The communication made by Admiral Boutakof, who has long distinguished himself by many years of labour in this region, was listened to with great attention, and received with great enthusiasm. We could not give here more than the mere outlines of the paper, which he is now preparing for the press, and which will appear with a map of the Syr-Daria. There is no doubt that Admiral Boutakof's work will be an agreeable acquisition for modern geographers.

Kashmir, the Western Himalaya and the Afghan Mountains, a geological paper by ALBERT M. VERCHÈRE, *Esq., Bengal Medical Service; with a note on the fossils by* M. EDOUARD DE VERNUEIL, *Membre de l' Académie des Sciences, Paris.*

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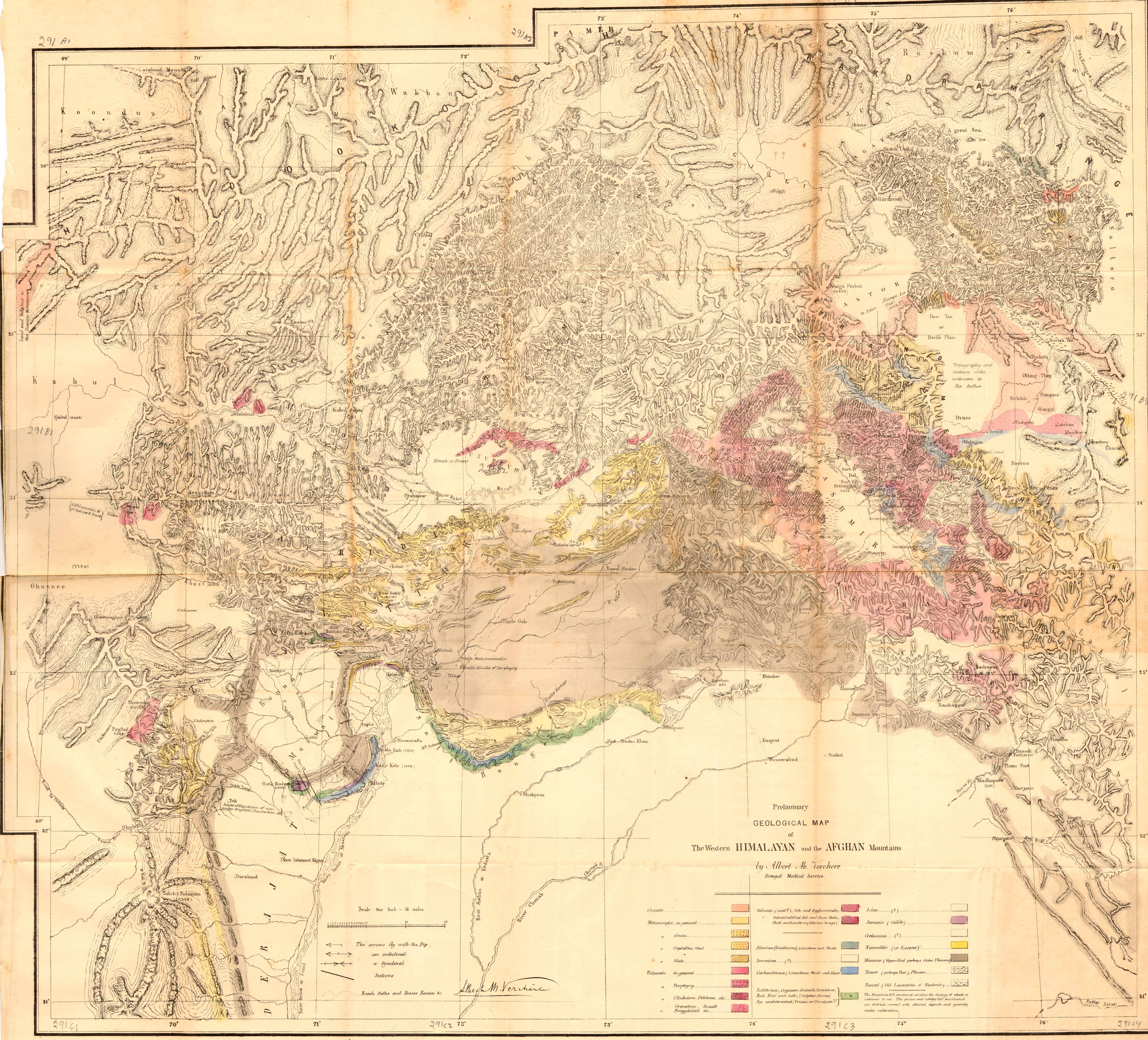
INTRODUCTION.

Of all the great chains of mountains on our Planet, the most stupendous is, singularly enough, the least known to the geologist. Many fossils have indeed been collected by travellers in the Himalaya, and a few have been determined; but satisfactory sections and careful descriptions are very scarce, and it has not yet been found practicable to attempt any general grouping and arrangement of the rocks and beds of these mountains. Jacquemont's researches in Kashmir have not, I believe, much advanced our knowledge of the geology of the country. Mr. Vigne was no geologist, and his observations were not sufficiently accurate for scientific purposes; the same remarks apply, more or less, to most visitors who have published what they saw amongst the higher ranges. Captain R. Strachey, R. E. in his papers on the geology of the Himalaya, between the Sutlej and the Kali rivers, gives a map and two sections which are of great interest; they do not, however, refer to the portion of the Himalaya which I have studied, and they leave yet a vast field for more precise investigations. I regret not having been able to consult Capt. H. Strachey's paper



On transfer paper by S. Ismail. &c

LITHOGRAPHED AT THE SURVEYOR GENERAL'S OFFICE, CALCUTTA FEBRUARY 1867.

on the physical geography of Little Thibet, and Dr. Thompson's work on the same country; neither have I had the benefit of Mr. Medlicott's Memoir on the southern ranges of the Himalaya, between the rivers Ganges and Ravee, nor any of the other papers which have been written on the Sub-Himalayan ranges.

Of the geology of Kashmir especially, I believe that very little indeed has ever been published, and that not even a geological horizon has been discovered. Mr. Vigne and Dr. A. Fleming reported having found in Kashmir "Nummulitic limestone disturbed and calcined by greenstone;" this was an error of some importance, as it gave a false datum from which to fix the age and relations of the Azoic rocks. Dr. A. Fleming, in his report on the Geological Structure of the Salt Range, published in Selections from Public Correspondence of the Punjab Administration, Vol. II., 1855, has the following passage:—

"From Kashmir, too, Mr. Vigne obtained limestone *containing* "*nummulites.* This we have seen in situ on the side of a mountain "at the upper end of the Manus Bal lake, where it is much disturbed "and calcined by greenstone. It probably forms the summit of "many of the higher hills on the northern side of the Kashmir valley, "a district fraught with interest to the geologist and hitherto quite "unexplored."

When I arrived at Srinuggur, Mr. Drew, who had visited Manus Bal, showed me some specimens of the limestone of that locality, and expressed a doubt about the markings seen on the rock being nummulites; he considered their markings to be the result of crystallisation and weathering; but I could not accept this view, and regarded the little marks as indications of organisms. I was unwilling to believe that Dr. A. Fleming could possibly have made a mistake about nummulites, after the experience he had had of their appearances in the Salt Range and the Bunnoo district; and, as Mr. Drew acknowledged that he was not familiar with the nummulitic formation, and the specimens shown me were very bad and ill-preserved, indeed merely faint marks in a coarse limestone, I temporarily admitted Dr. Fleming's view. I was, at the time, unable to visit Manus Bal, or to absent myself a single day from Srinuggur, owing to great sickness amongst the visitors; but I had the good luck to discover a bed of fossiliferous limestone and shales within a few miles of

Srinuggur. These beds were near enough to enable me to ride to them in a few hours, and I soon found that they contained the same forms as were known to occur in the dressed blocks of limestone (obtained from Buddhist ruins) of which the river-walls and river-stairs of Srinuggur are built, and I also found the remains of one of the antique quarries near my favourite locality. Ultimately, the rocks reported to be nummulitic were found to be carboniferous, and the so-called nummulites, rings of Encrinite-stems ; the volcanic rocks were also ascertained to be palæozoic in age and not intrusive. (See para. 53, where the Manus Bal limestone is described in detail.)

To my friend, Captain Godwin-Austen of the great Trigonometrical Survey, I owe my best thanks. I had wished that this paper might have been written in conjunction with that gentleman, and it would have been well for the reader, if it had been so ; but as Capt. Austen went to Bhotan and I to Bunnoo, such a hope had to be abandoned.

In drawing up the map, I have used for its topography whatever materials I could procure, but I have not had the benefit of many recent discoveries and surveys. The compilation was made from works of very different values. Kashmir, Hazara and the British Trans-Indus districts are, I believe, tolerably accurate ; the Salt Range is less so ; whilst the Korakoram Chain, the Hindoo Koosh, Kaffiristan, Chitral, Kabul, etc. only lay claim to give a general outline and direction of the ranges, valleys and rivers. About the Hindoo Koosh, I much regret not having been able to avail myself of the maps of Kaffirstan lately published in the office of the Surveyor General of India.

It may appear, on seeing how little of the Afghan mountains is geologically coloured, that there was no necessity of extending the map as far as the Hindoo Koosh, but I hope that the advisability of having sketched in this chain will be acknowledged, after reading the fourth chapter of this memoir.

The geology of the map is partly from my own observations and partly from information obtained from friends and travellers ; I have endeavoured to enter nothing which did not appear pretty certain. I have been able to sift satisfactorily a good deal of the information obtained, by means of specimens which were either shown or given to me.

I have added a few sketches of fossils which, I hope, will be found sufficiently well done to enable the organisms to be easily recognized. The forms sketched are those which have appeared to me most characteristic of the beds met with.

The two parts of which this paper consists are nearly separate memoirs. In the first, chapters 1 and 2, a description of the mountains of Kashmir is given in some detail. In the second theoretical views are discussed; but as Kashmir is merely a small portion of the Himalaya, it was found impossible to understand many fossils without taking such general views as referred to the whole mass of the chain; and, further, as the Himalayan chain is supposed by me to be intimately connected with the Afghan mountains, these mountains had also to be considered. In order to be intelligible, it became therefore necessary to write a cursory survey of the Afghan-Himalayan regions; this is done in the 3rd chapter. It is of course very superficial and incomplete; yet I hope that it may not be without some interest. On the data furnished by the first three chapters, the hypotheses advanced in the fourth are based.

I have not entered into many details on the eocene and miocene formations (except incidentally), as it would have lengthened to undue proportion this already too long paper; these formations deserve to be studied by themselves. The same remarks apply to the Jurassic and Saliferian rocks. In chapter 3, however, a few words will be found on the nature and relations of these beds. The principal object of this paper, in its descriptive portion at least, has been a study of the older rocks, viz. Silurian and carboniferous, together with the volcanic and metamorphic rocks.

I trust that the many imperfections and errors which cannot fail to occur in a memoir of this nature, will not be too severely criticised. My excuse is that this paper was prepared at one of the out-posts of the Punjab Frontier, where I had not the usual assistance of a Museum and a Library. Such as it is, I hope that it may not be without interest to some of the members of the Society who are fond of geological researches.

CHAPTER I.—*Felstone and Porphyry.*

The mountains South-West, South and West of Cashmir.

Baramoola is a small city, well known to the tourist in Cashmir and to the pedestrian coming from Murree; it is a haven of rest, for here boats may be hired to take him to Srinagar, the very heart of the valley. From the heights above the town the traveller gets his first view of the celebrated vale, and in the spring of the year it is difficult to imagine any more beautiful landscape than it affords. It is here also that disappointment or enthusiasm commences, according to the traveller's disposition: for to many Cashmir is an overrated land, whilst to the scientific man, to the artist or the antiquarian it is a mine of great wealth.

The town is built at the foot of a hill which has a direction west to east, and is cut in two to give a passage to the river Jheelum. It is approximatively in N. Latitude 31° 13′ and E. Longitude 74° 23′. Its southern view is limited by a small hill, the Atala, and on the west a mountain of 8,467 feet, the Shumalarum, also confines the horizon. Thus, placed in a cradle of hills, on the banks of the Vedusta, it has a picturesque aspect, a damp cold climate, a celebrity for rain and storms, and a great name for earthquakes.

The hills at the foot of which Baramoola is built are the extreme eastern extension of the great Kaj Nag Range, which, proceeding from E. to W. for 20 miles, bifurcates into a huge north-westerly branch (which I shall leave alone for the present, as I know nothing about it), and a southern branch which, proceeding S. S. W., divides again, one arm going west towards Mozofferabad, whilst the other, the Kiren or Kirna range, crosses the river at Ori (or rather the river crosses it) to be continued with the Kandi range in the direction of the Pir Punjal chain.

2. The whole range of hills near Baramoola dips S. by a few degrees E., and in describing the rocks from S. E. to N. W., we shall therefore proceed from the more superficial to the deepest.

On the left bank of the river, we find a clinkstone or felstone of a dark grey colour and slaty texture, and an appearance as if it had been drawn while in a viscid state. It has a sandy feel to the hand; it breaks into long narrow flags having a close resemblance to pieces of pine wood which have been cut and prepared for burning, and have weathered grey by exposure. It has a well marked stratification, which is cut obliquely to its plane by a slaty cleavage which forms with it an angle of about 113°. It has also a series of parallel joints, about 2 or 3 feet apart, and which cut the stratification at right angles but form with the cleavage an angle of 67°. The joints are usually lined by a coating of quartzite, and both quartzite and felstone are occasionally stained by iron.

The felstone appears to be entirely composed of elongated and flattened granules of felspar or albite, which has a sub-vitreous lustre when closely examined ; it has a dark bluish-grey colour, but weathers ash-grey and even dirty white and some pieces which are very fissile, assume somewhat the silky appearance of amiánthus. The colour of the paste appears to be due to augite; this, by decomposition, lets free a certain quantity of iron which causes the surfaces of cleavage and stratification to be covered by a powdery, rusty incrustation. Sparingly disseminated in the mass are seen minute fusiform nodules of dark shining augite; these nodules are never crystalline. Some strata are extremely thin-bedded, like sheets of paper, and fall to pieces very easily, ultimately decomposing into a brownish earth. Other strata present an alternation of very thin laminæ of nearly white and dull albite, and a dark grey shining mixture of felspar and augite, so that, when the rock is broken vertically, it appears striped white and grey.

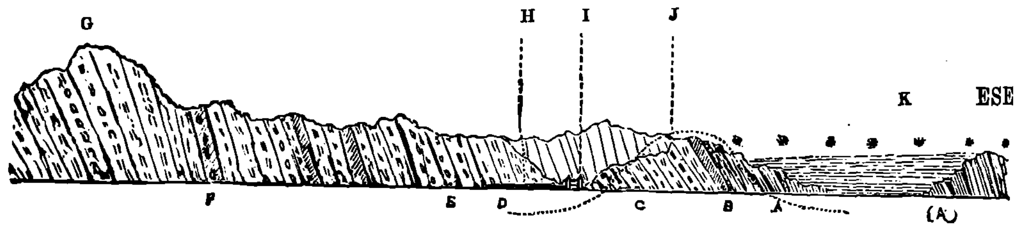
3. The above beds dip S. and a few degrees E., with an angle of 60° near the Atala hill, but the angle diminishes as we go towards the N. W., being no more than 45°, near the river at Baramoola. For two miles along the left bank of the Jhelum, this felstone was observed with, here and there, a band of amygdaloid interbedded. But I made too superficial an examination of the Atala to enter here into detail. Crossing the river to the right bank, we find that felstone also forms the hills which overhang Baramoola. Just over the city, it is similar to that of Atala, but as we proceed towards the N. W. and therefore see deeper beds, the character of the beds changes considerably. There is a beginning of separation of the minerals of the felstone, the dull white albite forming by itself innumerable penicilli having the shape of extremely elongated spindles which are imbedded in the grey felspathic paste. The rock has still,

however, a well marked stratification which is rendered very conspicuous by the white penicilli being parallel to it. There are also cleavage and joints as before, but a great deal more quartz in the latter.

The next beds, lower down, are much lighter in colour and more compact in structure. The paste is ash-grey, felspathic and dull looking, but instead of the penicilli noted before, we have here regular almond-shaped masses of white saccharine albite, usually about one inch long and two-tenths of an inch across, but often made larger and with the albite in the state of a fine incoherent sand. Then rocks, like the one with penicilli, but bluer in tint and interbedded with amygdaloidal greenstone and felspathic ash, containing oval nodules of augite, extend to the west, as far as the Shumalarum which they appear to entirely compose.

The angle of dip, on the right bank of the river, is again very great, being about 60°, and the beds are a good deal faulted. One fault has a direction N. E.—S. W. and the river runs in it at Baramoola. It is continued in a ravine on the right bank of the river, about a mile below the town. The angle of dip is not the same on both sides of the fault, and there has been a slight down-throw on the south. The Jheclum, while in the fault, is narrow but navigable; at the ravine, it turns suddenly to the south, quitting the fault and passing over a band of rock which stretches from W. to E., thus forming a small rapid. From this place to Ori, where the Jheclum enters the Sub-Himalayan tertiary sandstones, the Vedusta follows its course across the much up-tilted beds of felstone, changing its character of a winding, placid, broad and shallow river into that of a boiling, rapid, deep and narrow torrent, and forming, as it were, a succession of small falls and cascades all the way down. The thickness of the felstone near Baramoola is enormous. I can form but a mere appreciation, not having followed the beds sufficiently far to the west; but I am certain that it is much above 5,000 feet.

4. The following section (marked I. on the map) is merely a diagram to enable the reader to understand the position of the beds. It is oblique and not at right angle to the dip.



A. Dark grey felstone, slaty, stratified and with a cleavage and joints. Fusiform, elongated, minute granules of augite. Many thin-bedded strata, ... about 400 feet.

B. Felstone like A, interbedded with strata of felspathic ash containing nodules of augite, ... 30 „

C. Rough trachytic clinkstone or felstone, breaking in elongated slabs terminated by oblique, clean joints generally lined with quartzite, ... 500 „

D. Bluish grey felspathic paste with innumerable penicilli of white powdery albite,.. 500 „

E. Pale grey felspathic paste with almond-shaped masses of albite, either powdery or compact and saccharine. Beds of ash interstratified, ... 400 „

F. A succession of beds similar to D. and E. interstratified with bands of amygdaloid and of felspathose ash containing oval nodules of augite. This rock appears to form the whole of the Shumalarum, and was seen, as far as I could see, towards the west.

G. Shumalurum, 8467 ft.

H. River Jheelum or Vedusta.

I. Baramoola.

J. The dotted line is the Atala.

K. Lacustrine Clay and Boulders.

5. The rocks, which I have endeavoured to describe, are continued along both banks of the Jheelum as for as the fort of Ori, about twenty five miles south of Baramoola. Following them on the left bank, (Murree Road) we first cross the Atala, and can observe, near the village of Mihrur, very fine narrow slabs of felstone, twelve feet long, used as rafters to support a roof over a holy well or spring. Proceeding S. W. we cross a small marshy valley, and near the village of Ghaut Mullah we meet a succession of spurs directed towards the N. W., and which are the extreme north-western extension of the Pir Punjal Chain. These spurs are also made up completely of felspathic flagstone, identical to that which I have described above, but the dip and strike of the beds are different from that of the beds near Baramoola: the dip is W. with a

very high angle; but the rock is much decomposed, the vegetation rich, and little is seen until we reach Nausherra. Thence, the beds are well exposed, forming lofty cliffs over the path, of a grand and picturesque aspect; they are often quite vertical and seldom form an angle with the horizon of less than 85°. But the same force which has made those strata stand on end, has also broken them and wheeled round enormous sections of the beds. Even a superficial examination shows that portions of the hills, some thousands of yards long, caught as it were between two faults and thus set free in their movements, have been made to rotate on themselves, the strike changing its direction from a few to ninety degrees. Thus, near Buniar, the strike is N.—S.; a little further south it is W.—E.; four miles before we get to Ori it is W. 15° N.—E. 15° S. and the dip is southern and only 45°. At Ori the strike is again about N. W.—S. E. and the dip northern and 80°. But it is often difficult to see the stratification in these laminated rocks, as cleavages and joints are generally better marked than the stratification. The general strike, however, is from N. a few degrees W., to S. a few degrees E., and the dip is northern.

Between Nausherra and Ori, the felstone presents several appearances. The bulk of the hills is made up of a pale grey and extremely laminated felstone, having much the appearance of slate, and being crossed by numerous veins of opaque quartz. These veins are sometimes so thick that they form bands of quartzite. Near Ori, some beds are seen having the appearance of metamorphic chloritic slates. Others are made up of very thin-bedded felstone of an earthy appearance, and are wonderfully wavy and crimpled, whilst the beds above and below them are but gently undulated. It appears probable that these thin-bedded layers were deposited by water during periods of volcanic inaction, and that when the covering felstone contracted in cooling, the aqueous deposit was gathered in zigzag folds. They ought, therefore, to be considered either as an ash arranged by water, or as a laterite derived from the surface of decomposing felstone, and having the same composition as its parent rock.

6. About half way between Buniar and Ori, is a small Buddhist ruin concealed by brambles and wild roses, and built of a dark grey rough trachy-dolerite. This rock was obtained from a thick band

which is well seen close to the ruin. It is divided into somewhat prismatic blocks by joints; it is generally compact, but sometimes scoriaceous, and it appears to have had some influence on the cooling of the felstone above and below it, this being much more compact near the trachy-dolerite, and becoming gradually more laminated and slaty as we get further off. I cannot say whether the trachy-dolerite is intrusive, or interbedded; but it is perfectly conformable to the felstone.

7. At Ori, we find a small valley sunk between high mountains and crossed by a tolerably big ravine and by a torrent flowing from the S. E. to N. W. This torrent divides the hills on the S. W. which are miocene sandstones and shales, from the mountains on the E. and N. E. which are volcanic. The Jheelum describes a semi-circle round the extremity of the Kiren range, the beds of which cross the river to be continued with those of the Kandi or Kanda Range, which are the link between the Kirna Range and the Pir Punjal Chain. The river runs for a little while between the volcanic rocks of the Kirna and the miocene sandstones, but it very soon leaves this bed, and cutting a canal through the tertiary sandstones and clays, bids farewell for ever to rocks of a volcanic origin.

8. I will not enter into a description of the tertiaries in this paper, though we shall have to see much of them incidentally, but as it has been said and written by many persons that the miocene sandstones and clays dip under the volcanic felstone (generally described as metamorphic schists or quartzose mica-slate), I must correct the error, while we are at Ori. Both the volcanic and miocene beds are nearly vertical, but not quite, and dip northernly, and there is therefore an appearance of the miocene dipping under the felstone. On examining the high bank of the Jheelum, however, not far from the fort, I could see the miocene beds bend backwards, thus showing that they

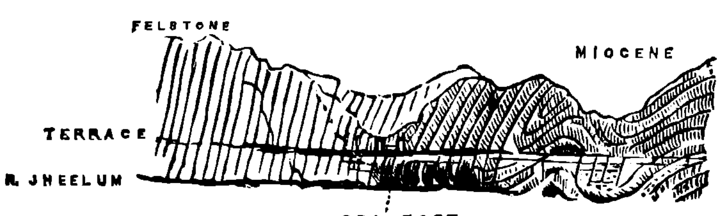


fig. 1.

are superior to the volcanic rocks, but have been dressed up against them by a lateral pressure. The diagram (fig. 1.) shows well the folded disposition of the miocene and the bending backwards of the beds in contact with the felstone. These beds are partially concealed by a very high river-terrace of conglomerate, but this has been washed off in many places and the rocks are left uncovered.

There is, in the Sub-Himalaya, sufficient evidence of miocene sandstone having been mostly raised by a lateral movement; there appears to have been a reflection, a *refoulement* of the miocene beds towards the S. and the W., as if the enormous masses of the central chains had surged up through a chasm of the earth's crust and forced the sandstone aside, instead of lifting it up. And thus the volcanic rock of my diagram would have pressed against the miocene, and curbed up and bent back the yielding plastic beds of sandstone and clay.

9. Returning now to Buniar, half way between Ori and Baramoola, we cannot fail to admire the remains of a Buddhist temple of considerable size and great beauty. It is built of a white porphyry, and of this porphyry we must now speak in detail.

The stones of the temple were obtained from huge blocks which are strewed on the river terraces on both sides of the Jheelum, in the neighbourhood of Buniar. Some of these blocks are of enormous size: one I noticed is about 20 feet above ground and nearly as thick and broad as it is high. No water-power could have moved such enormous masses, and they have evidently been brought down by glaciers. I have been told that Mr. Vigne supposed them to have been brought by icebergs floating on a huge Kashmir lake, but we need not go so far for their origin, as the Kaj Nag peaks, seven miles to the north, and the Sank or Sallar, eight miles to the south, are mostly composed of this porphyry. A glance at the map will easily demonstrate how glaciers, filling up the narrow valleys of the Harpeykai and the Khar Khol, brought down to the river-terraces blocks of porphyry detached from the summits of Kaj Nag and Sallar (13,446 ft. and 12,517 ft.). I had not time to visit these valleys and look for ancient moraines, but some blocks show striæ and scratches such as glaciers alone can produce. These glaciers no longer exist, but their disappearance is only the result of a change of climate of the Himalaya, which is abundantly proved to have taken place at a very late geological epoch by the river-terraces, raised lacustrine deposits and other indications of diminished rain-fall.*

10. Examining the porphyry of the Kaj Nag mountains in hand specimens, we find it composed of the following minerals:—

a.—Paste of granular, white, opaque albite, fusing before the blowpipe without much difficulty or = $4\frac{1}{2}$ of Von Kobell's scale of fusibility.

b.—Small transparent crystals of quartz-like rock-crystals.

c.—Large crystals of glassy shining albite, with a vitreous lustre and a lamellar cleavage. Sections of the crystals are sometimes as much as five inches long.

d.—Plates of white mica; sometimes grey.

e.—Dark augite (or Horneblende ?) with an Iodine lustre and a dark greenish grey colour. It fuses = 4, without swelling or boiling.

f.—Garnets; red, brittle and cracked.

g.—Grains of magnetic iron ore; metallic lustre; black.

h.—Gold; in invisible scales.

The paste of granular albite is hardly to be seen in the most crystalline specimens of the porphyry; but it increases very much as the several crystals are less abundant and less well defined, forming rocks in which we see, beside it, only a few specks of dark augite and spangles of white mica; even these occasionally disappear, and we have a rock having a saccharine appearance, and entirely composed of minute shining grains of albite. Specimens are found in all the stages of transition, from the highly crystallized porphyry to the saccharine rock.

The quartz is not very abundant in the most perfect porphyry, but it increases in some specimens, rows of small rock crystals appear-

* The diminished rain-fall is the result of the filling up with diluvial deposits of the great troughs situated between the Himalaya, the Affghan mountains and the mountains of Central India once covered by the sea, and now represented by the valleys of the Ganges and Indus. This filling up of the sea-communication once existing between the Bay of Bengal and the Arabian Sea, converted the Himalaya's climate, then insular, or at least littoral, to an eminently continental one. The tremendous rain-fall at Cherra-Poonjee ($50\frac{1}{4}$ feet during S. W. Monsoons) enables us to form an idea of what the snow-fall must have been on the high summits of the Himalaya in the days when the Bay of Bengal extended to the foot of the Siwalik hills, and the Arabian Sea bathed the Salt Range.

ing in the map. It becomes also amorphous and forms bands of considerable thickness of opaque quartzite, crossing the rocks in the same manner as similar bands often cross beds of shales or other stratified rocks.

The mica is also scarce in some specimens, small spangles being occasionally imbedded in the substance of the large crystals of albite (c) or sparingly disseminated in the paste. But in other portions of the porphyry it becomes very abundant, forming tufts of plates which resist decomposition better than the other minerals, and stick out of the rock where this has been worn and rounded by exposure. These tufts of mica often form irregular bands.

The augite varies from a few specks to laminar masses of considerable size. It is often found associated with felspar alone, the other minerals having disappeared, and it thus forms a rock composed of amorphous grains of albite and lamellar masses of augite. Before the blowpipe it fuses only in places, small globules of a shining black glass appearing on the assay.

The garnets are sometimes wholly wanting and sometimes very abundant. It is very difficult to extract them from the mass, owing to their brittleness. They are mostly found where the porphyry is well crystallized and the mica abundant.

The large crystals of albite vary in size from half an inch to five inches. They have two cleavages, one nearly at a right angle to the surface of the plate, or forming with it an angle of about 95°. The other cuts the first cleavage obliquely with an angle of about 115°.* The form of the crystals is, I fancy, uncommon, and I will describe one of them with its dimensions, in order to give an idea of the proportions of the crystals.

The crystal is always twin or composed of two hexagonal plates (fig. 2) two and half inches in diameter between opposite angles, and 0.4 inch thick. Either four or the six edges of the plate are bevelled by oblique facettes, which form with the plane of the surface an angle of about 138°, so that one surface is considerably smaller

* The angles of these crystals were measured with strips of paper and a graduated half circle; the crystals were also much weathered; the results are therefore mere approximations. If I had had the means of measuring the angles with precision, I would have figured the crystals.

than the other. Two such plates are applied one against the other by their greatest surface, but one of the plates has (apparently) rotated half a turn, so that A of one plate is opposite B of the other.

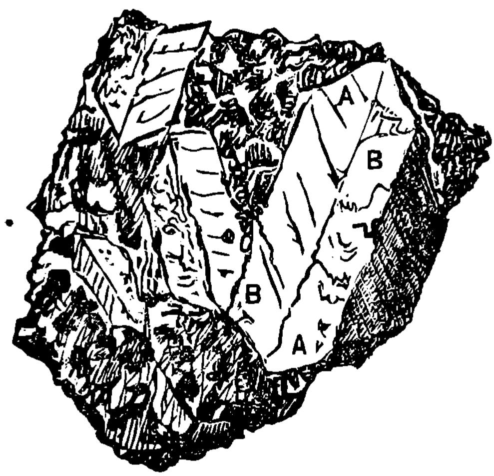


Fig. 2.

This rotation is of course only apparent, but it appears to have taken place from the cleavage of the two plates being opposite, so that when we look at a section of the double crystal (fig. 2), one side presents the shining striped surface of a lamellar cleavage, whilst the other shows the dull rough surface of a fracture across the grain. This opposition of cleavage is probably due to a play of opposite electricity generated during crystallization, but it gives the idea of one of the plates having made half a turn before applying itself against its fellow.

The perfect crystal is rarely seen; it is generally broken across, and the section (fig. 2) is conspicuous on the surface of the rock, so that, at first sight, one may fancy the crystals to be prisms, and a little trouble is necessary to understand the arrangement of the twin plates. This macle is therefore, to all appearance, a twin crystal of one of the numerous modifications of triclinic albite.

By exposure to the atmosphere, the porphyry crumbles easily and falls to a coarse gravel which is soon converted into a very white sand. While the rock is still hard and sound, the large crystals of albite sometimes become loosened in their matrices, and, falling out, leave angular cavities on the face of the rock. The rock, when fresh and well crystallized, is however very hard: some varieties appear to crumble much more quickly and completely than others.

II.—The grains of magnetic iron ore and the gold I have not seen in the porphyry,* but they are found in the sands which, I will now endeavour to prove, have been formed by the decomposition of these volcanic rocks.

Gold is washed in most of the rivers which traverse the miocene sandstones and conglomerates of the sub-Himalaya, and is always found associated with grains of magnetic iron ore. Let us examine one of the districts where the washings are, I believe, most abundant, the banks of the Soane river, in the districts of Jheelum and Rawul Pindee, especially near the villages of Pindeh Geb, Kothair and Mukud. Let us therefore go to Rawul Pindee and travel towards the S. W. along the road to Kalabagh. We find that this dreary road, about 120 miles long, crosses obliquely from the N. N. E. to the S. S. W. the great plateau of miocene sandstone, conglomerate and clay (Sect. G.).

There is a thick bed of miocene sandstone and conglomerate, above 2,000 feet thick, which might be called the upper miocene formation of the Sub-Himalaya (contemporary of the Sewalik hills and containing the same Mammalian fossils), whilst the sandstone and shales of Murree and adjacent hills, about 5,000 feet thick and without fossils, might be regarded as the inferior miocene. These two divisions of the miocene are not exactly one on the top of the other, but rather the upper bed thinning towards the north, covers in the southern edge of the lower bed in an intricated

* A similar granitoid porphyry exists in Portugal, in the hills near Cintra about five leagues from Lisbon. It is there very variable in appearance and consistency, and is generally made up of large grains of felspar and of quartz, and of large plates of mica. It contains grains of magnetic iron ore, but I am not aware whether it contains the large twin crystals of felspars seen in the Kaj Nag porphyry. The Portugal rock is generally described by travellers as granite, but is considered by geologists as decidedly volcanic. It presents the character of crumbling easily after a certain amount of exposure.

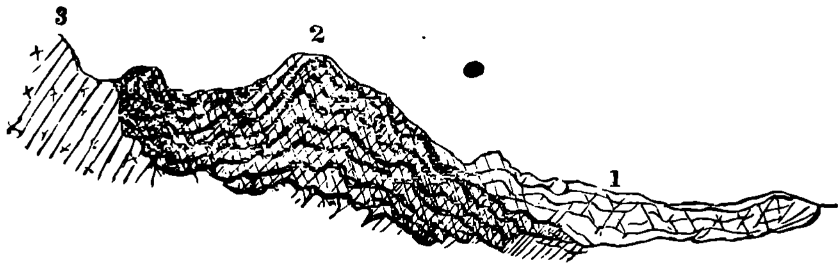


Fig. 3.

manner, as represented in the accompanying diagram (fig. 3): 1, Upper Miocene with Mammalian Bones; 2, Lower Miocene without fossils (excepting a few roots and stems and imprints of leaves); 3, Porphyry and Felstone, &c.

The upper bed is therefore not seen near Murree, whilst the lower bed is equally absent from the great plateau of Rawul Pindee, where the fossiliferous sandstone is always seen to rest directly on the Nummulitic formation, wherever this breaks through the miocene. The bed we have to deal with here is, therefore, the upper miocene only. It is much folded and faulted, forming stray folds and many faults at both extremities of the bed, and rolling in broad undulations in the centre of the plateau. Now, if we examine the much up-tilted beds near Futteh Jung, Nusrulla, or else close to the Salt Range near Kalabagh, we find them composed of a grey or greenish calcareous sandstone, of conglomerate and of sandy indurated clays containing nodules of kunkur. These beds look like inclined and parallel walls sticking out of the alluvium, and separated one from the other by open spaces or intervals; and one may at first sight fancy that the several strata have been wrenched apart at the time they were upheaved. But if we examine the beds where they are nearly horizontal, as in the neighbourhood of the Soane river near Kothair or Jubbie, we find that they consist of a hardly cohesive sand, very white and composed of minute grains of albite and quartz, with black grains of augite and spangles of mica. I have been in the habit, in taking notes, to call this sand, Pepper and Salt sand, and I shall here make use of this term, as it is a convenient one. Interstratified with this sand we find the beds of grey or greenish sandstone, of conglomerate and of sandy clay noted at Futteh Jung; and it becomes evident that at the places where we first observed the beds, and where they are much tilted up, the pepper and salt sand has been washed out from between the harder beds, whilst in the horizontal strata, the sand has been protected by one of the strata of harder rock which acted as a roof over the sand underneath.

Now this pepper and salt sand is the one washed for gold. The washings are done during and after the rains, as the swollen waters of the torrents bring down to the beds of the rivers a large quantity of fresh sand. It is washed in the usual manner, and gives a residue of a black sand which is composed of shining grains of magnetic iron ore and grains of augite. A little more washing in a smaller vessel removes the augite and a great part of the iron; and the gold, which is rarely visible with the naked eye, is picked up by mercury.

If we examine the pepper and salt sand in situ, we shall very soon become convinced that it is nothing but the porphyry of the Himalaya ground down to powder, for we find in it numerous pieces of the porphyry not quite crushed to sand. I have found some of these pieces half an inch long and composed of a hard fragment of albite supporting specks of augite. Pieces of the large felspathic crystals I have seen also, and the smaller crystals of quartz are frequent and hardly altered and rubbed. The sandstone consists mostly of undecomposed albite and augite. It is not easy to describe in words the great similarity between the porphyry and the white sand, but their complete identity strikes one at once when we study the beds. Dr. Fleming made therefore a good guess when he wrote the following passage: "We have been quite unable to trace the source whence the gold has been derived, and are not aware that amongst the quartzites and quartzose mica slates (felstone is meant,) which are much developed in the Punjal Range, near the Baramoola Pass into Kashmir, and stretch west into the northern Hazara mountains, the metal has ever been detected in situ. From similar rocks there can be little doubt that the auriferous sands have been derived."*

And again he writes: "In the neighbourhood of the Salt Range the scales of gold are small and almost invisible, but we have heard from natives, that, in Hazara, grains of gold are sometimes found of a size such as to admit of their being picked out of the sand. If

* Report on Geological Structure of Salt Range; Selections, P. Govt. Vol. II. 1855, page 342.

this be true, we may infer that the auriferous source is somewhere to the north, and that by tracing the gold stream, so to speak, we might arrive at a point where the drifted materials become coarser, and where the gold, from its high specific gravity, has been deposited in larger quantity."*

That the miocene deposit of the Sub-Himalaya has been derived from the mountains situated N. or N. E. of it, is evident from the boulders contained in the conglomerates of the formation, these boulders being mostly volcanic rocks, such as we have seen in the mountains near the Baramoola, and such as we shall see in other parts of Kashmir. We will see, by and bye, that these volcanic rocks extend to the west, along the northern boundary of the Peshawur valley, as far at least as Jelalabad, and to the east as far, at any rate, as 80° east long., and probably much farther, though it appears from Captain R. Strachey's memoir on the geology of part of the Himalaya mountains,† that the volcanic rocks in the eastern portion of the Himalaya are more intrusive than they are in the western extremity of the chain.

If it is indeed true that grains of gold of some size are picked out of the sand in Hazara, some valuable diggings might yet be found in the valleys situated between the spurs of the Kaj Nag range or its extension to the west. But I cannot help thinking that, with a population everywhere anxious to wash gold even in very poor washings, auriferous sands of any economical value would have been worked long since, especially as the sands formed by the decomposition of a porphyry, similar to that of the Kaj Nag chain, and situated on the eastern frontier of Kashmir are searched for garnets only.

The magnetic iron ore is tolerably abundant in the pepper and salt sand, and is at present wasted by the gold-washers of Kothair and Mukud: but it has not been always so. In traversing the great miocene plateau of Rawul Pindee, I noticed for many miles along the road, between Pindeh Geb and Jubbie, small pieces of black slag, often in some quantity and evidently very old, as many pieces were seen where ravines had cut the ground, buried a foot

* Ditto ditto, page 344.

† On the Geology of part of the Himalaya Mountains and Tibet, by Captain R. Strachey, Bengal Engineers, F. G. S. Proceedings of the Geological Society of London, 1851.

and half below the surface. Knowing nothing then of the magnetic iron sand, I could not conceive whence the slags came, but on seeing the large quantity of iron ore which is washed out of the sand by the gold-diggers, I was forced to conclude that a time had been when the iron powder was saved and smelted. It is not such a poor undertaking as it might appear to wash iron from sand, especially as the gold alone would pay the men 3 or 4 annas a day, and a very little arrangement would save the iron. It contains about 70 per cent. of metal of the very finest quality and the very best to make steel. It resembles Swedish iron, and it is the same as the Kangra iron which has been proved to be of excellent quality by experiments in England. It is very dear, selling at £14 a ton. It is probable that the smelting of this iron sand was discontinued from the want of fuel, which is now very scarce on the plateau. That fuel was once more abundant, is sufficiently proved by the amount of travertin seen in many places where no springs exist now-a-days; and these fossil springs, if I may call the travertin by that name, tell us of a time when a higher jungle on the plateau and forests on the hills arrested a good deal of moisture, and wrung from the humid monsoons a portion of the rains which are now poured on the Himalaya. It would be, I imagine, easy for the local government to find out whether the magnetic iron ore is still smelted in some localities in the district, or when the smelting was discontinued, and to resuscitate the trade, the iron ore being brought to Mukud from the neighbouring villages, and there smelted with charcoal brought down in boats from the Akora Kuttuck hills or from Hazara. Excellent limestone is abundant near the banks of the Indus ten or twelve miles above Mukud. It is also abundant in the conglomerate on which Mukud is built.

The smelting of this iron sand would not, of course, give profits or yield a quantity of metal worth mentioning in comparison to the results of European industry, but it might be a valuable enterprise for natives possessing some little capital, and might much ameliorate the miserable condition of the gold-washers.

12.—Returning now to Buniar and the Kag Naj range, I must insist on the very changeable appearance of the porphyry. We have seen that it consists of a granular mass, with large crystals of albite, small crystals of quartz, crystals of garnet, plates of mica and lamellæ of augite, and that any of these crystalline minerals or all of them may disappear, leaving a rock entirely composed of a saccharoid paste of albite. At other times the quartz becomes very abundant, and thick bands of white quartzite traverse the mass. Again, the augite, which is sometimes wholly wanting and at others in very minute specks only, may increase and at last predominate and form dark rocks with a semi-metallic lustre, the augite being generally collected in masses of aggregate plates having the lustre of iodine. It very often happens that the minerals are arranged in bands or layers as in gneiss, and this apparent foliation also varies much, and often it does not exist at all, whilst in other instances it is extremely well marked, thus gradually forming a passage to the clinkstone, described in the beginning of this paper.

13.—I have not visited the high summits of the Kaj Nag: indeed, I have only seen a few spurs of this enormous centre of mountains; but, from the road between Nausherra and Ori, one can see on the other side of the river, towards the tops of the hills, immense masses of the white porphyry glaring in the sun through the underwood which covers these mountains; and Captain H. Godwin-Austen, G. T. S., who assisted in the survey of this district, informed me that the white porphyry of the Buddist ruin at Buniar forms the summits and all the central system of the Kaj Nag range. From a coloured sketch kindly made for me by this officer we are enabled to see that the porphyry forms the whole of the main chain of the Kaj Nag, a portion of the huge North-Western branch, and extends along the western or Mozufferabad branch towards Hazara. The rock passes gradually from the granitoid porphyry I have described to less and less crystallized rocks, until it becomes the pencillated white and blue felstone which we have seen at Baramoola, and finally the earthy, slate-like felstone of the Atala mount.*

The summit of the Sank or Sallar, on the left bank of the Jheelum, I have also painted as volcanic porphyry, from my observing that the valley of the Apaikey is strewed with blocks of porphyry to a

* Captain Austen described the felstone as a hard slate, but as he said that this slate was identical with the "hard slate of the lofty cliffs over the road near Nausherra," it is evident that what was taken for slate, was an earthy slate-like felstone. At the time Captain G. Austen observed these rocks, he had not yet begun to study geology.

considerable height, and disposed in such a manner that they cannot have been brought from any other locality but the summits above. When I visited the Apaikey valley, the summits on both sides were covered with a thick mantle of snow, but the very shape of the peak, a smoothly rounded boss, was suggestive of a hill composed of materials which wear quickly and round easily under the influence of atmospheric vicissitudes.

14.—We must now endeavour to ascertain the extent of country covered by volcanic rocks similar to those I have described, and I am again indebted to Captain H. G. Austen for the following information: "The so-called granite, or, as you say more properly, volcanic porphyry, of the Kaj Nag is quite unlike the granite of the Deosais or Ladak, which is pure granite or syenite. This Kaj Nag rock is seen again in the mountains bounding the south-east end of the valley (of Kashmir) and in Kistwar; and the whole length of the Chota Dhar range, bounding Badrawar to the south, is of it; I have seen it nowhere else. It is so strikingly peculiar that I should certainly have noticed it, had I come across it in other parts of Kashmir."

How far the porphyry of Kistwar and Badrawar extends to the east, I have no means of judging;* but we have seen that the Kaj Nag extends towards the west into the upper part of Hazara; and I have had described to me some "granite" seen a few miles north of Mauserah, near the entrance into the Kaghan valley, which appears to be a volcanic porphyry similar to that which we have seen at Buniar.† But it extends still further west: Dr. Costello informs me that a great deal of "*granite*" and quartz occurs in and near the Umbeyla pass, lately occupied by the troops under General Sir Neville

* The "granitic" belt between the Sutlej and the Kali rivers, long. 77° to 80° 15′, appears to be a continuation of the porphyry of Kaj Nag, Kistwar and Badrawar. In Sirmoor, Garhwal and Kumaon it forms the centres of mountainous systems such as Chor, Dudatoli, Binsar, &c. Capt. R. Strachey describes it as "often porphyritic and much subject to decay." It passes into "*mica-shist* showing a distinctly laminated structure," (felstone ?) and also into greenstone.

† Also "a place on the road (to Mausera) as it passes along the eastern edge of the Pukti valley gets its name of *Chitti wat* (white stone) from several large blocks and hillocks of white felspathic rock containing large crystals, the same as that of the blocks on the ridge of Buri a few miles to the S. W., and like them visible "from a great distance."—*Journal of the Agricultural and Horticultural Society of India, Vol. XIV. Part I.*

Chamberlain. The General himself, in one of his dispatches, describes some of the hills as "granite," putting a note of interrogation after the word, and thus showing that the granitoid rock he noticed was sufficiently peculiar in its appearance to make it doubtful whether it was really a granite. From specimens of the mountains near the Pass, kindly given to me by Dr. Costello, I have no doubt that the so-called granite is one of the varieties of porphyry described in paragraph 12. It passes into a felstone composed of very elongated and large spindles of opaque, dirty white, and somewhat granular felspar and bluish semi-translucent glassy felspar, and in the spare felspathic paste which cements the spindles together, a few irregular grains are seen of a mineral having a metallic golden lustre, and which is probably Diallage or Bronzite. The rock has a great resemblance to, and is indeed identical with, the most compact sort of felstone seen at Baramoola. Bands of quartzite, of which I have seen very beautiful specimens as clear as Wenham lake ice, are also extensively developed, as well as enormous masses of compact gypsum and tabular selenite.

Dr. Bellew, in his "Report on the Yusufzaies," describes a variety of volcanic rocks occurring in the ranges which separate British Yusufzaïe from Chumla, Buneyr and Swat: "Feldspar grit" and "various combinations of mica and felspar," "porphyry in a variety of forms," "trap-rock in great variety," quartz, mica and clay-slate, hornblende-rock, felspar-rock and amygdaloid; "hard trap" (greenstone?) "loose, friable and crumbling" ditto. (ash?) He also describes granite and gneiss; but he adds that the gneiss is quarried for mill-stones, and, if these mill-stones, (which is very likely) are similar to the mill-stones of Jellalabad, they are a coarse gneissoid felstone, and not a gneiss. The granite again is a whitish rock, and we find it connected with and surrounded by, rocks undoubtedly volcanic. I have no hesitation therefore in regarding it as a granitoid porphyry, similar to that of the Kaj Nag. A great deal of slate and "*primitive limestone*" is also mentioned in these mountains.

Dr. Bellew concludes that these hills are "all of primitive and metamorphic rocks;" but the list of rocks he gives, proves conclusively that they are of volcanic origin.

These volcanic beds in Yusufzaie are capped, in some places, by beds of limestone, and these again by sandstone. No fossils have yet been discovered in either the limestone or the sandstone, and the age of these strata must therefore remain unknown for the present. Near Jellalabad beds of gneissoid felstone appear. This rock is quarried to make hand-mills which are brought down by the Povindahs and sold in Peshawur and the Derajat. These hand-mills are made of a coarse trachyte which has begun to effect a partial separation of minerals, and these minerals are arranged in streaks of white, granular felspar, greyish-blue felspar, with here and there a grain of augite. It is, therefore, again one of the varieties of felstone seen at Baramoola, and probably the same gneissoid variety quarried in Yusufzaie.

15.—By reference to the map we observe that the Pir Punjal chain is the first great parallel of the Himalaya, between the long. 73° 30′ and 76° E. It is a great chain, forming a belt of high mountains between the miocene districts of Jummoo, Rajaori, Poonch and Ori and the Kashmir valley, and at both ends of this great chain an immense accumulation of porphyries and other volcanic rocks, rising to tremendous heights, and covering some thousand square miles of country, are placed like two bastions at the extremities of a centric wall. What rocks then compose the connecting chain, the Pir Punjal? The reader will easily conceive how vexed I am that I was prevented visiting this range, more especially as the information I obtained from travellers is most conflicting and unsatisfactory. Mr. L. Drew, who has traversed the chain three or four times, was especially struck with the enormous development of a great slate bar of unknown age. We shall see in the next chapter, how very thick and extensive courses of slate are interstratified with beds of trachyte, ash and agglomerate, in the mountains bounding the Kashmir valley to the North. These slates are completely devoid of fossils, but as I hope to be able to fix the age of the volcanic rocks with which they are interbedded and contemporaneous, we had better reserve the discussion of their age until after the examination of the fossiliferous strata of Kashmir.

But the slates form only a band or bar in the Pir Punjal chain, and not the whole of it. I believe, that the remainder of the rocks of this range are mostly volcanic ash, felstone and agglomerates. A friend of mine and a very trustworthy observer, in the following passage from a letter to me, is describing, I think, volcanic rocks, especially agglomerates and ash full of lapilli and volcanic conglomerates. "It (the lacustrine deposit of the valley of Kashmir) rests unconformably on trapean rocks, quartzite, quartz conglomerate, very hard and forming a compact mass." And again, further to the S. W. on the road through the Pir Punjal Pass, he says: "The rocks are principally mica-slate, with *thick beds of a hard conglomerate having a very fine dark blue matrix; this, in some places, was a mass of water-worn pebbles; but in most of it these are scattered through the mass, and are often in that case angular and small.* Up to the Pir Punjal Pass the dip is N. with a high angle; having crossed the ridge N. E. this continues all the way to Barangulla, giving these altered sandstones, slates and conglomerates an enormous thickness."* The excellent observer who wrote the above remarks did not think, it appears, that the rocks were mostly volcanic in origin, but I cannot help imagining that his description applies, in great part, to stratified ejecta of volcanic eruptions, and the passage I have put in Italics is, I think, a very fair description of ash with lapilli. Again, I must also remark that the felstone of Baramoola has always been described by travellers, and by geologists also, as mica-slate, though it contains no mica and is nearly wholly made of felspar; what has been taken for mica, being minute spindles of glassy albite. It certainly has a slaty cleavage, and the most earthy varieties have a close resemblance to metamorphic slate, and it is probably this fact which has misled most people as to the nature of the rock. It is not therefore impossible that some of the "mica-slate," mentioned above, is in reality earthy felstone.

16. The position of the Pir Punjal chain is rather peculiar, abutting as it does at both ends against enormous centres of volcanic rocks, and being separated by a great fault (the valley of Kashmir) from mountains also composed of the same rocks. In the enormous accumulation of amygdaloidal ash, agglomerate and conglomerate which we shall see, by and bye, on the other side of the valley, there is abundant proof of the existence of open volcanoes in this part of the Himalaya, at the time the porphyry was in a fluid or viscid state. The extreme

* I do not give the name of the person who kindly gave me the information quoted, as I do not agree with him on the origin of these rocks, and believe that he missed appreciating their true value, though his description is accurate.

regularity and evenness of the stratification of these cinder beds renders it highly probable that the showers of ejecta fell in a shallow sea in which the volcanoes formed islands. It appears to me, that we cannot refuse to admit that the porphyry was the base of the volcanoes, and indeed the matter which failed to escape through the vent in the earth's crust, whilst the felstone or clinkstone and varieties of trachytic rocks into which the porphyry always passes, are lavas which have flowed under the pressure of the sea. If these views are admitted, we have a series of volcanoes beginning at the Kaj Nag, and forming an arc along the north-east boundary of the valley of Kashmir, down again to the mountains of Badrawar : of this arc of volcanoes the Pir Punjal chain is the chord. Can we wonder, huge though the chain is, at its being in a great measure formed by ejecta of volcanoes received in a sea gulf and there arranged in conformable layers ? The slate, as we shall see in the next chapter, was formed during the intervals of volcanic activity, and it is not improbable that the continual shower of ashes and hot stones into a shallow bay kept the water at a temperature too high for the development of animal or vegetable life.

Since writing the above paragraph, Capt. G. Austen has informed me that beds of unmistakably volcanic rocks, such as amgydaloid and coarse greenstone, are interbedded with the slate and other rocks of the Pir Punjal. This is precisely what occurs in the hills north of the valley of Kashmir, we may therefore regard the Pir Punjal as a mass of volcanic ejecta interbedded with slate which was deposited during the periods of volcanic tranquillity.

Chapter II.—*The Mountains North and North-East of Kashmir.*

17. By referring to the map, we observe that the Kashmir valley is an elongated trough with its longer axis directed S. E.—N. W. The Jheclum has a similar general direction, as far as the Woolar Lake, and the smaller stream which drains the north-western end of the valley flows from the N. W. to the S. E. To the north-east of this axis, we notice long spurs of hills which descend to the water-

edge of the Woolar Lake, the Manus Bal and the Dál and to the lacustrine plains of Pampur, Avantipoor, Bij-Behara and Islamabad. These spurs are the extreme south-western ends of a labyrinth of mountains which forms a barrier, nearly forty miles across as the crow flies, between the flat plain of the Kashmir valley and the chain of mountains which separates Kashmir proper from Drass, Sooroo and Ladak. If we consider the Himalaya as a series of parallel chains and valleys, we should have the Pir Punjal chain as one of the parallels; traversing the valley of Kashmir and the labyrinth of mountains to the north-east of it, we meet another great parallel chain, which has unfortunately no general name. It has been called by Col. Cunningham the Western Himalaya, but the name is evidently objectionable, as we want the term "Western," to designate the whole of the Himalaya between the longitudes east 73° and 79°, or between the Indus and the Sutlej. It has also been called the Central chain of the Himalaya by several authors, but the great quantity of snow which covers its peaks is merely the result of its being so placed, that it collects and condenses nearly all the remaining moisture contained in the south-western winds, and sends these winds perfectly dry to the Kailas and Karakoram ranges. The beautiful series of snowy summits presented by this chain is therefore no claim to its being the central chain of the Himalaya. I am afraid no other rule, but that of the division of drainage, can be considered safe in estimating which of the many parallel chains of a same system of mountains is the central one; and if we conform to this rule, the Karakoram range is to be regarded as the central chain of the Himalaya. It is therefore preferable to name the chain under consideration by the name of one of its great peaks, and as the Kun Nun or Ser and Mer Peaks (23,407 feet) are well known and very conspicuous in the western portion of the Himalaya, I shall make use of the term "Ser and Mer chain" to designate the great parallel range which separates the basin of the River Jheelum from that of the Indus.

Between the Pir Punjal and the Ser and Mer chains, we have not only the valley of Kashmir, but a number of independent and, as it were, isolated centres of mountains which, as I have said before, form a complicated labyrinth of hills and valleys to the north and north-east of the Jheelum. If we travel, on the map, from the N. W. to the S. E. of the valley of Kashmir, following the banks of the Jheelum, we shall notice a series of mountains of moderate height, encroaching into the valley, and separated one from the other by broad lateral valleys more or less filled with lacustrine deposits. The first mountain we meet is on the eastern side of the Woolar lake, and is called the Safapoor (10,309). Its foot is bathed by a small but exquisitely picturesque lake, (Pl. 6) the Manus Bal. The next is close to Srinagar and is the Zebanwan (8813). Ten miles to the south-east, the Wastarwan, near Avantipoor, is the next summit; then, after crossing the valley of Trahal, we meet the hill of Kamlawan (8601), over the village of Murhama, and the Sheri Bal close to the Kamlawan. Crossing the broad valley of the Lidar River, we find the Hapatikri, a mountain which sends a spur to the S. W. to form the small hill of Islamabad at the foot of which the town of that name is built. Crossing the valley of the Arpat river, we meet with the Dhar (8146) and the Nawkan (9207). We have therefore, from the eastern shore of the Woolar lake to the extreme south-east of the Kashmir valley, a catenated chain of mountains composed of isolated summits, whilst their relations are covered by the diluvial and lacustrine deposits which fill the Kashmir valley, and the lateral valleys which open into it. This chain is therefore presented to us as a series of summits and not as a regular chain.* Its direction is that of the general parallelism of the Himalaya, viz. from N. W. to S. E. Ten miles, as the crow flies, to the northeast of this chain there is another similar one, that is to say a series of summits, apparently somewhat detached one from the other, but being in a line with the parallelism of the Himalaya. These mountains are from the S. E. to the N. W.—the Liwapatoor, the Wokalbul (14,310) the Girdwali (14,060), Batgool (14,423), Boorwaz (13,087), Handil (13,273) Saij Aha (11,334). West of the Saij Aha, this catenated

* I need hardly say that the catenated appearance of the chains described in the text is in great part due to erosion, and that this great erosion is only what was to be expected, if we remember that the whole rain-fall of the southern slope of the Ser and Mer chain has to find its way to the valley of Kashmir across these catenated chains, and that the Ser and Mer chains receive a tremendous snow-fall. I use the word "catenated," in the same sense as it is used in Anatomy, to designate the arrangement of the lymphatic glands of the neck, viz. like the beads of a necklace or rosary.

chain becomes blended with the first one I have indicated. Ten miles again to the north-east of the series of peaks just enumerated, is another chain of detached peaks or centres of mountains, arranged along a line parallel to the two others and to the general direction of the Himalaya. From the S. E. to the N. W. we have the following summits or centres of mountains: the Rajdain (15,389), the Gwasbrari (17,839) the Harbagwan (16,055), the Basmai (15,652), the Kotwul (14,271), the Haramook (16,903) and the numerous peaks which, with their complicated spurs, separate the valley of Kashmir from Gurais and Tillail.

Between all these catenated chains, connecting spurs or branches are to be seen spreading in all directions, and it is extremely difficult to give the direction of the resulting masses of mountains. But the geology of these mountains will help us a good deal to understand their topographical grouping. As we see these mountains on the map, we should be disposed to consider them as long spurs of the Mer and Ser chain descending towards the S. W.; but we shall see that all, or at least most of these summits, are composed in their centre of rocks which have once been in a fluid or viscid condition, that is of porphyry, greenstone, basalt and amygdaloid; that these melted rocks are covered by enormously thick layers of ash, agglomerate and slate interbedded, and that on the top of these beds of ejecta fossiliferous strata rest quite conformably. It becomes therefore evident, that the summits represent separate and isolated centres of volcanic action, no doubt much displaced by the last upheaval of the Himalaya, but yet preserving their relations to the beds of ejecta which were collected around their feet and on their slopes. We have therefore a linear arrangement of volcanoes, or at any rate of volcanic fused matter, (for some of the collections of melted minerals may not have reached the surface and never had a vent), this linear arrangement forming three parallel lines, and these lines being parallel to the general N. W.—S. E. direction of the Himalaya. I believe that similar lines of volcanoes or collections of volcanic matter are to be found between several of the great parallel chains of the Himalaya, but whether they are thus general or not, the ones in Kashmir are sufficient to prove that during the Palæozoic epoch, the volcanoes of the Himalaya had an arrangement more or less linear, and that the great lines of fracture on which these volcanoes were situated, had the same direction as that of the Himalaya of our time.

18. Beginning with the southernmost line of summits, I will now describe in some detail the hills which compose it. I shall begin with that nearest to Srinagar, viz. the Zebanwan.

The Zebanwan is a mountain of 8813 feet at its highest point, with a general direction from E. to W. (Map B). Its eastern portion is nearly due E.—W., and is $2\frac{1}{4}$ miles in length. It then turns to the S. W., at the same time throwing out long spurs to the N. W. to embrace the eastern shore of the Dal. The Zebanwan keeps its N. E.—S. W. direction for $3\frac{1}{4}$ miles, when it bifurcates into two branches, a southern one, small and short, and a W. N. W. one, $2\frac{1}{2}$ miles long. It is at the end of this W. N. W. branch that the Tukt-i-Suliman rises, a very conspicuous little hill, seen from nearly every part of the valley. Still further to the W. N. W., $2\frac{1}{2}$ miles from the Tukt, the hillock of Hurri Parbut rises out of the lacustrine alluvial. It is evident that the Tukt-i-Suliman and the Hurri Parbut are only continuations of the W. N. W. spur of the Zebanwan, and appear as detached hillocks on account of the thickness of the lacustrine deposit. (Sect. A).

The following detailed section of Hurri Parbut, the Tukt-i-Suliman and the W N. W. spur of the Zebanwan is at a right angle to the axis of these hills. It will give, I hope, a good idea of rocks which we shall meet again and again, and which I will, therefore, endeavour to describe now with some precision, as they are nowhere better seen or more conveniently studied.

Section of Hurri Parbut, Tukt-i-Suliman and W. N. W. spur of the Zebanwan. (Sections A, B, &c.).

Direction of chain: S. 65° E.—N. 65° W. General strike of beds S. E.—N. W. General dip of beds, north-easterly. The Section follows the direction of the range and consequently cuts the dip at an angle of about 65° instead of 90°. (See Sect: A). (Section II. of General Map). See also Map B.

Hurri Parbut. This hill is a succession of hard layers of trachy-dolerite and soft layers of other rocks. The trachy-dolerite is rough, compact, very hard and dark. I have never seen it scoriaceous. It is sparingly amygdaloidal, containing sometimes a few large geodes filled with white quartz. These beds are nearly vertical, with a dip east-north-easterly, forming with the horizon an angle seldom under 75°. The most westerly beds are nearly vertical, whilst the most easterly layers are more sloping. There are seven or eight thick beds of this trachy-dolerite separated one from the other by the following rocks: (*a*) A slaty basalt, hard when fresh, but very soon falling into foliated debris. It reminds one somewhat of the earthy variety of the felstone of Baramoola. It is grey in colour. (*b*) an ash of a dirty-looking felspathic paste, full of rounded or oval nodules of dull augite or hornblende. These nodules are probably amygdaloidal in origin, being due to a bubbling of a hot paste of ash and water. It desintegrates very quickly into a yellow earth or a grey gritty soil on which grass grows well, soon concealing the rock below.

These beds of slaty basalt and ash are well stratified, and fill up all the spaces left between the layers of trachy-dolerite; this last rock forms prominent ridges or saddles on which the several works of the fort are built.

A marshy alluvial plain intervenes between the Hurri Parbut and the Tukt-i-Suliman.

Tukt-i-Suliman. The western extremity of this hill (as it appears above the lacustrine deposit) is a little knoll which has received the name of Rustun Ghurree.

1. Rustun Gurree: Compact greenstone either greenish or bluish; hard; fracture conchoidal. Either no amygdala or a few large ones, about the size of a pigeon's egg, often irregularly shaped, composed of white opaque quartz arranged in concentric layers and never crystallized.* Strike S. E.—N. W.; Dip N. E. = 50°. This is a hard rock and forms a prominent boss of a barren character. It is quarried for building purposes, but is too hard to be dressed, and as it breaks in angular pieces, it is altogether a very unsatisfactory building material. This bed has a thickness of about .... 60 ft.

2. A dirty yellowish-grey felspathic ash, full of geodes of dark augite. It decays fast, the nodules of augite, after partially decomposing and colouring the whole mass ochre-yellow, drop out of their niduses and leave a spongy mass of yellow earth somewhat resembling pumice, but not in its hardness. It is used as a good clay for pottery. It is much better developed on the northern than on the south-eastern side of the hill. In one section it is no more than .... 10 ft.

3. Resembling greenstone but much more amygdaloid. It is hardly seen on the southern aspect of the hill, where it is covered by vegetable earth and a cemetery; but it is well seen on the lake side near the water gate,... 20 ft.

4. Tukt-i-Suliman: A mass of amygdaloidal greenstone, sometimes compact, as at the base of the Rustun Gurree, but more generally showing dark specks of augite or hornblende in the mass. The amygdala of white quartz invade it, either as large and scarce geodes disposed here and there

* These amygdala of white quartz occasionally fall out of their matrices and are to be seen in numbers, half-buried in the soft silty mud of the lake near the village of Drogehand. Should this mud one day dry up into a rock, a false amygdaloid will be produced, all the more difficult to distinguish from fused amygdaloid, as the mud of the lake is entirely formed of the debris of volcanic rocks.

irregularly in the rock, or as smaller geodes mixed among long cylindrical and twisted branches of quartz running through the mass. (See figs. 1, 1*a*. plat. X.) I must confess, I had some difficulty in understanding these branches; they look precisely like the arms of a canal or like small rhizomes, and they sometimes have the form of worm-burrows; they begin with thick branches or trunks about the size of the finger and throw out smaller twigs; they are often 6 or 8 inches long, and are cut obliquely by both stratification and cleavage. I have come to the conclusion, after examining a great many of these cylinders, that they are gas-vents, similar to the amygdala in origin, the imprisoned gas, in its efforts to reach the surface, having had sufficient strength to force a long passage though the viscid paste.* Dip 55° to 60° .... about 600 ft.

5. Amygdaloidal greenstone, graduating to trachyte; with innumerable small geodes, rounded and pressed together. The greenstone becomes rough and gritty and passes into a trachyte, it is much less amygdaloidal; and on the other hand, where the rock is excessively amygdaloidal, the paste is a dark brownish black rock, which is cleaved into well defined slabs, and breaks easily into prismatic fragments. This bed forms a depression between harder layers. The stratification is easily seen by the several courses of the rock superposed one on the other; but of course it is not seen in the thickness of each course. .... about 200 ft.

6. Pale bluish greenstone, hard, compact, with conchoidal fracture; it is closely spotted with irregular dots of hornblende. At the base of each compact layer, there is a margin 1 or 1½ foot thick and very amygdaloidal, the geodes being filled with quartz. It is a very hard stratum ... about 150 ft.

7. Closely set amygdaloid. The paste is a greenish felspar, sometimes very compact and then dark, and cleaved into slabs half an inch thick; sometimes light in shade and with the amygdala rather irregular and nearly touching one another. In many specimens, the felspathic paste shows a division of the felspar into a bluish or greenish mass and patches of white felspar; but there is no crystallization. Dip 70° nearly due E. The felspathic paste decays pretty quickly and thus this bed forms a depression on the hill side.. 50 ft.

8. This is the stratum on which the celebrated Buddhist ruin is built; it is the highest summit of the Tukt-i-Suliman (6263 ft.) It is composed of very hard, dark greenstone, with amygdala of white quartz, occurring sparingly. Beds of lighter coloured greenstone, with specks and nodules of augite are interstratified. A great many well defined long cylinders of quartz, either white or black or smoky, such as I have described as gas vents, are seen here. This stratum is a hard saddle or ridge; nearly vertical, and dipping easterly. .... 60 ft.

* I have since read that Dr. MacCulloch observed in Little Cambay, one of the Western Islands of Scotland, amygdaloid containing elongated cavities similar, I believe, to those which are here described.

So far, the rocks have been purely igneous. We now meet an alternate succession of igneous rocks produced by the decomposition and arrangement under water of volcanic minerals. Ash, agglomerate and other strata of volcanic ejecta become also much more abundant.

9. A dark blue slate, in places clayey, in others calcareous, and effervescing slowly and feebly with acids. It decays soon and forms a depression. It contains no trace of organisms.... .... 15 ft.

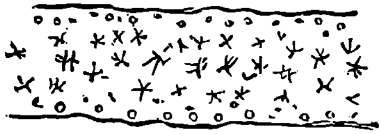
10. A lumpy brown rock composed of a coarse felspathic paste which weathers chocolate-brown and contains a great number of lapilli, mostly black and basaltic-looking. It shows thin, lenticular beds of pale grey felspathic ash containing innumerable geodes, filled, some with quartz, some with dark augite (?) This stratum is not very hard, and rounds by weathering, so that it forms a smooth round boss and not a sharp saddle. It is about ... 30 ft.

11. This bed is interesting and presents a very peculiar appearance.

The rock is a pale grey trachyte in which crystals of dull white albite have imperfectly formed and arranged themselves in tufts of imperfect crystals forming more or less a star or section, (see fig. plate X.) When the rock is polished, (such as is seen in the pavement of Srinagar where it is polished by people walking over it*) the starry disposition of the crystals is evident enough, though in the fresh broken specimen it is rather confused. The rock is a passage between a trachyte and a felspathic porphyry. I have never seen or read a description of this variety of volcanic rock, and I therefore propose to call it "Soolimanite." On the north-western flank of the hill, this bed of Soolimanite is better seen than on the other side, and there presents some layers which show well the nature of the rock. Some of these layers, rather darker than those we have seen on the other side of the hill, contain the starry crystals well developed in the centre of the beds only, whilst above and below, that is near the lowest and uppermost parts of the beds, the

* The stone is not abundant, and very few pieces of it are seen in the pavement of Srinagar. I have seen two however, one in the vegetable market near the great Musjid, and the other between the first bridge and the gate of the Shere Ganie on the left bank of the Jheelum.

Fig. 4.



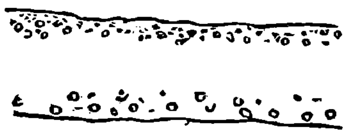


Fig. 5.

crystals disappear and are replaced by amygdala filled with quartz (fig. 4.) Other beds again of compact trachyte show neither starry crystals nor amygdala in their centres, but have their deepest layers invaded by large amygdala, and their uppermost portion full of small geodes, having besides a scoriaceous aspect (fig. 5).

In the middle of this bed of Soolimanite, some of the cylindrical tubes of quartz described before as gas-vents are well developed, branching in all directions through the rock.—Dip E. 70° .... about 30 feet.

12. Slate of various colours, laminated and very false-bedded, often squeezed and twisted. It has been folded, the lower part being nearly vertical with a dip westerly, whilst the upper part dips east 65°. The centre of the fold is much contorted and gathered in zig-zags, and in these contorted parts a great many gas-vents (branching cylinders of quartz) are well seen; some as large as the finger, others of the usual size, viz. a crow's quill. .... 200 ft.

13. A band of Soolimanite like 11. The slate of No. 12, has evidently been metamorphosed by the action of heat emitted by the band of Soolimanite which covers it. There must have been a considerable period of inaction between the two out-pours of Soolimanite to enable the slate to become collected, and it is evident that the slate was yet in the state of a silty mud at the time of the second eruption and was set bubbling by the heat of the Soolimanite.

I may here remark that I am satisfied that many of the layers of laterite, cellular slate and ash, which we shall see in this section, are nothing but true sedimentary deposits metamorphosed and rendered amygdaloidal by the bubbling or boiling of the waters which covered them. I had thought at one time, to try and distinguish the beds of ash and volcanic mud which were probably formed as I have just explained; but I found the work too uncertain and requiring too much time to be worth prosecuting. But no doubt can be entertained that, besides the slate and laterite, many of the beds of the mountains of Kashmir which appear to be volcanic ash or dust, are in reality metamorphosed sedimentary layers.

The Soolimanite has a thickness of .... 15 ft.

14. The band of Soolimanite gradually passes into a felspathic ash, often friable, but often also hard and compact and full of oval nodules of dark augite, varying in magnitude from the size of a pea to that of a pin's head. Occasionally the ash passes, along the strike, into a hard compact quartzite. The whole bed appears irregular and lenticular, and has been probably formed by ejecta falling into shallow pools of water .... 15 ft.

15. A calcareous rock which is not seen on the hill side, but gives out, on the brow of the hill, a good deal of nodular muddy carbonate of lime (kunkur). Here and there a brown ferruginous rotten ash (or metamorphosed calcareous shale ?) crops through the grass on the top of the hill. It effervesces feebly with acid, and is probably the rock which gives out the kunkur. This layer, which is probably squeezed out of its place near the foot of the hill by the gradual curving of the strike of the harder rocks, is, at the top of the mount, at least .... 20 ft.

16. A thin band of amygdaloidal greenstone .... 12 ft.

17. Slate, grey. On the western side of the bed it dips W. N. W. 65°. In the centre it is much folded; on the eastern side it dips E. S. E. 75°. This angle, however, diminishing quickly to 65° .... 20 ft.

18. Greenstone alternately coarse and fine .... 20 ft.

19. Slaty basalt, dark bluish black, fracture conchoidal. It dips E. a few degrees S. 70° .... 30 ft.

20. A crumbling, brown, lumpy metamorphic mud, slightly amygdaloidal. It decays rapidly into a dirty yellow coarse gravel. It is interbedded with bands of agglomerate, the lapilli being mostly basalt .... 50 ft.

21. Sandstone, hard, rough, quartzose and micaceous; apparently much altered by heat. No organisms .... 3 ft.

22. Coarse quartzose grit, very hard and rough. It appears to be composed up of angular grains of quartz, variously coloured, cemented together by a siliceous paste. It may be a siliceous deposit in which crystallization of the purer quartz has begun to take place .... 15 ft.

23. Sandstone like 21. Dip. S. E. .... 10 ft.

24. Blue compact slate, becoming gradually first coarser and more like a shale, and then more silty or like yellow and grey clay-slate. The stratification is best seen by the coloured markings which indicate it to be only 25° and E. The bed has probably been squeezed out of its place .... 150 ft.

25. Coarse yellow sandstone with a calcareous cement. Cleavage well marked. No organisms.. 20 ft.

26. Slate, thin bedded and falling into angular fragments. It is mostly deep blue with bands or ribbands of yellow and grey. The dip is more regular than that of the slates seen before. It is nearly due E. with an angle of 40° .... 200 ft.

27. Slate, fissile. It differs from the preceding by decaying much more quickly by exposure, the whole bed being covered by small débris. It dips W. on its western side, and E. on the eastern, whilst the centre of the fold is zigzagged .... 30 ft.

28. Slate, compact and dark blue .... 8 ft.

29. Slaty shale, grey and dark, dipping W. a few degrees N. at an angle of 55°. It is continued (underneath) by coarser shales which form an anticlinal (not easily seen on account of débris and of the decayed state of the shale). On the other side of the anticlinal the dip is nearly due E. 60°. The extent of outcrops of this layer (not its thickness) is about...... 5 to 600 ft.

30. Metamorphosed slate, fissile and greyish blue; much jointed; the joints are yawning, sometimes a foot apart; they strike W. E. vertically. The stratification dips E. S. E. with an angle of 50°, but that is much falsified by the stratum inwrapping the end of the spur. This bed presents in its middle, thin layers as follows:

a. Soft, yellow quartzose sandstone, nearly friable, 8 inches. *b.* Dirty quartzite, 8 inches. *bb.* Do. with veins of pure white opaque quartz, 1 foot. *c.* A hard, brown, baked quartzose with spreading veins of quartz, 6 inches. Total 3 feet. The whole outcrop of the bed (not its thickness) is about 130 ft.

Here ends the Tukt-i-Suliman, and between this hill and the foot of the W. N. W. spur of the Zebanwan passes the road from Srinagar to the Nishat Bagh. (Sect. A).

The W. N. W. Spur of the Zebanwan. Ascending this spur in the continuation of the section, we have the following beds:—

1. Slate more or less laminated, with large yawning joints striking W—E. The stratification is well shown by the colouring of the slate; it dips W. 45°; inwrapping the end of the spur.

It may be here remarked, that the beds of slate, ash and fossiliferous rocks nearly always present this inwrapping arrangement at the end of spurs and when they cross a spur; it appears that these beds had plasticity enough to bend all round when upheaved by inferior rocks. A fine example of this inwrapping arrangement is seen in the limestone which terminates the spur of the Zebanwan over the village of Zeeawan: the limestone, in endeavouring to arrange itself around the band of volcanic rock which upheaved it, has split into slices from 5 to 15 feet thick, diverging like an open fan. (Sect. C).

To come back to our section, the slate has a tendency to break into prismatic pieces, and the joint-surfaces are coated with a yellowish or dirty white quartz. This bed is evidently a continuation of the last bed of the Tukt-i-Suliman (30 of section A), and the road passes over a synclinal, which would be very evident, were it not for the inwrapping arrangement of the slate at both extremities of the bed. As we go up the hill, we observe that the bed forms a small eminence of its own, being separated by a fault from the western beds which have a general south-easterly dip. It extends for about a thousand yards along the southern aspect of the hill, wheeling round and, as it were, lining the foot of the spur, its dip becoming gradually more southerly until it is S. W.

2. Following our section, we find, after the fault, the same alternate disposition of felspathic ash with nodules of augite, of dark slate more or less laminated, baked and metamorphosed, and of volcanic agglomerate full of dark coloured lapilli. It would be tedious and unprofitable to give a minute description of each bed, especially as the enumeration would be a long one, each bed being seldom more than 10 feet in thickness. No greenstone was seen for more than half a mile; the ashes are always tolerably compact when not in a decomposed state, and always invaded by innumerable nodules of augite. They are always well stratified, and it appears therefore evident that the whole of the ejecta fell into water, by which they were arranged in well defined strata. The amygdaloidal condition of nearly all the rocks, whether ash or slate, seems to indicate that the water was raised to a high temperature during the volcanic eruptions; and the want of animal remains in the slate beds and amongst the agglomerates is in accordance with this hypothesis.

It goes on, as I said before, for above half a mile, alternating ash and slate, with occasionally a dirty-brownish bed of rotten and calcareous ash decomposing very fast and throwing out, on its surface and also between its joints, a large quantity of kunkur. The strike of the beds turns gradually to true N. S. and the dip is E., the angle with the horizon being between 60° and 70°. Beds of laterite now begin to appear, of a yellowish grey colour and resembling indurated clay. They are a little harder than slate, sparingly amygdaloidal, and the geodes are very small and filled with quartz. They break into small cuboid fragments. These laterites are interstratified with beds of dark slate, and lying over them we get the following strata :—

x. A band of greenish-grey trachyte with small rounded geodes of chalk-white albite. It weathers somewhat reddish on its outside and wears in rounded masses. It reminds one very much of some of the felstone of Baramoola. Strike N. 15° W.—S. 15° E. Dip Easterly 40°. But this stratum varies very much along its strike, becoming in places a ferruginous, rotten, augitic amygdaloid; in others a sandstone made of big rounded grains of quartz, of hornblende and of other volcanic minerals, with a calcareous cement which effervesces powerfully with acids. This sandstone forms slabs 1 to 1½ inch thick, and superposed one over the other like bricks in a wall. Again a little further on, it is a fine, very compact, smooth laterite, passing gradually into a more sandy variety containing very minute spangles of white mica hardly visible in the day time, but which shine well by candle light, and also a few small rounded nodules of a pale green semi-lucent mineral. The variations of this bed along the strike seem to indicate a very shallow shelving shore or a pool of water, the bottom of which had been frequently disturbed by the appearance of lavas or other heated matter. The bed is about 15 feet thick at the outcrop.

xi. Then the slate, blue and compact, comes again, with occasional thin beds of sandstone or dark-stone: a coarse grained highly ferruginous amygdaloid, a sort of peperíno, forms a bed 15 feet thick, and on the top of this, here and there, are patches of grey laterite. The slate and the sandstone alternate repeatedly in beds of more than five feet each, and this goes on for a thickness of about 160 feet.

xii. A ridge of coarse, brown, slightly micaceous sandstone, in superposed slabs like a built wall, now makes its appearance. It strikes S. W.—N. E. and dips easterly 45°. This strike S. W.—N. E., meeting the strike of the preceding layers *x* and *xi* which is N. 15° W.—S. 15° E., leaves an open angle or yawning on the northern flank of the hill, and this is filled up by laminated slate, much broken and of various colours, a good deal of it being yellow. It is the yielding of this soft slate which has allowed the hard and unyielding sandstone to take a direction to the S. W. instead of to the S.

The thickness of this sandstone ridge is about 45 feet, and that of the slate, which fills up the gap or yawning on the flank of the hill, about 40 feet.

xiii. Slate, hard but much cleaved; about 80 feet.

xiv. A ridge of very compact and massive baked clay, having a conchoidal fracture and large distant joints. It is yellowish grey in colour, with bands of lighter yellow: one would take it for a light-coloured basalt, if it were not for its trifling hardness, which is about that of slate. It appears to be a clay made up of silty mud, derived from basaltic and other volcanic rocks and baked after formation. Perhaps it would be best named "Massive Laterite." The joints and the surface are covered with a rich brown iridescent oxide of iron or a black crust of the same material. This rock is nearly vertical, and is near a fault of considerable extent which cuts the hill right across, and this proximity to a large fault might perhaps account for the metamorphosed appearance of the clay.

FAULT.

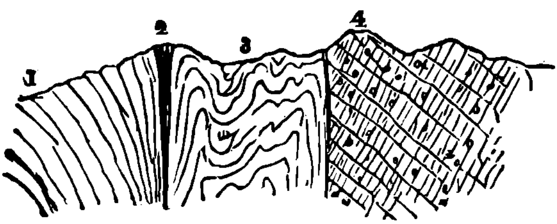


Fig. 6.

1. Slate. 2. Massive Laterite or Baked Clay.
3. Slate, Ash and Laterite in the fault.
4. Amygdaloidal Greenstone.

The fault is about 500 feet wide, and is filled with zig-zagged slate, ash and laterite. A very great deal of kunkur is found all over the ground. This fault goes right across the hill, from near the ruin of Pari Mahal to the small spur over the village of Pandrettan.

East of the fault, the rocks are very different; they are rocks similar to those we saw at the foot of the Tukt-i-Suliman; viz. greenstone and amygdaloid, and there has been therefore a downthrow on the west of the fault. The strike is very different on both sides of the fault. We have seen that on the west side it is S. W.—N. E. with an eastern dip; the greenstone and amygdaloid strike S. E.—N. W., dipping to the N. E.

There is no occasion to describe these greenstones and amygdaloids again, as I have done so before at the foot of the Tukt-i-Suliman. But we must notice here a very great quantity of what I have called gas-vents; the amygdaloidal greenstone is in some places completely perforated by these vents which are sometimes filled with quartz, sometimes with augite, and sometimes left empty. (See figs. 1. 1a, Pl. X.)

20. Crossing the broad ravine above the village of Pandrettan, a ravine in which once flourished a Buddhist city of which the ruined walls are still to be traced, we notice a spur composed of dark and brittle basalt, much jointed but not columnar. It is interstratified with a volcanic ash, similar to that seen in the Rustun Gurree. The end of the spur presents a fine example of beds of ash and laterite inwrapping or infolding subjacent beds: the spur is narrow and the layers of ash and laterite are bent down on each side of it, just as a layer of paste laid across a ruler would by its weight bend on each side of the ruler. The dip of the beds is N. E., and consequently the strike is obliquely across the spur which has a W. south-western direction, and when we look up the hill, facing to the N. E., we can then see the beds of ash and laterite cropping out one above the other, like steps,

and forming arches along the strike. This curvature of course falsifies the dip on both flanks of the hill, the dip becoming northern on the south eastern flank of the spur, and south east on the other flank.

The lowest portion of the spur forms a little mound on which may be seen the remains of a gigantic Buddhist figure. The figure is that of a woman, but it is now prostrate and headless. It is a huge block of limestone. There are many other Buddhist remains at Pandrettan, all built of that rock: amongst others, a small temple in a tank is well worthy of a visit.

From Pandrettan to Panchhooka, we have a succession of thick beds of dark basalt, cleaved and jointed but never columnar, and greenstone and amygdaloid, with a few beds of compact ash containing oval nodules of augite. The basalt is the only rock which has not been described before. It is best seen in a little spur which descends to the Jheelum, hardly half a mile east of the Buddhist figure on the little knoll. It has sometimes a very black and conchoïdal fracture, and at other times a pale pitch and bluish colour. It breaks into prismatic blocks which are quarried at the place where the spur hangs over the river. It does not appear to be amygdaloidal, but the greenstone into which it passes is sparingly so, the geodes being large and filled with quartz. It is difficult to ascertain the stratification or superposition, owing to the well marked cleavages and joints, but by observing the beds of compact ash occasionally met with, it is found to be easterly at a very high angle with the horizon. All the way from the stone quarry, at Alwajin, to that portion of the village of Panchhooka, designated on the map as "Large Cheenar Trees," there is a succession of these beds, but the angle of dip diminishes gradually as we travel eastwards and is only 45° at Panchhooka. There we find the following beds :—

A slaty basalt, dark and heavy, dipping to the E. a few degrees S. at an angle of 45° with the horizon. It has a cleavage dipping due W. with an angle of 45°, and vertical joints striking S. W.—N. E. It is succeeded by a coarse trap, a sort of trachyte showing a certain amount of crystallization, the rock having a granitoid or rather gneissoid appearance. The augite and the glassy felspar are the only minerals tolerably crystalline, the remainder being a paste which is sometimes nearly white, or yellow and rough; sometimes greenish-grey and conchoidal in fracture, or blue, indigo-blue and

French grey. There is much in these strata to remind one of the starry trachyte or Soolimanite of the Tukt-i-Suliman, but the starry arrangement of elongated crystals of albite is never perfectly seen.

A layer of amygdaloid covers in the trachyte.

From Pandrettan to Panchhooka, we have been examining the beds of the southern spur of the Zebanwan. The W. N. W. spur may be considered to end or rather to begin over Pandrettan, and from thence eastwards we cross the digitations of the southern spur. A glance at the horizontal section (Map B) will render any further explanation unnecessary.

Here ends our section through Hurri Parbut, the Tukt-i-Suliman and the W. N. W. portion of the Zebanwan.

21. We will now examine the south-south-eastern flank of the Zebanwan, following a section from near Panchhooka towards the E. N. E. (See Map B.) (Section III. of General Map or Map A.)

We meet first a long slender spur proceeding from the main range of the Zebanwan to the S. S. E., and as this spur is very interesting, I have called it the Zeeawan spur from the name of a village situated close to its extremity. (Sect. A, B and C.).

The Zeeawan spur is composed, high up the hill, of the same basalt, amygdaloid and greenstone which we have seen in the preceding spur, but towards its end it is made up of enormously thick beds of volcanic agglomerate. This agglomerate is composed of a cement having the shining appearance of a slag, but not in its vesicular arrangement. It contains lapilli of nearly all the rocks which we have seen before, viz. greenstone, basalt, amygdaloid, slate of various sorts, and pieces of both felspathic and augitic ash. These lapilli are quite angular and crammed together so close that in some places the cement can hardly be seen. This cement appears to have at first coated the fragments with a thin layer of a dark shining paste, and then glued them together with a coarser material; or it is very possible that this coating is a superficial melting of the lapilli, and that the cement is a lava. However this may be, this agglomerate forms the greater portion of the spur. A confused stratification is discernible, dipping to the E. S. E. at a higher angle, and cut at right angles by well marked joints; thus huge blocks are separated from the mass and strew the ground at the foot of the spur. Towards its end, the spur bifurcates into two digitations, the most westerly being entirely made up of agglomerate, whilst the most easterly presents the following section:—

Section of the end of the Zeeawan spur above the village of Zeeawan. (See Sections B. and C.)

1. Volcanic agglomerate with a shining, dark, semi-vitreous cement. It is interstratified with bands of amygdaloid and thin layers of peperíno.

2. Quartzite, white, opaque, stratified; it breaks into cuboid fragments, owing to numerous well-marked joints. It is sometimes yellowish, but usually quite white. It is a conspicuous layer and deserves to be remembered, as it always occurs between the volcanic rocks and the beds of limestone to be hereafter described.* .... 15 ft.

3. Compact basalt, of a dark colour and breaking in prismatic pieces. It is often scoriaceous on the surface of layers.. 20 ft.

4. Compact amygdaloidal greenstone. .... 3 ft.

5. Greyish-blue basalt; heavy; much fissured. .... 5 ft.

6. Coarse yellow sand, with numerous water-worn pebbles of the basalt No. 5 imbedded in the sand. The pebbles are lenticular in shape, such as are seen on the shores of lakes and sluggish rivers, and unlike those rounded by torrents. .... 6 ft.

7. Sandstone, grey and bluish, but weathering to a fawn-colour. It contains a few water-worn pebbles similar to those seen in the preceding layer. 3 ft.

8. Slate, greyish-blue; fissured and foliated. .... 5 ft.

9. Sandstone of rolled grains of quartz. .... 3 ft.

10. Slate, as before. .... 3 ft.

11. Compact and dark rock, much jointed and breaking in flat square pieces. Either a baked clay or a laterite. It is all broken to pieces on the surface of the bed. .... 5 ft.

12. A conglomerate of water-worn pebbles of trap united by a calcareous cement. The pebbles are not lenticular, but rounded. .... 2 ft.

13. Dark shales containing débris of fossils not determinable. ... 10 ft.

14. Limestone; dark greyish-blue; coarsely crystalline; in places very impure, argillaceous and shaly. It is a mass of fossils. .... 5 ft.

* Having now reached the fossiliferous strata, I shall not, in charity to the reader, give the section of the spurs of the Tukt-i-Suliman and Zebanwan which face the little lake or *Dal*. But the map (see Map B) will enable any one wishing to know the geology of these spurs, to satisfy his curiosity. I have indeed to apologize for the minuteness of the section of the Tukt-i-Suliman, &c. But in a country new to the geologist, a section, I think, cannot be too minutely detailed.

15. Dark brown calcareo-ferruginous shales, exfoliating in thin plates and undergoing quick decay. It weathers nearly black. Extremely rich in fossils. .... 10 ft.

16. Limestone. .... 10 ft.

17. Dark brown calcareo-ferruginous shale.................................. 15 ft.

18. Limestone. .... 10 ft.

19. Sandy shales, very dark nearly black; do not effervesce with acids; very rich in fossils. .... 10 ft.

20. Limestone; less coarse than preceding; very fossiliferous. . 15 ft.

21. Limestone; hard and arenaceous; separated by thin layers of shale which weather dark brown and appear in relief on the section of the bed.... .... 5 ft.

Any further bed which may exist is concealed under Eboulis.

22. When I first met with this bed of limestone, I was particularly delighted, as I had seen no limestone in Kashmir, except the huge carved blocks of the Buddhist ruins near Srinagar and at Pandrettan. I was told that the fine bluish-grey limestone of these ruins was no longer to be found in the country, and that nobody could guess whence the stone had been obtained. Even some of the Surveyors of the Kashmir Series, G. T. S. corroborated this opinion, which appears to be the received one amongst the natives. I could see at a glance that here I had the very stone, and in examining the bed I came across the remains of an old quarry. I subsequently found some much larger Buddhist quarries of limestone, as we shall see by and bye.

Misled by Mr. Vigne and Dr. A. Fleming, who, as I have said, stated that they obtained nummulites from the Kashmir valley, I began to look diligently for these foraminifers. I found indeed a few rounded bodies which might be taken either for nummulites or rings of crinoid stems. I did not at first hit on a very good portion of the bed for fossils; those I found were extremely weathered, and I could only pay flying visits to Zeeawan. But I tried once more to discover nummulites, when lo! I came across a Productus! The following genera were found to be abundant: Productus, Athyris, Orthis, Strophomena or Leptæna, and Spirifers amongst the Brachiopods. Very few lamellibranchiates and gasteropods were seen, but an immense number of Bryozoa, especially two or three genera of *Fenestellides*—viz. *Acanthocladia* and *Fenestella* and innumerable inviduals of what has been called *Vincularia multangularis* (Portlock), but which some say is not a *Vincularia* at all. Some of the fossils are familiar to every body: the *Productus semi-reticulatus* (Martin), *P. costatus* (Sow.), the *Athyris Roissyi* (L'Eveillé). Other fossils are interesting on account of their rarity, and first amongst these is the claw of a crustacean, the pincers of which are two and a half inches in length. Though the pincers are neither teethed internally nor flattened into organs of natation, we may, I think, refer the fossil provisionally to the genus *Eurypterus*, if it is not even a true *Limulus*. (See Pl. V. fig. 4.)

23. We have therefore, resting on the volcanic rocks, beds of carboniferous limestone. These beds are of great thickness, and they change their characters very considerably as we follow them upwards. I have divided them into three great divisions, and I have called these by the names of the localities where they were found to be well developed. The lowest bed, which we have just seen, I have called the Zeeawan bed, from the village of Zeeawan. The next above will be called the Weean bed, from the village of Weean near which it is well developed; and the uppermost division I have named the Kothair bed,* from the name of a small district at the foot of the mountains where this upper bed is well seen. I have preferred adopting these names to the plan of using the designations of Lower, Middle and Upper, as further observations may render it desirable to sub-divide any division into two or more sections, in which case the terms lower, middle and upper would become inconvenient. In the present state of our knowledge of the geology of Kashmir and the N. W. Punjab, we may nevertheless remember with advantage, that the Zeeawan is the lowest, the Weean the middle, and the Kothair the upper bed of the mountain limestone.

24. To come back to our section near Zeeawan: we must first notice the inwrapping disposition of the beds around the end of the spur. The general strike of the volcanic rocks is N. N. E.—S. S. W.

* So few fossils were found in the Kothair bed, that it is not possible to place it, with any certainty, in the carboniferous; the same reason prevents its being placed in the Permian or Triassic. The place of this bed as the uppermost carboniferous is therefore only temporary. See the remark after the list of fossils found in the Kothair bed, Chapter II., para. 50.

and the dip E. S. E. High up the spur, this dip forms a considerable angle with the horizon, but it diminishes gradually as we descend towards the plain ; at the bed of quartzite it is about 45°, and at the limestone it is generally 40°. But these rocks, that is from the quartzite upwards, appear to have been upheaved by a narrow band of hard rock catching them in the centre and pressing them upwards in that central point, whilst the sides of the beds were unsupported. Instead of yielding softly and shaping themselves into a carapace-like coating, as slate and ash would have done, the limestone and the shales have separated into thick bands or slices, and these bands have spread themselves out like a fan. At the small end of the fan there has been a considerable crushing of the beds one against the other, and enormous blocks, indeed whole pieces, of the limestone courses have been squeezed out of place ; whilst, at the circumference of the fan, the beds have been parted from one another, and in some places we can see the layers of limestone separated by open intervals two or three feet wide. (See horizontal section, Sec. C.)

25. I will now try to define the character of the Zeeawan bed of carboniferous limestone :—Its lithological characters are, that it is a rough, coarse and semicrystalline limestone of a dark bluish-grey colour, weathering a rich grey. If we break it, we find it made of innumerable irregular grains of a darker limestone united by a lighter cement more or less crystalline. It is full of debris of fossils ; indeed I am not quite sure that the darker grains are not the debris of the organisms or excrements of animals. It is fœtid. Portions of it are arenaceous or rather shaly, and these, when exposed to the air, decompose partially, becoming soft and crumbling. The stone is soft to work and cuts with great ease, except where there are too many large fossils. It contains an immense number of minute crinoid-stems converted into spar: it breaks obliquely to the surface and gives flashes of light at certain angles. It is interstratified with courses of rich-brown calcareous shale, often of a bright rust-colour, and generally much decomposed and with bands of a black, not calcareous, sandy shale: it is also full of fossils, these being apparently converted into oxide of iron. Finally, it contains limited short lenticular layers of a much paler limestone, in thin-bedded and false-bedded patches having somewhat the appearance of a fine mortar or cement.

The characteristic fossils of the bed are the following :—

Productus Costatus (Sowerby).

" *Semireticulatus* (Martin).

" *Cora* (D'Orbigny).

" *Humboldtii* (D'Orbigny).

" { *Flemingii* (D'Orbigny). / *Longispinus* (Verneuil). }

Athyris, Sp. ——— Pl. II. fig. 1 & 1*a*. *A. Subtilita* (Hall)?

" *Roissyi ?* (Verneuil) Pl. II. fig. 3 & 3*a*.

" Sp. Nora (A. Buddista, Verchère) Pl. II. 2, 2*a* 2*b*.

Spirifer (*Sp. Verchèrii* (Verneuil) Pl. I. fig. 1, 1*a* & 1*b*.

Spiriferina octoplicata ? ——— Sowerby, Pl. I. fig. 2, &c.

Orthis Crenistria, Phill. ———

Strophomena Analoga, Phill.? Pl. II. fig. 4.

Fenestella Sykesii (Koninck).

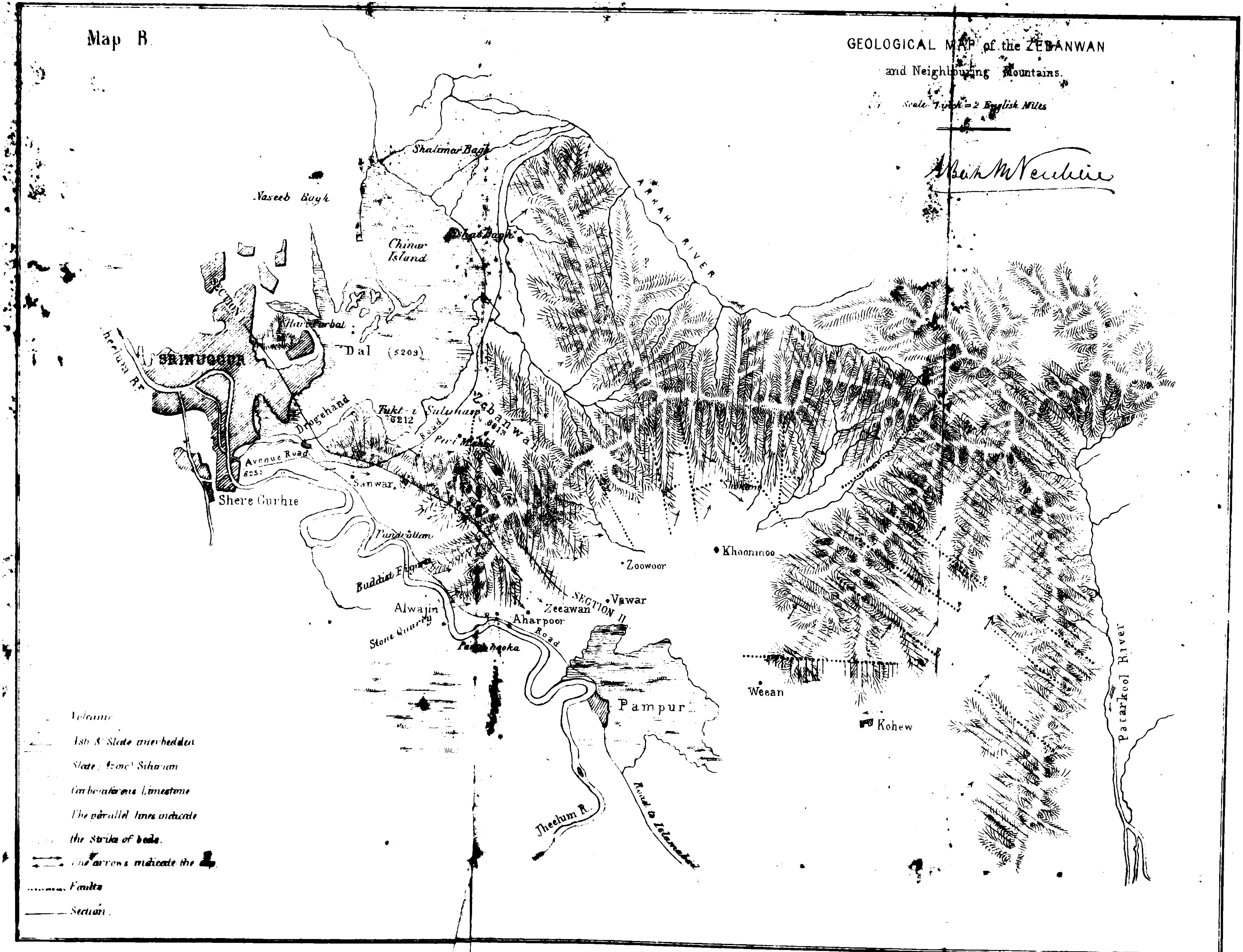
" *Megastoma* (Koninck).

" Sp. ——— Pl. V. fig. 1.

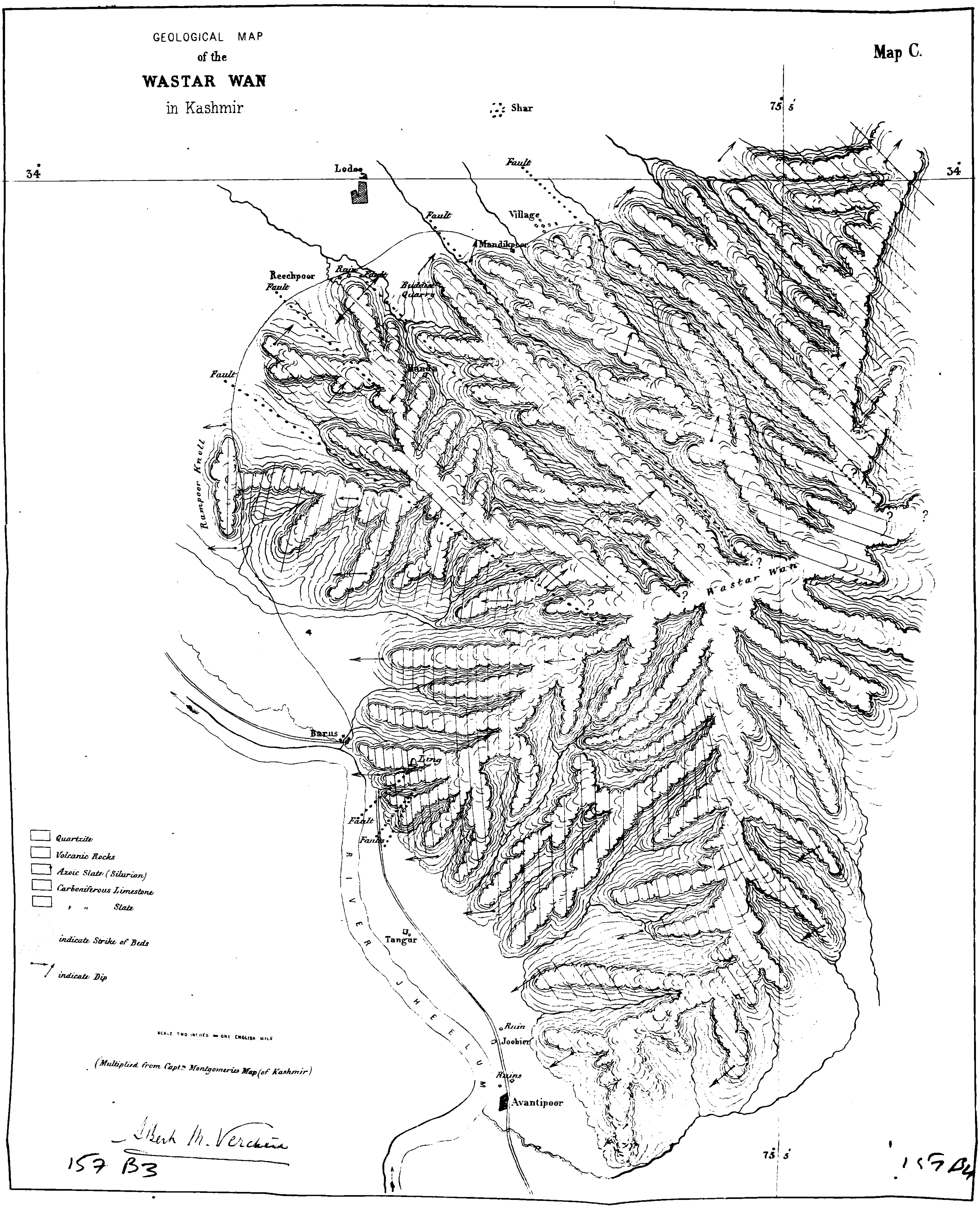
Vincularia Multangularis (Portl.)

Acanthocladia, Sp. ——— Pl. V. fig. 4.

We shall have therefore no difficulty in identifying this bed wherever we meet it, as the Bryozoa make a great show and immediately attract attention. The coarse granular limestone is unlike that of the other beds we shall see hereafter; the rich brown shales are also peculiar to the Zeeawan bed, and even the position close over the glaring white quartzite would assist us, if necessary.



Map B
GEOLOGICAL MAP of the ZEBANWAN
and Neighbouring Mountains.
Shalimar Bagh
Naseeb Bagh
Chinar Island
Hari Parbat
SRINUGGUR
Dal (5209)
Drogehand
Takt-i Sulimane
Zebanwan
Avenue Road
Sanwar
Shere Gurhie
Pandrettan
Buddist Frigan
Alwajin
Stone Quarry
Aharpoor
Zeeawan
Vawar
SECTION II
Zoowoor
Khoonmoo
ARRAH RIVER
Weean
Kohew
Pampur
Jheelum R.
Road to Islamabad
Patarkool River
the Strike of beds.
Faults
Section.


GEOLOGICAL MAP
of the
WASTAR WAN
in Kashmir
Map C.
Shar
75 5'
34
34
Lodoo
Fault
Village
Fault
Mandikpoor
Reechpoor
Fault
Ruin
Fault
Buddist Quarry
Nanda
Fault
Rampoor Knoll
Wastar Wan
Barus
Ting
Fault
Fault
RIVER JHEELUM
Tangur
Ruin
Joobier
Ruins
Avantipoor
75 5'
Quartzite
Volcanic Rocks
Axoic Slate (Silurian)
Carboniferous Limestone
" " Slate
indicate Strike of Beds
indicate Dip
SCALE TWO INCHES = ONE ENGLISH MILE
(Multiplied from Captn. Montgomeries Map (of Kashmir)
157 B3
157 B4

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JOURNAL

OF THE

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PART II.—PHYSICAL SCIENCE.

No. III.—1866.

Kashmir, the Western Himalaya and the Afghan Mountains, a geological paper by ALBERT M. VERCHÈRE, *Esq., Bengal Medical Service; with a note on the fossils by* M. EDOUARD DE VERNEUIL, *Membre de l'Académie des Sciences, Paris.*

(Continued from page 133.)

Leaving with regret the Zeeawan spur, we will continue our examination of the Zebanwan mountain along its southern aspect. (See Map B.) (Section III. on General Map.)

We first cross a considerable mass of volcanic rocks, well stratified, and which we will not stop to describe, as they are similar to the felspathic ashes, black slates and the amygdaloid seen before. They present, however, a few layers of a coarsely crystalline limestone, without fossils and interbedded with layers of ash; some of this limestone is quite black and remarkably well crystallized in small crystals of jet-black spar. It would be a valuable ornamental marble, if found in some quantity. I have only seen it in thin and small patches, accompanying an amygdaloidal dust-stone of fine texture, but much decayed and nearly as black as the limestone. These patches of black rock are well seen on the slope of the long spurs which descend towards the S. E., from the highest summits of the Zebanwan. These volcanic rocks dip easterly, and their inclination is not more than 20° to 25°.

Having crossed a ravine, we arrive at the spurs over Zowoor, where we find the following beds along one section, from W. S. W. to E. N. E. We begin with No. 4 of the Section : the Nos. 1, 2 and 3 refer to the volcanic rocks and black limestone just described.

1\. .... Amygdaloidal greenstone, dips E. S. E.
2\. .... Ash interbedded with thin beds of highly crystalline azoic limestone.
3\. .... Ash interbedded with black crystalline limestone in thin patches.

4\. Amygdaloid ; dip E. S. E. 20°.

5\. Quartzite, white and stratified. It becomes gradually sandy and coloured blue, yellow or grey in places, ... 15 ft.

6\. Crystalline limestone with the debris of fossils, undeterminable, 5 ft.

7\. Lenticular beds of coarse granular limestone, full of *Athyris* sp. ? (see Pl. II. fig. 1 and 1a) and *Productus Flemingi*,.............................. 1 foot.

8\. Limestone ; grey, weathering brown, presenting abundant sections of *Orthoceras* and a few *Fenestellides*, ... 10 ft.

9\. Coarse limestone ; *Fenestellides, Producti*, &c. passes into.

10\. Calcareo-ferruginous, brown shales with some fossils : 9 and 10, about .... 40 ft.

These beds 6, 7, 8, 9 and 10 are therefore the same beds as there seen at Zeeawan, or they are in other words, Zeeawan limestone. They all dip E.S.E. 20°.

11\. Limestone, thin bedded and shaly : no fossils, ... 5 ft.

A fault occurs here, and the following beds are seen on the eastern side of it.

12\. Limestone of the Zeeawan bed brought up again. It presents the same succession as above, viz. an Orthoceras bed, a Fenestellide bed, and a brown shale bed ; the Fenestellide beds are, however, less abundant, and the lenticular Athyris ones were not seen, ... 40 ft.

27\. Resting on this limestone, we find other beds of limestone having a very different aspect. In fact we have the beginning of the Weean bed of carboniferous limestone. The fauna changes considerably : no *Producti* are found, no *Fenestellides*, no great flat *Orthidæ*, but instead a very great number of small bivalves, much broken and comminuted, and here and there in lenticular beds, where fossils of one or two species have been heaped together, some small *Brachiopoda* of the genera *Spiriferina* and *Terebratula ;* some large mussel-shaped bivalves which are probably *Anthracosiæ* or some other near sub-genus of *Cardinia ;* some large and sometimes extremely gibbose *Aviculo-pectens ;* some *Pectens* four inches across ; *Goniatites* and an innumerable variety of *Encrinite* stems of all sizes. The appearance of the rock will be noticed as we get on with our section.

13. A light blue limestone, argillaceous and compact, weathering rugose like frosted glass, but without losing its fine, lustreless, clay-like, pale blue colour. It contains many remains of fossils in a bad state of preservation,... 30 ft.

A fault from N. N. W.—S S. E.; downthrow S. W. The fault is met near the end of the spur by another running W. S. W.—E. N. E. The end of the spur, detached, as it were, by these two faults, strikes S. E.—N. W. and dips N. E. 20°. The rock of this detached bed is a shaly limestone; the fossils are small and ill-preserved; they occur in patches, one or two feet of the bed presenting a great number of remains, whilst hardly a trace of organisms is to be seen for some yards. It is about 50 feet thick,......................... 50 ft.

Another fault from N. N. W.—S. S. E.; downthrow S. W. The effect of this fault has been to bring up again the bed of Zeeawan limestone, and we therefore have the following bed to the N. E. of the fault.

14. A coarse micaceous marly slate, without fossils, and passing gradually upwards into sandy shales of a dark brown colour and containing *Producti*, *Orthidæ* and *Spirifers* in a very bad state of preservation. These dark shales are identical in appearance and in some of their fossils with the brown shales of the Zeeawan bed, but the *Bryozoa*, so extensively developed in other localities, appear to be totally absent, and some small bivalves, which are found in the Weean bed and have not been seen in the Zeeawan bed, were discovered here.* These differences however may be easily accounted for by a difference of depth of the sea at the time the Zeeawan limestone and shale were deposited. The sandy and coarse micaceous slates seem to indicate a shallow sea with a drifting current on a shelving coast, a physical arrangement which may be a tolerable habitat for the large *Brachiopoda*, but unsuitable to the delicate *Bryozoa*.

This Zeeawan bed is succeeded by a shaly limestone, similar to that which is seen before the fault, that is to say Weean limestone. It has a well marked cleavage, due probably to its argillaceous impurities, and this cleavage is not unfrequently more conspicuous than the stratification.

The end of the spur is, like the preceding spur, cut off by a transverse fault W. S. W.—E. N. E. and the detached end dips E. N. E. 20°, whilst the body of the spur, above the transverse fault, dips E. S. E. 20°, the cleavage noted above dips N. W. 70°.

The thickness of these two beds together is about 100 feet; they form the whole of the spur above the village of Koonmoo, ... 100 ft.

28. Above Koonmoo, in the angle formed by the divergence of the two arms of the spur, is a spring with a Zyarat called Shŏkūm.

* A similar mixture of Zeeawan and Weean fossils is found in some parts of the Rotta Roh in the Punjab. See Chapter III. para. 60.

The rocks which are above this spring form a little knoll very insignificant geographically, but interesting for its fossils. These are often converted into hæmatite, sometimes crystalline, sometimes powdery. The rock of the bed is mostly a hard, cherty, pinkish limestone, and in this are lenticular beds of a soft, granular, pale french-grey limestone, with innumerable minute black dots which are the crystallized stems of a very slender crinoid. These minute rings are sometimes a round plate and sometimes a five radiated star. The rock is sometimes coloured pink by iron, and then the crinoid-rings are dark red instead of black. It is fœtid and it contains the large *Anthracosiæ* (Pl. VI. fig. 3,) and the Aviculo-pectens mentioned before, and also the little shell Pl. VIII. fig. 5. This spur contains also a very compact, dark, nearly black limestone, with a very fine grain, but with only a few fossils and encrinite-rings. It is a similar bed which has furnished the blocks of which the beautiful black marble pillars of the Shalimar Bagh are made of. It takes a fine polish, and is evidently very durable. It is probable that this bed of black limestone crosses over to the valley of the Arrah river, and has been quarried there for these pillars.*

The remainder of the little spur is made up of calcareous, micaceous sandstone without fossils (?). The thickness of the beds forming this spur, is about .... 60 ft.

Then we have again beds of limestone, shaly and sandy, much cracked and fissured, and with only the debris of fossils. The harder portion of the rock is blue, and is traversed by innumerable white lines cutting one another in all directions. It dips E. S. E. 20°.

It is succeeded by a bed of blue argillaceous limestone, weathering rugose, and traversed by thin streaks of yellow, ochrous limestone, and containing fossils in abundance, amongst others a plaited *Spiriferina* which appears common in some layers, whilst it is rare in others. Crinoid stems are also very abundant, occurring as it were in patches.

The above mentioned bed is covered in by a grey micaceous sandstone, weathering pale brown and containing the fragments of fossils, but no *Spiriferinæ*.

The total thickness of the three last beds mentioned is above ... 150 ft.

Crossing the dry bed of a torrent and a great deal of rubbish which apparently covers a fault, the sixth spur is reached, and presents the following layers :

* These pillars are generally described by travellers as black porphyry, a mistake which a very little attention would have prevented, as the sections of fossils are to be seen on the polished surface of the columns.

a. The bed with the spur brought up again after the fault, ... 20 ft.

b. The micaceous sandstone, thin and false-bedded, with well marked cleavage, ... 16 ft.

c. Fœtid pale brown, calcareous sandstone, viz. false-bedded; no fossils; dips. E. S. E. 30° .... 1½ ft.

d. Shales; no fossils,... 1 foot.

e. Limestone, compact and dark grey, and weathering brown. It is much shivered, and is divided by innumerable white lines crossing each other. No fossils except what appear to be worm-burrows filled with sandy ochre, 15 ft.

f. Very argillaceous limestone of a pale blue colour, with patches of a dirty yellow or pale brown colour, ... 3 ft.

29. I consider that these beds are the top of the Weean division of the carboniferous limestone of the Himalaya, as the following beds show a very great difference in their fauna, which is nearly entirely confined to gasteropods and corals, the gasteropods presenting a great variety of shape and size. The corals of the *Cyathophyllidæ* are abundant and of considerable dimensions. The crinoid stems, some of them minute and starred, continue to be seen everywhere. The beds characterized by gasteropods and corals form the Kothair bed, which we shall see better developed elsewhere.

Continuing our section, we have therefore, resting on the argillaceous limestone, the following layers:

g. Limestone, fine grained, blue, compact and argillaceous, with patches of dirty yellow. It contains many fragments of fossils, nearly entirely gasteropods. Some of these are two inches in length. Starry rings of crinoid stems abundant. The limestone becomes gradually of a richer blue colour, some portions being indeed light blue; it weathers rugose like frosted glass. The upper part contains no gasteropods, but fossil roots and rootlets the size of the finger. It is about 25 feet thick, ... 25 ft.

This is all we see here of the Kothair bed, as a fault running N. S. brings up again the Weean bed; but this patch of the Kothair is interesting, as showing its relation to the Weean bed, a relation which I have not been able to trace so well anywhere else. The Weean and Kothair beds are quite conformable.

On the other side of the fault we find:

a. A limestone, bluish-grey and compact; weathering sandy and dull grey. It is divided in layers by several sandy partings. It contains only a few encrinite stems and dotted white patches which are probably decomposed fossils. It is shivered and traversed by innumerable white lines,...... 20 ft.

b. Brown fœtid limestone, full of a transverse species of a plaited *Spiriferina* and a globular *Terebratula.* It is probably a lenticular bed, and takes the place of the Spirifer bed noted above, ... 3 ft.

c. Limestone like *a.*

The end of this spur is cut by a transverse fault in the same manner as we have seen in the preceding spurs. The cut off beds are much disturbed, being vertical at the tops of the ridge, and dipping N. E. at high angles along the slope.

Beyond this is I have not examined this fine section of the limestone of Kashmir. I was never allowed to visit it again, as I was suddenly ordered away from Srinuggur, my professional services being required elsewhere. Had I had time, I intended to follow the section across the range into Nawan and down to the bottom of the Harrah Valley.

30. From the brow of the last spur which I have visited, a fine view is obtained of the next spur, which is remarkable for a great twist of the strata which compose it. The limestone is extremely white and resembles chalk-cliffs at a distance. We shall, however, see this white limestone at Manus Bal, and find that it is probably a portion of the Weean bed altered by heat. We shall find it similarly altered at Islamabad.

The whole mass of hills of Nawan appears to be limestone. The summits of Boorwaz and Batgool appear behind the range, presenting high rugged peaks of porphyry. To our right, the limestone forms a small chain which advances for some miles into the Pampur valley, and behind this chain a long line of mountains, also entirely composed of limestone, runs N.—S. to join the Wastarwan. (See maps B. and C.)

31. The little chain which descends into the Pampur valley terminates over the village of Weean. At its extremity, the Weean limestone, or middle bed of carboniferous limestone of Kashmir, is well developed, and we will now proceed to examine this locality. It is, to me, the classical ground of the Weean limestone, as the Zeeawan spur is that of the Zeeawan Bed.

Section of the hills above the village of Weean in the Pampur valley. (See fig. 7.)

The little hillocks above the villages of Weean and Kohew, are separated from the main hill by a fault running W.—E. The beds have moreover been folded on themselves and dip due W. (at Weean), with an angle of 55°, whilst in the main hill the dip is to the N. E. with an angle between 20° and 30°. This does not, however, prevent the section of the little hill near Weean being a very good one for study. We shall proceed from E. to W.

1. Impure arenaceous limestone with fine spangles of mica. It is very shaly in the centre of the bed and there very much decayed. It changes its aspect repeatedly, adding here more sand and mica, there more clay, ... 100 ft.

2. Limestone, argillaceous; in blue and yellow patches,............ 4 ft.

3. Blue limestone, weathering brown and rough. It is arenaceous near its upper part. It contains a very few fragments of fossils, ... 20 ft.

4. Finely crystalline limestone; nearly saccharine; grey and rough,.. 15 ft.

5. Like 3,.. 8 ft.

6. Limestone in blue and dirty yellow patches; fossils much broken, ... 12 ft.

7. Flesh colour limestone; hard, cherty and magnesian, ... 4 ft.

8. Sandstone, micaceous, grey, calcareous and muddy. It decays faster than the other beds and forms a depression on the hill-side, ... 2 ft.

9. Limestone, patchy blue and brown. The hardest and roughest portions are full of the debris of fossils, ... 25 ft.

10. Sandstone, soft and wearing off quickly, forming a depression 20 ft.

11. Limestone, hard and grey; it is brecciated and weathers mammilated, ... 30 ft.

12. Marly and sandy limestone, compact and hard, dark grey and weathering into a granular surface, having the appearance of a sandstone. The debris of fossils, ... 40 ft.

13. Fawn-coloured limestone, very muddy; it weathers ochrous and decays fast, forming a depression on the hill side,.. 15 ft.

14. A wall of very hard, crystalline, dark greyish-blue limestone with

patches coloured brown. It weathers a dirty dark yellow, and becomes extremely rough and pitted by exposure. The organisms it contains are quite indistinguishable, ... 3 ft.

15. Fawn-coloured limestone like 13, ... 20 ft.

16. A wall of very hard and compact limestone, grey and very arenaceous. Where it is tolerably free of sand, it is bluer and contains the debris of fossils, ... 15 ft.

17. Sandstone, pale and calcareous, with bands of crystalline carbonate of lime. It decays fast and forms a depression, ... 10 ft.

18. A well marked wall of dark greyish-blue limestone, very rough and pitted; it is arenaceous and in places cherty, ... 5 ft.

19. Sandstone, micaceous, very false-bedded and very muddy. It effervesces with acid along the scum-markings of the false bedding only, ... 15 ft.

20. A very arenaceous and argillaceous limestone, extremely variable in its appearance, but being generally of a pale clayey yellow. It is formed of extremely thin layers of two distinct rocks, one being a yellow marl, and the other a bluish grey arenaceous limestone, and these thin layers are also very false-bedded. When we make a vertical section of a hand specimen, we have a striped rock; and in a horizontal one, a succession of regularly rounded patches of bluish grey and sickly yellow. This alternation of very thin and very false-bedded layers of rocks of two different colours is the cause of the patchy appearance of many beds of the Weean group. But it is rarely so well defined as in this present layer. In other places, the bluish limestone forms irregularly-rounded balls or nodules cemented together by the yellow marl, or the marl forms lumps imbedded in the limestone. Then again micaceous sand forms, here and there, small false-bedded layers or bands in the rock: and lenticular beds of a hard, brittle, pale yellowish, limestone, full of the fragments of bivalves and of small crinoid stems, are also found. But all these varieties of rock constitute a thick course of impure limestone, 60 ft.

Total ... 425 ft.

We have now arrived at the little ravine which indicates the centre of the fold of the beds; on its other side the same beds are repeated in an inverse manner as far as the bed 16 of the above section; the remaining beds have been denuded from the western branch of the fold. This fold deserves notice, as showing well how completely beds may be reversed in their position. It is probable that the beds nearest to the ravine are the deepest or oldest, whilst the bed which we have numbered No. 1, in the section, is the most superficial. If the hill had been denuded to half its present height above the village, the beds

Fig. 7.

Sketch Section of the hills above Weean and Kohew, bearing N.; to illustrate the descriptive Section of these mountains. (Not drawn to scale.)

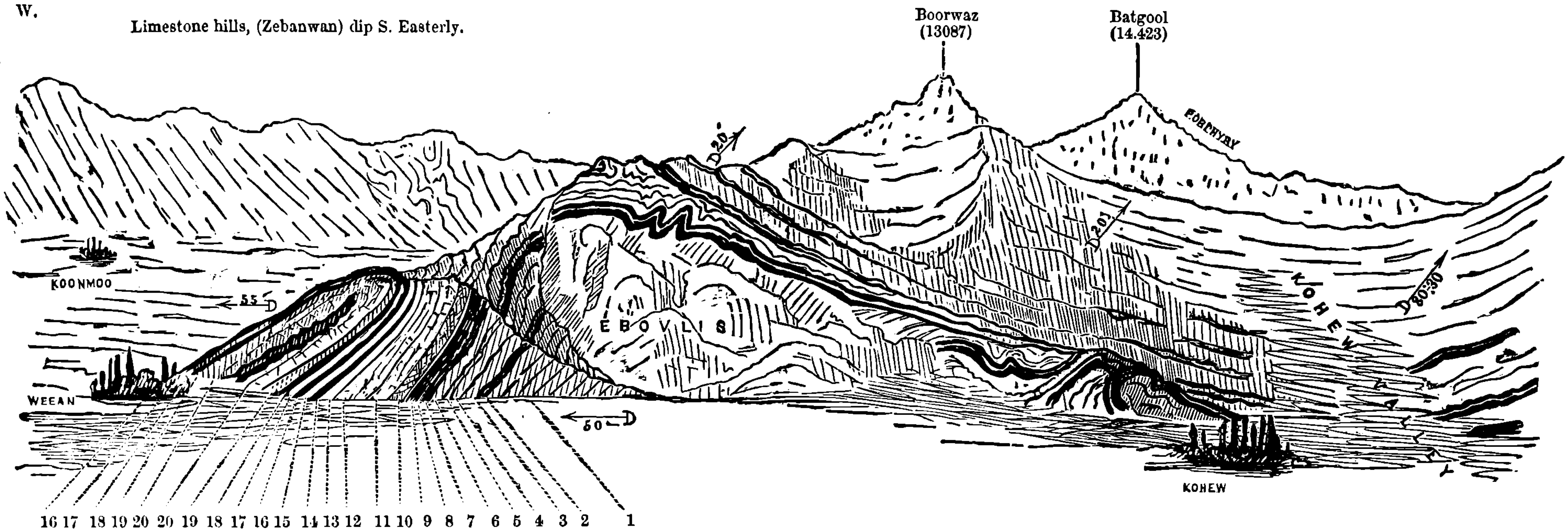
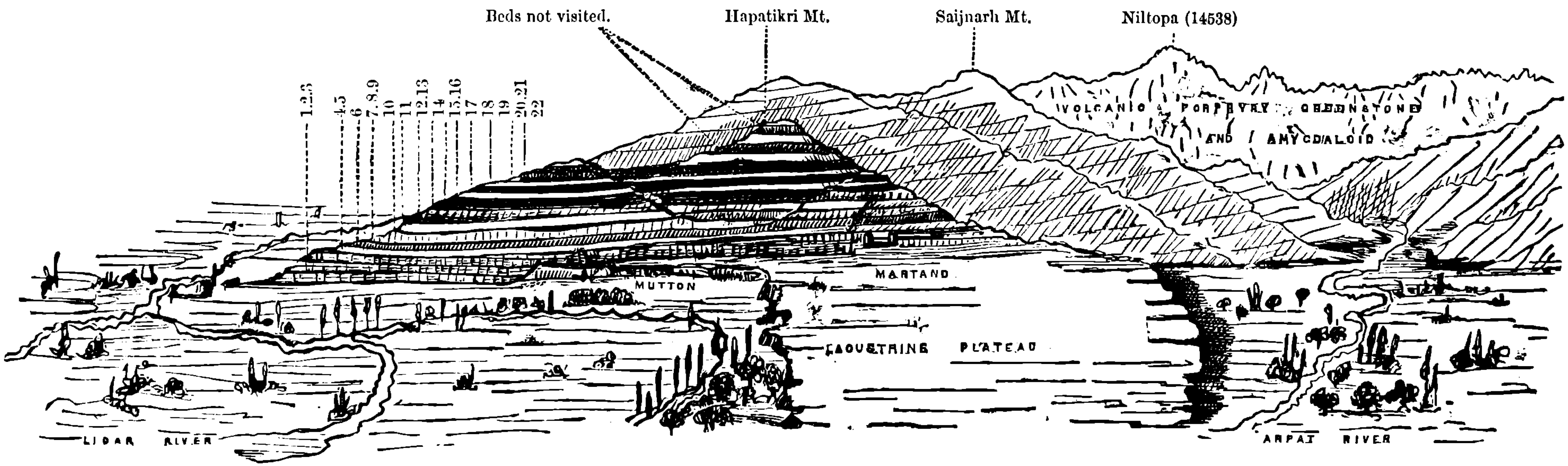


Fig. 8.

Sketch-Section of the Hapatikri and Saijnarh Mountains, bearing N. E. as seen from the top of the Ishlamabad Hill. (Not drawn to scale.)



would appear to succeed one another with considerable regularity from W. to E., and one bed, No. 1, would appear the deepest; but the top of the hill having been preserved, the beds can be seen plainly bending and folding themselves in two. There is a circumstance which renders it extremely easy to follow the beds along the hill-side and it is this, that the layers 16, 17 and 18 form a sort of broad ribbon at their outcrop; 16 and 18 being composed of dark grey walls of limestone which, from their hardness, are prominent 2 or 3 feet over the general surface of the slope, whilst 17, the layer between them, is a pale sandstone, decaying fast and forming a sunken furrow between the two walls. This broad ribbon, about 30 feet wide, can be followed with the eye for miles. The layers 7, 8 and 9 also form a ribbon, but less well marked than the other, being paler and not so sharp. Now, these two ribbons are of the greatest assistance in following the twists and foldings of the beds. We have seen that the ribbon 16, 17 and 18 ascends the eastern branch of the fold over Weean and curves over at the top of the hill, where its beds are perfectly horizontal, and then descends along the western branch. We see the two ribbons forming near the village of Kohew an anticlinal similar to that of Weean, but not quite so sharp, and the description of the ribbon also shows us plainly that the beds of the Weean hillocks are reversed. There is a great fault between the main hill and these two little hillocks of Weean and Kohew; on the north of the fault, the beds dip to the N. E. at a high angle, and all the soft and marly layers have decayed and tumbled down in *éboulis*,* but the hard ribbon has remained, and can be traced along the hill showing the outcrop of the beds. All the way up to Nawan we can see the beds of limestone dipping N. E. and we can infer the existence of many faults across the range from the reappearance of the ribbon on the top of each small spur which descends in the Kohew valley. We see these pieces of ribbon plunge under the soil of this small valley to emerge on the other side (fig. 7), giving us the strike of the beds of that long chain of limestone hills which connects Nawan with the Wastarwan Mountain; but although I have

* The French word is so convenient and expressive, that I do not hesitate to use it, as no English word expresses equally well the broken materials of beds which have slipped.

not visited that long chain of hills, and have not travelled up the Kohew valley, I was enabled in following these ribbons, to see that it is composed of the variety of limestone which I have called the Weean Bed.

We shall observe these ribbons wherever the Weean limestone is well developed; they are to be seen in the section I have given, between Zeeawan and Koonmoo, on the southern aspect of the Zebanwan. I did not mention them there, because they make but little show near these localities; but we shall see them well marked near Mutton, in the eastern portion of the valley of Kashmir.

32. I will now try to characterise the Weean Bed of carboniferous limestone.

It is a very arenaceous and argillaceous limestone, the sand being either in thin grey bands, or mixed with the general paste of the rock. A sandy, marly clay, yellow, dirty-yellow, pale brown or brown, forms thin and very false-bedded films in the rock, so that this is striped when bisected vertically, and patchy bluish and yellow when divided horizontally. The hardest beds are brittle, flesh-coloured and generally full of bright red minute crystals of hæmatite, and the fossils are here replaced by a powdery or semi-crystalline hæmatite which, however imperfectly, preserves their outlines. The harder rock is never blue, and the blue variety of rock is sufficiently muddy to have a soft, velvety, lustreless appearance like a fine clay, and not the clean brittle fracture of a pure and hard limestone. It has in places all the appearance of a very dirty dark-grey mud dried up, and it is then full of fossils and extremely fœtid. It contains lenticular beds of a very pale, nearly friable limestone, containing black specks which are the rings of stems of very minute crinoids, and this variety of soft limestone is the habitat of large bivalves. One single bed of limestone may be mistaken for Zeeawan limestone, bluish-grey, coarse hard and semi-crystalline, but it contains innumerable *Foraminiferæ* transformed into yellow ochre; very large *Pectens*, and an incredible quantity of fragmentary *Crinoidea*. Indeed, it is the great number of those small rings of crinoid stems, always crystallized, which causes the rock to resemble the limestone of the Zeeawan Bed.

Everything in the Weean bed tells of a shallow sea formation. The rocks in some localities, to be described hereafter, have been much altered by heat or other forces soon after their formation. We shall see them thus altered at Manus Bal and at Islamabad, and also at the Kafir Kote in the Punjab district of Bunnoo. It appears that considerable disturbances occurred while the Weean Bed was still in a soft state. But this subject will be examined more carefully in another paragraph of this paper.

The fossils differ a great deal from those of the Zeeawan Bed. In most layers they are mere debris hardly to be recognized. When they do occur, they are always crowded together in limited beds. The *Spiriferinæ* and *Terebratulæ* appear to have lived in shallow lagoons, in creeks in the sand, in pools on a flat marshy shore, and the large bivalves on sandbanks and shallows. The following fossils appear to be characteristic of the Weean Bed, as they are not found either in the Zeeawan Bed below or the Kothair bed above.

Spiriferina Stracheyii (Salter)?
„ *Stracheyii* (Salter)? var. *altior*, (Verch.).
Solenopsis imbricata? (Koninck).
Solenopsis sp. ——— Pl. VI. fig. 1.
Cucullæa? sp. ——— Pl. VI. fig. 4.
Anthracosia? (King)—*Cardinia*, sp. Pl. VI. fig. 3.
„ ? —— *Cardinia ovalis?* (Martin) Pl. VI. fig. 3.
Axinus, sp. n., allied to *A. obscurus*.
Aviculo-Pecten dissimilis (Fleming).
„ „ sp. n. —— (*A. circularis*, Verchère,) Plat. VII. [fig. 1, 1a, & 1b.
„ „ sp. ———? Pl. VI. fig. 6, 6a, 6b.
„ „ sp. ———? Pl. VI. fig. 7, 7a.
„ „ sp. ———? Pl. VI. fig. 7, 7a, 7b.
„ „ sp. n. ——? (*A. Testudo*, Verch.) Pl. VII. fig. 3, 3a.
„ „ sp n.? (*A. Gibbosus*, Verch.) Pl. VII. fig. 4, 4a.
Goniatites, sp. —— like *G. Henslowii* (Sowerby).
Entomostracæ —*Cypridiniæ?*
Foraminiferæ.
Crinoidea; Cyathocrinites and *Pentremites*.

A small bivalve, giving on section the appearance of a pair of spectacles is also found, but I never could detect the shell entire, although it is often the only fossil to be discovered.

33. But to the positive evidence afforded by these fossils, we must add the negative evidence: I mean we must remember that this is a bed of carboniferous limestone, and that notwithstanding we have no examples of the genera *Productus*, *Orthis*, *Euomphalus Bellerophon*, and *Orthoceratites*, and that there are no large *Spiriferæ* or *Fenestellides.* Neither have we the *Gasteropods* and *Cyathophyllides* which characterise the uppermost or Kothair bed, more by their number and variety, than by any species well defined by me. I am anxious to insist on the absence in the Weean group of these fossils, which are generally regarded as eminently carboniferous, because it has been found difficult to determine the age of rocks belonging to the Weean bed, when seen apart from the Zeeawan Bed; thus the limestone of Manus Bal, which belongs to the Weean group, has been twice reported to be nummulitic.

34. The next mountain to examine is the Wastarwan. It is a fine hill, its summits rising above Avantipoor, a small city on the Jheelum celebrated for its Buddhist ruins. An inspection of the map will be better than any description I can give of the position and relations of this mountain. It is a centre of elevation, with spurs descending in all directions, like the spokes of a wheel. I never ascended it, but I travelled along its northern and its western sides, and the following is a description of what I saw.

Section from Reechpoora towards the E. as far as longitude 73° 5′. *across the northern spurs of the Wastarwan : (See Map C.)*

The spur which descends to near Reechpoora is entirely composed of Zeeawan limestone with the characteristic fossils. The bed forms a sharp anticlinal of which the two arms slope or dip N. E. and S. W. respectively, striking N. W. to S. E. The beds of limestone inwrap the end of the spur, the layers seen above the little Buddhist ruin dipping nearly due N. The anticlinal is so sharp that the courses of rock have separated, and caves, now converted into holy quarters for a few fakirs, are to be observed on both sides of the anticlinal.

35. Proceeding eastwards, after crossing the bed of a stream, we

observe near Banda, a small Zyarut up the ravine above Ladoo, some very fine beds of limestone of which the following is the section.

Proceeding from the bottom of the ravine up the side of the spur we find.

1. Slates, so much decayed and broken that it is impossible to see their dip and strike. They are identical with those which we have seen inter-bedded with volcanic ash and agglomerate in the Tukt-i-Suliman and the Zebanwan, and they are very extensively developed in the Wastarwan. They are, as we have seen, more or less metamorphosed, often slightly amygdaloidal and always devoid of organisms, ... very thick.

2. Augitic ash, very amygdaloidal, the geodes being filled sometimes with dark augite, sometimes with bluish-white opalescent quartz. It strikes N. W. by W. and dips north-easterly. About .... 25 ft.

3. Trachyte, sparingly amygdaloidal; coloured brown outside by iron, ... 10 ft.

4. Metamorphosed slate, foliated, jointed, disintegrating, ... 20 ft.

5. Compact basalt, ... 4 inches.

The debris of volcanic rocks form a breccia over the basalt; but this bed is very irregular and lenticular. The basalt is replaced in some places along the strike by a dull, light-olive-coloured laterite or baked clay, about one foot thick.

6. Quartzite, sometimes pure, opaque, white; often translucent, bluish or smoky; never crystalline. It gradually invades the laterite mentioned above, and forms ribands of dull olive and pure white quartz, ... 2 & 3 ft.

7. Zeeawan limestone with usual fossils; dips N. 15°, ... 40 ft.

8. Zeeawan brown shales, ... 10 ft.

9. Fine blue clay-slate; calcareous and breaking in large thin slates. It contains no fossils, ... 10 ft.

Extensive old quarries remain here, showing how fine and free a limestone the Zeeawan bed can give, when quarried in portions of rock which are not weathered. The quarries are far from exhausted, or rather the amount removed is insignificant compared to what remains; blocks of any size and very sound could now be procured easily from the old quarries. It is a great pity that the Maharajah's government do not work this and other quarries for the limestone they want, instead of destroying the interesting Buddhist ruins which cover the valley, especially as the style of architecture now in favour in Kashmir is perfectly hideous.

Traversing a ravine we meet the spur which descends towards the village of Mandikpal, and the following section is met with :

1. Amygdaloidal greenstone.
2. Amygdaloid.
3. Quartzite.
4. Rotten Augitic ash.

Some of the ground is covered with ths debris of the ash, so that its relation to the next bed is not seen.

5. Limestone, argillaceous, pale bluish-grey, weathering fawn-coloured : afterwards patchy blue and brownish. It is thin-bedded and breaks in slabs about one to one and a half inch thick. It contains an abundance of *Goniatites* of 2 or 3 species. The bed is about .... 30 ft.

The dip of these several layers of rock is N. N. E. 25°.

This is the only locality where I have seen Weean limestone resting immediately on volcanic rocks.

From Mandikpal, our section goes through a succession of limestone ridges which, from the appearance of the ribbons described at the hillocks over Weean and Kohew (para. 31), are conjectured to be Weean limestone, but I had not time to visit them. The general dip of their beds is north-easterly.

36. The western aspect of the Wastarwan I shall describe from S. to N., that is from Avantipoor to Reechpoora. It is a series of spurs with a general westwardly direction, and at the end of one of these spurs is a little knoll which I shall call for convenience sake the " Pampur knoll."

The following is the section of these spurs from S. to N. (see Map C.).

1. The whole of the spurs between Avantipoor and Tangur are composed entirely of volcanic rocks, *viz.*, amgydaloidal greenstone, coarse basalt and ash, and black slate without fossils. The limestone is first seen about three quarters of a mile south of Barus, where two spurs approach very near the river Jheelum.

2. As we ascend the most southern of these spurs, we find, resting conformably on dark amygdaloidal greenstone, a bed of white quartzite about 2 feet thick, ... 2 ft,

3. A coarse and rough trachyte,.. 12 ft.

A fault N. N. E.—S. S. W. It opens towards the northern end, whilst the edges of it are crushed one against the other at its southern extremity. On the northern side of the fault we find :—

1. Quartzite, bluish grey, gritty and rough, ... 2 ft.

2. Trap, having a shaly appearance. A great deal of kunkur is seen along the line of fault, ... 1 ft.

3. Quartzite, excessively irregular and having a very peculiar appearance: it is divided in meshes like a very coarse travertin, or rather like lead which has been dropped in cold water while in a melted state. There is however a certain pretty well marked stratification or superposition of courses. The rock looks like a siliceous paste which had solidified suddenly when in a sate of ebullition. It first dips W. about 50°, increasing gradually to the vertical and then inclining the other way, dipping S. E. 80°. It, however, soon becomes vertical and gradually dips again W. 50°,.............................. 40 ft.

4. Pale trachyte. Dips W. 50°, ... 15 ft.

5. Limestone, crystalline and metamorphosed; no organisms. Weathering rough; much stained by iron-oxyde,.. 3 ft.

6. Zeeawan limestone with the usual fossils; dips W. 40°, ... 50 ft.

7. Zeeawan brown shales,.. 10 ft.

8. Slate; coarse, micaceous. Squeezed by proximity to a fault; no fossils? A fault, from N. E.—S. W. with a downthrow or the southern side. The slates are partially in the fault.

37. If we ascend the next spur, Barus spur, from the south, pretty high up the little ravine, and make our way to the monumental "Ling" which crowns the hill,* we see nothing but trap and ashes which have been brought up again on the northern side of the fault. The top of the hill is covered with grass and debris which prevent the rocks being seen in situ, but many pieces of ash, amygdaloid and white quartzite are seen loose on the earth, showing that the usual quartzite bed exists here. On the western and north-western aspect of the hillock, the rocks are uncovered and we have the following series.

Trap and volcanic ash ....

Quartzite ....

Here two beds are covered by vegetable earth, as mentioned above.

1. Zeeawan limestone with usual fossils. Dips W. 50°,............ 40 ft.

2. Greyish-blue limestone without fossils,.............................. 15 ft.

3. Beds concealed by vegetable earth and by lacustrine deposits 30 ft.

4. Shaly limestone with few and broken shells........................ 40 ft.

* This is, I believe, one of the largest, if not the largest "Ling" or "Emblem of Creation." It measures 14 feet in circumference and was about 20 feet high. The base is hexagonal; the preputial line is in relief, and appears to have been carved. This monster ling is now broken in two or three pieces, and the upper half is prostrate on the ground; the hexagonal base and about 6 feet of the body of the ling are still standing.

5. Limestone, very impure and containing immense numbers of a Spirifer of large size, very similar to *Spirifera Verchèri,* De Vernueil Pl. I. (fig. 1a. 1b. 4 ft.

6. Limestone with a few fossils, ... 30 ft.

7. Limestone, filled with *Productus costatus* (S. W.) often extremely depressed by pressure. Many other fossils associated with the *Productus,* such as *Athyris Spirifera,* and a species of *Chonetes,* &c. The limestone is arenaceous and micaceous, often so much so that it passes into a calcareous sandstone. This passes gradually into the next bed, the fossils becoming less frequent and the rock less sandy.

8. Shaly limestone. The beds 7 and 8 are together about, ... 60 ft.

All these beds are evidently, from their fossils, members of the Zeeawan group. The series is continued by beds of the Weean limestone.

9. Sandstone, grey, then pale brown. It contains lenticular beds of limestone. The bed is much disintegrated and overgrown with grass *Goniatites,*.. ?

10. Flinty-looking, shining limestone of a bluish grey colour. Divided by pastings of shale, thin and irregular. It weathers rugose and contains no fossils, ... 15 ft.

11. Calcareous slate, thin-bedded and exfoliating, ... 1 ft.

12. Flinty limestone like 10, ... 3 ft.

A lacustrine deposit covers any further bed which may exist.

The total thickness of this section is about 260 feet. The Zeeawan bed is nowhere so thick as it is here, being about 220 feet thick from stratum 1 to 8.

The remainder of the section is Weean limestone, but only partially seen here.

38. The end of the spur, immediatly north of Barus, presents also some Zeeawan limestone, but it was not examined. The two following spurs are entirely composed of volcanic ash and agglomerate.

39. Then comes the long spur which ends in the somewhat detached hillock which I have called the Pampur knoll. We find in this spur the beds we have just seen above Barus, precisely in the same position and relation. The similarity is so complete that it is evident that the Barus beds once extended to the Pampur knoll without a break, but that a great portion of this limestone has been denuded.

The volcanic rocks, in the long spur, are well stratified and rather thin-bedded as they approach the limestone. They dip W. N. W. with an angle of about 45°. The Zeeawan bed rests on quartzite and presents the same beds full of the gregarious fossil *Spirifera trigonalis (?)* and of *Productus Costatus* : the distance between these beds is the same as it is at Barus. On the top of the Zeeawan beds are seen Weean beds, but they are much more complete than at Barus, having a thickness, from the top of the Zeeawan bed to the foot of the knoll, of about 660 feet. But I believe there are probably some faults which cause beds to be repeated, and that the Weean bed is not quite so thick; about 500 feet.

The Pampur knoll gives the following approximate section from east to west.

1. Coarse grey limestone.
2. Slaty grey limestone.
3. Patchy blue and yellow or pale brown limestone.
4. Compact blue limestone, argillaceous.
5. Patchy blue and dirty yellow.

These beds are together about 100 feet thick. They dip W. with an angle of 60°.

6. Flesh-coloured limestone.
7. Shaly coarse blue limestone.
8. Flesh-coloured limestone.

These 3 beds are together about 80 feet. Dip as above.

Other layers are buried under lacustrine deposits. This little hillock was examined very superficially, owing to want of time. No fossils were seen except the small broken bivalves mentioned above, and which are so common in all the rocks of the Weean group.

40. The spur seen half way between the Pampur knoll and Reechpoora, is tipped with Zeeawan limestone, but was not examined in detail.

41. Here ends our survey of the Wastarwan. I need not say that the central ridges and summits are entirely composed of volcanic accumulations. Black basaltic rocks are abundant, and by their disintegration, and the rearrangement by water of the black mud they gave in decaying, a great quantity of black slate was formed which is seen interbedded with beds of ash and agglomerate. These volcanic rocks do not require to be described, as they are identical with those of the Zebanwan Mountain. All the rocks of the Wastarwan present a stratification or superposition; on the northern slope it

has a general dip to the N. E., whilst on the western aspect of the hill its dip is generally westerly. There is therefore a sort of anticlinal towards the centre of the hill, following a direction from the N. W. to the S. E. We have seen how this anticlinal affects the limestone at Reechpoora, a locality which happens to be at the end of it.

42. The next mountain we meet, travelling towards the S. E. along the banks of the Jheelum, is the Kamlawan (8601) which terminates over the village of Murhamma. The mountain is composed, like the Zebanwan and the Wastarwan, of volcanic rocks. Melted rocks predominate in the centre of the system, whilst ash and laterite compose, in a great part, the most extended spurs. Slate is intermixed with the beds of volcanic cinders, and over these carboniferous limestone rests conformably. But the limestone of the Kamlawan appears to have been extensively denuded, and is only found in a small bed which makes but little show. The following is a section of the spur immediately over Murhamma. Direction of the spur N.—S. Strike E. S. E.—W. N. W.; dip S. S. W. (See Pl. 11. Section D.)

1. Trachy-dolerite, coarse and dark, here and there amygdaloidal; it has large joints regularly disposed, at right angles to the stratification and yawning, giving it a somewhat columnar aspect. This bed appears to extend from the top of the hill, to the beginning of the spur now under consideration. It is of very great thickness, and, making allowance for faults, it cannot be less than 2000 feet.

2. Baked clay-stone or compact laterite, grey, smooth, much jointed; it dips S. S. W. 70°. It has a thickness of about .... 200 ft.

3. Limestone, crystalline, coarse and metamorphosed. It contains a few fragments of fossils, not recognizable and mostly transformed into spar, 3 ft.

A fault, ...

4. Grey laterite or baked clay, like No. 2, ... 200 ft.

5. Amygdaloid, ... 20 ft.

6. Sandstone, or perhaps volcanic dust-stone; no fossils, ... 5 ft.

7. Coarse grit of rounded grains.

8. Basalt, fine and dark brown. The beds 7 and 8 are together 150 ft.

9. Sandstone or duststone, like 6, ... 5 ft.

10. Beds covered with grass and earth. Pieces of white quartzite and rotten ash seen amongst the grass, ... 100 ft.

11. Limestone of the Zeeawan group with *Productidæ*, *Fenestellidæ*,

Orthidæ, etc. It is much fractured and fissured, and is evidently but the remnant of larger beds removed by denudation. It dips S. S. W. 50° and it is about, ... 25 ft.

Any further beds which may exist are covered by the lacustrine deposit, which is here 150 feet above the level of the Jheelum.

The Sheri Bal is a small mountain close to the Kamlawan, to which it is united by a connecting ridge. It is entirely composed of the same semi-columnar trachy-dolerite which forms the bulk of the Kamlawan. The compact, smooth, grey, laterite or baked claystone, described in the section as No. 2 and 4, is seen extending on the flank of the hill, both to the west and to the east. It forms a conspicuous belt along the side of the Sheri Bal, appearing, from the high angle of its dip, to rest against the trachy-dolerite. Some of the volcanic and azoic rocks, described in the section of the Kamlawan as superior to the laterite, were seen on the slopes of the Sheri Bal, but no limestone was observed, it having probably been denuded.

43. Crossing the valley of the Lidar River, we find the next mountains to be the Hapatikri and Saijnarh group. The whole of this system of hills appears to be composed of limestone. It is continued to the S. W. by a low ridge, which is mostly buried under lacustrine deposits, but rises above these at Islamabad, forming a small hill at the foot of which the town is built.

The following section (fig. 8) will, I hope, give a good idea of the rocks composing these hills. The section is above the celebrated Tank of Mutton, near which locality the lacustrine deposit is about 120 feet thick. Above the lacustrine we find :

1. A limestone, coarse arenaceous and apparently much metamorphosed. It contains hardly any trace of fossils, excepting very crystalline rounded bodies which are altered stems of crinoïds. The rock is divided into sub-beds by shaly or clayey partings, which are very false-bedded and very hard. Only a few feet of this rock appear above the lacustrine.

2. Limestone, jointed and cleaved ; but hard specimens have a remarkably compact, smooth appearance, like hornstone.

These 2 beds dip E. N. E. 20°.

3. The bed No. 2 becomes gradually bluer and more argillaceous and less cleaved ; towards the top of the bed it is the patchy blue and brownish rock which we have seen before repeatedly. It contains traces of fossils, but no shells sufficiently well preserved to be recognized. It has an enormous thick-

ness, varying however a good deal in places. There are remains of a Buddhist quarry in this bed.

The three beds have together a thickness of about .... 200 ft.

4. White and friable sandstone, apparently a compressed quartzose sand without cement. It dips N. E. by E. 25°. It contains traces of fossils. It is remarkably well seen near the Karaise or Irrigation Canal which is cut on the flank of the hill.* It is a thin bed and presents variations of color and aspect. It is only one and half foot thick, ... 1½ ft.

5. Argillaceous blue limestone, ... 2 ft.

6. Yellow sandstone, calcareous, not very hard, much disturbed and faulted, the faults, which are small and short, being at right angles to the strike. The sandstone has a thickness of about .... 10 ft.

In this sandstone, which, by the bye, does occasionally pass into lenticular patches of impure arenaceous limestone, a great many sections or outlines of large bivalves and some small ones were seen; but no shell in a tolerable state of perfection could be obtained; I, however, made drawings of the outlines presented by these bivalves, on the weathered flank of the rock. When I first saw these outlines, I did not know of the large *Anthracosiæ*, *Pectens* and *Aviculo-pectens* which exist in the Weean group, and it appeared poor and ungrateful work to copy them. Soon after, however, I found the *Aviculo-pectens* and other bivalves represented at Pl. VI. fig. 3, and Pl. VII. fig. 4, 4a, and my sketches of the sections came in very opportunely, proving, in the absence of better fossil evidence, the Weean nature of the Hapatikri limestone.

7. Very hard and brilliant white quartzose sandstone, ... 10 ft.

8. Sandstone, yellow and soft, like 6, ... 5 ft.

These sandstone beds are remarkably wavy and undulated, as if they had suffered from lateral pressure. The limestone above and below participates but very triflingly in these undulations.

9. Sandy limestone, blue and compact. The debris of small fossils, 10 ft.

10. Dark shales, slightly carbonaceous. In this bed, casts of roots of trees with a concentric arrangement and, in rare cases, the vegetable cells filled with coal, were seen. The roots are generally thoroughly petrified; they are numerous and mostly horizontally (to dip) arranged; they are branching and have generally a starry disposition like Stigmaria. Some pieces of these

* This canal was apparently intended to bring some of the waters of the Lidar to the Martand plateau; but it was never finished, and it is now falling into ruin. It is said to have been begun during the reign of the Mogul Emperors of Delhi; it is a work of considerable extent.

roots show a sort of epidermis, somewhat scaly like Lepidodendron. Large trunks were not seen. The bed is very thin, only 1½ foot, and is covered by a bed of limestone 25 feet thick. It appears therefore probable that, owing to littoral oscillations, the vegetable covering of the shale was denuded during the progress of the sinking of the coast and previous to the deposit of the limestone, ... 1 & ½ ft.

11. Argillaceous limestone, compact and weathering white. Shaly partings, ... 25 ft.

12. Calcareous sandstone, of a compact structure and a dark blue color when fresh, but weathering reddish in an irregular and patchy manner, the redder patches being due to shaly masses which are seen here and there imbedded in the sandstone: these shaly masses sometimes form lenticular thin beds, as thin-bedded as sheets of paper. No fossils, ... 10 ft.

13. Grey limestone; no fossils, ... 6 ft.

14. Limestone, patchy blue and pale brown,. .... 15 ft.

These two beds of limestone are not quite conformable to the sandstone and preceding beds; they are nearly horizontal, with a trifling dip of about 3° to the E. N. E. This is probably due to littoral oscillations or earthquakes.

15. Sandstones, greyish-brown and pale, ... 2 ft.

16. Limestone, ... 4 ft.

17. Very arenaceous, grey limestone, weathering a deep yellowish grey; it shows no organisms. It dips E. N E. 20°. It does not appear to participate at all in the faults and folds noted before. It has resisted atmospheric influence well and forms a prominent and striking wall near the top of the hill. It is about .... 20 ft.

18. Pale blue sandstone, marly and shaly, weathering greyish-brown and patchy. It decays fast into a yellow sandy marl and forms a furrow at its outcrop,.. 15 ft.

19. Compact limestone, very hard and cherty. It is fawn-coloured, but sometimes greenish blue. It contains no fossils, ... 5 ft.

These three beds, 17, 18 and 19, form at their outcrop a ribbon similar to those described at Weean. Another ribbon is formed by the layers 14, 15 and 16, which appear to be the equivalent of the ribbon 7, 8, 9 at Weean. (?)

20. Sandstone, brown, hard and micaceous, ... 2 ft.

21. Limestone in blue and brown patches, ... 4 ft.

22. Sandstone, shaly and much fissured. Color grey or brownish-grey. It is hard, cherty and calcareous. It has a slaty cleavage, cutting the stratification obliquely by striking W. E. and dipping N. with an angle of 60°. It contains a few fossils. This bed varies a great deal, being sometimes a pure enough sandstone, at other times a sandy shale, and again a coarse sandy slate. It goes to the top of the cliff.. 20 ft.

This section gives a thickness of Weean limestone and calcareous sandstone, of 360 feet.

When I ascended the Hapatikri, I unfortunatly did so above Mutton, and only carried my section as far as the top of the hill at that place, that is as far as layer 22. A little swelling of the surface concealed from me the summits to my right, and I thought that layer 22 was the highest of the hill. From the top of the Islamabad hill, about four miles to the S. W., I could see, while sketching fig. 8, that the summit of the Hapatikri is considerably above the layer 22. Two dark layers or ribbons are well seen near the highest summit of the Hapatikri, and it is not impossible that some faults bring up again the same beds. It is, however, probable that some beds of the uppermost or Kothair Bed exist near the summit of the hill, as I found amongst *éboulis* and lose stones near Martand some corals, which are, I believe, highly characteristic of the Kothair bed. (Pl. VIII. fig. 4, 4a.)

44. The Sketch-Section (fig. 8) shows that all the ridges of the Saijnarh are well and regularly stratified limestone and calcareous sandstones ; I did not, however, visit these spurs. Behind the Saijnarh and the Hapatikri are seen the rugged volcanic mountains which bound Kashmir on the east, separating the waters of the Jheelum from those of the Chenab. The Arpat river brings down boulders from these mountains, and the lacustrine conglomerates, which are so extensively developed at the point where the Arpat and other streams leave the mountainous gorges to emerge in the open valley, give us a good idea of the composition of these mountains. All the boulders and pebbles, both of the bed of the river and of the conglomerates, are volcanic rocks, of which many varieties of amygdaloid are the most frequent. I never saw a single pebble of granite, syenite or gneiss, but quartzite is common, as well as limestone. That the pebbles and boulders of the conglomerate have been brought down directly from these mountains by torrents and rivers, and have not been drifted to where they are by the waves of the ancient great lake of Kashmir,* is

* The valley of Kashmir has been a huge lake since the appearance of man in the Himalaya. It is probable that a lake filling up the whole of the valley existed before that period, and that it was drained or tapped by some cause or another, allowing the valley of Kashmir to dry up nearly to the same

sufficiently proved by the shape of the boulders, these being rounded and ovoid in form, and not worn into the flat lenticular stones which are found on the beach of lakes, and which are so much appreciated by persons fond of making "ducks and drakes in the water."[1]

45. I have said before that a spur of the Hapatikri extends to Islamabad, concealed under the lacustrine plateau (see fig. 8,) for a few miles, but appearing as a small hill over the town. The following is a section of this Islamabad Hill, from the S. W. to the N. E., beginning with the lowest strata exposed to view. The general dip of the beds of this hill is N. Easterly.

1. Marly limestone; bright blue; debris of fossils,............... 15 ft.

2. Ditto ditto; white; no fossils, ... 20 ft.

3. Ditto ditto; grey; often reddish. Enormous number of *Foraminiferæ* forming ochrous bands in the rock, ... 1 ft.

4. Arenaceous, dark grey limestone, divided by partings of shaly pale-yellow limestone, very false-bedded and very thin. Rich in the debris of fossils, but very few in a good state of preservation, ... 25 ft.

These four beds dip N. E. 15°.

5. Limestone having a slaty cleavage and joints, white or pale grey, cherty in appearance, Fossils very numerous, but in comminuted fragments, 10 ft.

6. Marly, yellow, limestone. It is often flesh-coloured, and then shaly in appearance and weathering with a rough pitted surface,................ 2 ft.

7. Limestone like 4; full of the debris of fossils,......................... 1 ft.

8. Limestone, brown and cherty; debris of fossils,...................... 1½ ft.

9. Very pale blue limestone, often white; very hard and rough; weathers rugose like frosted glass. Thin and false-bedded; fragmentary shells, 15 ft.

10. Sandstone; yellowish white or greyish-white, ... 6 inches

11. Coarse, gritty limestone, full of the debris of fossils; great abundance of *Foraminiferæ*, crinoid stems, *Fusus* (?) and fragments of a small bivalve, ... 3 ft.

12. Marly, dark grey-blue limestone; slaty cleavage, ... 3 ft.

extent as it is now, and that the valley then became populated. The lakes, however, began to fill up again, and the whole of the valley was again converted into one immense lake. This in its turn was tapped and drained to its present state. The earthquake, which broke up the barrier or dam at Baramoola, is reported by tradition to have been the beneficient act of the Hindoo god Kashyapa. The Mahomedans, however, say that it is Kashaf, Solomon's minister, who performed the wonderful work, and it is very probable that both Hindoo and Musulmans borrowed the tradition from earlier inhabitants.

I hope to be able to prepare before long a paper "On the Lacustrine deposits of Kashmir," in which the proofs of two successive lakes having existed will be given in detail. See also my note to para 9. page 100.

13. Marly limestone, deep blue in colour, cherty in appearance and weathering rugose; it is compact and contains no fossils,........................ 15 ft.

14. A portion of 13, in a brecciated state, ... 2 ft.

15. Same as 13,.. 12 ft.

16. Limestone similar to No. 2, ... 2 ft.

17. Foraminiferous limestone, similar to No. 3, ... 8 inches

This limestone contains many small yellow rounded bodies, mixed with the *Foraminiferæ* and appearing to have no organisation. They are perhaps excretions of mollusks. Also large patches of white, dotted, chalky, limestone which are, I believe, the remains of decomposed fossils of considerable size.

18. Argillaceous, pale grey, nearly white limestone. It gets coarse towards the top of the bed, and the uppermost layer is brecciated, ... 10 ft.

19. Indurated clay, ... 1 ft.

20. Limestone varying in colour, being white, yellow, flesh-coloured, grey or pale lustreless blue. It is very argillaceous, occasionally sandy. The debris of fossils mostly encrinite-stems, ... 10 ft.

21. Calcareous brown sandstone; no fossils, ... 4 ft.

22. Shales, hard and without fossils. These shales are in places, fine, silty and foliated; in other places sandy, coarse and thicker bedded, 10 ft.

23. Sandstone like 21, ... 5 ft.

24. Shales like 22, ... 10 ft.

25. A repetition of the beds 22, 23 and 24; but the materials are generally coarser, the shales never being fine and thin-bedded, but rough and thick-bedded; and the sandstone contains so much lime that it passes in some places into a very arenaceous limestone. It contains but little of the debris of fossils, but shows some flat impressions like those of large flat *Algæ*. These impressions are, however, ill-defined and could not be identified, ... 25 ft.

26. Pale but bright blue limestone; very argillaceous and interbedded with thin films of yellow silt,.. 10 ft.

27. A second repetition of the beds 22, 23 and 24. A few shells, but no imprints of algæ. It becomes gradually a coarse sandy limestone, and at the top of the bed it is an argillaceous and arenaceous limestone, pale blue or rather French-grey, weathering rugose like frosted glass and containing a very few fragments of shells only, ... 25 ft.

These three beds, 25, 26 and 27, seem to resist the influence of exposure better than the rocks above and below them, and they form at their outcrop a well defined ribbon; this, owing to the trifling angle of the dip, appears on the hill-side as a cliff which faces the city of Islamabad a little more than half way up the hill. These beds are slightly wavy along the strike, as if they had been pressed laterally. These undulations occasion trifling discrepancies in the dips taken in different parts of the hill. Along the line of our section, the cliff formed by the beds 25, 26 and 27 has a strike N. N. W.—S. S. E. and a dip E. N. E. 15°.

28. Limestone, patchy blue and yellow; argillaceous, ... 20 ft.

29. Limestone, very argillaceous and having a pure lustreless grey colour, and being striped on section, owing to bands of a lighter colour. The rock is so compact and fine-grained that it resembles a fine greenstone in structure. It is traversed by bands of rougher stone and also by bands of blue limestone. It weathers rugose and pitted,.. 20 ft.

30. Limestone like 28, ... 20 ft.

31. Limestone like 29, ... 15 ft.

32. Limestone, as white as chalk, but hard. It is full of geodes like an amygdaloid, the geodes being filled or lined with minute crystals of spar. The rock weathers in rounded bosses like granite or trap. It appears to have suffered a metamorphosis. It is probable that the calcareous mud which originally composed it was thrown into a bubbling condition by the infiltration of heated vapours or the immersion of hot volcanic products into a shallow sea. It presents no fossils or traces of fossils. The bed is not lenticular, but extends regularly along the strike the whole length of the hill, being conformable to the other beds, ... 5 ft.

33. Limestone similar to 31, ... 5 ft.

34. Marly, dark bluish grey and rough limestone, ... 5 ft.

35. Like 33 again .... 15 ft.

36. Hard and cherty limestone, pale grey or flesh-coloured. It contains a few geodes like No. 32. It weathers pitted and rugose; no fossils (?) .... 2 ft.

37. Limestone like 34, ... 5 ft.

The last three beds are a good deal denuded, owing to their being at the top of the hill, which is narrow and barren.

46. There can be no doubt of the Islamabad hill being composed of Weean limestone; the argillaceous and arenaceous condition of the rocks is exactly what we have seen in other localities where this sort of limestone is developed. The fossils are very unsatisfactory, being extremely comminuted. I have found, however, one *Spirifera* and one *Athyris* which are to be seen in the beds at Weean. I have seen also many sections and outlines of large bivalves (*Aviculo-pectens* and unio-like *Anthracosiæ*) similar to those found near Mutton. The *Foraminiferæ* are also extremely numerous, and the fossil shell which gives on the surface of rocks an outline resembling a small pair of spectacles, is very common amongst the debris of comminuted shells. The upper beds of the hill, from 29 upwards, contain no fossils and have a peculiar appear-

ance, suggestive of their having been baked, and they weather in rounded bosses like many volcanic rocks. I have suggested that their amygdaloidal condition and their "metamorphic weathering" may be accounted for by the hypothesis that hot ejecta of volcanoes, either hot water, steam, hot ashes or a current of lava, had found their way into a shallow sea and set it a-boiling. It might be said that these very impure calcareous muds might have had gases generated in their interior by the decomposition of organic matter or some other cause; but many layers which are much more fœtid and were therefore more likely to emit gases are not at all amygdaloidal, and besides, there is so much volcanic power manifested all over our tract of country, that it is more natural to invoke a little steam to boil mud with, than to look for less obvious hypotheses. But another reason in favour of volcanic metamorphism is, that these same white baked limestones have been observed in other localities, near Manus Bal in Kashmir and in the Kafir Kote mountain, in the Punjab, and in these localities they are disturbed by actions which appear to have taken place locally and to have affected these limestones much more than the rocks below them. The beds of Manus Bal will be described hereafter in these pages, and we shall be able to observe how faulted and twisted are the white limestones of that place. At the Kafir Kote there has been a similar local upheaval, and the disorder is very considerable. In this locality a felspathic sand, invaded by quartzite in tortuous branches, is the remains of the volcanic action which has taken place there, and the limestone, though much less marly than in Cashmir, is filled with geodes and veins of spar. I believe these actions to have been local and not very extensive; they had little effect on the Zeeawan bed which had, by the time they took place, become tolerably consolidated, and they merely fractured and pushed aside the nearest portion of the bed; but they acted powerfully on the yet soft and muddy Weean bed, curving it and twisting it in all sorts of manners and directions; and when these folds and twists were again disturbed, probably intensified and placed in new positions by the final upheaval of the Himalaya, they became what we see them now, viz. most incomprehensible doublings and reversings of strata. Let us also remember the beds which I mentioned as having been seen from the brow of the last spur of the Zebanwan visited by me; these beds were the top or near the top of the series of Weean limestone seen along the section of the southern aspect of the Zebanwan between Zeeawan and Koonmoo. I said, "From the brow of the last spur I have visited, a fine view is obtained of the next spur, and this is remarkable for a great twist of the strata which compose it. The limestone is extremely white, and resembles chalk-cliffs at a distance." Is it not highly probable that there again we had the same altered limestone? The beds were wonderfully twisted and folded, whilst those above and below them were hardly affected.

I consider, therefore, that these altered limestones are portions of the Weean group, and I believe that the alteration was produced by bursts of water at a very high temperature, or of gases hot and compressed; the eruptive power of these agents being sufficiently powerful to displace and uplift the calcareous mud of the sea-bottom, a mud which must have been plastic, from the great admixture of clay it contained, and which was covered by no great depth of water. It is for such an action, as I have supposed, that Mr. Dumont has proposed the term of "Geyserian" action, and for the rocks precipitated from these watery volcanoes (such as the felspathic sand with quartzite of the Kafir Kote) the name of Geyserian rocks. The name is sufficiently suggestive and requires no explanation. It is probable that the quartzite which we have seen placed between the volcanic rocks and the limestone, belongs to that class of rocks.

47. The Arpat river runs through a district named Kothair or Kotehar, and it is from this district that I have named the uppermost bed of the Carboniferous (?) limestone of Kashmir. We have seen a small patch of this bed near Koonmoo, in the Zebanwan, but we will find the bed well developed in the next hills we are about to visit.

A few miles to the S. E. of Islamabad is a mass of well-wooded and picturesque mountains which separates the valley of the Arpat river from the Nowboog valley. Arekbal, Tippoo, Karpur, Dhar and Nawkan are summits which appear to form the centre of a small system of hills; their height is between 8 and 9000 feet, and they deserve careful study. I was unfortunately not able to do more than pay the most superficial visit to Arekbal and the iron mines of Kothair; and the following are the notes taken during that visit.

The rocks which overhang the well-known Arckbal Garden, near the western foot of the hill, are a rough grey limestone similar to the grey coarse limestone seen on the Islamabad hill, (see No. 27 of the section of that hill), full of sand and other impurities. It dips W. by S. 52°. There appear to be beds of shales between the limestone courses, and these shales by their decomposition furnish the fertile soil on which grow the fine forests of those hills.

The foot of the Arckbal hill is therefore Weean limestone and shales.

I then proceeded to the small village of Kothair, on the eastern side of the Arckbal hill, in a small valley situated between it and Karpur. The rock of the spur of Arckbal, which extends towards Pahaloo, is a whitish or greyish limestone with very few fossils, and interbedded with beds of calcareous slate, apparently belonging also to the Weean group.

From Kothair, the path to the mines, crosses a couple of small spurs which have a direction S. to N. until we arrive at the ridge which unites Dhar and Tippoo and has a direction W. N. W.—E. S. E. The spurs above mentioned are composed of marly limestone, either lustreless and velvety pale blue or dark blue, weathering frosted. The beds are very badly seen, on account of the vegetation and humus. Where the limestone crops out, it seems to be dipping S. E. or E. S. E. with a very variable but considerable angle. The beds of limestone appear to be separated one from the other by thick beds of shales and slate. The limestone has exactly the appearance of that seen a little higher up, and which we shall see contains fossils characteristic of the Kothair bed; but I failed, however, to find organisms in the present beds.

48. The iron-ore is obtained from the sides of the main ridge between Dhar and Tippoo. The ridge presents many beds of very argillaceous limestone of a lustreless bright blue colour, dipping S. S. W. with an angle of 45°. This limestone is remarkable for the large number of gasteropods it contains; it is also rich in corals, especially of the *Cyathophyllidæ*, but the fossils appear generally as sections or outlines on the surface of the rock, and I could not obtain any of them whole.

Between the courses of limestone are beds of slaty shales of various colours, but generally dark grey, brown or reddish. The outcrop of these shales has disintegrated and decomposed into a vegetable earth of a dark red colour and covered by grass and underwood, and this earth has to be removed to bring the shales into view. In these shales the iron-ore is found as flat bands or ribbons of great tenacity and hardness, accompanied by softer ochrous clayey earth which is also used as an ore. The richest ore is the steel grey variety; this is not continuous as a regular bed, but forms bands or ribbons in the shale, sometimes thickening into a trunk a foot thick, at other times thinning into a flat ribbon a quarter of an inch thick.

The shales containing the iron-ore are about four feet thick, and are between beds of an arenaceous limestone which is blue and compact when freshly fractured, but weathers into a coarse, brown, nearly friable sandstone in the neighbourhood of the iron-shales. This change in the limestone (evidently produced by the infiltrating water becoming charged with peroxide of iron in its passage though the shale, and then acting as an acid on the limestone below the iron bed), is the indication sought after by the miners to dig an exploring hole; they dig above the altered limestone, and after removing a few feet of vegetable mould, discover the iron-ore in the upper part of the shaly bed. They make a hole just large enough to creep in and use a short miner's pick; the ore is difficult to detach, and, from the cramped position of the miner, the work is excessively laborious. The mines do not extend any distance under ground, and are generally abandoned in favour of a fresh hole, when artificial light is required to work.

From the examination of three or four of these small mines, I feel satisfied that the ore does not form a bed, but is arranged in a succession of ribbons and bands which run in the direction of the dip, sometimes anastomosing into a broad plane two or three feet across, sometimes thickening into a trunk or pocket, and sometimes dividing into thin and narrow ribbons which become lost in the shale.

The mines are all situated high up the hill (on this side of the ridge at least), within about 200 feet of the summit. The miner I had for a guide told me that no iron-ore is found lower down.

49. The ore is carried in kilters or baskets, carried on the back, by the means of shoulder-straps, to Kothair, a distance of two miles on a bad hill-path. It is not smelted nearer the mines, on account of the want of water; though it seems that it would be very much easier to bring up water for the miners, who only know of that element as a drink and therefore require but little of it, than to take the ore down to the village. The ore is broken into small fragments by children, and mixed with the ochrous earth and with coarsely powdered limestone. These materials are piled up in a small furnace about two feet high, with intervening beds of charcoal, and two hand bellows are used to create a blast; the smelting lasts about 12 hours, and the produce of a furnace is only a few seers. The heat is not sufficient to make the iron run; and it remains at the bottom of the furnace as a viscous mass, full of scoriæ, and very brittle when cold, with a tufaceous aspect. The slag is a black glass, compact, and much less scoriaceous than is customary. The iron is heated and beaten with hammers to refine it. It is short, probably from bad manufacture.

Two or three men and children and some women, all of one family, working as miners, carriers and smelters, turn out about two maunds of iron in the month from one furnace. There are only three furnaces at Kothair, giving a supply of six maunds of iron per mensem. There are similar mines at Loap and at Kookur Nag in the Bringh valley, on the southern side of the same mass of mountains. From the dip of the beds, it is probable that these works are in a much more favourable position than those of Kothair; they are said to be much more considerable; the ore is obtained in the same manner as at Kothair, and there are no regular mines. The ore is the same, according to my guide, a miner who had worked at Loap, but it is obtained much more easily and is found in thicker beds. Mr. Turner showed me some iron from Kookur Nag, and it appeared identical to the pig-iron of Kothair.

The turn-out I have given of the smelting at Kothair is not to be regarded as an indication of the richness of the mines. I believe that the miners only work the ore to pay their taxes to the Maharajah's government, and that their most usual occupation is to grow a little rice and Indian corn. I have no doubt that the amount of ore is considerable, and that a large quantity of iron could be obtained by increasing the mines, and adopting better furnaces with a blast worked by water-power, windmill or horse-power; but the miners and other inhabitants of the villages take great care not to mention to the Maharajah's officials any valuable deposit of ore which may be worked with advantage; they pretend that the Maharajah takes away all the iron for his arsenal and pays nothing for it, and that, when a supply of any ore is discovered near a village, the inhabitants have to work it by corvées, so that the discovery of a vein of valuable mineral is a calamity to the people of the neighbourhood. But this is probably untrue in many ways: the iron they supply is, as I have said before, taken in lieu of taxes; the care with which many of the holes are concealed with rubbish and branches, induces me to believe that a good deal of iron is smelted in a contraband way; and last but not least, making a secret of mineral wealth is quite consistent with the love of hoarding riches so prevalent amongst natives. The same concealment of ores is now going on in Huzara, where a little iron is known to exist, and where the reason of the Kashmir miners would certainly not avail; and it is reported by the geological surveyors of the Ranigunj coal-field that it is impossible to believe negative reports from natives. In Kashmir, moreover, the Maharajah's government entertain the same childish fear, lest the mineral wealth of the country should become known, and I well remember with what silly recommendations of secrecy I was shown by one of the Maharajah's servants a small piece of iron pyrites of the most insignificant value.

50. The rocks we have described form the Kothair bed (of Carboniferous limestone ?). They are a succession of courses of limestone, shales of a dark reddish or ochrous colour, dark slates and calcareous sandstones. I am sorry I cannot give a section, but the following remarks will, in a way, supply its want.

The limestones are of two descriptions, viz.: some coarse and very sandy, indeed so much so, that when the carbonate of lime is removed by water charged with peroxide of iron, a brownish sandstone is left; it contains no fossils, and passes gradually into a rough grey sandstone with a calcareous cement. The other variety of limestone is argillaceous, and passes into calcareous slate; it is dark blue or even perfectly black when fresh-fractured, lustreless like a clay and with a strong earthy smell; it weathers much paler, becoming covered with an incrustation which is bright pale blue, yellowish or whitish; the surface being at first velvety or satin-like, and so fine-grained in some specimens, that drops of rain or of dew falling from grasses leave small blots or stains, which after a while becoming frosted. The fossils of this limestone are well brought out on the weathered surfaces, as outlines or sections which are slightly in relief. The shales when ochrous, are very sandy. sometimes calcareous, oftener not so; they contain beds of clay iron-stone in irregular and wavy tabular bands or ribbons of an iron black and bluish black colour, and also of yellow carbonate of lime, and iron in a more or less friable condition. These shales have a well-marked slaty cleavage cutting the strata at a right angle. The slate is black, thick and massive and contains no fossils. It often becomes pale green and unctuous, and is then very thin-bedded and exfoliating. The sandstone is composed of rounded grains of transparent glassy quartz which are brittle, and break across when the rock is fractured, and each broken grain reflects the light, so that the sandstone has somewhat the aspect of a micaceous sandstone.

The fauna of the Kothair bed is more remarkable for the abundance of certain animals than for any species that I can well define. *Gasteropoda*, generally small, and corals of the "*Cyathophyllidæ*" are nearly the only animals seen. A few bivalves, small and thin-shelled, also occur, but they are rare, compared to the quantity of gasteropods. A few roots and stems, generally small, have been observed in some beds, but could not be recognized.

The following fossils are the most usual in the Kothair bed.

Naticopsis ?
Macrochilus ?
Chemnitzia ?
Loxonema ?
Nerinæa ?
The fragments of *Gasteropoda* in great number.

Cyathophyllum	?	sp.	Pl. VIII. fig. 2.
,,	?	sp.	Pl. VIII. fig. 3.
,,	?	sp.	Pl. VIII. fig. 4.

It is evident that a list of fossils, such as is given here, is insufficient to determine the age of a bed. My calling the Kothair bed Carboniferous, is therefore only temporary, and it is possible, and indeed probable, that the bed is either Permian or Triassic. I have often felt inclined to regard it as Triassic; but the total absence of *Monotis*, *Ammonites* and other characteristic fossils prevents my doing so. I have therefore preferred to represent the Kothair bed as the top of the Carboniferous series, until some characteristic forms be discovered. The Kothair bed was examined much more superficially than the others, owing to want of time; yet it is worthy of notice that I have never heard of an ammonite having been found in the valley of Kashmir, though the mountains of Kothair limestone, at the extreme eastern end of the valley, are very often visited by tourists and amateur geologists.

51. The Kothair formation differs from the Zeeawan and Weean by the great quantity of shales it contains, these being in thick strata between thin beds of limestone. The fauna is, I believe, strongly indicative of a low swampy shore bathed by a shallow brackish sea. The arrangement of the iron-ore is, I fancy, to be explained only by the hypothesis of a clayey shelving sea board: any one who has observed hot chalybeate springs issue from the earth, near a flat piece of ground, must have noticed the sluggish stream divide into rills and rillets, form shallow pools here and there, reunite and divide again, meandering over the clayey soil; he will have noticed the oxide of iron contained in the water precipitated along the rivulets and in the pools as a bright red peroxide, whilst the surface of the nearly stagnant water is covered by a many-coloured film. This, I would submit, is the very process by which the iron of the Kothair shales has been deposited on the flat muddy shore of the Carboniferous sea: the rills of chalybeate water have become the tabular ribbons of our iron-ore, and we have therefore the iron-stone arranged as a main flat vein, or rather in somewhat parallel veins, with irregular small shoots on both sides, and occasionally a thickened and widened mass representing a pool or a hole in the bed of the stream. Many springs, such as I have described, exist now-a-days in the Salt Range, near the Kafir Kote hill, and in several localities in the Himalaya; the iron mud they deposit would, under favourable circumstances, and in the course of long years, form beds

similar to the iron-ore of Kothair; and when it is remembered how essentially volcanic the Carboniferous period has been, it is no great stretch of imagination to assume, that much of the iron contained in the rocks of that period was derived from hot chalybeate springs, rather than from decomposed minerals on the surface of the earth.

Here ends the description of the Kothair bed. No rocks superior to it (excepting lacustrine and alluvial deposits) were seen in Kashmir, and the Kothair bed appears the most superficial stratum existing there. In other localities, both in the Himalaya and in the Punjab, Secondary and Tertiary rocks cover in the Palæozoic beds, but neither Oolitic, Nummulitic nor Miocene are to be seen in Kashmir proper, that is, between the Pir Punjal and the Ser and Mer chains, and between the northern branch of the Kaj Nag and the chain connecting the Ser and Mer chain to the Kistwar mountains.

52. As far as I could learn, the whole of the hills, which fill up with their spurs the south-eastern end of the valley, are composed of carboniferous limestone; this appears to go as far as the foot of the range which separates Kashmir from Maroo and Kistwar, where the limestone rests on volcanic rocks. *Producti* have been found among éboulis close to the volcanic rock high up the slopes, and it is therefore probable that the Zeeawan bed reappears under the Weean and Kothair beds, as we near the volcanic rocks. The river Bringh, which drains all the S. E. and a good deal of the east of the valley, carries in its bed boulders of volcanic rocks and of carboniferous limestone. No granite was seen.

As I have not visited these hills and possess only little information on their geology, I will not enter here into any detail of what may be inferred from reports received by travellers who are not geologists, and I must refer the reader to the map for the probable position of the several rocks which compose these hills.

53. To the N. W. of Srinuggur there is one more mountain belonging to the same catenated chain of summits which we have described in this chapter; it is the Safapoor, with its outlier, the Aha Tung, and the beautiful little lake of Manus Bal at its foot. This locality is interesting, and I will describe it in detail. (See Sections E and F; Section IV. of General Map). The Safapoor and the Aha Tung are both composed of volcanic rocks exactly similar to those which we have seen at the Tukt-i-Suliman and the

Zebanwan. In the small valley or gap between the two hills are beds of limestone which I will now describe. (See Section E; and also Sketch-Section F.)

Proceeding from S. to N., we first find at the northern end of the Aha Tung a limestone quarry. The limestone is about 120 feet thick, and dips south with a very high angle. It appears to be covered by beds of greenstone confusely stratified; but on examining the bottom of the quarry, the courses of limestone are seen to bend towards the N., and the limestone is therefore superior to the trap. The diagram here given fig. 9, represents the position of the rocks. I am indebted to Captain Godwin-Austen of the Great Trigonometrical survey for calling my attention to this bend of the courses of limestone at the bottom of the quarry. If this curving of the limestone was not seen, it would be nevertheless easy to understand the true position of these beds, as they are precisely similar to those on the other side of the road (see Section), but in an inverse position: the rock nearest the greenstone is a glaring white and much altered limestone. It is succeeded by a dark, greyish, argillaceous limestone, weathering bluish and rugose. On the other side of the road, the dark limestone appears first, and underneath it the bed of glaring white altered limestone. There is therefore every evidence of a synclinal; but, of course, the discovery of the bend of the beds in the quarry completes the evidence very satisfactorily.

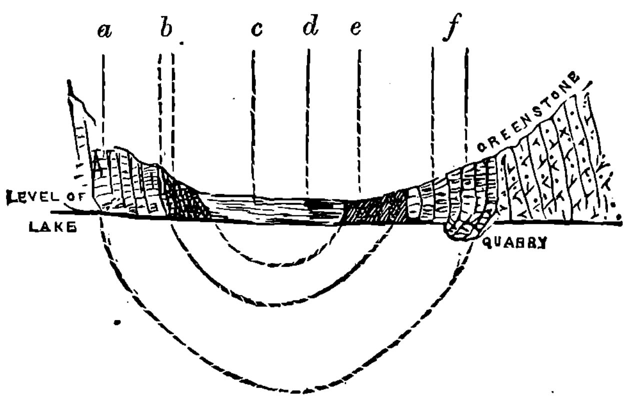


Fig. 9.*

Taking our Section from the S. to N., beginning at the road and leaving out the beds redressed against the Aha Tung which I have just described, we have the following strata :—

1 Greyish-blue limestone; marly, rugose, hard, dips S. 60°, increasing to 70°; much broken bed: about ... ... 20 ft. thick.

* *a* White Limestone. *b* Dark Limestone. *c* Alluvium. *d* Road. *e* Dark Limestone. *f* White Limestone.

2. Pale limestone, weathering glaring white; filled with geodes, lined with small spar-crystals. No fossils. Dips S. 80°, ... 100 ft.

3. Thin-bedded, shaly, striped limestone, ... 5 ft.

Fault. It runs E.—W. and is about 10 feet wide at the top. It is filled with rocks similar to No. 3, folded in all directions.

4. Limestone like 3; vertical, ... 15 ft.

5. Pale limestone; with geodes, like 2. Traces of fossils were observed, but much altered and not recognizable, ... 100 ft.

6. Pale blue, shaly limestone; dips N. 80°, ... 3 ft.

7. Like 5; dips N. 80°, ... 50 ft.

Fault; it runs E.—W.

8. Same as 7, ... 50 ft.

9. Argillaceous, thin-bedded, pale grey limestone, breaking in flat thin pieces, like pottery, ... 80 ft.

10. Sandy limestone, hard and dark, ... 20 ft.

11. Conglomerate limestone, varying from a coarse sandy limestone to a perfect conglomerate, the pebbles being rounded, pieces of limestone imbedded in a soft calcareous paste. It contains many sections of the *Aviculo-pectens* and other large bivalves peculiar to the Weean bed. Portions of the bed are white and altered, ... 100 ft.

12. Sandy, micaceous, limestone; dark grey, ... 2 ft.

13. White limestone; no fossils, ... 15 ft.

14. Argillaceous limestone, blue and pale; weathering lustreless and velvety, ... 5 ft.

15. Conglomeratic limestone like 11, ... 50 ft.

16. Brecciated and sandy limestone; sometimes a coarse calcareous sandstone, ... 5 ft.

17. Ash-blue, pale, muddy limestone; weathering lustreless, ... 25 ft.

18. Brecciated and sandy limestone, ... 12 ft.

19. Ash-blue, pale and muddy; weathering lustreless, ... 25 ft.

All these beds dip S. with an angle diminishing gradually from 80° to 35°.

20. This bed is the top of a well defined anticlinal. The rock is a yellowish-grey limestone, with rolled pieces of limestone imbedded. It is sandy, sometimes quite a sandstone, oftener a sandy impure limestone. It contains a great many remains of fossils. The southern branch of the anticlinal dips S. 35°; the northern branch dips N. N. W. 25°. There is therefore a squeezing of the strata at the western end of the strike, and a divergence or opening of the fault at the eastern end. Thickness about 30 feet.

Then we get a repetition of the beds seen before, as follows:

21. Ash-blue, lustreless muddy limestone, ... 25 ft.

22. Brecciated and sandy limestone, ... 12 ft.

23. Ash-blue limestone, ... 25 ft.

24. Brecciated limestone,... ... ... 5 ft.

25. Conglomeratic limestone, with sections of large bivalves, ... 50 ft.

26. Ash-blue, lustreless limestone, ... 5 ft.

27. White limestone, ... 15 ft.

28. Micaceous and sandy limestone; thin-bedded dark grey; dips N. N. W. 80°, ... 2 ft.

29. Conglomeratic limestone; gritty; in places a conglomerate, in others a breccia; dips N. N. W. 85° at first; then it becomes vertical and at last dips S. 80°, ... 100 ft.

30. Arenaceous limestone, dark, rough and forming a prominent ridge; it dips south 80°, ... 20 ft.

31. Thin-bedded, muddy limestone, breaking in pieces like pottery; dip irregular; bed folded and wavy, much disintegrated, ... 80 ft.

32. Shaly limestone, very impure; dips N. 80°.

33. Sandy limestone, dark and rough and hard; dips N. 70 to 75°. These two beds together are about, ... 30 ft.

34. Limestone, generally sandy and grey, but sometimes more compact and bluer, and then showing innumerable white lines crossing each other in all directions. It dips N. 70°, ... 100 ft.

35. These several varieties of limestone, viz. shaly and sandy, and blue with white lines, repeat themselves continually as far as the top of the hill, but the rock becomes more and more massive and presents portions of crinoid stems well preserved and petrified into a black spar. Sometimes the rock is flesh-coloured, and then the crinoid stems are lighter in colour, and weather in relief on the surface of the rock. These are the sections of crinoid stems which have been taken for nummulites by Mr. Vigne and Dr. A. Fleming. 150 ft.

The strike of the beds of limestone wheels more and more to a N. to S. direction. As we approach the volcanic rocks of the Safapoor, the dip becoming more and more westerly. This wheeling of the strike is well shown by the Sketch-Section (Sect. F), where we see the face of the limestone-courses uncovered and exposed, and facing the W. N. W. The thickness of the Weean bed is altogether 649 ft.

A large fault, well marked by a deep ravine, separates the limestone from the volcanic rocks. It runs N. E.—S. W. At the highest point the limestone is seen to attain, the fault is a mere crack, and the limestone is in contact with the volcanic rocks; but at the S. W. end of the fault, it widens considerably, and beds of limestone are to be observed on its northern side, applied against the trap and conformable and superior to it. The trap dips S. S. E.

On the western face of the Safapoor, long beds of well-stratified laterite and ash are conspicuous; they dip S. with an angle of 40.

54. Our section runs through the spur of limestone nearest to the lake; three other spurs, parallel to it, descend towards the village of Paturmoola (see Section F.). They present very won-

derful twists and foldings, but appear less altered than the beds which are bathed by the lake; their fossils are better preserved. I have not ascended these spurs, but amongst the *éboulis*, I saw many fossils characteristic of the Weean limestone, amongst others large *Aviculo-pectens* and *Anthracosiæ*, of which sections only had been discovered in the rocks in situ.

Some blocks of limestone were also found exhibiting *Gastero-poda*, so conspicuous in the Kothair bed, and it is therefore evident that this bed forms the uppermost layers of the limestone of the higher spurs. I need hardly say, that the beds of Manus Bal belong to the Weean group, and that they have been folded and altered in part by volcanic action, subsequent to the formation of the volcanic rocks on which they rest. The order of the beds is from the anticlinal upwards on both sides of it, and the rocks nearest to the trap are the most superficial, excepting, however, the detached beds which are conformable to the volcanic rocks on the northern side of the great fault. If the limestone had been baked by the amgydaloid and the greenstone, we would naturally expect to find the beds nearest to these rocks most altered; the reverse is however the case; and we must therefore admit that a burst of hot gases or hot water had taken place at the time these limestones were still a soft and plastic mud, and that it upheaved, folded and metamorphosed them.

It must not be forgotten, that the limestone might have been much less folded by this first disturbing action than we see it now, when the last upheaval of the Himalaya took place: the beds then slightly folded would naturally give way in the same direction as they were already bent, especially if the space they occupied between two un-yielding trappean hills had become so restricted that the limestone must of necessity either be folded or override the trap. On the application of such lateral pressure, a straight, flat, hard bed might have slided over the trap, but a bed already undulating would more naturally give way at the weakest parts, viz. the angles of the undulations, and thus become gathered in crumpling folds. Such folds are well shown in the Sketch-Section, (plate F).

55. Having terminated our examination of the several mountains which form the first catenated chain on the N. E. of the valley of Kashmir, we can now understand how this chain was once conti-

nuous, the several summits being re-united to one another by ridges of stratified ash, agglomerate and limestone. These connecting ridges have been denuded by the several streams which flow towards the bottom of the valley, and the limestone is now found only in limited beds, which have escaped denudation from the shelter they received of large and hard volcanic mountains. These streams and rivers, it is hardly necessary to mention, have had a volume very different from what we see now-a-days; the enormous layers of lacustrine conglomerate, which they have accumulated near their entrances into the valley, demonstrate plainly their former great denudating power. The direction of these streams being from the high mountains in the N. E., to the bottom of the valley in the S. W., they have cut for themselves channels which are directed from N. E.—S. W., and thus bands of the ridges, which united the summits of our first chain to those of the second chain, have remained between the channels of these streams, and given to those mountains the appearance of being long spurs descending from the N. E. to the S. W.

56. I shall, I hope, best terminate these detailed Sections, by appending a table of the fossiliferous and other rocks in Kashmir, together with such observations as the nature of the rocks or the fauna best justify.

Formation	Masses, Beds, &c. &c.	Fossils.	Conditions indicated.
A. VOLCANIC ROCKS.	*a.* Granitoid porphyry; trachyte and felstone.	......	Melted masses which have not flowed, or have flowed under water. Centres of volcanic action.
	b. Greenstone amygdaloid, basalt.	......	Melted masses which have flowed under water or in the air.
	c. Felspathic and augitic ash; agglomerate, &c.	......	Volcanic ejecta falling in shallow water.
	d. Black slate, sometimes amygdaloidal.	......	Mud derived from volcanic rocks, rearranged by shallow water, often heated by showers of hot ashes, vapours or currents of lava.
	e. Laterite, slate, baked clay.	......	Same origin and same conditions.
	f. Quartzite.	......	Geyserian action. End of the great volcanic eruptions approaches.
	g. Similar to *c.*	......	Occasional eruptions and slight fall of ashes and dust in shallow seas.

Formation	Masses, Beds, &c. &c.	Fossils.	Conditions indicated.
	ORGANISMS APPEAR.		
B. Zeeawan Bed.	a. Crystalline limestone, coarse and with very few fossils.	Few.	Open sea coast, not very deep.
	b. Massive limestone, granular, or crystalline.	*Productus, Orthis, Spirifera, Fenestellidæ, Orthoceras.*	Open sea coast. About 50 fathoms.
	c. Ferruginous calcareous brown shales.	Same fossils.	Sea coast, not distant. Heavy water-fall on Volcanic islands.
	d. Dark sandy shales.	Same fossils.	Sea coast, not distant. Drift near shore. Heavy water-fall on Volcanic islands.
	e. Limestone, shaly, with shaly partings. Thickness = 200—250.	Same fossils; no *Bryozoa.*	Sea becoming shallow; shore shelving and drifty.
	FAUNA CHANGES.		
C. Weean Bed.	a. Shaly and sandy limestone.	*Encrinites;* small bivalves; Debris.	Shallow shelving, coast line.
	b. Black argillaceous limestone.	Debris.	Shallow sea between islands.
	c. Altered, amygdaloidal limestone.	None or mere traces.	Local volcanic action; geyserian bursts of water or vapours. Earthquakes.
	d. Flesh-colored limestone with lenticular beds of pale blue, nearly friable limestone.	*Anthracosiæ. Aviculo-pectens. Pectens. Solenopsis.*	Proximity of land; banks and shallows on a shelving coastline.
	e. Thin-bedded, argillaceous limestone, breaking in slabs.	*Goniatites.*	Slow formation of fine silt in well protected creeks.
	f. Shaly, muddy, very fœtid limestone, with gregarious fossils.	*Cyrtia* and small *Terebratulæ.*	Warm, damp and shallow sea, swamps, teeming with life.
	g. Argillaceous and arenaceous limestone paleless blue and yellow.	Debris of small thin bivalves. Roots of plants.	Very shallow sea-shore; sublittoral oscillations; frequent freshes of fresh water carrying mud to the sea.

Formation	Masses, Beds, &c. &c.	Fossils.	Condition indicated.
	FAUNA CHANGES.		
D. KOTHAIR BED.	*a.* Dark, blue or black argillaceous limestone.	*Gasteropoda* and *Cyathophyllidæ.*	Protected creeks, rather swampy.
	b. Slate and shale.	None.	Rivers bringing down mud to a shallow sea. Sublittoral oscillations.
	c. Sandy limestone without fossils.	......	Drift on shallow shelving coast.
	d. Shales; sandy shales; clay iron-ore in ribbons.	......	Shelving low land near seashore, traversed by rills from hot chalybeate springs. Sublittoral oscillations.
	e. Limestone like *a*; passing into calcareous slates.	*Gasteropoda* and *Cyathophyllidæ.*	Shallow creeks or protected sea coast. Swamp with grasses? Shallows between tides?
	Thickness = 500 feet.		

This succession of beds shows a steady shallowing of the sea. If we reflect for a moment how the sea bottom which received the limestone was formed, by volcanic ash and ejecta falling into the sea around the craters of numerous volcanoes, we would be led to expect a shallow shelving sea coast. Whether the volcanoes had existed for ages and prevented the development of life during the Silurian epoch, or whether they broke out after the Silurian beds had been deposited and buried these beds under their ejecta, I cannot say. It appears much more probable however that the volcanoes existed during the Silurian epoch, and prevented marine animals from living, by keeping the water at such a temperature or permeating it by such gases as were incompatible with life. However this may be, there can be no doubt that the volcanic ejecta were disposed in very gently sloping beds all around the volcanoes which produced them, and, as these ejecta were arranged by water, we would naturally expect the beds they formed to extend far into the sea. Hence a long shelving shallow coast would be formed, a coast which would speedily become more and more shallow from the enormous amount of sand and clay which was washed into it from the volcanic islands which studded it, by a rain-fall of tremendous volume.

57. We have yet to describe the second and third catenated chains of Kashmir; the second is marked by the summits of Liwapatur (13,012), Churn Wolkalbul (14,310), Girdwali (14,060), Batgool (14,423), Boorwaz (13,087), Handil (13,273), Saijhaha (11,334), and joins the first parallel at the Safapoor on the eastern shore of the Woolar lake. On the other side of the lake, it is continued by the Kahoota, the Manganwar (8,728), and the Sheri Bal. These mountains are all composed of volcanic rocks and of azoic slate interbedded with ash and agglomerate. They need not therefore be described in detail. The Boorwaz, Handil and Batgool form a porphyritic mass which is generally described by travellers as granite; it passes gradually on the west into amygdaloid and greenstone to form the summits of Saijhaha over the village of Gunderbul. The transition between the porphyry and the greenstone is a feldspathic rock of a pale colour and imbedding very numerous transparent crystals of quartz, a description of rock which is also found to form a passage between the porphyry and the felstone of the Kaj Nag. From the examination of a few specimens, kindly given to me by travellers, I have no doubt that the whole of this mass of mountains is composed of volcanic rocks, volcanic ejecta and slate. I am not aware that limestone exists anywhere amongst the spurs of these hills. Between the valley of Thral or Trahal and the river Lidar, there is a great labyrinth of mountains with many of the summits enumerated above, but I could obtain no information regarding them. I therefore requested Captain MacQueen, of the Punjab Irregular Force, who had arranged a shooting expedition to these hills to be kind enough to bring me a few specimens of the commonest rocks of the country he was about to visit, and also any rock which appeared to him in any way remarkable. By the use of the specimens thus obtained, and the examination of Captain MacQueen's route on the map, I was enabled to ascertain that the whole mass of these mountains is composed of the same volcanic rocks, which I have described in detail at the Tukt-i-Suliman and the Zebanwan. Ashes appear to have been accumulated in enormous quantity; they are interbedded with bands of black compact slate such as is so well seen

in the Wastarwan and Zebanwan, and both ash and slate are occasionally cellular or amygdaloidal. There is neither limestone, granite or porphyry among Captain MacQueen's specimens, and I believe therefore that the two last rocks at any rate do not occur in these mountains, as pieces of granite and porphyry generally attract the attention amongst the dull ash-rocks and would not have failed to form part of the collection, if they had existed. It is very possible that remains of beds of limestone are to be found amongst the spurs of the hills.

On the north of the Woolar Lake, many mountains of no great height form a sort of amphitheatre. They are nearly entirely composed of amygdaloidal greenstone, ash and slate interbedded, but near the village of Bundipoor, about two miles east of the road, some beds of limestone are seen. Mr. Drew has kindly sent me some specimens of it that are a flesh-coloured, sometimes greenish, very arenaceous and argillaceous. They are not at all crystalline, but contain an enormous number of encrinite stems transformed into spar with a cleavage oblique to the axis of the stem, so that when the section of a stem weathers, it appears striated across. This crystallisation has destroyed the structure of the stem, but the central canal is seen in a few specimens. We have seen this rock well developed at Manus Bal, towards the end of our section, where the beds of flesh-coloured limestone alternate with grey sandy liméstone containing crinoid-stems transformed into a spar as black as coal. (See 35 of the section of Manus Bal). The limestone of Bundipoor is therefore Weean limestone.

On the west shore of the Woolar lake, the Taltiloo and the Chralkoot present perpendicular cliffs of volcanic rocks descending into the water. From a boat on the lake, it is easy to observe the usual thick and confusely bedded masses of greenstone and amygdaloid forming the centre of these hills, and the more sloping and regularly stratified layers of ash, laterite, agglomerate and slate well developed, in the long spurs which descend on all sides. The whole mass of hills appears to be made of volcanic rocks, and the lowest spurs which approach the shore of the lake present no fossiliferous beds. Of the higher peaks, the Kahoota, Manganwar and Sheri Bal, I know nothing, but there can hardly be a doubt, however, of their being volcanic in their formation.

58. The third catenated chain is composed of summits of great height, the Gwashbrari (17,839), the Harbagwan (16,055) the Basmai (15,652), and the Haramook (16,903), and many other peaks which, with their spurs and connecting ridges, separate Kashmir proper from Tillail and Gurais. All these high summits are formed by porphyry having a granitoid appearance, which passes, towards the north, into felstone generally earthy and similar to the earthy felstone of the Atala Mount near Baramoola. On the north-western extremity of the chain, this felstone becomes continued with that of the great chain of hills which unites the Kaj Nag to the Ser and Mer chain. This flaggy rock is continued to near the city of Gurais where, in the valley of the Kishengunga, beds of limestone appear extending from about 15 miles N. W. of Gurais to Tillail. The limestone is, after a break, continued at the Sono Murg and is in all probability identical to that of this locality. I have never seen any specimen or fossil from the Tillail limestone, but the Sono Murg limestone is Carboniferous, and it is most probable that the Tillail limestone, which appears to be the continuation of that bed, belongs to the same epoch.

Due north of Sono Murg, the limestone is much developed and forms the summit of a considerable peak.

The porphyry-centres of mountains pass towards the south to rocks of an appearance different from that of the northern spurs; while we have seen that, towards the north, the porphyry generally graduates to a felstone more or less earthy. Towards the south it changes, as we travel from the peaks towards the end of the spurs, into trachyte, greenstone, amygdaloid, basalt, ash and agglomerate, together with interstratified, azoic and often amygdaloidal slate.

The northern spurs of Gwashbrari, the Harbagwan and the Basmai are composed of felstone, and near the road to Drass, in the valley of the Sind Torrent, of amygdaloid and ash. On these beds of ejecta rest fossiliferous beds, and, near the small village of Sono Murg, the beds of limestone are well developed. Captain Godwin-Austen found in that locality some fossils which he was kind enough to show me. They were identical with the forms described as characteristic of the Kothair group of Carboniferous limestone, viz, the *Gasteropoda* and *Cyathophyllidæ* which are represented at Pl. VIII.

fig. 4, 4a. They occur in a thin-bedded, dark-grey, argillaceous limestone, having in some places the appearance of a calcareous slate. But beds of Weean limestone must exist not far from Sono Murg and form propably some of the beds of limestone which are seen in the high valley between the Ambernath and the Gwashbrari, as blocks of limestone of this description, rounded by running water, were found in the bed of the Sind, near the traveller's home at Sono Murg.

To be continued.

EXPERIMENTAL INVESTIGATIONS *connected with the supply of* WATER *from the Hooghly to* CALCUTTA, *by* DAVID WALDIE, *Esq. F. C. S. &c.*

[Received 31st August, 1866.]

The attention which of late years has been given amongst civilized communities to the preservation of health and prevention of disease, has naturally been directed amongst other subjects to that of the water employed for economical purposes, and more particularly to its purity and wholesomeness as a beverage and as the medium for the preparation of food. The subject has been under the consideration of the municipal authorities of Calcutta, who, as is well known, have organised a scheme for the supply of the town from the river Hooghly, for the carrying out of which arrangements are now in progress. The Sanitary Commission appointed some time ago in the Bengal Presidency, and I believe in the other Presidencies also, recommended to the several governments of the Subdivisions, that the water of the various cantonments and stations should be subjected to chemical analysis for the purpose of ascertaining their wholesomeness, and these recommendations are in course of being carried out.

In England, and more particularly in the metropolis, much attention has been given to the same subject, and also to another one closely connected with it, namely, the disposal of the sewerage of towns. This subject is connected with that of water supply, not only, because in the plan generally followed for getting rid of sewerage in towns, a large

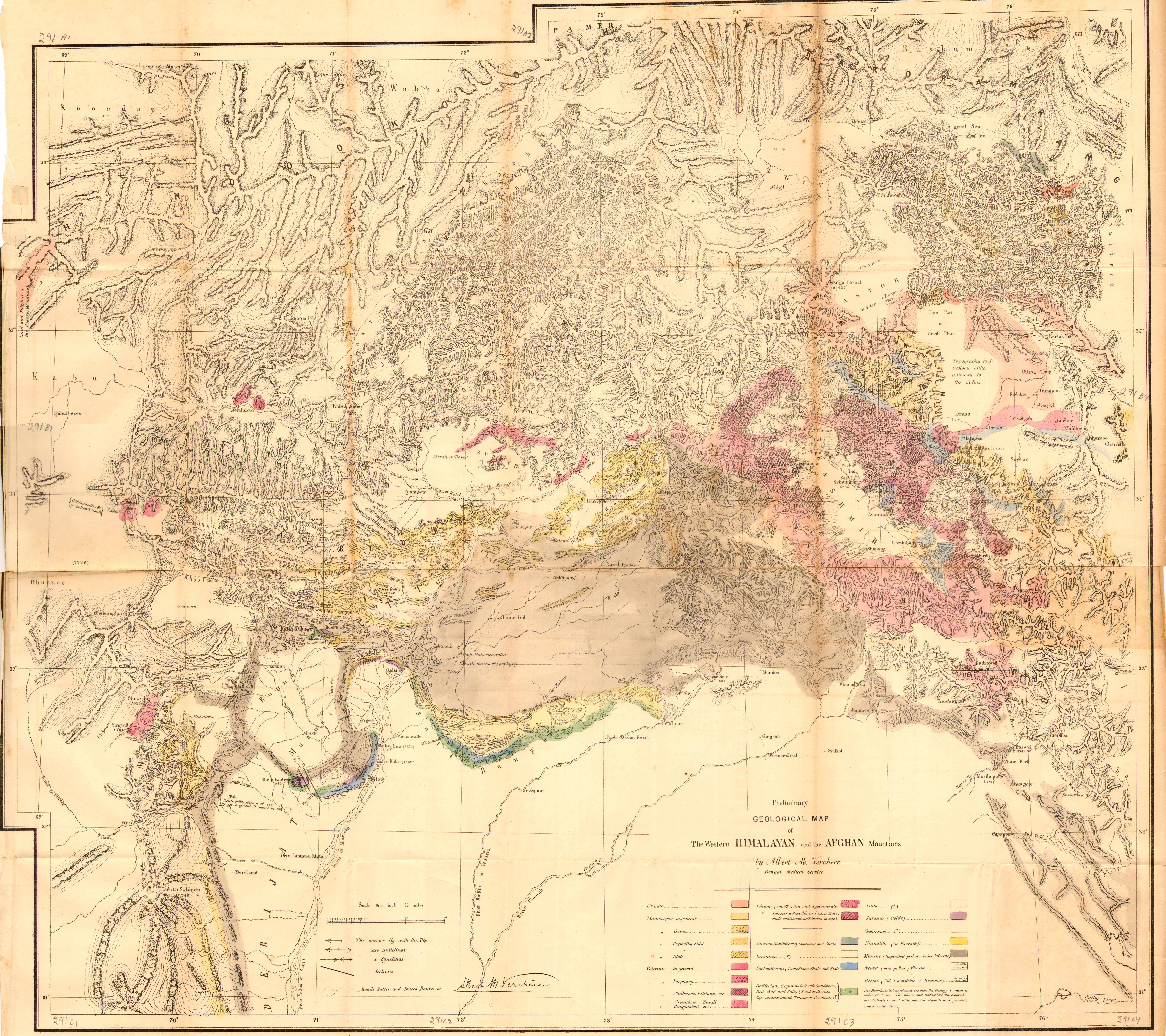
Kashmir, the Western Himalaya and the Afghan Mountains, a geological paper by ALBERT M. VERCHÈRE, *Esq.*, M. D *Bengal Medical Service, with a note on the fossils by* M. EDOUARD DE VERNUEIL, *Membre de l' Académie des Sciences, Paris.*

(Continued from page 203, of No. III. 1866.)

CHAPTER III.—*Cursory Survey of the several chains of the Western Himalaya, the Afghan mountains and their dependencies. Preliminary geological mapping of the Western Himalayan and Afghan Ranges.*

59. It is intended, in this chapter, to give, in as few words as possible, an idea of the general geology of the several portions of the Western Himalaya, the Afghan mountains and their respective dependencies. In doing so, I have availed myself of all sources of information which have been opened to me; I have, however, been sadly in want of the help of a more extended library, and I have never seen some excellent works which would have much improved this chapter, if they could have been consulted. I need therefore hardly say that it is a most superficial of surveys; but I hope nevertheless that it may be found to contain a few interesting observations and some new matter yet unpublished. Such as it is, it will enable us to sketch at least the first preliminaries of a geological mapping of the Himalayan and Afghan Ranges; and also to attempt, in the last chapter, to draw the history of the mightiest mountainous mass of our globe.

By reference to the map and and to the long Section (Sect. G) it becomes evident that the Himalayas are a succession of more or less regularly parallel chains, having a general N. W. to S. E. direction. Between the chains are situated valleys which are elevated above the sea in proportion as one nears the centre of the mountainous mass: thus the Rawul Pindie plateau, between the Salt Range and the Sub-Himalayan hills, is about 1700 feet high; Poonch valley, between the Sub-Himalaya and the Pir Punjal chain, is under 4000 feet; Kashmir between the Pir Punjal and the next chain (called in the map Ser and Merchain), is above 5000; Ladak between the Ser and Mer chain and the Kailas chain is 10,000 to 11,000; Nubra and the valley of the Shayok,



On transfer paper by S. Ismail. &c.
LITHOGRAPHED AT THE SURVEYOR GENERAL'S OFFICE, CALCUTTA FEBRUARY 1867.

between the Kailas and Korakoram chains is a plateau nearly 15,000 feet high. It is probable that on the other side of the Korakoram chain the elevation diminishes and that the Aksai chain and the valley of the Yarkandkash river, between the Korakoram and Kuen-Luen chains, are about 10,000 feet high; beyond the Kuen-Luen is the province of Kotan which has been satisfactorily determined by its vegetation to be no more than 5000 feet high.

We have therefore a series of steps rising from the plains of the Punjab to the high plateau of Little Thibet, and descending from Little Thibet towards Turkish China. These steps are supported by parallel chains or walls which tower by some thousands of feet above the plateaux which they support. These chains offer a considerable impediment to the flow of rivers towards the plains, and most rivers have a considerable course parallel to the direction of the chains, before they can find a gap to pass through.

The Afghan mountains present the same arrangement as the Himalayas; the direction is from the N. E. to S. W. the direction of parallel chains is less well marked than in the Himalaya, but this is probably due to the little which is correctly known of the topography of these mountains. The plateaux are similarly graduating: Bunnoo being about 1200 feet above the see, Kabul 7000 feet, Kaffiristan higher, whilst the plateau of Koonduz, on the other side of the Hindoo Koosh, slopes gradually towards the west. This arrangement by plateaux is the same as is seen in the Andes with their high central chain and their plateau between that chain and the Cordilleras.

From the hypothesis, advanced in the next chapter, of the manner the Himalayan and Afghan mountains were upheaved, we will deduct which of the lower hills belong to the Afghan and which to the Himalayan mass, and I will therefore not discuss this subject here, as it would but lead to useless repetitions. I shall begin with the hills which one first meets crossing out of the alluvial plain of the Punjab, as he travels north from Mooltan; and I shall take the parallel regions of the Himalaya one after the other, noticing as I go on whatever little I know of the geology of the Afghan mountains in the same latitude.

60. In latitude 32° 10′, longitude 70° 50′ to 71° 20′ rises the double chain of the Kafir Kote range or Rotta Roh and the Sheikh

Bodeen range. A small valley, the Paniala valley, separates the Rotta Roh range from the Sheikh Bodeen range, and the direction of both small chains is from the N. E. to the S. W. as far as the highest summit of Sheikh Bodeen, whence westwardly the Rotta Roh altogether disappears, and the Sheikh Bodeen range is continued by a small and low ridge of hillocks directed towards the W. N. W. and supporting the plateau of Bunnoo. (See map.)

The Rotta Roh is mostly composed of carboniferous limestone. The Zeawan bed is well developed, but extraordinarily disturbed; it is a yellowish rock, often very sandy. It forms the base of the hills on the E. and S. E.

Dr. A. Fleming sent home some fossils from Kafir Kote, which were ascertained by M. de Verneuil to belong to the following species:—

Productus cora (D'Orb.); *Productus costatus* (Sow.).
Productus Humboldtii, (D'Orb.) *Spirifer ?*
Dentalium ingens, (DeKönig).

All the species of which I have given drawings in Pl. I, III, and V, were found in the Rotta Roh limestone, with the exception of the Spirifer like *S. trigonalis.** Several species of corals, either not found at all or very rare in Kashmir, were found abundantly in the lower beds of the Rotta Roh; but altogether the fauna of the Zeawan bed in Kashmir and in the Rotta Roh is so very similar, that it can be called identical.

The limestone rests† on a quartzite rather peculiar in some localities. It is composed of opaque white quartz in which are imbedded plates of pearly white mica half an inch wide; these plates of mica are arranged in tufts; there are also some irregular nodules or granules of black augite (?) quite lustreless (see fig. 74, pl. IX). There can be

* A distinct species of Sp., according to Mr. de Verneuil.

† I failed to find the bed of quartzite in situ; my examination was much more superficial than I could wish. But it is hardly to be wondered at that the quartzite beds are not found in situ, if we consider the wonderful state of confusion the beds are in. The limestone is in an extremely shivered condition, having been thrown into stray arch-like anticlinals separated by numerous faults. The shivering of the beds often goes so far that it is difficult to ascertain the dip and strike of the beds. In such convulsions as those which must have taken place in these hills, the brittle and fragile beds of quartzite must have been entirely broken, and are therefore not to be seen in situ at their outcrops, but are only indicated by the fragments into which they were reduced. In several localities the ground is covered with angular pieces of quartzite, either with mica as described in the text, or plain and opaque.

no doubt that this micaceous quartzite represents the bed of quartzite which we have seen invariably underlying the Zeeawan bed in Kashmir. The beds of volcanic ash which it probably covers are not exposed in the Kafir Kote Range.

The Zeeawan bed of limestone is capped by very extensive and thick beds of Weean limestone rich in goniatites, in mussel-like anthracosiæ, in *Aviculo-pectens* and other characteristic fossils. I found some blocks of the sandy limestone in which the *anthracosiæ*, *solenopsis* and *A. pectens* are generally found, containing one specimen of *Productus semireticulatus*, several *Athyris subtilita* (Hall) and *A. Royssii* (L. W.), and also the *P. Bolivicutis* (D'Orb.) mixed up with the *anthracosiæ* and *A. pectens*, a mixture of Zeeawan and Weean fossils which I never saw in Kashmir. Some very large bivalves of which debris had been found in Kashmir and resembling an aviculoid inequilateral *pecten* were also found; the transverse diameter is 7½ inches. Fine *nautilides* and spines of *cidaris* six inches long were also found. In the Rottah Roh the difference between the Zeeawan and Weean beds is not everywhere so well marked as it is in Kashmir, as I have just exemplified; generally, however, the assemblage of fossils given in the plates as characteristic of the beds is the same as it is in Kashmir.

In the northernmost end of the Rottah Roh, the Zeeawan bed does not appear, and is only represented near Kumdul by a few small mounds of debris rising through the sandy plain close to the foot of the hill. As we travel south and approach the Kafir Kote river, the Zeeawan bed appears under the Weean, and can be traced without interruption as far as the southern end of the hill a few miles from Paniala. It is impossible to give the dip and strike of the Zeeawan bed, as not a hundred yards of it keeps the same direction; the broken fragments of the bed are more like packed ice in the polar seas than like courses of rock in a hill. The Weean bed above is much less disturbed, except the deepest beds which rest immediately on the Zeeawan; it dips generally N. W. with a very trifling angle varying from 20° to 8° or 9° with the horizon; occasionally the dip becomes W. and even S. W.

I have not seen any beds in the Rottah Roh similar to the Kothair bed of Kashmir.

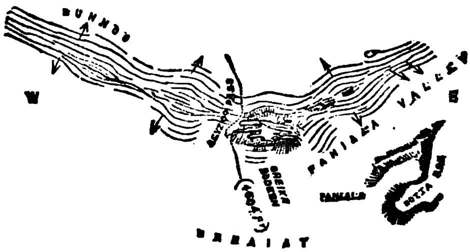
At the northern end of the Rottah Roh, the carboniferous limestone is immediately covered in by a Miocene sandstone and conglomerate. A little further south, some beds of reddish limestone and some sandstones, grey and bituminous, are either the top of the carboniferous or possibly Permian or Triassic beds. The fossils are very scarce and mere debris. The sandstone contains thin layers of a shale which is full of carbonized remains of plants, and from the sandstone, near the shale, a black bitumen oozes out. It is a mineral pitch or impure petroleum ; the quantity is insignificant.

As we continue to travel south and west, we find the Weean bed forming the top of the hill the whole way; with here and there patches of gypseous marls, red marl, grey sandstone and variegated thin-bedded non-fossiliferous limestone, or rather dolomite, which are in all probability Triassic, but which will require much more careful study than I have been able to give them, before they can be satisfactorily classed. I believe them identical to the red marl and gypsum of the Saliferian formation of the Salt Range. Close to the village of Paniala these supposed Triassic beds are well developed, and from them issue some saline hot springs. Near Gunga, at the other (northern) extremity of the little Range, a patch of these same gypseous sandstones and marl appear at the end of a fault in the carboniferous limestone, and from these supposed Triassic beds two or three small hot and saline springs issue. It is a remarkable fact that everywhere in the Himalaya and in the hills of the Punjab, where these gypseous marls, red marls, sandstones and dolomites appear well developed, they are generally accompanied by saline springs, usually hot.

At the northern extremity of the Rottah Roh, over the village of Kundul, we have seen that the Weean limestone forms the bulk of the hill. Under it, at one place, is found a feldspathose sandstone invaded by tortuous veins of quartzite ; it has acted powerfully on the limestone near it, this being much metamorphosed, cellular, traversed in all directions by thick bands of crystalline carbonate of lime, and all fossils being obliterated or changed into a lump of spar. The feldspathose sand has the appearance of having been forced between the broken ends of the beds of limestone which is thrown into an anticlinal ; it is generally white, occasionally coloured

red in patches; it is not stratified, but mammilated, globular, irregular, and branching like a dyke. This intrusion of a feldspathose solution or paste took place before the final upheaval of the Himalayas, as there is evidence that some of the beds have been redisturbed by this upheaval, and as the Miocene conglomerate which partially fills the fault is unconformable to the limestone. A full description of this locality would be complicated, and I have no intention of giving here such a description. I merely want to point out that we have here Weean beds disturbed and baked by a geyserian action, similar to that which we have seen at Ishlamabàd and at the Manus Bal.

61. The Sheikh Bodeen Range is mostly composed of miocene sandstone, clay and conglomerate. These beds are thrown into an anticlinal, the south-eastern and southern slopes dipping to the S. E., and the S. and the north-western and northern slopes dipping N. W. and N. One can see, from the top of the highest summit, that deeper rocks have endeavoured to push their way through the miocene, the beds of sandstone and conglomerate being arranged in semi-theatres on both sides of the points where an underground mass has endeavoured to break through. But everywhere these underground masses have failed to find a way to the surface except at one point, *viz.*, the Sheikh Bodeen summit, in the centre of the Range. This summit is 4604 feet above the level of the sea, whilst the Miocene range does not reach higher than 2800 feet and is generally very much lower. There is evidence that the Miocene was at one



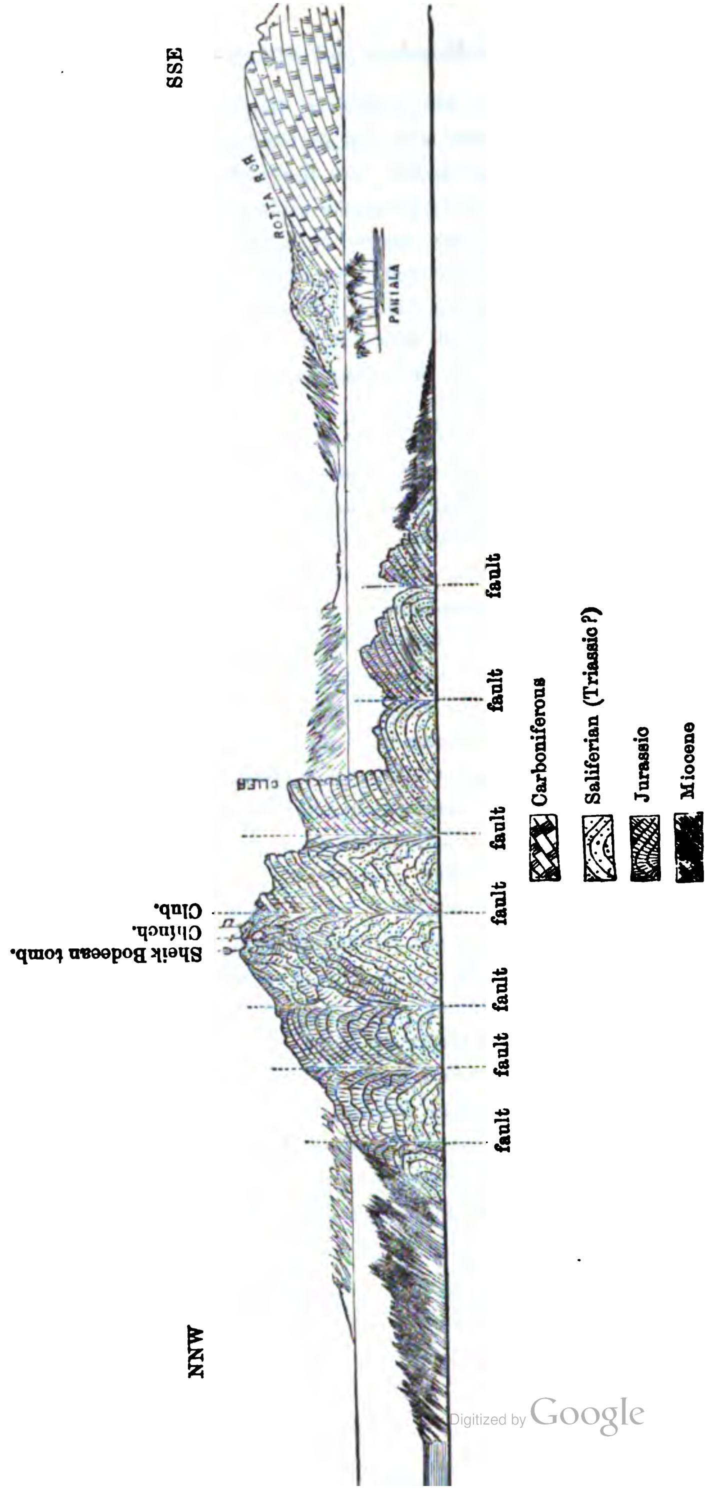
Horizontal appearance of the Miocene beds, Sheikh Bodeen range.

time much higher and reached to within 8 or 900 feet of the summit of Sheikh Bodeen. But the friable sandstone and loose conglomerate disintegrate very quickly, whilst the limestones of Sheikh Bodeen summits decay but slowly; hence the Miocene portions of the Range have become low hills, whilst Sheikh Bodeen summit has nearly retained its original height, and appears therefore to stand now as an isolated summit in the middle of insignificant, low, barren and crumpling sandstone and conglomerate hillocks.

Sheikh Bodeen hill (not range) is mostly composed of Jurassic limestone, excessively shattered from having been thrown into a succession of very sharp anticlinals. The anticlinals are separated by faults which run from W. S. W. to E. N. E. The following diagram sections are from the N. N. W. to the S. S. E.

Sections V and VI General Map.

The section in the distance is about a mile north of the section through Sheikh Bodeen Hill. Jurassic limestone is at least 800 feet thick; it is rich in fossils which are, however, seldom well preserved. The lower beds contain Belemnites, Ostreæ, Rhynchonellæ and Terebratulæ in great abundance, especially in and near some ferruginous sandy beds. Shaly beds are full of petrified branches of trees. The limestone is sandy and impure; along the great cliff facing the S. S. E. and formed by the removal of half the arch of an anticlinal (see section, marked cliff) some very fine specimens of ripple-marking are exhibited on a large scale. *Ammonites* are also found, but very much broken. *Cariophyllides* and an *Astræa* are the commonest corals. Two or three species of *Pholadomya* are tolerably abundant. In the uppermost beds I have found a *Nerinæa*, very likely the *N. Bruntrutana* (*Thuma*) of the coralline. In both the lower and upper beds the mineral characters appear to be identical, and many species of fossils are common to both, especially *Rhynchonellae*, of which no less than ten species are abundant. In the lower beds I have found eight species of *Terebratulæ* with short loops, or true *Terebratulæ*. The *Belemnites* are three or four species, of which a thick one like the *B. sulcatus*, a grooved species like the *B. canaliculatus*, and a *hastate* species like the *B. hastatus* are the most abundant. Gasteropods are extremely abundant in some beds, most especially a species of *Acteonina*; a few encrinite stems were found, but no heads.


SSE
NNW
Club.
Chinch.
Sheik Bodeean tomb.
fault
fault
fault
fault
fault
fault
fault
Carboniferous
Saliferian (Triassic?)
Jurassic
Miocene

From this fauna it appears therefore that the limestone of Sheikh Bodeen* is equivalent to the Oxfordian formation of England, and that the uppermost beds are contemporary to the English Coral Rag or rather to the *Calcaire a Néimaes* of the Zena. We shall see presently in the country of the Wuzeerees, beds which are, in all probability, the equivalent of the Coral Rag. Some of the Oolitic shells collected by Dr. Gerard in Spiti are represented in Dr. Royle's Illustrations of the Botany and other branches of the Natural History of the Himalayan mountains; the drawings are by T. Sowerby and are remarkably good. The form numbered 17 in Royle's plates and described as an Arca or *Cucullæa* is found at Sheikh Bodeen; the *Rhynchonellæ* 20 and 21, described as *Terebratulæ* or *Atrypæ*, are common at Sheikh Bodeen; the two species of *Ammonites*, figs. 22 and 24, are also found at Sheikh Bodeen, as well as the two species of *Belemnites* represented figs. 25 and 26 and fig. 27. The fig. 23, called a *Delthyris*, has also been found at Sheikh Bodeen, I believe, but I do not possess a specimen of it.

The *Rhynchonella* represented by Royle and which is common at Sheikh Bodeen, has also been found in Rukshen by Captain Austen.

The Jurassic limestone of Sheikh Bodeen rests in variegated dolomitic limestone without fossils (?), red marls, gypseous dark marls, and feldspathose white sandstone extremely friable; and this formation appears identical to the Saliferian formation of the Salt Range. From these lower beds issue a few small springs of brine, and it is, probable that masses of salt exist here and there in the marl, as it does in the Salt Range, but nowhere does the salt crop out. Some beds of massive gypsum occur on the southern side of the hill near its base, but are not extensive. The Oolitic and Saliferian formations conform in all their folds, faults and twistings most perfectly, but there is a slight nonconformity between the Saliferian and Oolitic beds and the Miocene sandstone and conglomerate. The Saliferian and Oolitic formations had been upheaved to some extent before the Miocene began to be deposited, as boulders of gypsum and Oolitic limestone are found in the Miocene conglomerate in company with boulders of volcanic rocks, of nummulitic limestone, of carboniferous limestone, and with rolled *Producti* brought from the Bilote Range. But the

* A few fossils of Sheikh Bodeen are sketched at Plate XI. figs. 2 to 6.

hills formed by the first upheaval were so low, and their beds probably so near the horizontal position, that the non-conformity of these beds and of the Miocene beds is not now very apparent, both sets of beds having been redisturbed to a great extent by the final great upheaval of the Himalayan mountains.

62. In the country of the Wuzeerees, lat. N. 32° 15′ to 32° 45′ and Long. E. 69° 45′ to 70° 15′, we find the continuation towards the north of the Soolimanee Range to be formed of a chain of mountains of which the Pir Gul (11,583) and the Shewy Dhur (10,998) are the highest summits. These high summits were not ascended by the expeditionary force against the Mosood Wuzeerees in 1860, but the army marched along the fine plateau of Rusmuk (7,000 ft.) which skirts the main chain; and by collecting the pebbles of the torrents which descend from these high peaks I was enabled to estimate to a certain extent the mineral nature of the central ridge. These pebbles were all volcanic, trappean and metamorphic, and none of a granitic nature were found. The following specimens of rocks were collected in ravines descending *directly* from the Shewy Dhur: basalt, having the appearance of hard jet; it is divided by joints and by innumerable cracks filled with carbonate of lime. It fuses quietly before the blow-pipe into a black bead. Some varieties do not shew the cracks filled with carbonate of lime, but are schistose in appearance, and the joints, which are large, are lined by quartzite. Half inch thick plates of volcanic ash, composed of a central layer of a pale dirty-greenish and compact mineral, and external layers of a brownish granular substance. The central layer fuses very easily before the blow-pipe, boiling up into a swollen and blistered surface; it has the appearance of tremolite, the outer layer appears to be a mixture of tremolite with grains of augite; the augite here and there forms little masses, and these fuse partially, the assay becoming studded with minute dark globules. Hornblende rock with grey mica. The paste appears to be an intimate mixture of felspar and hornblende, and is invaded by irregular and small plates of grey mica; the rock is divided by a series of well-marked joints, an inch apart. An augitic porphyry; the paste is perfectly black and apparently composed of chatoyant augite; it is invaded by closely set and minute prismatic crystals of dull white albite; it is more like a porphyritic lava than like a true prophyry.

A metamorphosed micaceous limestone, schistose, the foliation being extremely wavy. It has the appearance of a thin-bedded micaceous and calcareous shale which had been both crumpled and highly metamorphosed. It is nearly entirely composed of exfoliating mica imbedded into grey bands of magnesian (?) carbonate of lime, which effervesces feebly, and other bands of white felspar. The felspar forms bands by itself, a quarter of an inch thick and free of mica. The rock exhibits a foliation or stratification which is thin-bedded and wavy. Greenish, soapy, spotted chlorite schist. Jaspery flint, bluish and transparent, with veins and patches brownish and opaque, and occasionally threads of milk-white quartz. Quartzite with well formed crystals, six-sided prisms, at one end terminated by a six-sided pyramid.

These rocks are therefore mostly volcanic; the four last are, however, metamorphic, and such rocks are not seen in Kashmir; but they are extensively developed in the most northern portion of the Himalaya, as in Skardo, Zaskar, &c.

63. Between the range of the Pir Gul and Shewy Dhur and the plains of the Derajat, is a thick belt of low hills which are nearly entirely made up of nummulitic limestone, slate and shales, and of Miocene sandstone and conglomerate. At Palusseen, however, (see map) under the nummulitic limestone is discovered a rock of a very hard and dirty appearance and not forming beds, but huge masses of flesh-coloured limestone which are imbedded either in a grey sandstone or in the lower beds of the nummulitic limestone. These masses are most evidently old coral reefs, once rising from the bottom of the sea and ultimately covered by sand and calcareous mud; they are a confused agglomeration of corals of many species, imbedding shells, but unfortunately neither corals nor shells are in a good state of preservation. I am not sufficiently familiar with the forms of the Coral-Rag of England to say whether this bed is its representative in India, but it is not unlikely to belong to secondary strata, for the following reasons.* 1. It is situated under the sandstone, which generally forms the base of the nummulitic formation. 2. It does not contain any of the

* A coral reef formation, apparently closely analogous both in lithologic characters and mode of occurrence, occurs at the base of the Ootatoor division of the cretaceous rocks in Trichinopoly. See Mem. Geological Survey, Vol. IV, Pt 1, pp. 52-72.—*Ed.*

fossils found in the nummulitic limestone above. 3. It appears much disturbed and dislocated by local movements, whilst the nummulitic limestone is to be seen in regular, though much tilted-up beds above it. 4. It rests immediately over beds of red marl and gypsum which are always found, in the Punjab, where Oolitic beds occur much disturbed. 5. Some of the corals appear identical with some species found near Maree on the Indus, in a limestone containing the same fossils as those of Sheikh Bodeen which is decidedly an Oolite.

I have therefore, in consideration of these reasons coloured these beds as Oolitic, but there is a doubt about it. The country was so dangerous at the time we were encamped at Palusseen, that I could collect but very few fossils, and I have not yet had the good luck to discover a similar bed in British territory.

These coral reefs reappear in many places in the country of the Wuzeerees: at the entrance of the plateau of Rushmuk a great quantity of this bed was again seen, but the rock was different, though the fossils were identical; the limestone was extremely impure, full of small rounded grains of gravel, and so much invaded by iron that it is often quite brown, and often also spotted by the iron forming little dark nodules in the mass.

Again, near the hot spring of Sir-Oba, similar beds were seen resting on red marl, with here and there masses of gypsum. This gypsum is opaque, white and compact, and contains a great number of crystals of quartz, very fine in their form, and terminated at both ends by a six-sided pyramid. The same crystals occur at Maree and Kalabag in the gypsum which accompanies the rock-salt of these localities, and are there collected and sold to natives as ornaments, under the name of Kalabag diamonds.

One of the members of the nummulitic genus in the Wuzeeree Hills requires notice on account of its economical value. The Wuzeeree iron is obtained by the smelting of a brown shale, extremely rich in brown hæmatite; the beds of the shale are situated under the nummulitic limestone, and seem to replace the extensive beds of slate, with nummulites, seen in other localities. The quantity of the ore is enormous, whole ridges being formed of it. It is not quarried, as far as I could discover, but merely broken off the surface of the beds. It is first roasted, and becomes black and highly magnetic. It is then worked either with nummulitic limestone or pieces of the coral-reefs and smelted with charcoal in small furnaces identical to those seen in Kashmir. I found at Mackeen a house with two of these furnaces and heaps of charcoal, of iron-ore and of limestone, evidently collected for smelting, and I could thus identify the ore used by the Wuzeerees, though no information was to be obtained from the people. I have had, since, pieces of ore brought to me, at Bunnoo, by the Wuzeerees engaged in trade and who bring the pig-iron to the plains for sale, and it is exactly the same ore which I had seen at Mackeen, and which I had observed in situ as one of the members of the nummulitic formation. This shale is heavy, generally covered with a rusty powder; it varies in colour from reddish-brown to nearly black; it soils the hand, it is not calcareous, and the richest parts of it have a tendency to form concretions, or at least to assume a sort of concentric slaty cleavage. It is only smelted to a paste, not to a fluid, and is refined by hammering. The iron produced is soft and fine-grained, but apt to exfoliate, a defect which is evidently the result of the metal being half worn-out by the extensive hammering to which it is submitted.

The carboniferous limestone was found in situ in Wuziristan. But that such rocks do exist in the hills between the British border and round the central chain of the Afghan mountains, is proved by the boulders in the rivers which drain those countries. Major Vicarey found boulders of limestone containing carboniferous fossils in the streams near Peshawur; Dr. Fleming found "*Productus*-limestone" in the ravines which drain the Solimanee chain towards the east; and I have found in the bed of the Korum, a torrent which drains the southern slopes of the Sufed Koh, boulders of a black limestone containing *Productus cora* and *P. Humboldtii.*

64. In the Salt Range the carboniferous limestone is well developed and attains, according to Dr. A. Fleming, a thickness of 1,800 feet. It begins near Noorpoor in Long. E. 72° 30′, as a thin bed, which increases as it goes towards the west, and attains its maximum of development near Vurcha, in Long. 72°. It decreases again towards the Indus, and is not seen at all near Maree and Kalabag; but on the right bank of the river it reappears about six miles west of Kalabag, and is continued in the Chichalee range and the northern

end of the Speen or Lowa Gur. It appears to be identical, in fossils and in lithological characters, to the limestone of Kashmir. Dr. A. Fleming does not mention its ever resting on quartzite or volcanic ash, but supposes on the contrary that it rests on the Saliferian formation, which he, in consequence of this view, calls Devonian. Whatever little of the carboniferous limestone of the Salt Range I have myself seen, is too much disturbed to allow me to form an opinion; I certainly never saw any quartzite underlying the limestone in the Salt Range; but such quartzite exists in the Rottah Roh, and it is evident that the Rottah Roh carboniferous limestone, and that of the Salt Range are one and the same sheet of deposit, broken and separated by convulsions of a posterior age. This, however, does not prove much either way.

The long controversy about the age of the salt and gypsum in the Alps bids fair to be repeated in the Punjab. The Saliferian of the Salt Range has already been placed by successive observers in nearly every formation from the Devonian to the Miocene! In the Alps, geologists appear to have once become desperate at the fight, and M. Sismonda published in the *Comptes rendus de l'Académie des Sciences de Paris (Vol. III. p.* 113*)* the somewhat startling hypothesis that "in the Alps the shells of the Lias lived at the same time as the carboniferous plants"!!!... It is not a little curious resemblance that in the Maurienne, in Savoy, (the great field of contention,) the gypsum, quartzite, marl, &c., are much disturbed by local foldings and bendings, and appear to be placed under the carboniferous rocks *(terrain houiller)*. Fortunately a thin, but very persistent and well-characterised bed, the *Infra-lias*, has enabled the geologists who have best studied this locality, to fix the position of the red marl, red and green shale, quartzite, gypsum, &c., in the Trias, and to show that the apparently inferior position of these Triassic layers was due to such great disturbances and reversions of strata as one may reasonably expect to have accompanied the surging up of mountains like the Alps. Less fortunate or less industrious than they of Europe, we have not yet found the *Infra-lias* in India, and we have not therefore got hold of the thread which led so successfully the Swiss and French geologists to a true understanding of the Alpine Saliferian.

I wish that I could have determined satisfactorily the age of the salt of the Punjab, before forwarding this paper to the Society; but I see at present but little chance of my being able to visit again and study the Salt Range within a reasonable time. My own impression, from what I have seen, is that the Saliferian of the Punjab is Triassic or Permian.

This Saliferian formation, (whatever its age may be,) plays a very important part in the economy of Upper India, and may possibly be made a great deal more of than at present. It gives a supply of salt which pays to the State a handsome revenue; it has been the original source of the Reh or Kullur of the soil, an impure and effervescing mixture of saltpetre, of soda and chloride of sodium, which renders fields barren and thus causes very serious losses to that same revenue. There can be little doubt that it contains some at least of the numerous minerals discovered in the Russian salt mines of Stassfust-Anhalt, and it is very possible that it will one day give some fertilizing material which will more than repay the loss caused by the Reh. It is a fine field for research, and only wants work bestowed upon it to yield valuable results.

Any one who has visited the Saliferian of the Punjab must have been struck by the much disturbed state of the beds. These appear as if they had been raised into a succession of small cones or "boursoufflures," and suggests at first sight the idea of the Saliferian having been at some time or another violently dislocated by eruptive gases and sublimated minerals. This is so marked in some localities that Dr. A. Fleming advances, as a possible hypothesis, that the salt may be of volcanic origin. But the stratification is generally so well defined (the courses of salt being separated by thin layers of red marl or of cellular gypsum) that we cannot regard the salt as intrusive; it is decidedly sedimentary. That the disposition of the salt gypsum, bipyramidal quartz crystals, &c., &c., took place under the influence of heat, due probably to hot springs, is pretty certain. For Charpentin and de Beaumont have shewn that the gypsum was first deposited as anhydrite, and this anhydrite must of necessity have been precipited from hot solutions; neither do we see how sea water could deposit gypsum, unless submitted to a high temperature; whilst, high temperature being admitted, the precipitation of gypsum becomes easily explained, if we remember Mr. David Forbes's observation in Peru:

"The quantity of sulphates and more especially of sulphate of lime, "included invariably in these deposits, might, at first sight, appear to "the observer too great to suppose it due only to the evaporation of "the sea-water; but I believe that this impression will be dissipated "when he sees the enormous amount of gypsum removed in the form "of hard white cakes or sedimentary crust, from the boilers of the "large distilling machines in use along this arid coast, for producing "from the water of the sea a supply of fresh water for the maintenance "of the inhabitants, beasts of burden, and even the locomotive engines "of the railways along the coast. It appears not necessary to suppose, "as has been put forth, that the sulphates present have been formed "by volcanic exhalations acting upon the bed of salt."* What induces us readily to admit of the existence of very numerous and extensive hot springs during the Triassic epoch in the Punjab is, that even now-a-days the Saliferian formation is remarkable for the great number of hot springs it contains; indeed hardly a hot spring in the Punjab and the Himalaya is to be found unconnected with the Saliferian, and whenever we find Saliferian beds, we generally also find hot springs. This is true of the Salt Range, of the Rottah Roh, of Kangra,† of Rukshu in Thibet, &c. We may therefore conclude from these remarks that the salt, gypsum, &c., is sedimentary, though deposited under peculiar circumstances, viz., the presence and influence of hot springs. How then to account for the very disturbed state of the Saliferian beds, for these limited, local, fragmentary disturbances which give to the beds so elastic an appearance? Two ordinary causes appear to me sufficient to account for this: one is the transformation of the anhydrite into gypsum by absorption of water, a phenomenon which continues to take place now-a-days. This absorption of water and the consequent increase of volume of the gypsum brought about the swelling up of the beds in cones and "boursoufflures." Then the

* "The Geology of Bolivia and Peru," by David Forbes, with notes on fossils, by Professor Huxley and J. W. Saller, Esq., published by Taylor and Francis, Red Lion Court, Fleet Street, 1861, communicated to Geological Society in 1860.

† The saline springs of the Towala Mookhi and of Kangra-basa, in Kangra, issue from Saliferian ranges immediately covered by Miocene beds. Mr. Marcadieu has found that the water of these springs contains Iodine, in addition to the usual saline matter of the springs of the Saliferian formation in Upper India. Vide Report, No. 84, by M. Marcadieu. Sketches of Correspondence, Punjab, 1860.

second cause of disturbance began to act: the beds of salt are often dissolved and removed by water infiltrating through cracks in the rocks; a cavity is thus formed under the vault of rocks which covered in the salt and one day the vault falls in.

This process is to be seen now-a-days in actual existence, on a small scale, in the hillock of Maree on the Indus.

Thus, from the swelling of the gypsum by its transformation from anhydrite to common gypsum, and from the falling in of the vaults formed by this swelling, the beds of the Saliferian formation in the Punjab have a most broken and turned-over appearance.

Add to this that these beds have participated in the convulsions produced by the great final upheaval of the Himalaya, and you will have no difficulty in understanding how difficult it is to make out with certainty the stratography of these rocks, and how it is that the Saliferian appears here and there inferior to the Palæozoic beds. Before quitting the Saliferian formation, let us notice that the beds of it appear to have suffered very great denudation. We can easily understand that the red marl was very easily denuded, when we see how it crumbles into a powdery, friable, fluid earth, after a few days exposure to the atmosphere. It is on account of this denudation, on account of the very considerable amount of material which this formation gave to the Miocene and to the alluvium deposits of Upper India, that the presence of Reh or Kullur in the soil of the Punjab and the North-West Provinces is to be credited to the Saliferian. I shall say a few words about this again, when we explain how the Miocene was made up, in the next chapter.

As there is yet such incertitude about the age of the salt, I have called the formation "Saliferian," without entering it on the Map as belonging either to the Palæozoic or to the Mezozoic epoch.*

The carboniferous limestone is covered in, north of Vurcha, by an Oolitic formation of trifling thickness and containing Oxfordian forms.

* I have purposely avoided insisting on the mineral characters of the Saliferian formation of India, as it is now-a-days the fashion to undervalue very much these characters; but it may be as well to remember that in the Salt Range we have beds of gypsum full of rock-crystals of a bipyramidal shape; that the layers of gypsum are separated by calcareo-magnesian bands, having a cellular disposition (Cargneule of the Swiss, Rankwacke of the Germans) and that the salt is accompanied by a bright red marl without fossils. These several characters are found in the *Triassic* salt and gypsum of Switzerland, of Savoy and of Spain, and, I believe, in no other formation.

As the carboniferous limestone thins out in approaching the Indus, the Oolitic formation increases in importance and forms much disturbed hills, all the way from Moosa Khel to Kalabag. It is continued west of the Indus in the Chichalee Range and the northern end of the Speen Ghur; a little above Moola Khel it disappears under the alluvial, and does not reappear till Sheikh Bodeen, where, as we have seen, it attains a considerable thickness.

65. The salt and gypsum is continued on the west side of the Indus, in the hilly country of the Kuttuks, but it is there much covered by tertiary clays and sandstones. It crops out near Bahadoor Khel and along the course of the Teeree Towe. At the first named place the Saliferian forms an anticlinal arch; the salt, above fifty feet thick, is the lowest bed seen, and is very regularly stratified; above it is a thin bed of red marl, another of grey sandstone, also thin; then gypsum, about twenty-five to thirty feet thick; then a thin band of a limestone with minute debris of fossils, and which resembles lithologically the Oolitic bed of Kalabag and Maree on the Indus; then the dark, brown, sandstone which often forms the base of the nummulitic formation; some coarse and crumbling shales without fossils; and finally, a bed of limestone rich in nummulites, volutes, veneridae, &c., and about ten to twelve feet thick. This is at last covered by the marly lumpy clayey beds of Miocene. A fault running approximately W. E. through the Soordak Pass, has caused an upthrow of the beds on its southern side, and there the nummulitic limestone, much tilted up, forms a pretty high hill.

Along the Teeree Towe the Saliferian is immediately covered by Tertiary. As far as Lachee the rocks seen are Miocene sandstone, clay and conglomerates; thence to Peshawur the country is entirely covered by nummulitic limestone and shale, and the Miocene sandstone is only seen here and there in small detached beds and patches, which are evidently the remains of layers which have been mostly removed by denudation.

66. North of the Salt Range we have also a great extent of Tertiaries. Nummulitic limestone, shale and sandstone first covers in the secondary layers in the western portion of the range, but rests directly on the salt marl and gypsum in the eastern half of it. It attains a great thickness, where well developed, (4500 feet,) and forms

the summits of nearly all the highest hills of the Salt Range. It is continued to within two miles of Maree on the Indus where it thins out, but reappears near Kalabag, and is very well developed in the Chichalee Range and in the Speen Ghur. Near the Indus, all the beds of the Salt Range, excepting the Saliferian marl itself and the secondary strata where much locally disturbed, dip towards the N. E. On the western bank of the Indus, that is in the Chichalee Hills and the Speen Ghur, the dip is W. N. W. or N. W. This last dip is generally that of all the strata of the Kuttuk hills.

The nummulitic formation appears in the Salt Range as a thick belt which, beginning at the Mount Tilla near Jheelum, is continued to near Maree on the Indus, where it disappears for a little space, but reappears on the other side of the river, and is to be seen forming the bulk of the Speen Ghur to near Esokhel. The formation keeps a remarkably similar aspect the whole way. It is, from below upwards, composed* of — 1. Sandstone often coloured by iron, but generally dirty white or pale grey. 2. Very arenacious, thin bedded or lumpy limestone, with gasteropods, few and small nummulites and innumerable debris of oysters or gryphese. 3. Shales of various colours, with beds of lignite and of alum carbonaceous shales. The alum shales are only developed where the lignite is situated close to the Saliferian formation, and appear to be patches of lignite metamorphosed. 4. Argillaceous limestone, full of large nummulites, chama, cardita, crassatella, ostrœa, many gasteropods, very large echinodermata, &c., &c. 5. Shales often replaced by a clay-slate containing nummulites. The shales contain sometimes lignite and Rol (alum-shale), but the seams are made less well defined than in the lower shales. 6. Argillaceous limestone, extremely white in some places and containing the same fossils as layer 4; in the eastern portion of the Range it contains flints; it is often fœtid. 7. Chert, hard limestone, weathering rough and pitted; pale yellow or flesh-colour, brittle and

* Occasionally a bed of white soft fragile limestone is seen to form the base of the nummulitic formation. It is characterized by a planorbis which is tolerably abundant; but it contains neither nummulites nor any other fossil. It is found in lenticular beds of little extent, and rarely more than two or three feet thick. It suggests to the mind beds formed in pools or creeks among sandy islands and promontories at the mouth of a river. Whenever it occurs, I have found in the nummulitic limestone above it a great number of teeth and bones of fishes (sharks).

splintery. Shells fewer, nummulites small, but very abundant, especially the *N. variolaria,* whilst the flat and irregular *N. pushi* and *N. lævigata,* so abundant in beds 4 and 6, are not to be found here, or are at least rare. A nummulite about the size of the *N. pushi,* but thicker, is, however, found pretty abundantly, though not in swarms like the *N. variolaria.* A ribbed cardita is the only bivalve which appears tolerably abundant.

67. Resting on the nummulitic formation of the Salt Range are thick beds of Miocene sandstone, clay and conglomerate. I have described in chapter I. how these sandstones form a great plateau between the Salt Range and the foot of the Maree Hill, and indicated that thay may be considered as the upper Miocene Bed, whilst the Maree Hills and the whole of the mountains between the Jheelum and the Pir Punjal chain are to be regarded as lower Miocene. The upper bed is rich in mammalian fossils, and is identical to the Sewalik formation. The lower bed is devoid of fossils,* containing only a few debris of plants, rootlets, small stems and occasionally small niduses of lignite. The upper Miocene has probably been a great deal denuded; remains of the bed are, however, to be seen in the valley of Poonch; they are there rich in very well preserved fossils, teeth of elephants being common and very perfect.

68. The sandstones and conglomerates just mentioned form a great belt from the E. N. E. to the W. S. W. (see Map) and to the north of it appears another belt, having a similar direction and composed of nummulitic limestone and slate. It begins in Hazara in Lat. 34°, and forms all the superficial covering of the Hazara mountains as far as the Sirun river and as high north as Mausera, being about thirty miles in width as the crow flies. It proceeds from N. E. to S. W. towards Attock, keeping the same width and extending in that district from the Indus to Janika Serai. Crossing the Indus, it forms the whole of the Akora Kuttuck and Afreedee hills between Peshawur and Kohat, extending about sixteen miles south of Kohat. It has been followed as far as longitude E. 70°. The beds of this nummulitic formation have a general dip to the N. W. A similar

* It is said that one or two bones have been found in the lower Miocene, but this is doubtful; if they exist, they are at any rate very rare. Mr. Medlicott has pointed out a non-conformity between the lower and upper Miocene; he makes three beds of the formation.

nummulitic tract follows the foot of the Himalayan ranges along the southern versant of the Pir Punjal chain and its continuation to the S. E. It begins in the valley of Poonch; it is seen north of Rajaori, and the pebbles of the streams near Rajaori are often nummulitic limestone, though the parent-beds have not yet been discovered. I cannot say whether nummulitic beds are to be seen to the north of Tummoo, Basaoli, and Noorpoor or in Kangra, but they appear near Subathoo in long. 77° lat. 31°, and have further been just discovered by Captain G. Austen on the east of the Ganges in Kumaoon. But this nummulitic along the foot of the Himalaya is either much denuded or much covered up by Miocene, and does not make such a show on the surface as the other belt which follows the direction of the Afghan mountains.

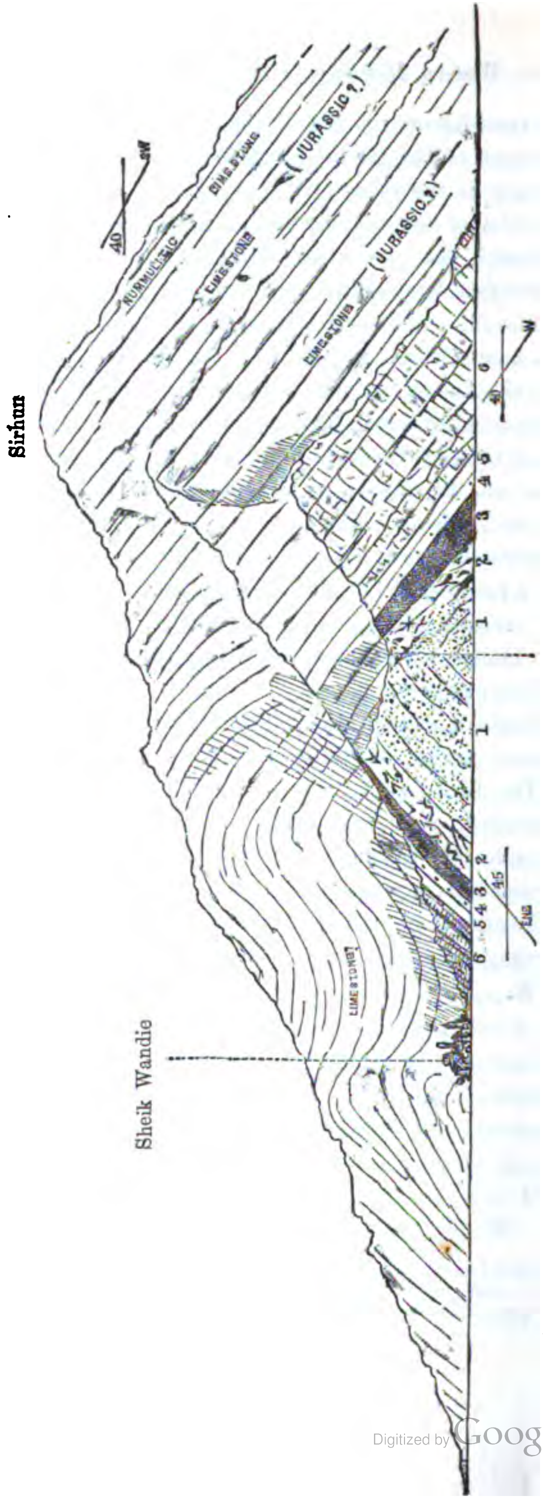
To the north of these zones of nummulite we meet the volcanic hills, which I have described in the first chapter.

69. The stratum of nummulite in Hazara, occasionally broken through, or faulted or denuded sufficiently to allow of older rocks making their appearance.

At the northern end of Mount Sirbun near Abbottabad, carboniferous limestone resting on volcanic rocks is quarried for building purposes. The limestone belongs to the Weean and Kothair groups and is thin-bedded, arenaceous, marly and occasionally conglomeratic. It is of considerable thickness and immediately covered in by limestone, the lower beds of which are so poor in fossils that it is impossible to identify them, the upper being nummulitic.

The following is a section near the small village of Sheikh Wandie, from E. to W.

(Section VII. of General Map.)



Level of the Abbottabad valley about 4700 ft. above the level of the sea.

Section of the Northern extremity of Mount Sirbun, near Abbottabad, from E. to W. bearing S. (not drawn to scale.)

1. Very compact and very hard Cornean rock, composed of a paste of white feldspar and grey hornstone in intimate combination. The joints and exposed surfaces are smooth and have a quartzy glimmering. In the paste there is often a partial separation of white feldspar in spots of a dull white colour. Splinters of the white spots can be rounded on their edges before the blow-pipe, but the grey paste of the rock appears to be more refractory, though there is certainly a softening of the mineral compound and a slight smoothing of sharp edges after long exposure to heat. It is a bed of very considerable thickness, stratified and much jointed.

2. White quartzite in a brecciated state, the pieces being recemented together by a grey feldspathose paste. It appears as if the bed had been broken after its formation and the fragments reunited by a feldspathose paste.

3. Very heavy, chocolate-coloured, clay-stone, with bands of quartzite.

4. Indurated clay, with round nodules, the size of a bean, of a black mineral having the lustre of jet, whitening to a milk-white colour before the blow-pipe, and finally melting with difficulty on thin edges; it belongs probably to the hypersthene group. The clay itself is grey, smooth and meagre.

5. Chloritic clay; grey, very smooth and soft to the touch; hardness of slate. It is full of ninute round grains of a semi-transparent mineral, grey like the clay, but a little darker. The clay becomes white and meagre before the blow-pipe; it is unaffected by muriatic acid, and does not form a pasty mass with water, either before or after grilling.

6. Limestone, at first extremely arenaceous and argillaceous, and presenting particles of dirty blue and brown colour. It becomes gradually conglomeratic and at the same time thin-bedded, the layers being made of layers of pebbles of limestone cemented by a calcareous sandy cement; the top of the layer appears to have been worn flat by the action of the waves, before the deposit of the next stratum took place, the pebbles appearing as sections on the surface of the bed. The next layer is a muddy limestone containing a few flat athyris, remarkable especially for three internal raised lines or ribs proceeding from the beak as far as the middle of the valve. But these shells are in a very bad state of preservation. This layer is only two feet thick, and is succeeded by another equally thin and containing numerous debris of gasteropods and corals. Then comes a black, sometimes blue-black limestone, extremely fœtid. The bluer portions are crossed by white lines intersecting each other in all directions and containing only debris of fossils.

The limestone forms altogether a bed of about thirty feet, when it is cut by a fault which causes it to be repeated, and a succession of faults directed W. N. W. to E. S. E. keeps the same limestone on the surface for more than half a mile, it becomes finally covered by nummulitic limestone.

This Mount Sirbun forms the left side of the Abbottabad valley. Following the slopes of this hill, we find beds of quartzite, similar to No. 2 of the above section, reappearing three or four times in short anticlinals; above it are beds of limestone containing a few fossils, principally casts of gasteropods. This limestone is often strongly oolitic in structure, but presents also the very unusual appearance of resembling beds of travertin which had been entombed in a calcareous mud after their formation, so that the cavities of the travertin have become filled up with a limestone less hard than the original deposit. I have usually regarded these beds as fresh-water origin near a low coast, and referred them, in a general and provisional way, to the Jurassic; of course this is doubtful.

70. On the lower road from Marree to Abbottabad, near the village of Sayd Kote, great disturbances are observed, and rocks of a geyserian nature make their appearance about half way between Sayd Kote and the Dowr river. They are principally a chocolate-coloured sandstone, becoming coated by weathering on the surface as well as in the joints, with a shining dark incrustation. It is much jointed and breaks in prismatic blocks. A great quantity of dark boulders of this rock may be seen in the bed of the river Dowr. It appears to be similar to some variety of dust-rock or sandy ash or earthy ash seen in Kashmir. It is capped by a bed of quartzite composed of large, opaque, angular grains of quartz, jammed together and cemented by a feldspathose white paste of which there is very little. Angular grains of black augite are sparingly disseminated in the rock. Under the brown sandstone is seen a thick bed of crumbling clay slate, very dark and foliated. This is the lowest bed seen. These three beds, viz., slate, sandstone and quartzite conform together in their dip and are capped by a patchy limestone of doubtful age, and interbedded with grey soft slate. There is much kunkur near the locality.

At Sayd Kote the limestones are wonderfully disturbed: beds having the appearance of Kothair limestone and containing a great number of gasteropods and *cyathophyllides* are seen repeatedly, as the road crosses nearly perpendicular beds which are much faulted. Nummulitic limestone appears to cover in directly the carboniferous (?) beds ??

Again on the upper road from Murree to Abbottabad, at the bottom of the ravine under Doonga Gully, volcanic or rather geyserian rocks are to be seen. They consist of a very white and friable rock composed of acicular minute crystals of albite easily fusible before the blow-pipe and pressed and entangled together; there does not appear to be any cement to bind the small crystals together; the rock has a coarsely saccharine aspect and can easily be crumbled between the fingers. It rises in vertical and contorted bands, from half an inch to two and a half feet thick, amongst sands and disintegrated shales. It assumes very many remarkable colours, being sometimes flesh-coloured or reddish, and at other places azure-blue; its general colour is, however, snow-white; where it is blue, the shales near it are of the same colour. It is interbedded with thin beds of tufaceous limestone which have probably found their way there by infiltration. It is covered in by a rubanneous and dark slate, much disturbed, extremely cleaved and jointed and falling into small angular pieces. This slate appears similar to that seen near Syad Kote, and the feldspathose rock is intrusive. These two rocks are at the bottom of the ravine, on a fault, and form a little mound by themselves. There are no rocks to be seen in immediate relation to them, and the beds of the sides of the ravine appear to be entirely nummulitic.

From the examples given of volcanic rocks in Hazara, it seems evident that that district has participated in the great volcanic accumulation which preceded the carboniferous epoch, and that it has also been disturbed at a later date by intrusive volcanic action of a local and geyserian character.

71. Of Chumba, Kulu and Kunawar, districts which occupy the hilly tracts south of the extension of the Pir Punjal chain towards the Sutlej, I know nothing.

72. Kashmir is continued to the south-east by the highlands of Lahul and Spiti which are situated in the same Himalayan parallel, viz., between the Pir Punjal chain or parallel and that of the Ser and Mer. Spiti has been pretty often visited by geologists, and we know that carboniferous and Jurassic fossils were brought thence by Dr. Gerard. Liassic fossils have also been found there. As for crystalline rocks, M. Marcadieu mentions much granite, and Captain W. E. Hay, granite penetrated by huge veins of ter-sulphuret of antimony and "other metals." Gypsum is reported as extremely abundant in Spiti, forming, it is said, whole mountains; and here I

would mention again that several hot springs are found in close vicinity to these gypseous beds.

But I must draw back here, and leave the ground to Dr. Stoliczka who has been for some time studying the geology of Spiti with great care and is preparing a work on the subject. Dr. Stoliczka has found in Spiti rocks of the following ages: Silurian, Carboniferous, Triassic (?), Liassic, Oolitic and Cretaceous. I have said before that most of the fossils from Spiti represented in Dr. Royle's Illustrations, are to be found in the Jurassic rocks of Sheikh Bodeen.

73. The great chain of Ser and Mer (called by Capt. R. Strachey, between the Sutlej and the Kali, the chain of Snowy Peaks, and by Cunningham, the western Himalaya or central chain of the Himalaya) appears to be, as far as I have been able to ascertain, made up of granite, gneiss, and other rocks of the plutonic and metamorphic groups. From the Nanga Parbat (26,629 ft.) to near the Sojji La pass, (11,300 ft.) the range is, I believe, mostly granite; it is traversed by the road of Skardo viâ Guzais, and Mr. Drew informs me that the range, (which here forms the southern boundary of the Deosai plain) is "chiefly granite, partly schist." The plain of Deosai is a singular plain or steppe entirely covered with debris and loose stones; it is tolerably flat, considering how it is situated, and has perhaps once been the bed of a gigantic glacier. It is surrounded by granitic mountains on the southern and western sides; the north end is bounded by mountains of schist and slate, and the eastern side is closed in by granitic hills which gradually pass, over Drass and Kurgyl, into volcanic rocks.

If we cross the Ser and Mer chain by the Sojji La, from Kashmir into Drass, we find near Baltal, a village on the Kashmir versant of the pass, that the carboniferous limestone ceases and is succeeded by beds of very coarse and micaceous slaty shales, often very sandy and always very thin-bedded. The specimens I possess of this rock show it to be identical with the sandstone and sandy coarse shales seen in the Zebawan and there interbedded with ash, agglomerate and slate. This rock goes on to nearly the top of the pass, where it becomes a dark and hard slate, having a metamorphic appearance. Then limestone reappears and is seen as far as Drass; it rests the whole way, as far as can be seen, on volcanic rocks and azoic slate. It is pro bably continuous, through Sooroo, with beds of limestone seen between Moolbek and Khurbu.

I do not know what sort of rock forms the summit of the Kun Non or Ser and Mer Peaks (23,407 ft.) but their north-eastern slope and spurs are composed of gneiss and schist; these metamorphic rocks extend as far as the Sojji La, where they are graduating into beds of the coarse slaty shales described above; on the north of the road it is continued by beds of slate and of sandstone extremely micaceous and resting on mica-schists, of which some specimens effervesce powerfully with acids. Beds of metamorphic white marble are also seen, but the great bulk of the mountains between Tillail and the Deosai is made up of granite, shist and mica-slate.

Following the great chain to the S. E. we find it crossed by several passes of which the Bara Lacha (16,505 ft.) and the Parung la (18,794 ft.) are the most celebrated and frequented. Mr. Marcadieu describes these passes as being principally through granitic rocks; but unfortunately Mr. Marcadieu does not seem to have enjoyed much his visit to these "*belles horreurs*" and he gives us little geological information, but many complaints, about these "delights of Satan," as he calls the mountains.

South-east of the Sutlej, the chain continues to be mostly granitic. It is studded with noble peaks, Porgyul (22,700, ft.) Baldang (21,400 ft.) Kamet (25,000) and Nanda Devi (25,700, ft.) all of them made up of granite, gneiss, and schist. But I must refer the reader to Captain R. Strachey's paper "on the geology of part of the Himalaya mountains,"* for the mountains south-east of the Sutlej.

74. Having crossed the Ser and Mer Parallel, we find ourselves in the great trough between this chain and that of the Kailas peak (which I shall call for convenience sake the Kailas chain) and we may hardly call this trough a valley, considering that it is a plateau from 10 to 12,000 feet high above the level of the sea; and yet it is a valley between the two great parallels which tower over it by some 10,000 feet more. It comprises the districts of Deosai, Soroo and Drass, Ladak proper, Zanskar, Rukshu and in the S. E. the great plateau of Tibet through which runs the Sutlej and inhabited by the Hundes. This last or south-eastern portion of the trough is toler-

* Proceedings of the Geological Society of London, June, 1851.

ably flat, only a small volcanic peak rising here and there, detached and isolated, through the thick horizontal bone-beds of sandstone and conglomerate which fill up the valley.* But in the other districts, the trough is nearly entirely filled up by vast mountains, which occupy in the parallel valley of Ladak the same position as the catenated chains we have described in Kashmir do in the parallel valley of Kashmir; the chain formed by these mountains has been called by Colonel Cunningham the "Tso Moreri" chain, and has been raised to the position of one of the great parallel chains of the Himalaya, but it will best suit our purpose to consider it as an inter-parallel mass of mountains.

Deosai has been described already. Drass and Kurghyl are covered with volcanic rocks into which the granite of Deosai gradually passes. Mr. Drew tells me that he found near Kurgyl a rock composed exclusively of mica and felspar, graduating into granite. Some specimens I possess from Tashgam, half way between Drass and Kurgyl, are composed of a dark green hornblende which fuses with difficulty and swelling a little before the blow-pipe. Felspar is not conspicuous, but is probably intimately combined with the hornblende. But rocks undoubtedly volcanic are also seen, such as greenstone and amygdaloid. A considerable bed of limestone reposes on the volcanic rocks and appears to be the continuation of the bed seen near Drass. I do not know the age of this limestone. The Drass bed contains fossils which are, I believe, carboniferous, and I have coloured the bed now under consideration, carboniferous, assuming the continuity of the two beds to be true.

Of the mass of hills traversed by the road from Kurgyl to Le I know very little indeed. They are said to consist mostly of slaty rocks capped here and there by conglomerates and grits.

As we near the valley of the Indus in Ladak proper, near the village Kulsi, interesting beds appear. Resting on a hornblende rock or trap is a series of slate, light-coloured limestone, conglomerate with rolled boulders of the same limestone, sandstone, shales and dark purple indicated clays. The dip is not very great and the several beds appear to conform together. The whole valley of the

* Proceedings of the Geological Society of London, page 306.

Upper Indus from Kulsi to Nodmo (and probably further east) appears to be excavated in this formation and the river flows in a fault of it or more probably in the centre of a denuded anticlinal.* The series of rocks (series of Upper Indus Valley) rest, on the North, against the granite of the Kilas Range. Captain G. Austen, to whom I owe these details, estimates it to be at least 3,000 feet thick, and mentions also its appearance in Rodok at the North of the Pang Kong Cho, resting there unconformably on slate. In the limestone layer of this series (about 150 feet thick or more) Captain Austen found a few fossils which he was kind enough to show me. They were very ill-preserved and fragmentary, but appeared to resemble some forms found in the Kothair bed in Kashmir; some cyathophyllides are certainly not to be distinguished from those represented at figures 56 and 57, Plate VII. Another fossil was supposed to be the radical end of a Calamite. To complicate matters, the fossils were declared by palæontologists at home to be *cretaceous*. The specimens are so bad, that I apprehend that this determination must have rested entirely on the *one* fossil which I took for a Calamite, and which was regarded, I suppose, as a Hippurite. My own impression is, that the limestone is identical with the Kothair bed of Kashmir, and therefore either the uppermost layer of the carboniferous or perhaps the lowest of the Triassic.

Above this Upper Indus series come the nearly horizontal grits and coarse sandstones which form the flats called in Ladak Chang Tang and Rang. The non-conformity between the Indus Series and the Chang Tang beds is not conspicuous, as that dips at a very low angle and these are nearly horizontal. There is also, I believe, a great similarity of lithological character between the two formations, one being merely the resettlement of the other. I conceive that some difficulty may be experienced occasionally to decide where one formation ends and the other begins. A few mammalian bones have been found in the Chang-tang sandstone, and there is but little doubt that this bed is similar to the sandstone and conglomerate of the Great Thibet plateau to the north of the Niti Pass. These high horizontal plateaux of conglomerate and sandstone are also observed

* A very great number of rivers in the Himalaya run part of their course in the centre of a denuded anticlinal.

in the Afghan mountains, where they are called in Pooshtoo Ragzhie. I have examined some of these ragzhies, of which the plateau of Rushmuk in Waziristan is a good example at an elevation of 7,000 feet, and I feel satisfied of their fluvio-lacustrine origin and of their age being posterior to the final upheaval of the Himalaya and Afghan mountains.*

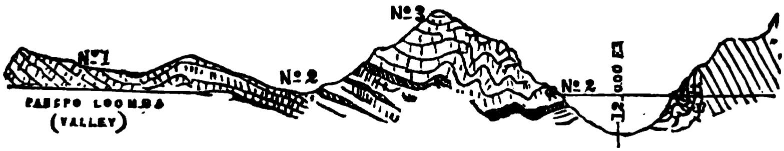
Zaskar and Rukshu or Rupshu are interesting districts, on account of their lakes, numerous hot springs and borax mines. The country is an elevated labyrinth of mountains and valleys, having a mean height of 15,600 feet. The principal peaks are the Korsok Too (above 20,000 feet) and the Napko Gondo ; but there are great many other nameless peaks ; the passes are all a good deal above 17,000 feet. In Zaskar we find a great mass of gneiss and schist which appears to be the eastern extension of similar rocks which begin in Sūrū, and, after entering largely in the formation of the mountains of the highland of Zaskar, are prolonged eastward into Rukshu, where they graduate into beds of metamorphic slate on which rest fossiliferous rocks. The gneiss, schist, slate and limestone are all stratified and conformable together, and they all dip towards the S. S. W. The limestone appears to be the continuation of the bed of limestone seen in Sūru reposing on the gneiss and schist of the foot of the Ser and Mer peaks.

The occurrence of fossils in Rukshu had been noticed by several travellers, but little was satisfactorily known, and to Captain G. Austen is therefore due the credit of having first brought trustworthy fossils from Rukshu, and to him I am indebted for the following details :—

Two of the valleys of Rukshu are the Tso Moreri valley and the Pang-po-loomba ; they are separated one from the other by the ridge of the Korsok Tso, composed of granitoid rocks and of gneiss and schist. From the Pang-po-loomba (valley) one passes into the valley of the Tsa Rup (river) by the Pang-po-la (pass), towards Zaskar. This Pang-po-loomba (valley) and Pang-po-la (pass) are the localities where fossiliferous beds have been noticed. The

* Col. R. Strachey appears inclined to regard these horizontal beds of the Great Thibet plateau as contemporary of the Siwalik hills and a sea-formation. I believe that both hypotheses are untenable.

whole bottom of the valley is uneven and its southern portion is formed by beds of limestone in which both Captain Austen and Mr. Marcadieu found carboniferous fossils (No. 1.) At the foot of the Pang-po-la the carboniferous becomes covered by a muddy sandstone (No. 2) which is, however, not seen in situ on the northern slope of



Section across the Pang-po-loomba (valley) and Pang-po-la (pass) in Rakshu from a sketch by Captain Godwin Austen (approximate).

the Pang Po, but of which numerous debris fill the ravines. Above this sandstone is found Jurassic limestone (No. 3), all the way to the top of the pass, full of Belemnites, Ammonites, Rhynchonellæ and Terebratulæ. One of the Rhynchonellæ collected there by Captain Austen appears identical with a form very common in the middle Oolite of Sheikh Bodeen in the Punjab.

Having crossed the top of the pass and descending towards the Tsa Rup (river), the same bed of muddy sandstone (apparently) again crops out. It is there interbedded with thin beds of impure limestone, and in these beds were discovered a great many Belemnites in fine state of preservation. Mr. R. A. C. Austen, to whom the fossils of these parts were forwarded, pronounced some of them to be *Liassic*, but I do not know whether these liassic forms came from the muddy sandstone bed or from beds inferior to it.

On the other side of the valley of the Tsa Rup, some beds of limestone, much folded and bent, again appear, but they showed no fossils and their age is therefore unknown ; they rest against beds of slate much up-tilted and apparently unconformable to the limestone. At the back of the slate is the great mass of the Ser and Mer chain, attaining immense height and crossed by passes above 16,500 feet high.

75. The Tso Moreri is the largest of many salt lakes which form one of the features of Rukshu. It is 14 miles long and more than 15,000 feet above the sea. Its water is very salt and bitter, though Mr. Marcadieu affirms that it contains only one part of saline matter

in 10,000 parts of water; the saline matter is sulphate of soda and sulphate of lime. Another lake, the Karso-Talao, about 6 miles long, is reported by the same gentleman to contain a great deal of chloride of sodium and sulphate of soda, with a little carbonate of lime and carbonate of soda. These two lakes are said to be surrounded by mountains of crystalline rocks, principally mica-schists and granite. But one of the most interesting subjects connected with the geology of Rukshu is the existence of borax in the valley of Puga. The manner in which it occurs as an efflorescence is too well known to require description here, but one cannot but regret that Mr. Marcadieu's report is not more geological; indeed it can only be regarded as chemical, and the geology of the district is still a work to be done. I have never visited Puga, but, from the several descriptions of it I have read, I am satisfied that the borax ground is the bottom of a dried up lake. The analysis of impure borax collected at Puga shows it to contain, besides borax, sulphate of soda, sulphate of lime, chloride of sodium and carbonate of soda. These impurities are precisely the composition of the Kullur salt of the plains of the Punjab and of the saline matter of many hot springs and salt lakes of the Himalaya and the Salt Range, and it appears to me evident enough that the lacustrine mud which fills up the bottom of the Puga valley, is similar to the alluvial deposit of the Punjab. Boracic acid, which probably once rose freely to the surface of a small lake and was deposited in an uncombined state, is now arrested by the bed of lacustrine mud which fills up the fumarole and combines with some of the salts of soda. It appears therefore much to be regretted that an attempt was not made to estimate the thickness of the lacustrine deposit and that a few wells were not sunk into the borax ground and the waters and gases which might have been collected in these wells carefully examined; possibly such researches and experiments might have led the way to an increase of the present supply, and to a system of collecting the borax or boracic acid sufficiently pure not to require refining.

76. In Ladak, Rukshu, Sooroo and Zaskar, no fossils were ever found, as far as I know, older than those of the carboniferous formation. But if we follow the great valley, between the Kailas Range and the Ser and Mer chain towards the S. E. we find, on the other

side of the Sutlej, great beds of limestone rich in Silurian fossils.* Mr. Salter has recognized the following genera among Captain Strachey's fossils :—

Cheirurus.	Strophomena.	Cyrtoceras.	Chœtetes.
Lichas.	Orthis.	Litnites.	Crinoid Stems, &c.
Asaphus.	Leptœna.	Tentaculites.	
Calymène.	Lingula.	Murchisonia.	
Illœnus.	Orthoceras.	Ptilodictya.	

Mr. Salter, M. Barrande and M. de Verneuil, who saw some of the fossils collected by Colonel Strachey, agree that they indicate beds of Lower Silurian. We shall see that beds of Silurian also exists in the huge mountains to the north of Skardo and near the Mustak Pass in the Korakoram chain.

But let us first relate what Colonel R. Strachey found in the high ranges south of the Sutlej.

The Silurian above mentioned rests on beds of slate without fossils, and this slate rests on schists, mica-schists and other rocks of the metamorphic group. Then above the Silurian limestone, some beds of carboniferous must exist, though they were not found in situ by the explorer ; *Producti*, *Athyris Royssii* and other well known fossils were found in loose boulders near the Niti Pass. I believe also that some of the shells placed by Colonel Strachey and Mr. Salter in other groups belong really to the carboniferous ; such is the *Chonetes* placed by Colonel Strachey in the Mushelkalk, but transferred to the carboniferous by Mr. Salter ; the *Ptilodictya Fenea* (Salter), the narrow variety, which I have found in carboniferous beds in Kashmir ; (it was naturally placed with the Silurian fossils by Mr Salter, on account of the *Ptilodictya* having been found as yet only in Silurian beds in Europe and America) ; the *Spirifer Stracheyii*, (Salter) placed among the Triassic fossils by Mr. Salter, and which is common enough in the Weean bed of carboniferous limestone in Kashmir; and lastly the *Spirifer Rajah* (*Spir. Keilhavii*,

* On the geology of part of the Himalaya and Tibet, by Capt. R. Strachey, Bengal Engineers, F. G. S. in Proceedings Geological Society for June 1851, also "Palæontology of Niti in the Northern Himalaya, being descriptions and figures of the Palæozoi and Secondary fossils collected by Colonel R. Strachey R. E." "Descriptions by T. W. Salter, F. G. S., A. L. S. and H. T. Blanford, A. R. S. M., F. G. S.—Calcutta 1865."

Von Buch), which has been removed from the Trias by Dr. Oldham, and declared to belong to beds anterior to that epoch.

There is therefore a strong probability that both the Zeeawan bed (*Productus semireticulatus*, *Athyris Royssii* &c.) and the Weean bed (*Spir.* f. *Stracheyii*, *Spir. Keilhavii*) exist in the ranges near the Niti Pass, but have been much denuded and broken in loose fragments along the section followed by Colonel R. Strachey.

Then comes what Colonel Strachey supposed to be Muschelkalk, and which Mr. Salter refers to the Keuper and Hallstadt bed of the Upper Trias. I cannot refrain from expressing a suspicion that a few of the shells referred to these beds do not really belong to them, and that fossils of various ages have been mixed, either from collecting them, without due care being paid to the strata in which they were respectively found, or from careless packing. There is such a great likeness between the figures of some of the Triassic Ammonites of Mr. Salter and those of the carboniferous ceratites of M. DeKoninck,* (see *Ammonites Blanfordii*, Salter, nov. sp. and *Ceratites Lyellianus*, Dekon. nov. sp.) that one finds it difficult to decide between these two great authorities. The species of ammonites figured in the Palæontology of Niti have nearly all the ceratite-like sutures usual in triassic ammonites in Europe, and therefore much resemble deKoninck's ceratites.

It may be advanced, on the other side, that M. DeKoninck's ceratites belong to triassic beds; but these ceratites are to be seen in the Rotta Roh associated to some of the fossils which I have given as characteristic of my Weean bed of the carboniferous in Kashmir and the Punjab; and a portion at least of this Weean bed would have then to be made over to the Trias. Unfortunately for this view, the mixture of Weean and Zeeawan fossils in some layers of the Rottah Roh (described in para. 60 of this paper), does not allow us to make the Weean anything but carboniferous, unless we are prepared to regard the *Prod. semi-reticulatus*, the *A. Royssii*, the *A. Subtilita* and other such essentially

* "Description of some fossils from India, discovered by Dr. A. Fleming, of Edinburgh." By Dr. L. de Koninck, F. M. C. S., Professor of Chemistry and Geology in the University of Liege—Journal Geological Society of London, Vol. XIX. p. 1.

carboniferous fossils as occasional inhabitants of the Trias!!! If we are prepared to stretch the point so far, we may as well give up at once all idea of successive faunæ.

I have, since writing the above, found in the Rottah Roh, some beds containing a few fossils which appear Permian. I have not yet had time to examine the fossils with care; but should they prove Permian or Saliferian (St. Cassian),—and I have little doubt that they will be found to belong to either one or the other of these formations,—the presence of patches of such a bed on the top of the carboniferous would explain away, in a great measure, the difficulties I have now been considering.

I have said before that I believe the Saliferian of Upper India to belong to the Paikilitic formation, but that it has been found impossible as yet to *demonstrate* that such is the case. The discovery of one or two fossils may settle the question, if they were forms thoroughly well known as characteristic of the Indian Trias. The study of the fossiliferous Triassic beds in India is therefore of the greatest interest; but much care is required lest the mixture of Palæozoic and secondary types should take place in our packing boxes and not in nature, and we thus become accustomed to regard, as characteristic of the Trias, shells which really belong either to the carboniferous, or to the Lias and Oolite.

To Colonel R. Strachey, however, is due the honor of having first discovered fossiliferous Triassic beds in the Himalaya; and we may hope that much light will be thrown on the Indian fossils of that age by Dr. Stoliczka, in his expected work on the Geology of Spiti.

Over the beds last described, Colonel Strachey found Jurassic beds; but the relation between the Triassic and Jurassic beds could not be ascertained, owing to a great fault running parallel to the general N. W.—S. E. direction of the Himalayan ranges. The section exposed by this great fault is at least 5,000 or 6,000 feet in thickness, but the difficulties of the route prevented Colonel Strachey from examining it from top to bottom; the lowest beds were not examined. The *lowest which were examined* gave forms which Professor E. Forbes was inclined to identify with fossils which occur in the fuller's earth and cornbrash of England. No Liassic forms were discovered.

These inferior oolitic beds are capped by dark coloured shales containing belemnites and ammonites, and referred by Professor E. Forbes to the age of the Oxford clay. These shales are therefore the representatives of the several Jurassic beds we have already seen in several parts of the Himalaya and of the Punjab.

The oolitic beds are covered by grits, shales and limestone of unknown age, and finally by the great horizontal bed of what Colonel Strachey considers to be miocene (Siwalik) sandstones and conglomerates. I have said before that the identity of these sandstones, grits and conglomerates to the Siwalik formation is far from established, and that there are more reasons for considering them pleistocene, than for assuming them to be coeval with the deposition of the Sub-Himalayan tertiaries.

77. The Kilas Chain is of less elevation than the Ser and Mer, and its peaks are neither so numerous, nor so well known or so remarkable for their enormous mantles of snow. The principal summit is the Kailas (or Tise) peak, which rises to 22,000 feet above the sea, in longitude 81° 18′, and is therefore far to the S. E. of our Western Himalaya. As it is, however, the only well known peak of the Chain, I have called the whole chain from its name.

The Kilas chain begins near Mount Haramash, N. of Astor and N. W. of Baltistan, and is traversed near Skardo by the Shigar river which cuts a passage across the range. The summit, Mashkulla, (16,919) towers over the alluvial plain of Skardo, Shigar and Kuardo. This mountain is mostly granite ; its spurs show a great deal of metamorphic slate at a high angle of dip ; and the little hill close to Skardo, evidently an off-shoot of the Mashkulla, is composed of an imperfect shist. All along the left bank of the Shigar river, schists of various sorts, especially mica-schists, and micaceous slates, together with metamorphic marbles, form the great wall of mountains that bound the Shigar valley to the N. E. Following the road which leads from Shigar to the Thale valley, by the Thalé la (pass) Captain G. Austen discovered some beds of limestone, resting on the mica-slate, and I have coloured that bed of limestone Silurian in the Map. My reason for believing it to be Silurian is its proximity to limestone beds of similar appearance and position at the Mashabroom, and there, I believe, decidedly Silurian ; and also the fact that the discoverer of the bed found there a few fragments of fossils which he regarded as Palæeozoic, though different from any of the carboniferous forms which we found together in Kashmir. There is therefore presumption that this bed is Silurian, though of course it is merely a presumption. I have also assumed that a bed of limestone, seen to the South of Skardo, between that town and the Deosai (plain), is Silurian. We shall see the bed discovered at the Mashabroom, when we describe the Karakoram Chain.

From Skardo towards the S. E., the Kilas Chain appears to be nothing but a great granitic wall, along the foot of which runs the Indus. Near Lé in Ladak the range is crossed by the Digor La (pass), the road going through a succession of granitic rocks.

78. Between the Kilas and Karakoram Chains, we find the rugged district of northern Baltistan, the valleys of Saltoro, Nubra Shayokh and the Chinese province of Rodok. In the country of the Baltis, the Kilas and Korakoram Chains approach each other to within about 45 miles, as the crow flies, from range to range; whilst on the contrary the chains diverge as we proceed towards the S. E., the Korakoram chain having apparently a less southward direction that the other parallels of the Himalaya. In northern Baltistan, consequently, we find the country covered with mountains, cut with deep narrow valleys and mantled with immense glaciers;* in Radok on the contrary high plateaux are abundant, and form to the north of the Pang Chong Tso (lake) and Pang Chong La (pass) considerable plains, 14,000 to 15,000 feet above the sea, arid and rainless, often not presenting a shrub for several marches; high deserts on which roam a thin population of nomade Turkomans who graze shawl-wool goats on the scarce and far-between Aghil or grassy vales of these inhospitable regions.

There is no doubt that these high plateaux are similar in origin, age, and appearance to the great Thibet plateau through which runs the Sutlej, to the north of the Niti pass, and described by Colonel R. Strachey; and also to the Chang Tang and Rong plateaux of Ladak. All these high plateaux present a horizontal stratification;

* "On the Glaciers of the Mustakh Range," by Captain H. G. Austen, F. R. G. S., &c., read before the Royal Geographical Society, London, on the 11th January, 1864.

and it appears therefore impossible to regard them otherwise than as accumulations of debris washed from the ranges into the great troughs between these ranges, and therefore posterior to the great final upheaval of the Himalayas.

Very little is known of the nature of the rocks forming the ridges, ranges and spurs in Saltoro, Nuha and Shayokh. Dr. Thomson,* on native information (Izzet Ullah), tells us that the rocks of the Shayokh and Nuha valleys are in great part primitive limestone. "The limestone continues towards Rodok and the water of the Pang Gong Tso (lake) hold a sufficient quantity of lime to form a calcareous deposit which cements the pebbles together in patches of concrete at the bottom of the lake." The water of the Pang Chong Tso is sufficiently brackish not to be fit for drink, and it has a bitterness probably due to sulphates of Soda and of Magnesia. From the examination of a specimen of the calcacerous incrustation which is formed on the shore of the lake, I found that Magnesia is about as abundant as lime.

An extremely pretty species of Limnea or rather Physa once lived in the lake, and dead shells of it are abundantly found in the band of tufaceous deposit, a few feet above the present level of the water. These shells no longer exist in the lake (Austen). They have probably been destroyed by the diminution and concentration of the brackish water.

General Cunningham informs us† that the rocks of all the high ranges and peaks of Rodok are granite and gneiss, and this appears to be highly probable. Metamorphic rocks also abound; the mountains near the Pang Chong Tso containing a great deal of mica-schists; and crystalline marble is also found on the shore of the lake, apparently in immediate contact with granitoid rocks.

In the northern portion of Rodok some hot springs exist in a locality called Chong Chin Mo; there water deposits largely a grey tufa which is composed of carbonate of lime, sulphate of lime and sulphate of soda. Such tufa is common near the warm springs of the saliferian in the Punjab. Its composition is also that of the saline impurities of the brackish lake of Tso Moreri in Rukshu, and

* "Ladak," by General Cunningham, R. E.
† "Ladak," by General Cunningham, R. E.

of the efflorescence which accompanies the borax at Puga. From the extensive beds of gypsum and impure salt found in Rukshu, little doubt can be entertained that the saliferian is there well developed, and by analogy it is to be presumed that the same formation is also to be seen in Rodok. Borax is said to be exported from Rodok in large clean crystals, but I do not know whence they are obtained; that it does come from Rodok appears however pretty certain; and that is another resemblance with Rukshu, and another reason for believing that the saliferian is probably well developed in Rodok, and is there accompanied by hot springs and fumaroles exhaling boracic acid.

I have never seen any fossil which had been brought from Rodok, Shayokh or Nuba; it is impossible therefore to say to what age belong the beds of limestone mentioned by Dr. Thomson. The beds are called "primitive limestone;" but as Jacquemont, Vigne, Thomson and others speak sometimes of fossiliferous limestone (such as the Manus Bal limestone in Kashmir) as "primitive," it is difficult to know for certain what is meant by that somewhat antiquated term.

79. The Korakoram Chain is a range of very great extent, beginning at the Pamer Steppes and reaching to the S. E. as far as the centre of Thibet in longitude E. 94° and as low as latitude N. 30°. The plateau near its south-western slope is from 15,000 to 17,000 feet high, and is an arid tract of horizontal alluvian covered with loose stones and supporting very little vegetation; more to the north it is a labyrinth of wild valleys. Near the Mashabroom mountain (above 26,000 feet) the soil of the valleys between the spurs is to a great extent covered by glaciers; where not so covered, it is often an indurated clay strewed with debris of pale limestone a good deal worn and weathered, and with globular cystideæ in very great abundance. Mr. Ryall, of the Great Trigonometrical Survey, gave me one of the pieces of limestone and some of the fossils. The limestone is an argillaceous dolomitic limestone, pale yellowish brown, with a few patches pale blue, weathering like frosted glass, and resembling a good deal of the rocks of the Weean and Kothair groups of carboniferous limestone. The *sphæronites*, however, point to a silurian epoch, these echinoderms having not been found as yet in formations posterior to the Wenlock limestone.

The *sphæronites* of the Mashabroom are probably a new species; they were found in considerable variety, from the size of a small walnut to that of a large orange; the largest were perfectly round and polished like a cricket ball, without warts, spines or facettes, pierced by numerous pores. Some of the smaller have the stems scarcely visible (fig. 6, Pl. VIII), and are covered either with large tracts set well apart or with smaller ones set closer; some spines are depressed or lenticular; all are pierced by innumerable pores, none shows traces of polygonal plates; mouth not to be seen in any of the specimens I have examined. (See figs. 5, and 6, pl. VIII and plate IX fig. 1.) The discoverer, not being a geologist, did not look for other fossils: the cystideæ were so numerous and so curious in appearance, that they gave quite a peculiar aspect to the ground.

The Mashabroom is stratified to its very summit, the beds being limestone and shales, dipping towards the S., at a moderate angle. This stratification is so well marked, that it can be distinctly noticed from a long way off. These sedimentary beds repose on metamorphic layers of mica-schist and gneiss. The limestone is extremely rich in magnesia, principally towards the base of the bed, where it passes into Steatite in patches (Austen). Some of the Serpentine and Jade (compact Tremolite) brought to Srinuggur and there worked into ornamental articles by the stone-cutters of that city, come, I believe, from the neighbourhood of the Mustak Range and of Mashabroom, though the greater quantity is supposed to be derived from the Yarkandkass valley and the Kuen-Luen Chain in Khotan. There can be little doubt that the limestone of the Mashabroom is the parent bed of the cystideæ found in the valley between two of the spurs of that mountain; and at least a portion of the limestone of Mashabroom is Silurian,

The following sketch-section embodies the information kindly given me by Mr. Ryall and Captain G. Austen.

Approximate vertical Section of the Masha Brum mountain, one of the great summits of the Korakoram Chain, from S. to N. bearing W.

1, granite; 2, gneiss and mica-schist; 3, sandy shales and coarse slate without fossils; 4, pale dolomitic limestone containing patches of Steatite; 5, pale ochre-coloured limestone, the probable parent rock of the Sphæronites found at the foot of the mountain.

To the north of the great glacier Baltoro is that portion of the Korakoram Range known as the Mustakh and crossed by the Mustakh Pass at an elevation of 18,400 feet. The whole S. Western face of this Mustakh is covered by enormous glaciers through which the rocky spurs of the mountains rise like islands and promontories. These rocks Captain Godwin-Austen found to be limestone dipping to the N. E., but he failed to find fossils in it, though he noticed traces and fragments of organisms. It is so very probable that these beds are a continuation of the limestone of the Masha Brum, that I have not hesitated to colour them in the map as Silurian. Of course, this requires confirmation. Unfortunately the difficulties of reaching even the foot of these gigantic mountains are nearly insurmountable.

80. I could not get any information on the nature of the rocks forming the remainder of the Korakoram Chain. The few European travellers who ever saw the chain, agree, I believe, in representing it as being mostly composed of granite.

On the other side of the chain we find, between it and the next parallel, *viz.* the Kuen-Luen Chain, the valley of the Yarkandkash (river), which extends from the Korakoram or Yarkand pass to Tashgurkhan, and the Akzai Chin or White Desert, which is continued towards the S. E., nobody knows how far. The valley of the Yarkand river and the Akzai Chin are separated one from the other by a low ridge of mountains similar to the masses of mountains found between the other great chains of the Himalaya. All we know of the valley of the Yarkandkash is that some mines of rock-salt occur there, and that both in the beds of the Yarkandkash and Karakash and in the the ravines of the neighbourhood, some pebbles are collected and used for cheap jewellery; and these pebbles are either quartzy stones or rocks decidedly volcanic. There is apparently some analogy between these mountains and those of the centre of Rupshu and of Ladak. The Akzai plain is also very similar to the countries just mentioned, in at least the one character of being an elevated, rainless desert, spotted with small lakes, some fresh, and others salt.

It is superfluous to say that I know nothing of the Geology of the Yarkandkash and Karakash valleys and of the Aksai Chin; neither is there anything known of the formation of the Kuen Luen or Piryukh Chain, except that it is reported to contain valuable copper and gold mines. Another small chain or range, half way between the Kuen Luen and Yarkand seems to be the last parallel of the Himalaya. Yarkand is supposed to be in latitude N. 38° and about 5000 feet above the sea. From the top of the Korakoram pass to the foot of the hills, the distance is approximately 110 miles, and the descent 13,000 feet or about 118 feet per mile, a mild slope for a mountainous country.

(To be continued.)

Kashmir, the Western Himalaya and the Afghan Mountains, a— A Geological paper, by

Albert M. Verchere, Esq. M. D.
Bengal Medical Service, with a note on the fossils by
M. Edouard de Verneuil,
Membre de l'Académie des Sciences, Paris.
(Continued from page 50, of No. III. 1867.)

CHAPTER IV.—*General Remarks, Geognostic History, and Conclusion.*

81. In the preceding chapters I have often insisted on the parallelism of the several chains of the Himalaya; this parallelism is at once evident by reference to the map. Between the great parallels, we have seen that smaller, catenated chains make their appearance, filling up, as it were, with their spurs and branches, the great troughs formed by the principal parallel ridges. All the peaks and sinuosities of these catenated chains appear to present the same arrangement, viz. a highly crystalline and porphyritic variety of volcanic rock, passing gradually into others less crystalline, such as Trachyte, Felstone and Greenstone, and finally covered by ash, cinders, agglomerate, laterite, and compact azoic slate: these beds of ejecta, together with their interstratified layers of slate and sandstone, are all conformable to the fossiliferous strata by which they are covered, and have behaved like those at the final upheaval of the great system. But the more crystalline rocks, the several porphyries, the hornblende rocks, &c. do not appear to have been displaced laterally in any way to the same extent as the stratified layers; they rather seem to have been upheaved from underground as a solid mass, breaking through the beds of superficial trap and of volcanic ejecta. A similar disposition is likewise usual in granitic mountains, the granite supporting gneiss, schist, metamorphic slate and marble, and these being covered by fossiliferous rocks.

To explain the cause of this arrangement, let us consider what is the section of a volcano, as far as it is known at present from a study of active and extinct ones. We have under the surface of the country, in which the volcano occurs, enormous masses of trachyte, becoming more and more crystalline and prophyritic as we proceed deeper, and probably passing gradually into granite. In some volcanoes this mass is perhaps upheaved during their activity, but what is upheaved above ground is certainly but a small proportion of what remains underneath. This mass is covered by the materials which have flowed out and have spread themselves on the surface, either under the sea or in the open air. A great deal of this fluid material does never reach the surface, but finds its way into the cracks and fissures of the trachyte and porphyry. The portion which flows on the surface, whether in the air or under water is a lava; on the top of and interbedded with the lavas, scoriæ, ashes, cinders, dust, broken rocks and mud, thrown into the air or into the sea by volcanic discharges, are arranged in gentle slopes on the sides of the volcanoes and in flat strata further off. Now, let us suppose that the volcanic activity becomes dormant or ceases: we shall have under the spot where the volcano once broke out, great masses of melted and metamorphosed matter solidifying into various sorts of trappean rocks, while on the surface, stratified and fossiliferous beds will be deposited on the top of the lava and ashes. Should then the whole district be submitted to an expansive force acting from within outwards, this force will be first and most intensely felt by the great mass of underground porphyry and trachyte, which will be forced up and break through whatever covers it; the beds of basalt and amygdaloid through which it is forced, will be displaced and thrown aside or on their flank, dragging with them the stratified beds of cinders and fossiliferous strata. If instead of one volcano, we have many, situated not very far apart, we shall have the superficial rocks thrown into endless confusion by the upheaval of the many masses of porphyry and trachyte, which once formed their bases. The surging up of these masses of crystalline rock will of course diminish very materially the space occupied by the lavas, the cinders and the fossiliferous rocks at the time of their deposition; and these have therefore no other alternative but to be broken in pieces, and these pieces to be raised more or less towards a vertical position, according to the quantity of rocks to be packed in a given space. Thus, for example, near the Kaj Nag range, we have vast deposits of felstone well hemmed in, on the south, by an enormous thickness of passive tertiaries. When the huge mass of porphyry of the centre of this system of mountains received its last upheaval, it took possession of a great extent of ground formerly covered by the felstone; and this in its turn did its best to push the tertiaries further south, but this it only partially succeeded in doing; and as there was much felstone and little room for it, the bed broke into pieces and these pieces became packed edgeways.

82. Granite may be considered as the solidified matter of a volcano seated so far from the surface of the earth, that it never broke through its covering while the minerals were in a fluid or viscid state. It is the remains of a "blind volcano." Humboldt has described volcanic action, "the reaction of the interior of the earth on the external crust." This crust has to be broken through to allow of the escape of some of the internal matter; where the earth's crust resists the upward pressure, no crater is formed, no true volcano appears; but the melted matter remains imprisoned under the crust, and there gradually solidifies under great pressure. The solidification will necessarily be made more slow at a great depth, than it would be near the surface and near a rent which allows of the evaporation of the intermolecular water to take place; and it is the slowness of the cooling, the pressure sustained during the period of cooling, and the retention of intermolecular water and gases which cause the melted minerals to crystallise as granite and not as porphyry, greenstone or basalt.

83. In regard to their geographical disposition, volcanoes can be classified into "central" and "linear." The "central" are those which arise by themselves and appear not to be connected with any other volcano; the "linear" are several outlets arranged along a probable fissure in the earth's crust, and the fissure is often parallel to one or many other fissures similarly indicated by a line of volcanoes; or two fissures may cut one another obliquely, as we see in the Lipari Islands.

84. Applying the above general remarks to the volcanic rocks of Cashmir, we first notice that previous to the carboniferous epoch, there existed linear volcanoes arranged in a direction parallel to the present general direction of the Himalaya, viz. N. W. and S. E.; these volcanoes are now represented by the summits of Kaj-Nag and of the Kistwar and Badrawar and the peaks of the catenated chains of Cashmir. These volcanoes vary much in importance, but no doubt can be entertained of their general great activity, if we remember the enormous amount of ejecta which they have thrown out. The well

stratified arrangement of these ejected materials, especially those which are ejected in a loose and fragmentary condition, the amygdaloidal nature of nearly all the ash-rocks and some of the slates, and the existence of these slates interstratified with the volcanic rocks, justify the idea that some of the volcanoes were islands and others subaqueous craters, in a sea of moderate depth, and it requires no great effort of the mind to picture to ourselves an archipelago of fire-emitting islands in the Silurian sea.

At what time the volcanoes first out broke out, it is not at present possible to determine; they appear to have subsided at the beginning of the Carboniferous epoch; and though phenomena related to volcanic power, in the most general acceptance of that term, were not wanting during and after the Carboniferous epoch, yet it is certain, as far as we at present know, that no regular volcano ever existed in the western Himalaya after the great Silurian volcanoes had become extinct.

85. It has been remarked in many parts of the world that, when a volanic district is, after the extinction of all craters, so disturbed that fissures are formed in the crust of the earth, these fissures do not pass through the old volcanic accumulations, but rather at a little distance from them. This has been explained by supposing that the masses of porphyry, trachyte and other once melted rocks, which have been ejected in the original volcanic fissures and amongst the rocks near this fissure, have so much strengthened the crust of the earth in the site of that fissure, that a new fracture takes place anywhere rather than across or along the old crack. If instead of one old crack we have many parallel cracks, the new fissures will then naturally take a direction parallel to the old fissures and will be situated between them. This has been the case in the Himalayas, and the great lines of fracture which were formed at the last upheaval, are none of them along the catenated volcanic chains, but between and parallel to these chains. But the catenated chains or lines of linear Silurian volcanoes determined the direction of the great lines of fracture which were formed at the last upheaval. We see therefore in the Himalayas great lines of fracture running N. W. and S. E., these fractures present a downthrow on the S. W. and the beds of rocks north-east of them form the great parallel chains of the Himalaya. The general dip of all these chains, and indeed of all the

great beds of rock in these mountains, is towards the N. E.; an explanation of the cause of this dip will be given hereafter.

86. We have said that granite may be considered as the consolidated materials of "blind volcanoes;" that is, the cooled down masses of fluid or viscid matter propelled by internal tension towards the surface of the globe, but not with a force sufficient to overcome the resistance offered by the earth's crust. The soundness of this hypothesis appears supported by the metamorphic influence of granite over immense tracts of country: the conversion of shales, limestone, and sandstones and other rocks into gneiss, schist, marble and quartzite can only be explained either by supposing these shales, limestones, and sandstones to have been plunged deep into the bowels of the earth, there to be metamorphosed,—or else to have been the lid, covering and keeping under waves of fluid mineral matter. Now, the first supposition necessitates the assumption of very great disturbances of the earth's crust, of such disturbances as we cannot conceive or imagine by the analogy of anything we now see in the rocks of the surface of the globe. Neither is the idea of superficial stratified beds being plunged to a great depth into the earth, agreeable to the universal observation of a forcing-out power acting from the centre to the surface. The other supposition does not present the above-named objections: immense masses of melted matter may have approached sufficiently near the surface to have imparted great and continued heat to the deepest stratified beds, and may have underlaid great tracts of country, without disturbing, to a very great extent, the position of the strata which they metamorphosed. Hence do we find beds of gneiss, schist and marble retaining great regularity of stratification for very many miles; so much so, that it has been possible to classify these metamorphic rocks in regularly superposed formations, and to ascertain non-conformity between these beds, proving beyond a doubt their successive deposition.* It is impossible to understand how these beds could have preserved their relations, over a great extent of country, if it had been submitted, at one time, to a "*bouleversement*" so terrific and complete as to have plunged them under the solid crust of the earth, and, at another time, to the great upheaval necessary to bring them up again to the surface.

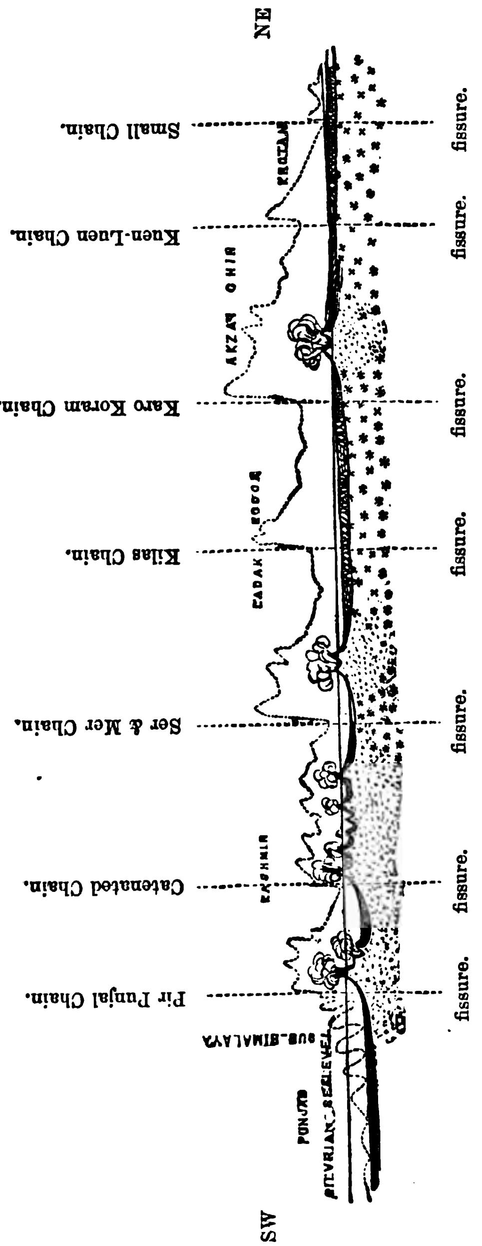
* The great example of this is Sir W. Logan's Laurentian formations in Canada.

It is hardly necessary to add that the rolling of this great wave of melted minerals, under a certain part of the earth's crust, would set all the deep-seated waters to boil, would sublimate certain metals and elements, and that steam at a great heat, and occasionally impregnated with various vapours, would add its metamorphic influence to that of the heat disengaged from the molten granite underneath, and would here and their percolate and alter certain distant beds which would have otherwise escaped metamorphosis.

It has been advanced that steam alone was sufficient to account for the metamorphism; to me it appears inadequate to the work, when we come to consider the extensive beds of metamorphic rocks seen in several parts of the world. No Geyser, ever so hot, has yet been reported to have changed shales in its vicinity into gneiss or crystalline schists, though, I admit, the influence is often evident enough in beds of limestone. On the other hand, we know that dykes of greenstone, of basalt, or of amygdaloid have often converted sandstone into hornstone or quartzite, and slate clay into flinty-state or jasper. It appears therefore evident, that heat is one of the most powerful, if not the principal agent of metamorphism; it appears also necessary that the heat should be long sustained to produce such a great extent of metamorphosed beds as those we are considering, and that it should be equally and uniformly distributed. It does not appear likely that this persistent and uniform heat was supplied by bursts of vapours, nor indeed have we any analogy in the present days of large tracts of country being sensibly modified by the permeation of steam. The slow cooling of a mass of molten mineral under pressure would be admirably adapted to the work of metamorphosing the superincumbent crust, over several hundred square miles of country.

If the hypothesis advanced just now be accepted, we have no difficulty in understanding the graduating of granite into volcanic rocks; it is indeed what we would naturally expect to see, wherever subsequent upheavals have exposed extensive granitic and trappean regions.

To facilitate the application of these remarks to the Himalaya mountains, let us make a theoretical section from the south-west to the north-east across the Silurian Archipelego of Kashmir and the sea to the north-east of it.



Theoretical Section for the S. W. to the N. E. across the Silurian Archipelago of Kashmir.

This theoretical section shows us a succession of volcanic islands or maritime or sub-aqueous volcanoes of which the base is a mass of melted matter, destined to solidify as porphyry, trachyte and other volcanic rocks, whilst the melted materials situated further from the vents are to solidify as granite. Over the granite, we find the crust more or less intact, though metamorphosed into gneiss, schist and marble; over the porphyries and trachytes we find that it has been removed and torn up by the ejecting power of the melted mass making its way to the vents. Over and between the volcanoes, we find a very thick bed of ashes, broken stones, agglomerates and lavas. Over the granite we find, after the gneiss and schists, stratified deposits of Silurian shales and limestone. After the extinction of the volcanoes, we find the whole sea-bottom covered with the fragments of animals of the Carboniferous period; and thus do we see in Kashmir the Carboniferous limestone resting conformably on the volcanic rocks, and not disturbed by their intrusion.

Of course many changes, oscillations, denudations and depositions took place between the extinction of the Silurian volcanoes and the great final upheaval of the Himalayas; but these changes do not appear to have been on a sufficiently grand scale to have affected, to any great degree, the lithological features of the earth's crust, in the portion of the globe we are considering. At the final upheaval, a series of new fissures were formed and are represented in the diagram above, and the position assumed by the several slices, between these fissures, is represented by the dotted outline. There are many more parallel fissures, I have no doubt, but they did not cause a great upthrow of one of their edges, and have therefore little to do with the general configuration of the Himalayas.

The position of the fissures, *between* the old volcanic lines, and not *on* them, has produced the phenomenon that nearly all the highest peaks of the Himalaya are not situated on the chain to which they belong, but a little distance from it. The fissures, taking place in the weakest parts of the crust, followed the old valleys between the lines of volcanoes, and the volcanic masses are therefore superior to the chain formed by the edge of the fissure by the height these volcanic masses originally possessed. It is also reasonable to admit that the movement of upheaval was more powerfully felt by huge masses of prophyry, trachyte, granite, gneiss, &c., which cannot be easily compressed or folded, than by the flat beds of dusts, slates, lavas, ashes and fossiliferous rocks.

87. Glancing now at the Afghan mountains, we find that their chains have a steady direction from the north-east to the south-west. We find also that, as far as has been ascertained, the dip is invariably N. W. or W. N. W.; that is, presents the same phenomenon as in the Himalaya, of the beds of rock rising towards the plains of India. This dip is that of all the rocks of the trans-Indus districts; it is that of the beds in Verziristan, and of most of the nummulitic strata in Hazara, and indeed, wherever it has been possible to examine it, it has been found to be north-westerly. We cannot therefore refuse to admit, that the strike of the Afghan mountains meets the strike of the Himalayas, and the dip of the latter being North-easterly and that of the former North-westerly, we are justified in concluding, that the whole of these huge mountains forms one and the same system of upheaval; that a tremendous dome or swell did surge up in the region of our Silurian volcanic archipelagoes, and that the Himalayas on one side and the Afghan mountains on the other are faulted slopes of a gigantic oblique anticlinal!

A true anticlinal it cannot be called; it is more properly the result of an incalculable force pressing outwardly the crust of the earth and endeavouring to raise it into a dome; and as such a dome could neither be raised nor settled down again without much fracturing of the crust of the earth, the lines of fracture followed the direction of the old volcanic lines, and on one side ran N. W.—S. E. (Himalayas) and on the other N. W.—S. E. (Afghan mountains).

No good explanation has yet been advanced of the general N. E. dip of the Himalaya; none has even been attempted of the N. W. dip of the Afghan mountains. By placing the axis of the dome between these two masses of mountains, and considering these mountains as the opposite jambs of an oblique anticlinal, the singular dip of both is satisfactorily explained.

88. Pl. XI. is intended to give an idea of the great fissures of the Afghan-Himalayan system of mountains.

We must not forget that the fissures went through portions of the crust, having a much greater power of resistance in some places than in others, being here brittle, there tenacious, here rigid and there easily bent; and we must not expect too much regularity in the fissures, but be prepared for occasional deviations from the general direction. The Miocene beds, which present the greatest uniformity of formation, have everywhere the most regular strike, in spite of their numerous foldings and faults; the great beds of felstone are also tolerably regular in their general dip, and so are the great beds of Carboniferous limestone in Kashmir, though of course the smaller beds, especially those close against high summits, have a local dip and strike. The interminable masses of metamorphic schists, described by travellers in several parts of the Himalayas, have also a steady N. E. dip, and Captain R. Strachey tells us that in that portion of the Himalayas which he examined, the N. E. dip was the general one. On the Afghan side of the oblique anticlinal the Miocene again presents the greatest regularity, and the Nummulitic formation nearly equals it; the dip of both these formations is very steadily towards the N. W.

Another cause which has no doubt contributed to break the uniformity of the parallelism of the chains is the pressure, in some places, of such enormous accumulations of volcanic porphyry as we see at the Kaj-Nag and in Kistwar and Badrawar. These centres of volcanic rock appear to have been very huge; they were undoubtedly solidified long before they became upheaved, as they were formed during the Silurian epoch, and did not receive their upheaval until the Tertiary period had been nearly run out. They were, therefore, raised up bodily as solid masses, and they had been too huge to arrange themselves in the general parallelism of the fissures. I have represented them in the plate as huge centres of volcanic action, regarding them as too enormous to be displaced by even the force which has uplifted the great dome of the Afghan-Himalayan system; they were merely forced up. The Sufed Koh and the Koh-i-Baba in the Afghan mountains occupy a similar position in relation to the parallel chains; the first named is probably a volcanic mass, and I have assumed that the other is likewise a porphyry centre. It is probable that certain granite masses have acted in a like manner; but it would be of little profit to speculate about those masses, knowing at present nothing positive regarding them.

The fissures just described being once formed, we have no difficulty in understanding how the slices of crust between them were compelled to remain in an oblique position, viz. dipping N. E. and N. W. respectively, when the settlement took place, if we remember, that a great deal of granite, lignite, porphyry, trachyte, &c. buried under the surface before the upheaval, had now been forced up and occupied a great portion of the room; unable to find space enough to resume a horizontal position, these bands of the earth's crust became impacted in the position we now see them.

89. Coming down from the high regions of the Himalaya and of the Afghan mountains to the Salt Range and the hills of the district of Bunnoo, we notice the interesting phenomenon of the tilting up of the angular extremity of the piece of crust that had been broken off, between the converging fissures of the Sub-Himalaya and the Sub-Afghan hills. This crop-fracture is just such as we see near the point of an angular piece of a window-pane which has been starred by a blow. The dip of the Salt Range and the Bunnoo hills is consequently disposed in a somewhat converging manner, such as is indicated by the arrows in Pl. XI.; the crop fracture is not a straight line; it is a succession of segments of a circle, and the dip of each segment is converging more or less towards the centre of its circle.

It is, however, possible that this breaking of the tip of the triangular piece of crust is only apparent, and that the segmentary and converging dip of the beds may be due to a complexity of resultant forces, at the place where the N. W. and N. W. dips meet.

To the south of the Salt Range extend the vast plains of the Punjab, Ajmeer and Marwar, covered mostly with clay and sand, often a desert without a hill or even a mound to relieve the monotony, and with hardly a pebble to be found for some hundreds of miles. So far south as Lat N. 27° these great plains extend without a break, and then we find the volcanic rocks of Central India, supporting here and there beds of sandstone with mammalian bones* similar to those which are so well developed in the Sub-Himalaya and Sub-Afghan ranges. Whether the whole, a portion, or none of the volcanic rocks of Central India are contemporaneous to those of the Himalaya, I know not,

* Bones of extinct mammals have been found in the Valley of the Nerbudda. South of Lat. N. 21°, no Miocene has ever been found.

though it is highly probable that some at least belong to the same epoch. I think it would be a most interesting point to study, whether the Central Indian Mountains participated in the great upheaval of the Afghan-Himalayan system, and to what extent they did so. Such a subject is not, however, to be discussed here, *en passant*. We must know more of what is buried under the alluvial sands and clays of the Punjab and the desert of Ajmeer, before we can decide on the relations of the Himalaya and Central Indian Mountains. The study of the Miocene beds appears the most likely sort of research to lead to interesting results. Could we once show satisfactorily that the plains of Northern India have been one day, and that not long ago (geologically speaking) a rugged country covered with Miocene hillocks and ridges, we should soon get an insight into the participation of the Central Indian Mountains in the great Afghan-Himalayan upheaval, and also into the nature of the soils and sub-soils of Upper India.

90. Let us now endeavour to sketch a geognostic history of the Afghan-Himalayan system of mountains, in accordance with the observations and hypotheses recorded in this paper.*

In the days of the Silurian epoch, the centre of Asia may be assumed to have been a sea uniting the Arctic to the Indian Ocean. In the middle of this sea, an archipelago of volcanic islands and subaqueous volcanoes existed, displaying great activity and ejecting into the sea an immense quantity of matter.

The position of these volcanoes and subaqueous vents is now represented by the porphyritic masses of Kaj-Nag, of Kistwar and Badrawar, by the summits of the catenated chains of Kashmir, &c., &c. The volcanoes were linear in their arrangement; one line, that of Kaj-Nag, Badrawar and Kistwar being continued far towards the south-east; and it is probable that the peaks of Chor, of Dodatoli and others in the same districts, are volcanic peaks on the same fissure. Another line or rather series of lines is that of the catenated chains in Kashmir, with a probable S. E. extension in the range of mountains which separate Lahool from Chumba. Another line again is that of Drass and Karghyl, at the back of the Ser and Mer

* A few unavoidable repetitions which occur in this portion of the paper will, I hope, be excused.

chain, and which is continued far towards the S. E., forming numerous and considerable volcanic mountains which appear as islands and promontories above the flat plain of the great Thibet plateau, through which the Sutlej runs.

These lines or fissures had a direction N. W.—S. E. and were all parallel, but the activity of the volcanoes was not the same on all the lines or in different parts of each line. Thus, in the line of Kaj-Nag and Badrawar, Chor and Doḍatoli, the north-western end of the line is eminently distinguished and marked by very numerous and very long volcanoes, whilst the eastern one only gave passage to a few vents separated from each other by considerable intervals. On the other hand, (on another line) in Ladak, the volcanoes appear to have been small and few, whilst the eastern ends of the fissures appear to have been marked with many volcanoes of great size and activity. No volcanoes appear to have existed in that portion of the Silurian sea, where we now have the high mountains of Kailas and Karokoram; but where the Kuen Luen chain was at a later age to appear, it seems, that one or two lines of linear volcanoes did exist at the beginning of the Palæozoic epoch.

How long, how many thousands of years these volcanoes kept at their work, it is impossible even to guess. Their activity was immense, and it appears that in the waters which bathed the shores of the volcanic archipelago, too many outlets kept continually pouring out hot ejecta and noxious vapours to have allowed life to be present. We have seen that there is considerable evidence of the sea-bottom having been frequently heated enough to become cellular and amygdaloidal, and a reference to the section of the Tukt-i Suliman in Kashmir will, I think, leave little doubt of the frequency, the violence and the abundance of the discharges of lava, of lapilli, of ashes, and of hot liquid mud, We therefore find no Silurian fossils in Kashmir, and the slates and sandstones which are interbedded with the volcanic ejecta are completely deprived of fossils. This want of organic life did not, however, affect those portions of the sea which were sufficiently distant from the subaqueous craters and volcanic islands to escape the destructive effects of ejected materials; and we find, therefore, in the Karokoram chain and also in the Himalaya, between the Sutlej and the Kali, large beds of Silurian rocks with the usual fossils. These rocks are, as we have seen, slates and shales which have until now proved azoic, but covered in by limestone rich in forms of the older Palæozoic period.

I need hardly say that the azoic slates, shales and sandstones which are interbedded with the ashes and amygdaloids in Kashmir are of Silurian date; if we wish, therefore, to colour a map of Kashmir solely in regard to the age of the rocks, we should have to colour all the ashes, slates, &c. Silurian. As the volcanic ejecta much predominate in quantity over the azoic slates and sandstone, I have not coloured the mass solely by age, but rather in view of the nature of the rocks.

But the Himalayan lines of insular volcanoes were not the only ones in that portion of the Silurian sea which we are considering; other linear volcanoes were directed from the N. E. to the S. W. in the longitudes and latitudes where we now find the great Afghan mountains. We know very little of these mountains: we have seen, however, that volcanic rocks of a granitoid appearance form the ranges of hills between Yeusofzaie and Bonneyr, and that clinkstone, granular and porphyritic, is quarried at Jellalabad. Dr. Bellew also tells us that he noticed volcanic rocks amongst the southern spurs of the Sufed Koh.* He also mentions that sharp earthquakes are frequent in the valley of the Korum, and it is reported by the Povindas who trade through the Gulwaira Pass, that a city situated at the back of the Suliman chains has been destroyed by a terrific earthquake. I need not point out the usual relation of severe earthquakes with accumulations of volcanic porphyries, in countries where no active volcanoes have been known to exist for several geological ages past. Then we have seen that the summits of the main chain of mountains, in the Vuzeeri country, are mostly composed of volcanic rocks; but the greatest amount of evidence is

* After crossing the hill-pass of Hazrah-Shutur-Gardan, the road lies through a gorge, and a stream or rivulet flows to the westward; in the bed of this rivulet pebbles of porphyry, hornblende and syenite (?) were seen; the surface of the soil was also covered with similar pebbles............Near the top of the Shinghai Kothul, the volcanic rocks were again seen: Dr. Bellew says: "The surface was strewed with great blocks and fragments of porphyry and syenite, the latter was of various shades, from yellowish-green to greenish-brown, and its fragments shone with a vitreous lustre and broke with a similar fracture." *Chapter II. Narrative of a Mission to Kandahar.* The above description of syenite does not look much like syenite, it is nearly certain that the rock observed was a hypersthene rock.

derived from the boulders brought down by torrents and from those formerly carried down and now imbedded in the Miocene conglomerates which fringe the base of the Afghan mountains. These boulders and pebbles are mostly greenstone, felstone, trachyte, and porphyry identical with the Himalayan hornblende rock; and that peculiar variety of amygdaloidal greenstone, pierced with gas-vents, which has been described at No. 4 of the section of the Tukt-i-Suliman in Kashmir, para. 18, occurs in great abundance. (See also Pl. x. figs. 1. 1*a*.)

There can be, therefore, no possible doubt that the Afghan mountains were at the Silurian epoch an archipelago of volcanic islands and subaqueous volcanoes; indeed, they were merely another group of the same great archipelago; but the fissures or lines on which the vents were situated had a direction N. E., S. W.

Towards the end of the older Palæozoic epoch, the volcanoes appear to have subsided in violence, and allowed the waters of the neighbouring sea to cool. They did not do so, however, until they had ejected so much lava, scoriæ, lapilli, ashes, and debris of the inside of the earth that a great bar, a bar going from the North-west to the South-east and studded with the island-cones of half extinguished volcanoes, had been formed across the sea. A similar bar was produced by the Afghan group of volcanoes, directed N. E., S. W. and the two bars formed a gigantic V, with the angle pointing to the north. On these bars the sea was shallow; neither was it likely to be very deep between the two branches of the V. The end of the great activity of the volcanoes appears to have been marked by the breaking out of a great number of fumaroles or hot springs, depositing an immense quantity of silica, and forming thick beds of quartzite, sometimes pure and clear as glass, sometimes white and opaque as porcelain. We must not forget also, that all analogy points to a general rising of the sea bottom at the north-east of the Himalayan volcanic bar, not as a break, but as a gradual and slow upheaval of the earth's crust under the pressure of viscid granite.

But even these last efforts of the great volcanoes, these bursts of vapours and hot waters, became rare and intermittent, and animals made their appearance in the creeks and bays of the sea between the islands. It was then the dawn of the Carboniferous epoch, and all over the great bars of volcanic debris a calcareous mud was deposited, teeming with the remains of animals, with the glimmering shells of the *Producti*, with large flat *Orthidæ*, and innumerable *Bryozoa* and numerous *Encrinites* which grew luxuriantly on the half chalky, half clayey, fœtid bottom of well protected island seas, gulfs and channels. And so it went on for years and years, until the sea became too shallow for *Producti* and *Orthidæ* to live in, and too easily disturbed to its very bottom to suit the delicate *Bryozoa*. These animals retired to greater depths on either side of the great bar, and in their stead appeared small *Cucullæ*, globular *Terebratulæ*, with here and there, on sandy banks, colonies of large *Cardiniæ* or *Anthracosiæ*, gibbose and smooth *Aviculo-pectens*, or radiated ones of great size. In calm waters, flat and large species of *Goniatites* basked in the sun in company with small *Orthoceratidæ* and large species of *Bellerophon*. Earthquakes were, however, frequent and terrible, raising and depressing large tracts of sea-bottom, folding and undulating the newly formed beds of limestone, so that most of the shells are found broken, and many of them are deformed to a wonderful extent.

Many changes occurred in the sea: clay and sand had been brought down in large quantities from the volcanic islands, and many of the creeks and inland seas were turned into swamps. Long shelving coast-lines extended from island to island, and many groups of the great archipelago were probably united by a low land into larger insular countries. The genera *Cucullæa*, *Cardinia* and *Aviculo-pecten*, and small *Brachiopoda* disappeared; and in their stead myriads of *Gasteropoda*, especially the *Pyramidellidæ*, living with numerous corals, made their appearance. As the islands joined more and more into larger dry lands, and approached nearer to a long strip of land supporting numerous peaks of extinct volcanoes, the rain-fall increased more and more, sand, mud and gravel accumulated in thicker beds at the mouth of the mountain torrents which now became rivers, and on the swampy shores forests of calamites and other trees grew up, whilst, out at sea, the mollusks and other animals continued to thrive at various depths, according to their kind. What has now become of these forests of calamites? Have they been buried in sands by oscillations of the coast and converted into coal? If they have, has the coal been denuded at a subsequent period? or has some portion of it escaped removal and does it now lie concealed under newer formations? There is no doubt that great denudation has taken place repeatedly in the Himalaya and subordinate hills; yet basins nicely protected by eruptive or metamorphic rocks, bottoms of valleys or down-thrown beds might have escaped removal. Not a trace of true coal has yet been found in the Himalayas, the Punjab or the Afghan mountains, excepting (geologically speaking) the few grains of coal which fill in the cellular tissue of the lepidodendron-like plants described in para. 43, as having been found in one of the layers of the Wean group. This is not very encouraging; but any person who has observed what a thick mantle the Miocene sandstones and the old and new alluvia form over the older formations, would not expect to find coal cropping out in a conspicuous manner. If coal does exist, it will be one day discovered, no doubt; but the discovery will be made by patient and careful study, and not by digging at random with a pickaxe wherever something black is observed. It may be said with truth that the means hitherto employed, by Government or persons interested in the search for coal, have been such that not the smallest reasonable chance of success could be anticipated.* But all this is foreign to our subject.

91. The end of the Palæozoic epoch or beginning of the Secondary period was marked by new volcanic action, trifling indeed, if we compare it to the intensity of volcanic power displayed during the Silurian time, but yet highly interesting. I allude to these local outbursts of hot vapours, gases and waters, charged with several minerals, which have taken place in many distant places of the Himalayas and their dependencies. The action is geyserian rather than volcanic, as no true volcanic rocks, that is, no lava, no scoriæ and no ash appear to have been discharged by these vents. The existence of this force is mostly manifested by the metamorphism it has caused in some of the upper beds of the Carboniferous limestone, and by the peculiar way it twisted rocks, then soft, in a manner which appears now incomprehensible, and totally abnormal to the surrounding layers. In some localities, however, it seems that the waters, erupting through the calcareous mud, were so rich in felspars, that this crystallised in

* This remark applies only to the Punjab and the mountainous districts studied in this paper.

minute crystals which now form a sort of intrusive band of a friable incoherent rock.

When this geyserian action subsided, the Palæozoic animals had died out.

92. I now enter upon debatable ground. I have said before, that the salt, gypsum and red marl of the Salt Range—and I need hardly say the gypsum and red marl of Spiti, the gypsum of Rukshu (and that of Rodok?), and most probably the salt of the Yarkandkash valley, and also that of the Lataband mountains in Badakshan, all belong to the same epoch and have probably a common origin. I have said before that, this Saliferian formation has been placed by Dr. A. Fleming in the Devonian. Dr. Jameson makes it superior to the Carboniferous; Major Vicary and M. Marcadieu believed it to be Miocene or Pliocene; some will have it volcanic, others sedimentary; but nobody gives a good and well defined section of the relations of this formation to the rocks above and below it.* This is much to be regretted, and I will not increase the confusion by discussing here the reasons which make me believe that the salt and gypsum of the Himalayas belong to the Trias or the Permian. My opportunities of observing the Saliferian formation have been few and of short duration, and I have no good section to give in support of my opinion. I shall therefore refer the reader to the note to para. 64, and proceed with the next formation.

93. Whatever had taken place beeween the end of the Carboniferous epoch and the beginning of the Jurassic, it appears tolerably evident that the Jurassic sea bathed the shores of a long strip of land or succession of large islands, very similar to those which the Carboniferous sea had bounded. The Jurassic sea does not appear to have been much deeper than the Carboniferous one had been; the same impurity of the limestone is noticed, the same admixture of sand and clay with the calcareous matter, the same rarity of clean drifted sands, the same prevalence of thin-bedding, false-bedding and continual

* Dr. A. Fleming gives some sections in his Report on the structure of the Salt Range; but only two of these show the relations of the salt marl to the Carboniferous limestone, and in one, sect. No. VIII., a number of more or less theoretical faults are introduced which, if placed at the base of the mountain limestone escapements, would then make this rock inferior to the salt. Another section, No. VII. shows an anticlinal across a ravine, and then the salt marl appears indeed to be placed under the Carboniferous limestone.

change of the nature and weight of materials. All these conditions, and the frequency of ripple marks, indicate a shallow sea easily influenced by heavy outpours of muddy waters from the land. The thickness of the Jurassic rocks vary veries much, and the extent of the beds is limited to very small areas, compared to those of the Carboniferous. This is probably due to the deposition taking place in creeks of a deeply indented coast, and in great part to the oscillations of the land and sea bottom, causing in some localities repeated denudation of materials newly deposited, and in others a steady sinking and consequent thickness of formation. The fossils being frequently much deformed, is a good evidence of these oscillations having taken place.

The Jurassic beds have always been considered conformable to the Carboniferous. I am inclined to believe that this conformity is only apparent. The dip of both formations is generally great, seldom under an average of 45°. In such highly up-tilted beds, a difference of a few degrees is not easily appreciated, unless a careful measurement is taken, and I fancy that most writers have been satisfied with an approximation. However this may be, there is no doubt that the Jurassic limestone presents, in very many places, indeed in most, the appearance of having sustained very sharp local upheavals, soon after the end of the Secondary period, but of little extent; and here again we find the salt, gypsum and red marl always underlying these sharp and dome-like anticlinals. We remember how Sheikh Bodeen is thrown into a succession of short, gothic, arch-like anticlinals; and that under the Jurassic beds the Saliferian are to be seen, perfectly conformable to the limestone and following it in all its oscillations. At Maree on the Indus, a similar appearance occurs: thick masses of salt, gypsum with bi-pyramidal crystals, quartz, red marl and magnesian mud stone more or less cellular, support a very sharp anticlinal of Jurassic limestone; and the Saliferian and Jurassic are conformable not only in general dip, but in all the details of the fold. Moreover, both the Silurian and Jurassic dip S. (2 or 3 degrees E.) and N. (2 or 3 degrees W.) on both sides of the anticlinal dip, which are not the usual ones of the other rocks of that portion of the Salt Range, the Nummulitic and the Miocene dipping N. E.

Whether these local upheavals are merely due to the swelling of the gypseous beds from the change of anhydrite into common gypsum by absorption of water, is more than I can say. The Saliferian beds would naturally break, dislocate and lift up the superincumbent Jurassic when swelling itself into undulations. We should thus obtain undulated beds of Saliferian and Jurassic. Let such undulated layers be submitted to the lateral pressure which must have accompanied the great upheaval of the Afghan-Himalayan system, and we have the undulations folded into arches and sharp bends.

The Saliferian and Jurassic have been very much denuded, their debris being extremely abundant in some beds of conglomerate and sandstone of the Miocene, especially on the western side of the Indus, in the districts of Kohat and Bunnoo.

94. There are but few traces of the deposits which may have taken place between the Oolite and the Nummulitic, and I have never myself seen any cretaceous rocks in the western Himalaya* or the Afghan mountains, neither have I found any pebbles with cretaceous fossils in the conglomerates of the Miocene. From the development of considerable vegetation in the shales near the base of the Nummulitic formation, it is evident that a steady rising of the land went on during the time of the upper Jurassic and Cretaceous periods, and with such a rising we would naturally associate the great denudation of the Jurassic beds, soon after their deposition. Little doubt can be entertained that during the Cretaceous period, the Himalayan and Afghan islands had become united into a continent of considerable extent, traversed by chains of extinct volcanic ridges, and therefore receiving an abundant rain-fall which caused great denudation. We know how quickly volcanic mountains decay, when once they have ceased to receive fresh supply of ejecta. I believe that the cretaceous beds which have been found in and near the Himalaya are very limited in extent, even more so than the Jurassic beds. The small horizontal area of these Secondary beds contrasts widely with the great superficial extent of the Carboniferous, the Nummulitic and Miocene formations; and yet when they do occur, the Jurassic beds at least have considerable power. A continent with a deeply indented coast appears to be indicated by these peculiarities of the Secondary beds.

* Dr. Stoliczka has found Cretaceous rocks in the mountains of Spiti. *Editor's note.*

95. The Nummulitic epoch must have been a long one, if we can judge by the thickness of its deposits. There does not appear to have been any violent volcanic action, nor any great and sudden movement during the period, but there was a great deal of very slow and probably imperceptible oscillation. Thus we first find the base of the Nummulitic to be generally a sandstone without fossils,* this is gradually impregnated with calcareous matter, becoming a sandy, very impure limestone, full of shallow water fossils and containing only a few very small species of Nummulites. This has been therefore a period of slow and trifling sinking of the land, and it is probable that the sea never covered it by more than a few feet. Then the oscillation went the other way, and the land appeared again, and was covered by forests. Another slow sinking brought on a fresh incursion of the sea, which soon covered the forests (lignite) with a layer of limestone, full of large Nummulites and other shells. The depth of the sea was greater than before the growth of the forests, but it probably did not much exceed 20 fathoms. Another movement upwards again exposed the land, and again forests grew and formed thin seams of lignite. Again the land sank and the sea covered in the lignite-beds with calcareous mud. At first the depth was trifling, little exceeding 20 fathoms, but the sinking continued to the end of the Nummulitic period, and the limestone assumes more and more the appearance of a deep-sea formation as we get higher up the series. It is, however improbable that the volcanic mountains of the great bars of the Himalaya and Afghan mountains were ever covered by the Nummulitic sea, as no nummulite has ever been found amongst the central chains;† but that sea filled up the whole of the space between the arms of the great everted V formed by the Himalayan and the Afghan chains, and probably also bathed the outside shores of the arms of the V. This slow, gradual and long continued sinking of the land, during the deposition of the Upper Nummulitic formation, accounts for the appearance of no great depth in rocks which have

* Sometimes a fragile limestone with *Planorbis,* and probably fresh-water. See note to para. 66, chap. iii.

† Dr. T. Thomson reported having observed Nummulitic Limestone in Little Thibet at an elevation of 16,500 feet. But I much doubt the accuracy of the observation, and cannot help imagining that the Thibet nummulites are, like those of Manus Bal, weathered encrinite rings. See "*Introduction,*" page ii.

a very considerable thickness; the sinking was, however, greater than the amount of deposit could compensate, and the rocks have therefore the appearance of a tolerably deep sea formation at the top of the Nummulitic series. Then again, we have a long and steady rising of the land, and in consequence a great denudation going on, a denudation which has caused the removal of a great deal of the Nummulitic formation, in localities where sea-currents, high-tides and other unfavourable circumstances assisted in the work of destruction. It is curious to notice on the top of the Nummulitic limestone, how the surface of the rock has been broken by the waves; how the fragments have been rolled and rubbed and then glued together again. This appearance is always seen as a bed of transition between the Nummulitic and the Miocene. A considerable time must have elapsed between the end of the deposition of the bed and the breaking up of it, as we must allow time for its solidification. But at any rate, here, at the beginning of the Miocene epoch, we had the Nummulitic limestone forming a nearly horizontal and far-reaching sea-coast, covered with a very thin sheet of water, rolling and polishing pebbles. But this conglomeratic layer is thin, and we very soon see a large quantity of mud and sand, and pebbles of far distant rocks, brought down to the sea.

96. Let us consider the kind of map we have at the beginning of the Miocene epoch, and we will have no difficulty in understanding the formation of the Miocene sandstone and conglomerates of the Sub-Himalayan and Sub-Afghan chains. We have an immense expanse of sea, north of the tropic of Capricorn, between the latitudes 90° W. and 90° E., for, in these days, the Andes had not yet surged up and most of South America was under water, as well as nearly the whole of Africa, Arabia, Persia and India. There were probably groups of islands where these continents now stand, but the immense, dry, thirsty plains and plateaux of these countries were then under the sea. There was therefore no impediment to the regular play of the Trade Winds, no monsoons or winds deviated by the rarifying power of arid deserts, but especially no chains of mountains to dry the S. E. trade-winds before their arrival at the equator, and their ascending to become upper currents with a direction to the N. E. At the tropic of Cancer, these winds, still charged with the whole of the

humidity they had sucked from the sea in the Southern Hemisphere, descend again and become under or lower currents, keeping their N. E. direction.* Before proceeding far, these winds meet a couple of ranges of mountains forming a great everted V, opening to the south, and on these ranges they poured such a quantity of rain that a denudation began to take place to an amount nowhere else exemplified. The only approach to this rain-fall is that now observed in Patagonia, a high country which happens to be situated in the Southern Himisphere, somewhat in a position analogous to that of the Himalaya in the Northern Hemisphere during the Miocene epoch. In Patagonia "Captain King found the astonishing rain-fall of "nearly thirteen feet (151 inches) in forty-one days; and Mr. "Darwin reports, that the surface water of the sea, along this part of "the South American coast, is sometimes quite fresh, from the vast "quantity of rain that falls."†

We are now therefore prepared to anticipate a formation composed of coarse debris of the older mountains, washed down by violent torrents; we understand how it is that the waters of the sea lost their saltness, and that marine shells deserted these regions, and are therefore not to be found as fossils, or are at any rate excessively rare. The continual and violent rushing of streams, charged with mud and boulders, did not allow of the development of fluviatile animals; and thus we find the lower Miocene a mass of clay, sand and large boulders, in beds considerably false-bedded and totally free of fossils, with the exception, in a few protected localities, of some bulrushes imbedded in salt. These torrents occasionally tore up forests from the mountain sides in their headlong course, and thus it is that we find here and there small niduses of semi-carbonized wood, interred in the sandstone. The masses of conglomerate, accumulated in certain places, are of tremendous size, and probably mark the exit from the hills of the principal torrents of the Miocene Himalaya. The deposit of this coarse debris of the old volcanic chain and of the several deposits which had become gradually accumulated round it, attains a thickness of no less than 5,000 feet, and probably in some places much more. This mass of

* See for a general explanation of the routes of the winds and the causes which alter these routes, the work of Captain Maury, L. L. D., U. S. N. entitled, "The Physical Geography of the Sea and its Meteorology."

† Maury's Physical Geography of the Sea and its Meteorolgy. Page 129

clay, sand and boulders could not fail to convert the sea, which we have seen was shallow, into dry land, and thus we have this overlapping of the Upper Micoene on the edge of the Lower which is represented at para. 11. The Lower Miocene was itself exposed to the denudating influence of the rain, and boulders of Lower Miocene sandstone are common in the Upper Miocene.

The Upper Miocene appears to have been altogether a fresh-water formation; I mean, an accumulation of materials brought down by rivers of large size, which, in all probability, wandered through the flat plains of the lower Miocene, and extended in deltas and marshes and creeks, just as the Ganges and the Indus are observed to do now-a-days. We may fairly imagine these Miocene tracts to have resembled closely a modern Indian plain traversed by large inundating rivers—a thick jungle of high grass and small trees for the elephant, the mastodon, the monkey. and a host of other animals to dwell in, and on the sides of the large meandering rivers, wastes of sand and clay, shallow pools and quicksands for the delight of the crocodiles, the tortoises and the hippopotamus. On sands left dry by changes in the course of the rivers, or piled up in undulating hillocks by the winds, grew thinly planted trees, such as we now see in the sandy tracts of Scinde, to feed and shelter the camel, the giraffe, and innumerable deer of various species; and on intermediate lands, good pasture supported the horse, the ox and sivatherium.

In the districts of Rawul Pindee, of Jheelum, of Bunnoo, of Kohat, the Upper Miocene has a thickness of more than 2,000 feet; but in the Rajaori and Poonch provinces of the Maharajah of Jummoo's kingdom, the bed attains a much greater thickness.

Any one who travels through the plains of the Punjab will notice the great quantity of cows, of oxen and horses seen loose on the sand near every village, and will remark at the same time, that when a stream has cut through the sand and thus exposed a section, not a bone is seen buried under the surface. If, however, he comes to a marsh, such as the one near Guriwall, in Bunnoo, he will observe that the bones will remain perfectly preserved in the thick mud, saturated with *kullur*,* which forms the bottom of the

* Impure Sulphate of soda, with a little carbonate of soda and chloride of sodium, which impregnates, more or less, nearly the whole of the soil of the Punjab, and effloresces on the surface after rain or irrigation.

marsh. Now this *kullur* appears to have existed in the soil of the Upper Miocene, as the sandstones of that age are often covered with an efflorescence of that salt; and, indeed, that now seen in the alluvium is derived from the disintegrating, decaying and washing away of the Miocene beds. The fossil bones are always found either in a dark clay-stone, which has a bitter taste when applied to the tongue, or in a light-coloured sandy claystone. It is therefore highly probable that the existence of a marsh or swamp is necessary to the preservation of bones and their fossilification. This accounts for the bones being found in beds of limited extent, whilst for many miles not one is to be discovered; but it also brings additional evidence that the Upper Miocene was deposited as a growing delta, similar to the Sunderbunds of the Ganges and to the creeks of the mouths of the Indus.

What a singular landscape this belt of land must have presented! If we remember that at least seven different species of elephants roamed in these jungles, some much larger than the living one, and with tusks nine feet and a half long; that the dinotherium had a skull three feet and nine inches in length; that the mastodon was 17 feet long from the tail to the end of the tusks; that the sivatherium was a gigantic four-horned antelope-like animal; that the crocodiles were much larger than they are at present, and that the tortoises had a shell measuring 20 feet across; we may wonder indeed at the strange appearance which the jungles must have presented!!

I have called this fossiliferous formation Upper Miocene. In placing it in the Miocene, I have adopted the general opinion of geologists, but it may be Pliocenic and not Miocenic. I have not succeeded yet in discovering shells in these beds, and without shells it is impossible to fix with certainty the age of the formation.

I have forgotten to notice, that during the whole of the Miocene epoch there was a slow and steady sinking of the land. This sinking allowed of the accumulation of materials to the great thickness I have indicated, but unlike that which took place during the Eocene period, it was not sufficient to keep the country under the sea, the quantity of sand and clay and boulders, deposited by the rivers, being more than adequate to compensate for the sinking. The country, however, by the sinking was kept to a very little height above the sea level, and the inundations of great rivers added continually to the thickness of the deposit.

97. There is no evidence of any violent action having taken place during the Eocene and Miocene epochs. There had been risings and sinkings of the whole country, but these were imperceptible to the senses, and were probably not more active than the same phenomena which now occur in many parts of the world, unknown to the inhabitants. The belt of flat land had increased to a good breadth, and the coast had become sufficiently distant from the mountains to enable the animals to live in peace and plenty, away from the storms and torrents of the hills, when the whole of the portion of the earth we have been considering was raised into an immense vault, by the forcing up of granite assisted by gases. When the gases condensed or escaped, the arch settled down by fracturing its sides, and these faulted sides of the arch are now, what we call the Himalayas and the Afghan chains of mountains.

When the settle-down began to take place, and the sides of the arch or vault were being broken, the direction of the linear volcanoes of the Silurian epoch compelled the new fractures to conform to it. On the eastern slope of the vault, the fractures ran from N. W. to S. E., on the western slope from N. E. to S. W. As is generally the case in an anticlinal, the highest portion of the vault settled down again to a level much lower than the sides, and we have therefore, in the northern Punjab, low hills, whilst on each side we have mountains towering to the sky.

It is not necessary to enter here into all the details of the complications which the masses of porphyry, trachyte, granite and other rocks, which had been cooling ever since the middle of the Palæozoic epoch, caused in the upheaval of the Afghan-Himalayan vault and in its settle-down. These details have already been sufficiently indicated in paras. 81 to 87. But I will insist on the effect of these masses being forced up like wedges through the rocks which covered them, and by their filling up a great deal of the space once occupied by these covering rocks, they compelled these last to be either folded or broken into pieces and packed edgeways.

It is not necessary to imagine that the top of the vault was raised to the same height as we now see the great peaks of the Himalayas.

In the settle-down, the parallel zones, into which the sides of the vault were broken, would naturally assume an angle of dip much greater than was that of the vault previous to its fracture, as the sides of the vault, in coming down again, would be submitted to considerable pressure, and therefore much redressed. It is not unlikely, therefore, that it is the effect of this pressure which has caused, in many mountains of the Himalayas, the appearance of younger rocks dipping under older, of felstone under porphyry, of schist and gneiss under granite.

The geologist must naturally expect to find a great many complications amongst these immense mountains. The view I have endeavoured to explain is a general one, and will, I hope, be better substantiated when we know more of the countries of the Afghan-Himalayan system. With a little thought, I entertain a hope that the geologist, in finding apparent contradictions to what I have advanced, will always be enabled to discover the cause of the complication, at first apparently irreconcileable to my hypothesis.

There is one more remark to be made. The direction of the Silurian linear volcanoes of the Himalaya not being parallel to that of the Afghan chains, we have not a true anticlinal, but an oblique one. At the northern end of the axis of this oblique anticlinal, we have therefore a pressing of the sides one against the other, whilst at the southern end, we have a wide divergence of the ridges : at the northern end of the axis, we have the chains abutting one against the other, and thus supported at a great height; at the southern end we have the central beds unsupported and sunk down very low when the settle-down took place; hence the high plateau of Pamer at one end and the low plains of India at the other. Again, when the Himalayan slope of the anticlinal was settling down, many of the great masses of porphyry, schist and gneiss resisted the general tendency to dip N. E., and caused a local fault to take place. This fault acted as the axis of an anticlinal for the locality immediately surrounding the mass of porphyry, schist or gneiss; and we find therefore such huge masses assuming the dip of the western branch of the Afghan-Himalayan anticlinal, or dipping N. W. Hence, the singular phenomenon, long ago noticed by Captain R. Strachey, that some of the great peaks of the Himalayas dip N. W., whilst all the beds round them dip N. E. It is also this same obliquity of the anticlinal' which has caused these numerous transverse faults observed in the Himalaya, which have a general direction from N. to S., and with the beds crushed one against the other at the northern end, whilst the fault gapes at the southern extremity.

All these phenomena, and several others which strike the naturalist as he travels through these mountains, appear to me to prove without a doubt, that the upheaving force was not applied at one certain point or along one certain axis, but that the whole country, now covered by the Afghan and the Himalayan mountains, was forced up into an immense dome or arch, which broke along certain lines determined by pre-existing volcanic zones, and settled into an oblique anticlinal, of which the slopes are sliced by a succession of parallel faults.*

98. It is a question of considerable interest to determine, with some precision, the epoch at which the great and last upheaval of the Himalaya occurred. We know that it was after the great mammals had become developed; and the extraordinary number of mammalian species found in the Sewalik hills would naturally induce one to consider a portion at least of what I have called the Upper Miocene as older Pliocene. The Aralo-Caspian formation or steppe limestone, a brackish water deposit, has been placed by Murchison and DeVerneuil in the older Pliocene; and one cannot help thinking that these shallow but immense inland or inter-insular seas must have existed previous to the final upheaval of the great mountains of Central Asia, and that it is indeed movements connected with this final upheaval, which have dried up the steppe-limestone and reduced these great seas to their present dimensions.

On the other hand, we have seen, that there exist in Thibet and in Ladak great beds of horizontal deposits, unconformable to the beds on which they abut, and containing fossil bones. Captain R. Strachey appears inclined to believe these beds to have been deposited previous to the upheaval of the Himalaya; but I think the hypothesis is not tenable, as it is impossible to understand how a "true sea-bottom

* The hypothesis (advanced, I believe, by Professor Ansted in his "Ancient World") that the rising of Central Asia caused a depression in the Indian Ocean, marked by the coral islands of the Lacadives, the Maldives, the great Chagos bank and some others, is ingenious; the depression, however, requires proving by actual observations.

could have been uplifted from under the sea to an elevation of 15,000 feet," without losing its horizontality, whilst not only the beds on which the "true sea-bottom" rested, but the probable contemporaneous beds of the Sewaliks (according to Captain Strachey's hypothesis only,) are dipping N. E. at a high-angle. Captain H. Strachey describes the same bed, where it extends into Ladak, as old alluvium, and mentions its containing fossil bones of extinct mammals. Captain Godwin Austen calls these beds, in Ladak, Rodok and Skardo, a fluviatile deposit. The bed is not limited to the belt of country situated between the Ser and Mer (Snowy Peak Range) chain and the Kailas chain. It is well developed in Rodok, near the Pang Chong Lake and up to the foot of the Korakoram chain, and it is very probable that the great Desert of Aksai Chin is a similar bed. I have said, in another place, that I believe these horizontal beds to be identical to the Ragzaier or elevated plateaux of the Afghan mountains. How were they formed?

In order to answer this question, let us consider what was the physical topography of the Himalayas soon after their final upheaval. There was not much difference in the configuration of the great ocean between the tropics; if we are to believe the geologists who have studied the Andes, these mountains had not yet appeared; the great plains of Africa, Arabia, Persia and India, were still under water; the mountains of the Indian peninsula may have appeared (and did probably appear at the time of the Himalaya's last upheaval) but were separated from the Himalaya by a considerable sheet of water; the great inland sea now represented by the desert of Gobi was not yet dry,—in short, there was little cause to diminish the humidity of the winds which blew from the south, and there was nothing to change their old direction. But the Himalayan and Afghan mountains were very different from what they had been. Instead of low ranges with volcanic peaks which did not probably soar above 5,000 or 6000 feet, we have now an immense wall, some hundred miles broad and 25,000 feet high, with deep longitudinal valleys offering no exit and much embarrassed by detached rocks and debris. The humidity of the winds which produced the tremendous rains of the Miocene period was now deposited as snow. Huge glaciers appeared and filled the longitudinal valleys, and the rivers which ran from them began to deposit a sediment which, in time, formed the great flat plateau of Thibet, Rodok, Aksai Chin, &c. &c. Thus we see the altered physical conditions which were brought about by the difference of elevation of the Himalaya, before and after its final upheaval. Before the upheaval, the humidity was collected as rain, and the mountain debris was washed to the coast by boisterous torrents; but after the upheaval, the humidity was collected as snow, and the mountain debris was quietly collected in the great valleys, under the cover of glaciers.*

All the while, a different action was going on in the outer or low Sub-Himalayan ranges. There the humidity continued to fall as rain and great denudation was the result. The same process of land gaining over the sea, which I have described at the Miocene epoch, began to form the plains of India; this process is still in operation now-a-days, but necessarily its power diminishes in intensity as the sea-coast becomes more distant from the hills and the course of rivers becomes longer. It is the process which is now anxiously watched by the pilots of the Hooghly, and which no engineering skill can avert: the sandbanks advance in the sea, the river-bed fills up, more dry land appears and what was yesterday a dangerous shallow out at sea, to-day is the shore of the delta, and to-morrow will be far inland.

As the plains of India extended, the rain-fall of the Himalaya diminished. Even if we suppose the humidity of the winds to have been the same as before, we must deduct from the Himalayan rain-fall the amount of rain which fell in the plains. But we know that the humidity of the rains had also become less; the Andes had surged up and the South-American continent had appeared; the plains of Africa, Arabia, Persia and Central Asia were gradually appearing above the waters, and instead of the trade winds, the monsoons were establishing themselves. There was therefore a great diminution in the snow-fall on the Himalayas, and the glaciers began to decrease and to expose a great deal of the plateau on which they had gradually raised themselves. It is easy to understand how this decrease of snow-fall

* The filling up of the great parallel valleys of the Himalayas by mud and boulders, under the cover of the glaciers, is analogous to the filling up of depressions of the surface by the glacial drift in some parts of Europe. The glaciers of the Himalaya, soon after the great upheaval, were too huge and too general to have had a ploughing and scouring action on the valleys.

must have been very gradual, if we keep in mind what brought on that decrease; and as the glaciers retreated, animals advanced and soon populated the high plateau of the Himalaya. These animals have left their remains interred in the clayey grits of these elevated lands. It may appear strange that elephants once lived at such a great height, and in a climate so cold, but the osseous remains found in the elevated plateau of Mexico belong to true elephants of extinct species,* and the Siberian mammoth which was covered by a warm fur, lived on the leaves of conifers and roamed over the ice-drift. There is therefore no doubt that these animals had a great plasticity of organism, and could adapt themselves to very extreme climates.

The mammals discovered in the plateau of Thibet and Ladak, all belong to extinct species. On the other hand, all the shells which I have been able to collect in the old alluvium found near the foot of the Sub-Himalaya belong to living species, and it is therefore most probable that the older alluvium of the plains of India, and the high plateau of the Himalayas belong to the post-pliocene epoch.

From the above considerations, and the present state of our knowledge, it appears that the Afghan and Himalayan mountains suffered their last upheaval during the pliocene period.

99.—The description of the deposition of beds subsequently to the great upheaval has been given incidentally in the preceding paragraph; the glaciers began to melt, great lakes were formed in several localities. The Kashmir valley is a good example, Rukshu is another, and so is Abbottabad valley. These lakes at first fed large rivers, and both lakes and rivers had a considerable power in carrying mud, sand and boulders, and thus raising their beds by several hundred feet; but as the waterfall diminished, the lakes and rivers diminished also, and the rivers soon began to cut for themselves deep ravine-like beds in the middle of their ancient bottoms, leaving on each side a great river-terrace.

Before the rivers had lost their great volume, however, and while they filled the whole of their original beds, they floated icebergs of sufficient dimensions to carry blocks of stone of great size. The Salt-Range for a time intercepted the free passage of the waters towards the south and a shallow lake filled the whole country between it and the

* Cosmos, Otte's translation, Vol. I. page 280.

Munee Range.* On this lake floated the icebergs brought down by the rivers, drifting gradually to the south, and finally grounding near the Salt-Range or averted by it. Thus we see between Jubbee and Nikkee large erratic blocks, being porphyry, resting on the top of the old alluvium; and we find similar but smaller blocks imbedded in horizontal taluses of debris which have been piled up in horizontal layers against the hills of Maree on the Indus. These blocks are not water-worn, but present either flattened or scratched surfaces; the ground all over that district is covered with boulders of porphyry, greenstone, felstone, &c. but these boulders are well rounded and are easily traced to disintegrated beds of Miocene conglomerate. The erratic blocks are very different in appearance, and have the striking, or somewhat odd and *déplacé* aspect peculiar to erratics. One of them, three miles south of the village of Thrapp, measures 6 feet 4 inches by 7 feet 4 inches and 5 feet. There are four or five smaller blocks near it, but none are rolled; they are all of the gneissoid porphyry of the Kaj-Nag. The largest presents the very singular appearance of having its greatest flat surface (not vertical) marked with a number of cup-like holes of various size, from 6 inches across to the size of a walnut, and from 1½ to 2 inches deep. There are from 70 to 75 of these cups. They resemble wide rounded holes or cups, as water would make by dropping. Whether these cups are a glacial effect, or have been made by a race of men for some unknown purpose, is, what I am unable to decide. I am inclined to the first hypothesis.

Erratic blocks near Thrapp.

100. The oldest indications of Man having become an inhabitant

* The damming of the water behind the Salt Range and the Chitta Range was the cause of that thick deposit of silty mud now cut by ravines, which has been the source of so much difficulty and expense in making the great Trunk Road between Jheelum and Attok. A similar damming occurred in the Huneepor valley and several other localities, but to a less degree.

of the Himalayas is, at present found in the Upper Lacustrine deposit of Kashmir (see note to para. 44). This deposit contains a very great many fragments of pottery, bones of goats, and pieces of charred wood. It is much older than the Buddhist ruins of Avantipoor, and attests the presence of man in the valley during the period which elapsed between the first and the second lake. The Buddhist ruins were not built until after the second lake had been drained. But though we may call the race of men who lived in Kashmir before the second lake historically ancient, they cannot be considered so geologically: a cowry has been found* in the deposit, and this evidence of a currency indicates at once an amount of civilization and trade far removed from the state of the primitive races.

(To be continued.)

Experimental Investigations connected with the supply of water to Calcutta, Part III.

By D. Waldie, Esq.,

F. C. S. &c.

(Continued from page 8.)

[Received 1st March, 1867.]

The present communication is intended to give an account of the results obtained in prosecuting the investigations indicated by the title, the first of which have already appeared in this Journal. To some of the results given in the original paper objections were raised, which were examined in a subsequent article, entitled, " Supplementary Observations, &c.," these being founded on experiments made during the month of September last. Since that time the enquiry has been continued, with the view of more fully examining these objections, of supplying certain deficiencies, of correcting some errors, clearing up some obscurities, and generally rendering the enquiry more complete.

I propose also to endeavour to correct some misapprehensions which seem to have arisen, and indicate points of importance which do not

* The cowry was discovered by Captain Godwin-Austen while we were examining these lacustrine beds together. I saw Captain Austen dig it out of the clay with his penknife.

Kashmir, the Western Himalaya and the Afghan Mountains, a Geological paper, by

Albert M. Verchere, Esq. M. D.
Bengal Medical Service, with a note on the fossils by
M. Edouard de Verneuil,
Membre de l'Académie des Sciences, Paris.

(Continued from page 115, of No. II. 1867.)

In April 1864, I sent a box of fossils, mostly from Kashmir, to Professor Faire, of Geneva. M. Faire kindly forwarded these to M. E. J. de Vernueil, who was good enough to examine them carefully, and to write a most interesting note, of which a translation is now given.

Some of the fossils represented in the Plates were not sent to Professor Faire, and some which were sent, are not figured here; the numbers at the head of some of the paragraphs of M. de Vernueil's note refer to the fossils represented in the Plates.

Note on the fossils forwarded by Mr. Verchere, *by* M. Edouard de Vernueil, *Member of the Academie des Sciences, &c. &c.*

The largest of the two specimens sent, of which the matrix is a dark brown limestone, belongs to the *Productus Semireticulatus*, (Martin), one of the most characteristic species of the carboniferous limestone, in Europe, in Russia and in America. This species has been brought from the south of the Oural, and Mr. Tchihatcheff has found it in Siberia in the Altai mountains.

A specimen of *Productus costatus* (Sowerby). This is a species scarcer than the preceding. The specimen from India shows well the characters of the species such as they are figured by Sowerby, whilst those from Missouri, figured by M. de Konnick, do not possess the large and thick ribs which characterise the original species. The *Productus costatus*, first found in England, does not exist in Continental Europe, except in Russia where I found it in the government of Toula. Some Russian authors mention it from the government of Tiver and of Kalonga.

Productus Humboldti (D'Orbigny). This species is very like *P. Granulosus* (Phillips) and *P. Heberti* (Vernueil, Bull. Soc. Geolog. de

France, Vol. XII. p. 1180). It is distinguished from this by its well marked sinus, and its fine and numerous spines strewed without order on the surface and not forming concentric series. The *P. Humboldti* is mentioned by Keyserling as having been found by him in the carboniferous limestone of the Soiwa, an affluent of the river Petchora on the western slope of the north of the Oural. Mr. Davidson has thought proper to make a new species which he calls *P. Purdoni* (on some Carboniferous Brachiopoda collected in India by A. Fleming and W. Purdon in 1848 and 1852, Quarterly Journal of the Geol. Soc. of London, Pl. 2 fig. 5, 1862) based on specimens similar to those under examination, and which came from Chederoo and Moosakhel (Salt Range, A. M. V.). He gives a drawing, under the name of *P. Humboldti*, of a species on which the spines are fewer and confusedly arranged in quincunces, and of which the sinus is very slight and only visible near the front of the shell. I would regard this rather as the *P. pustulosus.*

Productus Cora, (D'Orbigny). Two good specimens possessing well the characters of the species.—Discovered first in the Bolivian plateau by D'Orbigny. This species is one of the most characteristic of the carboniferous limestone in England, in Belgium, in Spain and in Russia.

At the time I found it in the last named country D'Orbigny had but just described it; I did not know his work, and, as this shell varies much, I had made two species of it under the names of *P. Tenuistriatus* and *P. Neflediwi.* It is found on both slopes of the Oural, and also in the white carboniferous limestone of the plains of Russia at Sterbitamak on the river Oka, and in the carboniferous region of Douety. Finally it is also mentioned in North America. It has therefore a great geological range.

Four specimens of *Productus.* That in the black limestone and brought from Kashmir is the *P. Flemingii* or *Longispinus* or *Lobatus* (three names of the same animal). It is one of these *Producti* largely distributed on the globe. It has been found on the Mississipi in the state of Ohio and in Kentucky. It exists in England, in Spain, and in Belgium. Messrs. Keyserling and Murchison and I have found it in the governments of Tiver, Kalonga, on the Douetz as well as on the river Belaja near the glacial sea. The specimens from the white limestone of the Kafir-Kote are a distinct variety, remarkable for a pretty considerable number of tubular spines, and by the large size of its longitudinal striæ, which are often well marked.

Four specimens of a small species which differs from the *P. Longispinus* or *lobatus* by the want of lobes and of a sinus on the middle of the greater valve. It is perhaps the *P. Aculeatus*, (Martin), but the specimens are not good enough to be determined rigorously.

Very small specimens of *Productus* which are perhaps the young of the *P. longispinus* or of *P. Boliviensis*, (D'Orbigny), of which Keyserling found a valve in the carboniferous limestone of the basin of the Petchora (government of Archangel). It is characterised by well detached ears.

Two specimens of *Athyris*, without the test and too imperfect to allow of their being determined (*Terebratula Subtilita*, Halls?)

Four specimens of a species of *Athyris* which is perhaps new. It belongs to the class of *Terebratulae* with concentric striæ and internal spires, called by D'Orbigny *Spirigera* and by M'Coy *Athyris* (a name, let us remark, which means the reverse of what exists, since, instead of being imperforate, these species have a round hole on the beak). This species from Kashmir approaches the *A. Ambigua*, (Sowerby), and the *A. Globulosa*, (Phoill.), but it is more transverse and the beak is more detached and sharper. It may be called *A. Buddhista*, as proposed by Mr. Verchere. The *A. Ambigua* is found in Russia in the carboniferous limestone, but is rare there, whilst it is common in England.

Two specimens, of which one is perhaps a variety of the *T. Subtilita*, (Hall*) or the *T. Subtilita* itself. The other appears to me to be an *Athyris Royssii*, (Vernueil), discovered by myself in the carboniferous limestone of Belgium. When this species is well preserved, the shell is seen to be covered by a pilose investment or coating, consisting of very fine spines continuing the lines of growth. The specimen I possess presents traces of this structure in the shape of a pubescence of very fine hairs.

Three specimens in a bad state of preservation, which are probably merely varieties of the *A. Roysii.*

* The *Terebratula Subtilita* is a species of Hall, found in the carboniferous of the Great Salt Lake in America. Mr. Davidson mentions it from India.

One more specimen of the same species.

Two specimens of a *Terebratula* which is probably new, but the specimens are not good enough to be determined.

Six specimens of a *Spirifer* which appears to me to be new. At first sight one would take it for the *S. Trigonalis*, (Martin), but it differs from it by the narrowness of the sinus, and by the want of folds in that part which most commonly shows some of them, more or less well marked, in the Sp. *Trigonalis*. The narrowness of the sinus reminds one of the *S. Mosquensis*, of Russia.

Spiriferina nearly allied to the S. *Octoplicata*, (Sow.), and still more to the *Sp. Cristata* of the Zechstein, two species which Mr. Davidson unites into one. This author figures the *S. Octoplicata* among the fossils of India. The specimen, which is marked No. I6, has narrower ribs and broader furrows than the specimens figured by Davidson. On another are admirably well seen the granulations peculiar to the genus *Spiriferina* of the lias, and to the Permian and Carboniferous species under notice. Pl. I. fig. 2, a, b, c, d.

Great *Cardinia*, perhaps new. Pl. VI. fig. 2.

Two specimens of *Cardinia* bearing a distant likeness to the *C. Ovalis* (Martin,) *C. Uniformis* of the Carboniferous of England and also to the *C. Listeri Unio* (Sowerby,) of the Lias.

M. de Koninck has figured a shell very similar to this under the name of *Solenopsis imbricata*, (Descrip. of new fossils from India, discovered by A. Fleming, by de Koninck, Quart. Journal of the Geol. Soc. vol. 19 Pl. IV fig. 3.) obtained from the carboniferous limestone of Varcho, (Vurcha, Salt Range, Punjab. *A. M. V.*)

Aviculo-Pecten dissimilis (*Pecten id.*, Fleming), This specimen reminds one of the *Pectea Ellipticus*, (Phillips), which is found in the Carboniferous of Russia.

Axinus, sp. nova. This shells resembles much the *Axinus obscurus*, (Sow. *Schizodus*, King,) of the magnesian limestone or Permian of England. It has also some distant likeness to the *A. Carbonarius (vernus)* Sow. Geol. Transac. vol. V. pl. 38.

Fenestella Sykesi, Koninck, Quart. Journ. vol. 19, pl. I. fig.,

Fenestella megastoma, Koninck, Quart. Journ vol. 19, pl. I.

Fenestella. Undetermined. Pl. V. fig. 1.

A very pretty species which I do not know. Perhaps the *Vincu-*

laria multangularis (Postlock). It is to be regretted that the surface is not seen and that the branches are split in two.

Lithostrotion floriforme, Flem. a common enough species in Russia in the carboniferous; found also in England.

Michelinia or Beaumontia. Ill preserved specimen.

Phyllopora cribellum, Konnick, Quart. Journ. vol. 19. pl. I fig. 2.

List of species which have been identified from the specimens sent by Mr. Verchere.

1. *Productus Semireticulatus*, Martin.
2. " *Costatus*, Sow.
3. " *Humboldtii*, D'Orbig.
4. " *Cora*, D'Orbig.
5. " *Flemingii*, Sow. = *P. Longispinus* and *P. Lobatus*, Vernueil.
6. " *Aculeatus*, Sow.
7. " *Boliviensis*, D'Orbign.
8. *Athyris ambigua ?* Sow. (perhaps *Sp. hova*).
9. " *Royssii*, Verneuil.
10. " *Terebratula Subtilita*, Hall.
11. *Spirifer Vercheri*, Verneuil (new species, nearly allied to the *S. Trigonalis*, Martin, but distinct).
12. *Spiriferina Octoplicata*, Sow.
13. *Cardinia ovalis ?* Martin.
14. *Solenopsis imbricata*, Konn.
15. *Aviculo-pecten dissimilis*, Flem.
16. *Axinus, Sp. nova* (nearly allied to *A. Obscurus* of the Gechstein)
17. *Fenestella Sykesii*, Konn.
18. " *Megastoma*, Konn.
19. *Vincularia multangularis ?* Postlock.
20. *Lithostrotion floriforme*, Flem.
21. *Phyllopora cribellum*, Konn.

Remarks.

Several notes on fossils collected in India have been published lately; the fossils were forwarded by Messrs. Fleming and W. Purdon and more recently by Captain Godwin-Austen. These publications are 1st, Davidson's Memoir "On some *Carboniferous Brachiopoda* collected in

India by A. Fleming and W. Purdon, Quart. Journal, vol. XVIII. p. 25; 2 plates. 2nd, Description of some fossils from India discovered by J. Fleming, by Dr. L. de Koninck, Quart. Journ. vol. XIX. with 8 plates on which are figured among others some very curious goniatites. 3rd, Geological notes on part of the N. W. Himalayas, by Capt. Godwin-Austen, with notes of fossils by T. Davidson, R. Etheridge and P. Woodward. It is only an abstract of the memoir, without plates. Capt. Godwin-Austen followed the Carboniferous limestone along the foot of the mountains at the north of the valley of Kashmir as far as Ishmalabad.* The carboniferous series is, according to Capt. G. Austen, as follows, from the highest to the lowest. 1st Layers with goniatites more or less analogous to the ceratites of the Musckelhalk. These layers are the highest of the carboniferous formation. 2nd. Below is found a compact limestone poor in fossils; 3rd, argillaceous series; 4th, limestone rich in fossils, *Productus*, &c. 5th quartzite.

As early as 1850, Sir Roderick Murchison had shown me some of the fossils sent by Mr. Fleming, and I had identified the *P. Cora*, *costatus*, Flemingi, the *Athyris Roysii*, *Orthis crensistria*, &c. Quart. Journ. vol. 7, p. 39. At the same epoch Dr. Falconer and Major Vicary had announced the existence of palæozoic fossils in the mountains which separate British India from Kabul, as remarked by Sir R. Murchison, Quart. Journ. vol. VII. p. 38. In 1852, Mr. A. Fleming published his observations on the Salt Range in several letters addressed to Sir R. Murchison, Quart Journ. vol. IX. p. 189.

All the fossils collected by Mr. Fleming, Mr. Purdon, Captain G. Austen and Dr. Verchere belong to the carboniferous formation. Captain Strachey alone has proved the existence of more ancient rocks (in a palæontological point of view.)† He sent to London a series of fossils collected in the mountains, from 17 to 18000 feet above the sea, which separate Thibet from the British provinces of Kumaon and Garhwal. I have identified among these fossils some *Asaphus*,

* Capt. Gordon-Austen and myself visited the localities referred to in the geological notes, during a tour we made together in the autumn of 1863. We thought at one time of writing a memoir in collaboration, but having been sent to the extremes of India, we arranged our notes separately. A. M. V.

† In the present paper are figured a few Cystoids which are in all probability *Silurian*, see Pl. VIII. fig. 61 and 62.

Lychas, *Illœnus*, *Cheirurus*, *Orthoceras*, &c. all characteristic of the Lower Silurian. In the upper part of the beds Captain Strachey found goniatites, ceratites and even ammonites, which remind one much of the Trias. So far, therefore, two of the four great divisions of the Palæzoic formation have become well known in the Himalaya, viz. the Silurian and the Carboniferous. The Devonian will be found also, for we have received from a Missionary travelling in China three species of *Brachiopoda* characteristic of the Upper Devonian rocks, among others the *Terebratula Cuboides.* These fossils have been presented this year to the Académie de Sciences de Paris. Mr. Davidson has also figured and described, as received from China, *brachiopoda* which also are characteristic of the Devonian, among other the *Spirifer*, Verneuil. The discovery and determination of the Devonian in the Himalaya requires attention and research.

I have further to remark how great is the analogy between India and Russia; I have found in this last country most of the species which Mr. Verchere has found in the Himalaya. Russia, the Oural and the Altai, are connecting links between England and India.

In terminating this note, we wish to observe that if, according to Mr. Verchere, the coal measures, (which should be superior to the carboniferous limestone), are wanting in India, this want is one more resemblance with Russia, for in all the carboniferous zone which extends from Moscow to Archangel the carboniferous limestone is never covered in by coal measures. There has been a slow upheaving motion of the ground, which has raised the strata above the sea-level, without, however, otherwise disturbing them, at the epoch when in other countries, the coal was being deposited. It is in the south of Russia only (the Douetz), and in a few localities on the western slope of the Oural, that coal measure deposits are to be found.

(Signed) Ed. de Verneuil.

Paris, 21*st Nov.*, 1864.

APPENDIX.

FOSSILS.

Silurian.

Sphæronites sp. Pl. VIII. fig 5.

Perfectly globular; covered with small rounded warts sharply defined. The whole shell, between the warts, is pierced with minute pores. No trace of plates; no mouth nor stalk-scar visible.

Found in the rocky plains at the foot of the Masha Brum, Korakoram Chain.

Sphæronites sp. Pl. VIII. fig 6.

Proposed name of a new species: *S. Ryallii, Verch.*

Globular. Large warts well set apart and not very sharply defined. The whole shell is covered with pores. No mouth. A stalk-stem very conspicuous.

From the same locality as the preceding. Name proposed in honour of Mr. Ryall, Gt. Trig. Survey, who discovered the shell.

Sphæronites sp. Pl. IX. fig. 1.

Depressed. No warts or spines; no plates or traces of plates, no stalk-scar. The whole surface pierced by minute pores.

Same locality.

Carboniferous.

Zeawan Beds.

Cephalopoda.

Nautilus Flemingianus, DeKon.

Journal, Geological Society, Vol. XIX. Part I, No. 73, p. 15. Pl. VIII. fig. 2. A fragment of this shell was found at Zeawan, Kashmir.

Nautilus Favranus, Verch., n. sp.

A very large globular Nautilus, eleven inches across the mouth. Perfectly smooth and inornate. Siphon large and central, formed by a series of dilatations, giving it a beaded appearance.

Rotta Roh in the Punjab.

Orthoceras sp.

Zowoor and Zeawan in Kashmir.

GASTEROPODA.

Macrocheilus Avellanoïdes, DeKon.

Journal, Geological Society, Vol. XIX. No. 73, p. 10. Pl. III fig. 4. Rotta Roh.

Dentalium Herculeum, DeKon.

Op. Cit. p. 8. Pl. IV. figs. 10, 11 & 12. Several specimens were found in the Rotta Roh, but none in Kashmir.

Trochus sp.

Some large specimens of Trochus, four inches across, were found at the Rotta Roh, Punjab.

LAMELLIBRANCHIATA.

Anomia Lawrenciana, DeKon.

Journal, Geological Society, Vol. XIX. p. 6. Pl. IV. figs. 7, 8 & 9. Found in the Rotta Roh, but not in Kashmir.

BRACHIOPODA.

Terebratula sacculus, Martin.

Journal, Geological Society, Vol. XXII. p. 40. Pl. II. fig. 1. Found at Zeawan Zowoor and Barus, Kashmir.

Remark. A few other species of true Terebratulæ were found in the Zeawan group of Carboniferous limestone, but I am unable to identify them at present.

Spirifer Vercheri, de Verneuil, new sp. Pl. I. figs. 1, 1*a*.

See M. de Vernueil's note.

Barus in Kashmir. It has been found in Spiti.

Spirifer striatus, Martin.

Journal, Geological Society, Vol. XVIII, No. 69, p. 28. Pl. I. figs. 9 and 10.

Several fragments were found at Zeawan and Zowoor, and complete specimens in the Rotta Roh.

Spirifer Moosakhelensis, David.

Op. Cit. p. 28. Pl. II. fig. 2.

This shell is extremely abundant at Zeawan, but was always found in fragments. It is also common at the Rotta Roh.

After comparing numerous specimens of the last two species, in various states of weathering, I must express my impression that the S. Moosakhelensis is only a variety of the S. striatus, in which the concentric laminæ (which do exist in the striatus) have become exaggerated. All stages of transition are to be observed in a moderately large series.

Spirifer Rajah, *Strachey* [*Syn. S. Keilhavii Buch ?*]

Paleont. of Niti, page 59.

Fragments found at Zeawan and Barus.

Spirifer, *spec. nov. ?* Pl. III figs. 1 & 1*a*.

Hinge-line straight and much longer than the greatest width of the shell. Umbones prominent above the hinge-line; hinge-area not seen. Six or seven irregular ribs radiate from the umbo to the margin in a wavy manner. Fine ornamental raised lines (coarser on the larger than on the smaller valve) radiate likewise in a wavy manner. Shell flat. It varies a great deal in shape and size, but is always very flat, so much so that it has somewhat the appearance of such shell as the *Strophomena grandis* of the Silurian. It may possibly be, like the precedent, a variety of the *S. Keilhavii.*

Found at Zeawan in Kashmir and at the Rotta Roh.

Spiriferina octoplicata (Sow.), var. Transversa (Verch.)

Pl. I. figs. 2, 2*a*, 2*b*, 2*c*, and 2*d*.

Specimens like *a*, are not common at all; but fragments of the shell such as are represented at *b*, are innumerable in the brown shale of Zeawan. Found also in the limestone of Kafir Kote in the Rotta Roh, but it is there rare. This shell seems to vary wonderfully, from the narrow forms figured by Davidson, (Journal Geological Society, Vol. XVIII. Pl. I. figs. 11 and 14,) to the very transverse variety represented here.

Athyris sp. (Ath. subtilita. Hall), Pl. II. figs. 1 and 1*a*.

This species varies considerably, especially as to size, but is easily recognized by the overlapping of the upper edge of the lines of growth, so that the shell looks as if made up of several layers laid one over the other, like the many capes of a coachman's cloak.

Found at Zowoor in Kashmir, in lenticular beds where it appears to be gregarious. Also in the Rotta Roh and Salt Range.

Athyris Buddhista, Verch., n. sp. Pl. II. figs. 2, 2*a*, and 2*b*.

It has flat, expanded sides on each side of a well marked sinus of the larger valve and sharp fold of the lesser. The beak terminates in a point, occasionally pierced by a small foramen but generally imperforate. The spiral oral arms appear to fill nearly the whole of the shell, leaving only a small hour-glass-shaped space in the centre.

This shell varies a good deal, some specimens being much more transverse than others, some being very flat and others less so. It was a gregarious animal found now accumulated in lenticular beds.

Zeawan and Zowoor. The name proposed is derived from the first few specimens which were found having been discovered in blocks of stone of a Buddhist ruin.

Athyris sp. probably A. Royssii, (L'Eveillé) Pl. II. fig. 3-3.

Less transverse than the preceding and ornamented with fine and closely set concentric lines of growth strongly marked. Foramen generally obliterated. Imprints showing the fringe-like expansion round the margin are very common in the brown shale of Zeawan. The shell is abundant in all the localities where the Zeawan bed has been observed in Kashmir and the Punjab.

Remark. Several other species of Athyris were discovered at Zeawan, Zowoor and Barus, some having the general facies of our figs. 2 and 3 and being probably varieties of the *A. Royssii.* Others with the umbo-marginal diameter longer than the transverse and being probably narrow varieties of the *A. subtilita.* Others again have the general facies of the *T. Digona*, and others the carinated appearance of the *Ath. Navicula* (Sow).

Retzia radialis (Phill), var. grandicosta (Davids.)

Journal, Geological Society, Vol. XVIII. p. 28. Pl. I. fig. 5.

Very frequently met with at Zeawan and Zowoor, and also in the Rotta Roh.

Streptorynchus crenistria, Phill. var. robustus.

Op. cit. p. 30. Pl. I. fig. 16.

This shell attains a very large size in Kashmir and in the Punjab, specimens five inches in tranvserse diameter not being rare. Fragments of this shell, and young shells, swarm at Zeawan and in some beds in the Rotta Roh.

Orthis resupinata, Martin.

Op. cit. page 31. Pl. I. fig. 15.

Abundant in the brown shale of Zeawan, Kashmir.

Orthis sp. Pl. III. fig. 3.

A cast of an Orthis belonging to the type of the *Orthis plicatulla*

(Hall) of the Silurian. It has six ribs, not very conspicuous, and two well-marked lines of growth; and is ornamented with fine radiating striæ. Only one specimen was found at Zeawan.

Remark. An immense number of small, or perhaps young, Orthisidæ occur in the ferruginous dark shale of Zeawan, in some places so abundantly that they cause the shale to exfoliate like a disintegrating mica-schist. The shells are, however, so thin and brittle that imprints alone can be procured.

Strophomena analoga (Phill.) ? Pl. II. fig. 4.

There is, I think, little doubt of this shell being Phillip's species. The shell is raised in irregular concentric furrows and ridges, and is ornamented by fine radiating striæ. Both valves are nearly flat; the umbones are hardly marked; the hinge is linear and nearly as long as the greatest diameter of the shell. These Indian specimens are very large, above four inches across.

Seldom found entire in Kashmir; but even pieces of it are conspicuous and easily recognized. Good specimens were obtained from the Rotta Roh in the Punjab.

Strophomena ? sp. Pl. III. fig. 2.

An internal cast only. Found at Zeàwan in Kashmir.

Productus costatus (*Sow.*)

Journal, Geological Society, Vol. XVIII. p. 31. Pl. I. figs. 20, 21.

Numerous specimens of this well known species were found at Zeawan and Zowoor in Kashmir, and in the Rotta Roh and Salt Range.

Productus semireticulatus (*Martin.*)

Op. Cit. p. 21.

It varies considerably, some specimens being very transverse. The Kashmir and Punjab specimens are usually very large and often deformed by pressure.

Zeawan, Zowoor, Barus. Rotta Roh, Salt Range.

Productus cora (*d'Orbigny.*)

Found abundantly every where in the Zeawan group.

Productus Humboldtii (*D'Orb.*)

Journal, Geological Society, Vol. XVIII. p. 32. Pl. II. fig. 6.

Large specimens found at Zeawan and smaller ones at Barus. Also in the Salt Range and Rotta Roh, Punjab.

Productus Purdoni (Davids).

Op. Cit. p. 31. Pl. II. fig. 5.

Zeawan in Kashmir and Rotta Roh in the Punjab. In a series of specimens of *P. Humboldtii* and *P. Purdoni*, it is quite impossible to decide where one species ends and the other begins.

Productus Flemingii (d'Orb.)

Syn. *P. longispinus (de Vern) and P. lobatus (de Vern.)*

Journal, Geological Society, Vol. XVIII. p. 31. Pl. I. fig. 19.

Davidson's figure does not show the enrolled and horn-like ears so well defined in our specimens.

M. de Vernueil regards the Rotta Roh specimens as a well defined variety ; see his note.

Found at Zeawan and Zowoor and in the Rotta Roh.

Productus Boliviensis (d'Orb.) and P. aculeatus ? (Martin).

See M. de Vernueil's Note.

Found at Zowoor and Zeawan in Kashmir.

Strophalosia ? Arachnoïdea,) Verch.) n. sp. Pl. IV. figs. 1, 1*a*, 1*b*.

The specimen of the larger valve is from the Rotta Roh and the other two from Zeawan in Kashmir ; they may be different shells. The larger valve resembles the *Productus Purdoni*, but the spines are fewer, better defined and less slanting towards the margin. The other two specimens are remarkable for the excessive length of the thread-like spines and for some complications in the hinge.

Crustacea.

Eurypterus ? Limulus ? sp. Pl. V. fig. 4.

Claw of a Crustacean, belonging apparently to one or the other of the two genera above. It was found on a slab which had been worn by running water, so that a horizontal section of the claw is produced. The same slab was full of *Athyris Buddhista* (Verch.), *Productus Flemingii* (D'Orb.). *P. Aculeatus*, *Fenestella Sykesii* (deKön.) and *Vincularia Multangularis* (Patlock).

The tegument is smooth and pierced by pores, which are seen vertically sected on the margins of the claw, and appear like dots where the tegument is not worn off. The tegument forms septa in the upper mandibule, but none in the lower. The ends of the mandibules are hooked. There are no traces of teeth on the internal margin of the claw. No other part of the animal could be found.

Kashmir.

Remark. Another crustacean has been found abundantly in the Carboniferous of the Himalaya. It is a *Trilobite*, with the rings sharp and rib-like. Though common, it has not been found good enough for identification and figure.

Zeawan, Banda and Barus in Kashmir. Also Rotta Roh and Salt Range in the Punjab.

ECHINODERMATA.

Cidaris Forbesiana, (*deKön*).

Journal, Geological Society, Vol. XIX. No. 73, p. 4. Pl. IV. figs. 1 and 2.

Rotta Roh, but not in Kashmir. There are several species or varieties.

These cidarides will have, I think, to be made into a new genus when better known. They appear to have been borne on long thin branching stalks. The body has not been found yet, but I have found *hexagonal* plates with an articulation cup in the centre, spines four inches long, and stalks of considerable length.

Crinoid stems were found in enormous quantity in all the layers of the Zeawan bed. Sometimes the rock is nothing but a mass of rings pressed together. In the Rotta Roh I found a great number of an Encrinus, cup-shaped and nearly a foot in height, belonging apparently to a new genus. I cannot describe it at present. It supports a multitude of minute arms and fingers, the debris of which form a glaring-white rock, very conspicuous as one of the layers of the Zeawan bed in the Punjab.

BRYOZOA.

Tenestella Sykesii, (*deKon.*) Pl. IV. bis. figs. 1, *a. b. c. d.*

Journal I. Geological Society, Vol. XIX. p. 5. Pl. 1 fig. 1.

The colony forms a wavy leaf. The openings of the cells cover the whole surface of the longitudinal bars without assuming a linear arrangement; the transverse bars are barren of cells. The cells are arranged in bundles imbedded in sockets of the support, so that a vertical section along one of the longitudinal bars shows a succession of little cups or sockets, in each of which are collected from six to eight elongated cells, disposed fan-like. The calcareous support between the sockets is massive.

This Bryozoon is extraordinarily abundant in the Zeawan bed. The colonies are often packed one over the other like dead leaves, and I have counted seven and eight colonies in a piece of shale not an inch thick.

Fenestella Megastoma, (*deKon*). Pl. IV. bis. fig. 2, *a. b. c. d.*

Op. Cit. Vol. XIX. p. 5. Pl. II. fig. 3.

The shape of the colony was not seen. The openings of the cells cover the longitudinal bars, without assuming a linear arrangement. The bars are rounded on the cell-bearing side and are angular on the barren surface. They are hollow or tubular, and the cells are arranged over the roof of the tube, like bricks in an arch, and are not connected in bundles and contained in sockets as in the Fen. Sykesii.

Fenestella, *sp.* Pl. V. fig. 1.

Shape of colony not seen, but generally very flat and wavy. The oscules, which are small, are somewhat quadrangular. It is found mostly as an imprint. Disposition of the cells not seen.

Very abundant at Zeawan, Zowoor, Banda, in Kashmir and also in the Rotta Roh.

Vincularia Multangularis, (*Portlock*) ? Pl. IV. bis., figs. 3, *a. b. c. d.*

See M. de Vernueil's note.

The colony has a moss-like appearance. The cells are arranged all round a calcareous support, and inclined forwards.

This Bryozoon is extremely abundant in the Zeawan bed, the branches extending in all directions but never anastomosing; their division is nearly always dichotomous. I have seen colonies cover more than a square foot of rock with their ramifications.

Disteichia ? ? (*Sharpe*). Pl. V. fig. 2.

I am unable to refer it to any genus which I know, unless to the genus *Disteichia* (Sharpe). It is found at Zeawan, but is there rare; in the Rotta Roh it is very common. The layers of cells accumulate one over the other to a great extent, forming occasionally large masses of Coralline rock.

Acanthocladia, *sp.* Pl. V. fig. 3.

The colony has the aspect of a fern. The central stem throws out branches at regular intervals, and at a certain fixed angle, and these branches throughout younger branches. Both stem and branches support short spines like leaflets. The disposition of the cells was not seen, as only imprints of this animal were found.

Found near Banda in Kashmir.

Phyllopora ? Cribellum (deKon).

Journal, Geological Society, Vol. XIX. p. 6. Pl. I. fig. 2.

Fragments are not scarce in the Rotta Roh, but it was not found in the Kashmir beds.

Retepora Lepida, (deKon).

Op. Cit. p. 6. Pl. I. fig. 5.

Several fragments found at Zeawan and in the Rotta Roh.

Remark. A few other species, not yet satisfactorily determined, were found in this group.

ANTHOZOA.

Lithostrotion Floriforme, (Flem.).

Beautiful specimens are to be obtained near Bilote in the Rotta Roh. Not found in Kashmir.

Lithostrotion Irregulare, (Phill.) ?

A Lithostrotion which is this species, or a very near ally, is very common in the Rotta Roh. The calyces are long, rounded, irregular cylinders, more or less vermiform in appearance and varying considerably in size in various specimens, but always of nearly the same size in each individual colony.

Very small fragments only were seen in Kashmir, but in the Rotta Roh colonies of this coral attain to great size, forming masses of rock several feet across, and many tons in weight.

Alveolites Septosa, (Flem.) ?

Journal Geological Society, Vol. XIX. p. 4. Pl. II. fig. 1.

It often forms shapeless masses, the centre of which is converted into flint.

Zeawan in Kashmir and Bilote in the Rotta Roh.

Michelina, sp.

Rotta Roh. Never found in Kashmir.

Remark. The abundance of corals in the lowest beds of the Zeawan division of the Carboniferous at the Rotta Roh is sometimes astonishing. In Kashmir they are rather scarce. We have a few specimens not yet determined.

PISCES.

Saurichthys ?

Teeth of fishes, large for the genus to which they appear to belong, were found in Kashmir and in the Rotta Roh. They are conical, but compressed so that the section is an oval; they are strongly striated or rather grooved the whole length. The largest i about three quarters of an inch long.

Wean Beds.

CEPHALOPODA.

Goniatites Gangeticus, (*deKon.*)

Journal Geological Society, Vol. XIX. p. 14. Pl. V. fig. 2.

I had thought at first that this Goniatites was more like *G. Henslowii*, Sow.; but better specimens, which I have since procured, leave little doubt that the species found was DeKoninck's shell. Some of the species from the Rotta Roh are much larger than DeKoninck's figure, and some are elliptical.

Found near Banda in Kashmir and near Gung and Oomurkhel in the Rotta Roh.

Goniatites Curvicostatus, (*Verch.*), *nov. sp.* ?

The species is well characterized by curved ribs, rather coarse and irregular. The suture is like that of the *G. Gangeticus*. Only one specimen, from near Gung; not good enough to be figured.

Remark. Several indeterminable Goniatites were found near Banda, and at Barus in Kashmir.

Nautilus Clitellarius, (*Sow.*) ?

Fragments very like this species were found near Gung. Two or three other species, indeterminable, were found in the Goniatite-bed in Kashmir and at the Rotta Roh.

Orthoceras, *sp.*

A small species, about two inches long and a third of an inch thick, was found in the limestone with *Goniatites Gangeticus* near Gung.

LAMELLIBRANCHIATA.

Solenopsis Imbricata, (*deKon.*)

Journal Geological Society, Vol. XIX. p. 8, Pl. IV. fig. 3.

Found at Koonmoo and in the hills near Mutton and at the Manus Bal, in Kashmir. Also in the Rotta Roh. Good specimens were procured from blocks not in situ, near Bij-Behara in Kashmir.

Solenopsis, *sp. vel var. nov.* Pl. VI. fig. 1. Similar to the preceding but longer; the anterior end is narrower than the posterior extremity, whilst in the *S. Imbricata* both ends are nearly equal. The imbrication of the lines of growth is strongly defined.

Found with the preceding.

Cardinia, sp. (*C. Himalayana, Verch. nov. sp.*) Pl. VI. fig. 2.—(*Anthracosia, King.*) ? ?

The lines of growth are deeply impressed and imbricated, and the shell bulges a little between these lines. The hinge was not seen.

Animals gregarious; their shells occur heaped together in patches. Manus Bal, Koonmoo, Mutton ?, Rotta Roh.

Cardinia, sp. (*Cardinia Ovalis, Martin,*) Pl. VI. fig. 3.—(*Anthracosia King.*) ?

A species more elongated than the preceding. Lines of growth similarly disposed. Found with the preceding.

Cucullæa, sp. Pl. VI. fig. 4.

A gregarious small shell, sometimes so abundant that it forms masses of rock by itself. Lines of growth well defined, especially near the margin. Hinge not seen. It is perhaps the young of some larger shell.

Found at Wean, Koonmoo and Ishmalabad in Kashmir and in the Rotta Roh in the Punjab.

Pecten, sp. Pl. IV. fig. 5.

Small shell, perfectly smooth with the exception of a few lines of growth. It is ornamented with *painted* dark lines, which radiate from the beak to the circumference, increasing in width as they approach the margin. The convexity is very small, and the ears small.

Only one-valve specimens were ever found, through the shell is tolerably common in the reddish limestone of Koonmoo in Kashmir.

Found also in the Rotta Roh ?

Aviculo-pecten Dissmilis, (*Flem.*)

See M. de Vernueil's note.

This and the following Aviculo-pectens are apparently identical with the group of animals represented in England by the *A.-Pecten Arenaceus.* They were gregarious and all lived together, and are now found in a sandy somewhat friable limestone, in lenticular beds which are evidently the remains of sandbanks near the shore.

Our specimens of *A.-Pecten Dissimilis* are oval in shape, the umbo-marginal diameter being the longest. The shell was at first very gibbose, but after the second line of growth it is much less so. Four sunken lines of growth are well marked. Ears small and transversely striated. Shell nearly equilateral, beak prominent.

The cast shows two deep pits, corresponding on the inside of the shell to two tubercles. These pits are more than half way down the valve. The cast is covered with shallow irregular fossæ which correspond to small bosses inside the shell, and are probably due to the presence of pearly matter. There are traces of an epithelium.

Found at Koonmooh, Rotta Roh.

Aviculo-pecten, *sp.* (*A-pecten Ovatus*, *Verch.*) Pl. VI. fig. 6a, and 6b.

A small specimen, quite smooth. Outline elliptical; convexity trifling; ears meeting above the beak into a straight line.

The inside of the valve shows (*b*) two strong lateral ridges proceeding from the beak, and terminating about two-thirds down the valve in well defined tubercles. The hinge presents two short rounded ridges or teeth proceeding from the beak for about a quarter of an inch, when they also terminate in minute tubercles.

Aviculo-pecten, *sp.* (*A. pecten Ranus*, *Verch.*,) Pl. VI. fig. 7 and 7a.

Outline sub-circular; shell very flat; ears irregular. The whole valve is covered with fine radiate striæ, and with thin lines of growth. Shell thin. Internal cast not found. It is perhaps the *P. Crenisteria* (*de Koninck.*)

Aviculo-pecten Circularis, *Verch.*, Pl. VII. fig. 1a. and 1b.

Outline of shell sub-circular, rather transverse. Shell moderately convex; concentric striæ faintly seen. Lines of growth irregular and unconspicuous. The cast (*b*) presents two deep pits which are continued by a groove towards the beak, corresponding on the inside of the shell to two muscular tubercles and ridges. The ridge is much more defined posteriorly than anteriorly. Lines of growth strongly marked on the cast? No pearl fossæ. It may be a variety of *P. Ellipticus* (Phill.)??

Aviculo-pecten, *sp.* Pl. VII. fig. 2a & 2b.

Outline pyriform, umbo-marginal diameter the longest. Moderatly gibbose; beak much incurved and somewhat imbedded in the ears, which meet above it in a straight line.

The cast only was found. It shows two strongly marked lines of growth well set apart. No pearl-fossæ on cast.

The inside of the shell, (*b*) shows two ridges proceeding from the beak but not terminating in tubercles (at least not on one side; the other side was not seen). Two small teeth in the hinge terminate by minute tubercles. Beak grooved by a canal or foramen. Inside of ears concave.

Aviculo-pecten Testudo, Verch. Pl. VII. fig. 3 and 3a.

Shell pyriform, umbo-marginal diameter longest. Extremely gibbose. Beak pointed; ears meeting above in a straight line. A few concentric striæ. Lines of growth unconspicuous, excepting one near the margin.

Aviculo-pecten Gibbosus Verch. Pl. VII. fig. 4 and 4a.

Outline sub-circular, transverse. Shell enormously gibbose, especially as far as the second line of growth. Shell inornate. Lines of growth shallow and confused. Ears meeting in a line above the beak. Shell thick.

Remark. These Aviculo-Pectens were found in Kashmir in the Wean groups only; but in the Rotta Roh they have been found here and there mixed with shells of the Zeawan group, such as *P. Semireticulatus*, *A. Subtilita.*

Axinus, nov. spec. conf. A. Obscurus.

See M. de Vernueil's note.

Found with the Aviculo-Pectens.

BRACHIOPODA.

Spiriferina Stracheyii, (*Salter.*)

Paleontology of Niti, page 72, Pl. IX. fig. 13.

This shell is not rare in the Wean group near Koonmooo; in some beds it swarms in company with a small Terebratula. We have two varieties, one like Mr. Salter's figure and another higher and narrower Some specimens show plainly to the naked eye the punctate structure of the shell.

POST-SCRIPTUM. *Productus Lævis*, (David.) T. Geol. Soc. Vol. XXII. p. 44, Pl. XI. fig. 16, and *Spirifera Barusiensis*, (David), Op. Cit. p. 42, Pl. XI. fig. 7.

Both these shells are found in the Wean limestone near Koonmoo, and at the Rottah Roh in the flaggy limestone with *Goniatites Gangeticus*. I have not found them in the Zeawan group, except at the Rotta Roh in the mixed beds.

TRIAS (MIDDLE AND UPPER.)

Kothair Beds.

In the text I considered provisionally the Kothair group as either the uppermost layer of the Carboniferous, or else Permian or Triasic. I had no fossils then to decide the point. During the time which has elapsed between my first sending in this paper and its publication I have found, in breaking up some rocks from the Kothair bed in Kashmir, a Globosus with Ceratite-like sutures; and I have discovered in the Rottah Roh, in beds corresponding to the Kashmir bed, a few shells which do not leave a doubt of this group being Triasic.

CEPHALOPODA.

Ammonites, sp. conf. A. Gaytani (Klip.)

Paleont. of Niti, p. 65, Pl. TII. fig. 4.

Our specimen is a little more than half an inch across, and very globose. It shows well two or three of the sutures which are identical with Mr. Salter's figure.

From the Upper Bed, near Banda in Kashmir.

Ceratites Semi-partitus (Gaillardot.)

A very good and nearly complete specimen was found in the Rotta Roh, in a pale limestone which forms a high cliff above the much disturbed Carboniferous. The shell is slightly elliptical. The suture is exactly like that represented in Pictet's Traite de Paléontologie. It has some resemblance to M. de Konninck's *Ceratites Lyellianus* or more still to his *C. Lawrencianus*, but the suture differs. Cliffs above Kotela and Oomurkhel, Rotta Roh.

Remark. I have but little doubt that several of the Ceratites described by Mr. de Koninck (from Dr. A. Fleming's collection), as obtained from Carboniferous beds with Spirifers and Producti, had their situs in those cliffs or similar ones, and had dropped and become mixed with the much broken up and fragmentary rocks of the Zeawan and Wean groups below.

Ceratites Nodosus (Sow.) ?

On a slab of reddish calcareous sandstone from the Alged Wan, Rotta Roh, a shell, which has all the characters of this species, is to be seen in company with the Posidonomya to be hereafter described, with fragments of bone and what appears to be a tooth of Lepidotus (?)

GASTEROPODA.

Natica, sp.

Like *N. Subglobulosa* (Kl.) Pal. Niti, p. 68, Pl. VIII. fig. 12.

Only sections and outlines were seen on the weathered surface of rocks. Very abundant in the upper beds at Banda and at Kothair in Kashmir.

Macrocheilus, sp.

Sections and outlines of a shell of this genus are very abundant at Sono Murg and Kothair.

Nerinæa, sp.?

Small shells with a raised spot in the centre of each half-whorl.

Pyramidella or *Loxonema?*

Several specimens of this fine Pyramidella were seen on the weathered surface of the sandy limestone of the patch of Kothair rock near Koonmoo.

LAMELLIBRANCHIATA.

Posidonia conf. P. Minuta.

Minute shells of this genus, with well-marked concentric striæ, were found in the sandstone containing the *C. Nodosus.* Algerd Wan, Rotta Roh.

Outlines of small bivalves are very abundant on the weathered surface of the rocks at Sono Murg and Kothair, but the shells cannot be extracted.

ECHINODERMATA.

Pentacrinites, sp.? Pl. VIII. fig. 1.

Starry rings of Encrinite stems are very abundant in most of the arenaceous limestone of the Wean groups, and also in the rocks of the Kothair groups at Sono Murg and Kothair in Kashmir.

ANTHOZOA.

Cyathophyllum, sp.

Abundant on the weathered surface of Kothair-rocks.

Cyathophyllum, sp.

Same remark as above.

Cyathophyllun, sp.

Generally found as figured at (*a*). Found as represented at (*b*) near Martand, Kashmir.

Remark. Several small species of corals were seen in the Kothair limestone in Kashmir, but in a very bad state of preservation.

LIAS (LOWER.)

CEPHALOPODA.

Ammonites Tubar (*Strachey.*)

Pl. Niti, p. 32, Pl 20 fig. 2 a—c and Pl. 21 figs. 1 a—c.

Three good specimens of this shell showing well all the characters and the suture, as represented by Mr. Blanford.

From a muddy and sandy brown bed, very sparingly calcareous, in the Chichali pass near Kalabagh, Punjab.

Ammonites, sp.

Pal. Niti, Pl. 19 fig. 3 a, 6 and c.

The figure in the Palæontology of Niti is exactly like our shell; it is not described in the text and not named. It resembles a little the *A. Striatulus* (Sow.).—Found in the same bed as the preceding.

Belemnites, sp.

A coarse species when full-grown, with a well marked front sulcus, and often a back one also. The section is oval.

From the same bed as above in Chichali and from some brown sandstones under the Oolite at the foot of Sheikh Bodeen near Tora Obo.

POST-SCRIPTUM. I find this species described and figured by Mr. Stoliczka, (Sections across Himal., Mem. Geol. Surv. of India, Vol. V. Part 1, fig. 78, Pl. VIII. fig. 1-4,) under the name of *B. Bisulcatus* (Stol.) from the lower Lias of Spiti.

LAMELLIBRANCHIATA.

Gryphæa Arcuata (Lam.)

Some specimens, from the Chichali pass and the same bed as the Ammonites, belong certainly to this well-known species.

Astarte, sp.

A very circular Astarte from the same bed, Chichali.

OOLITE (OXFORDIAN).

CEPHALOPODA.

Ammonites Biplex, Sow.

Journal Asiat. Soc. No. 2, 1863, p. 129, Pl. II., fig. 5 and Pl. III. figs. 4 and 5.

Ammonites Strigilis, Blanford.

Op. Cit. p. 126, Pl. III figs. 1 and 1*a*.

Five fragments showing well the single ribs bending forwards.

Ammonites Triplicatus, Sow.

Pal. of Niti, p. 80, Pl. 13 fig. 1.

Ammonites Scriptus (Strachey).

Pal. of Niti, p. 81, Pl. 16, fig. 2.

Ammonites Guttatus (Strach.)

Op. Cit. p. 79, Pl. 18, fig. 2.

Ammonites Wallachii, (Gray.)

Op. Cit. p. 84, Pl. 15, fig. 1 and Pl. 19, figs. 1 and 2.

All these Ammonites are from the Inferior limestone bed of Shaikh Bodeen in the Punjab.

Belemnites Sulcatus, Miller.

Journal Asiat. Soc. p. 125, Pl. 1, fig. 1.

Very abundant in the Ammonite bed at Shaikh Bodeen. Rarer in the beds above.

Belemnites Canaliculatus, Sch.

This is perhaps a variety or a younger shell of the above. Found in the same beds.

Remark. One or two more species of Belemnities were found with the preceding at Shaikh Bodeen.

GASTEROPODA.

Acteonina, sp.

In all beds, Shaikh Bodeen.

Turbo, sp. and Scoliostoma, sp.

Both in Ammonite-bed, Shaikh Bodeen.

Natica, sp.

Same locality.

LAMELLIBRANCHIATA.

Pecten Arcuatus, Sow. ?

Not unlike *P. Comatus*, Munster, (Pal. Niti, Pl. 22, fig. 9). It is more strongly ribbed than Salter's figure of the *P. Comatus* and it is flatter, thus answering perfectly the description of the *P. Arcuatus.*

Ammonite-bed, Shaikh Bodeen.

Hinnites Tubulipora, Verch., n. sp.

Like *Spondylus Tuberculosus*, Goldf., but the ribs of our species are much coarser, fewer, and more foliated and the tubular spines are larger, more in number, and rather lamellar.

It is not rare in the Ammonite-bed, Shaikh Bodeen.

Homomya (Pholadomya) sp.

We have three species of *Pholadomya* without rays from Shaikh Bodeen.

Pholadomya (Ph. Semireticulata, Verch. nov. sp.) Pl. IX. fig. 2.

This pretty shell is mostly found as a cast. It is not rare in the Oxfordian bed and extends to the Corallian above.

Pholadomya (Ph. Quinque-costata, Verch., nov. sp.) Pl. IX. figs. 3 and 3a.

Ammonite bed, Shaikh Bodeen.

Plagiostoma sp. conf. P. Consobrina (D'Orb.)

Ammonite-bed, Shaikh Bodeen.

Ostrœa Gregarea, (Sow.)

Several specimens found near the Ammonite-bed, Shaikh Bodeen.

Ostrœa Marshii, (Sow.) ?

Same bed as above.

Ostrœa Flabelloides, (Desh.) ?

Fragments similar to Pal. of Niti, Pl. 22, fig. 1, found in the Ammonite-bed, Shaikh Bodeen.

Ostrœa conf. O. Deltoidea, (Sow.) ?

The only difference between our specimens and the figures of this species is that our *Ostrœa* have the muscular impression very strongly marked, forming a regular pit with a ridge round it.—From the same bed as the above.

Ostrœa like O. Nana, (Sow.)

In nearly all the beds, Shaikh Bodeen.

Ostrea sp.

A large flat circular oyster, very common in some of the lowest oolitic beds at Shaikh Bodeen.

BRACHIOPODA.

Terebratula Globata, Sow., Pl. IX. fig. 4.

Extremely abundant in the Ammonite-bed and in all the beds near it, at Shaikh Bodeen. It varies considerably.

POST-SCRIPTUM. The *T. Gregaria*, Suess, (Memoirs of Geol. Surv. of India, Vol. V. Part I. page 68, and *T. Tibetensis*, David, (Journ. Geol. Soc. Vol. XXII. p. 37, Pl. I. fig. 11—14, appear to be the same species.

Terebratula Bodeenensis, Verch., nov. sp. or *var.;* Pl. IX. figs. 6 and 6a.

It is very perfectly oval and varies but little in shape. It has, in most specimens, neither sinus or folds, and the line of junction of the valves forms a nearly perfect curve in front. In a few specimens there is a very trifling undulation of this line. The absence of sinus and fold distinguishes from the *T. Globata ;* it is also a smaller shell, but yet may be only a variety of it. Found with the above.

Terebratula Carinata, Lam.

Pal. of Niti, p. 99, Pl. 21. fig 5.

Our specimens are much more like the *T. Carinata* than the figure in Pal. of Niti. It varies considerably, but the shallow sinus is always well marked. Our specimens are larger than the Niti ones.

Shaikh Bodeen, with the other *Terebratulæ.*

Terebratula Numismalis, Lam.

Op. Cit. p. 99, Pl. 21, fig. 4.

Several specimens showing well the depressed aspect of the front of the greater valve, and the well-marked concentric lines of growth.

Ammonite-bed, Shaikh Bodeen.

Remark. Two or three specimens not yet identified were found in the same beds, together with a *Waldheimia* rather globular and of the type of *W. Impressa,* Bach, of the Oxford clay.

Rhynchonella, sp. (R. Concinna, Sow. ?) Pl. IX. figs. 5, 5a. and 5b.

See also Pal. of Niti, Pl. 21, fig. 8.

It has generally, but not always, the sinus better marked than in the Niti figure. Very common at Shaikh Bodeen in nearly all the beds.

Remark. Six other species of *Rhynchonella* have been found at Shaikh Bodeen, but are not yet satisfactorily determined.

Bryozoa.

Eschara Asiatica, Verch. n. sp. ?

A fenestella-like Eschara, appearing in large flat and undulated plates on the surface of the rocks. In the Ammonite-bed, Shaikh Bodeen.

Among the corals, a *Fungia* somewhat like the *Fungia Coronula,* Goldf., but too much worn to be identified, and a *Meandrina* like *M. vel Comoseris Vermicularis* (Edw and Haime), were found in the Ammonite bed at Shaikh Bodeen.

Oolite (Corallian.)

Cephalopoda.

Belemnites Canaliculatus, (Sch.)

Upper Bed, Shaikh Bodeen and Mari-on-Indus, Salt Range.

Gasteropoda.

Nerinæa conf. N. Goodhallii., (*Fitton.*)

Fragments and sections of this shell are very common in the upper beds at Shaikh Bodeen. The section of the whorls is precisely similar to the figure in Lyell's Elements, p. 304.

Lamellibranchiata.

Astarte Scalaria, (Roemer.) ? ? *vel A. Lamellosa*, (Roem.)——

An Astàrte with lamellous concentric lines, referred to the species above from description only, as I have never seen a specimen or a figure of these species.

Upper beds, Shaikh Bodeen.

Anthozoa.

Thamnastræa sp.

Upper bed, Shaikh Bodeen and near Palusseen, Wuziristan.

Thamnastræa sp.

A minute species found with the preceding at Shaikh Bodeen.

Tsastræa sp.

Much like the *T. Oblongata* (Edw. and Haime.)

Upper beds, Shaikh Bodeen.

Tsastræa sp.

Another species from Mari-on-the-Indus.

Thecosmilia Annularis (Edw. and Haime.)

Upper bed, Shaikh Bodeen and Mari-on-Indus.

Meandrina sp.

Mari-on-Indus.

Eunomia sp.

Mari-on-Indus.

Rhizangia sp.

Mari-on-Indus.

Areacis sp.

Wuziristan.

Lobocœnia sp.

A very pretty, spreading specimen from Wuziristan.

Turbinolia sp. ?

From Palussen, Wuziristan.

ROCK SPECIMENS.

Pl. X. figs. 1 and 1a.

Amygdaloidal greenstone with gas-vents branching through the mass. Abundant in the Zebanwan in Kashmir. Found also amongst the rolled stones of the torrents which drain the Afghan mountains.

Pl. X. figs. 2 and 2a.

Trachyte with starry crystals of dull white albite for which I have proposed the name of *Soolimanite.* From the Tukht-i-Sulaiman in Kashmir.

EXPLANATION OF PLATES.

Pl. I.

Spirifer Vercheri, (de Verneuil), n. s. Natural size.

Spiriferina Octoplicata (Sow.) Var. *Transversa,* (Verch.), natural size.

Pl. II.

Athyris sp. (*A. Subtilita,* Hall,)—natural size.

Athyris Buddhista, (Verch.), nov. sp.—natural size.

Athyris, probably *A. Royssii,* (L'Eveillé)—natural size.

Strophomena Analoga, (Phill.) ?—half natural size.

Pl. III.

Spirifer sp. ? (Var. of *S. Keilhavii,* (Buch.) ?—natural size.

Strophomena sp. ?—natural size.

Orthis sp.—natural size.

Pl. IV.

Strophalosia ? Arachnoidea, (Verch.), n. sp.—natural size.

Fenestella Sykesii (DeKon).

Fenestella Megastoma (DeKon).

Vincularia Multangulari, (Portlock).

Pl. V.

Fenestella sp.—natural size.

Disteichia ? ? sp.—natural size.

Acanthocladia sp.—natural size.

Eurypterus vel Limulus ? sp.—natural size.

Pl. VI.

Solenopsis sp.—natural size.

Cardinia Himalayana, (Verch.), n. sp —natural size.

Cardinia Ovalis, Martin), ?—natural size.

Cucullœa ? sp.— natural size.

Pecten sp.—natural size.

Aviculo-pecten sp. (*A. pecten Ovatus* Verch.)—natural size.

Aviculo-pecten sp. (*A pecten Planus*, Verch.)—natural size.

Pl. VII.

Aviculo-pecten Circularis, (Verch.)—natural size.

Aviculo-pecten sp.—natural size.

Aviculo-pecten Testudo, (Verch.)—natural size.

Aviculo-pecten Gibbosus, (Verch.)—natural size.

Pl. VIII.

Pentacrinite ? sp.—natural size.

Cyathophyllum sp.—natural size.

Cyathophyllum sp.—natural size.

Cyathophyllum sp.—natural size.

Sphœronites sp.—natural size.

Sphœronites Ryallii, (Verch.). nov. sp.—natural size.

Pl. IX.

Sphœronites sp.—natural size.

Pholadomya Sesquireticulata, (Verch.), nov. sp.—natural size.

Pholadomya Quinque-costata (Verch.), nov. sp. natural size.

Terebratula Globata, (Sow.)—natural size.

Rhynchonella Concinna, (Sow.) ?—natural size.

Terebratula Bodeenensis, (Verch.), sp. vel var. nov.—natural size.

Amygdaloid with gas-vents—natural size.

Soolimanite.

Irawady Shells, Plate III.

Fig: 1-3, Martesia fluminalis, W. Bl. enlarged 3 diams. Fig. 7-10, Scaphula deltæ, W. Bl. enlarged 2 diams.
" 4, Sphenia perversa, W. Bl. adult, D° " 11-13, S. pinna, Bens, D°
" 5, 6, D° younger, D° " 14-15, S. celox, Bens, D°

Fig: 1, Larina Burmana, W. Bl. nat. size.
„ 2–4, Tectura fluviatilis, W. Bl. D°
„ 5–6, Auricula nitidula, W. Bl. D°
7–10, Amphibola Burmana, W. Bl. D°
Fig: 11, 12, Assiminia rubella W. Bl. enlarged 3 diams
„ 13, 14, Irawadia ornata, W. Bl. D°
„ 15, Stenothyra monilifera, Bens, D°
„ 16, Plecotrema Comingiana, W. Bl. D°

Irawady Shells, Plate 1.

All the figures natural size

Fig 1-12 Neritina Peguensis W Blanf

„ 13-16 D° D° Var

„ 17-19 N. (Dostia) depressa, Rene.

Fig 20 22. N. (Dostia) crepidularia, Less.

„ 23 25 N (Dostia) cornucopia, Bens

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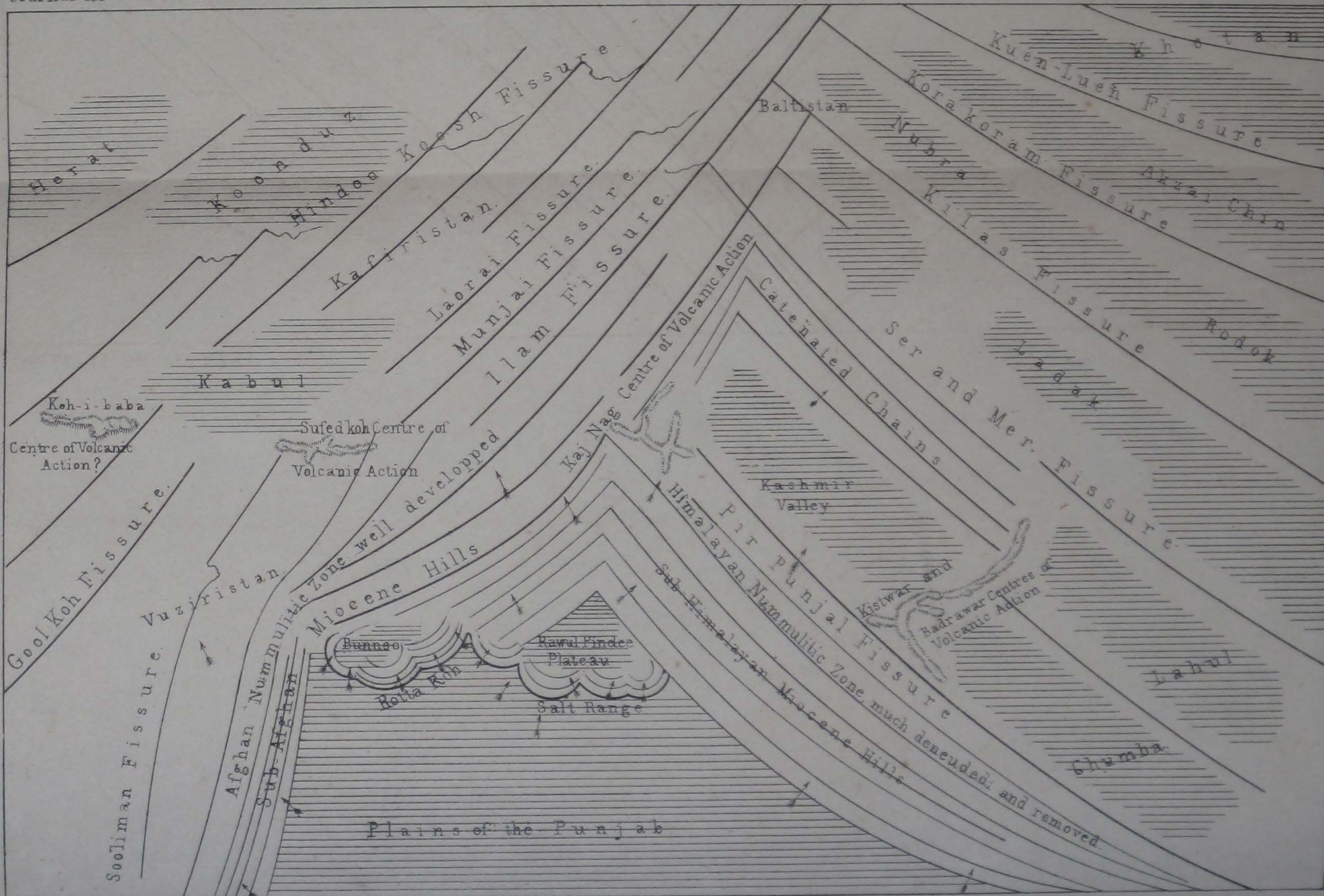
Plate XI



On stone by Ramanauth Dass.

LITH: AT THE SURVEYOR GENERAL'S OFFICE CALCUTTA JANY 1867.

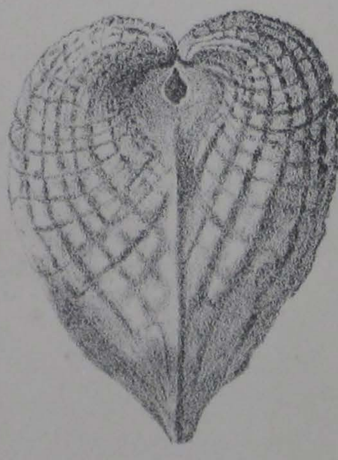
2.

2.a.

1.a.

2.

4.



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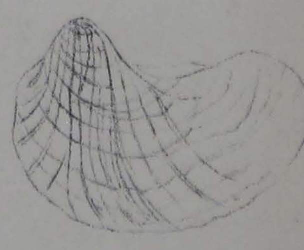


3.a

5

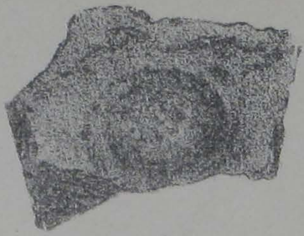
5.a

5.b

6

6.a

1.



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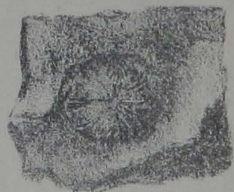

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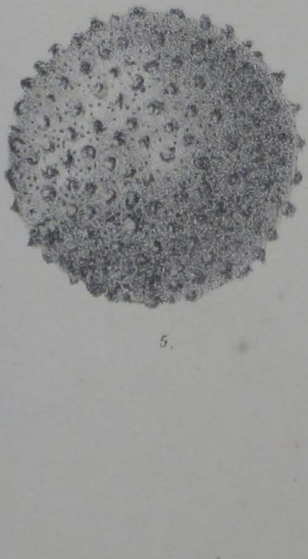

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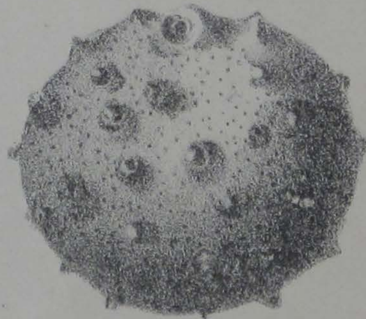
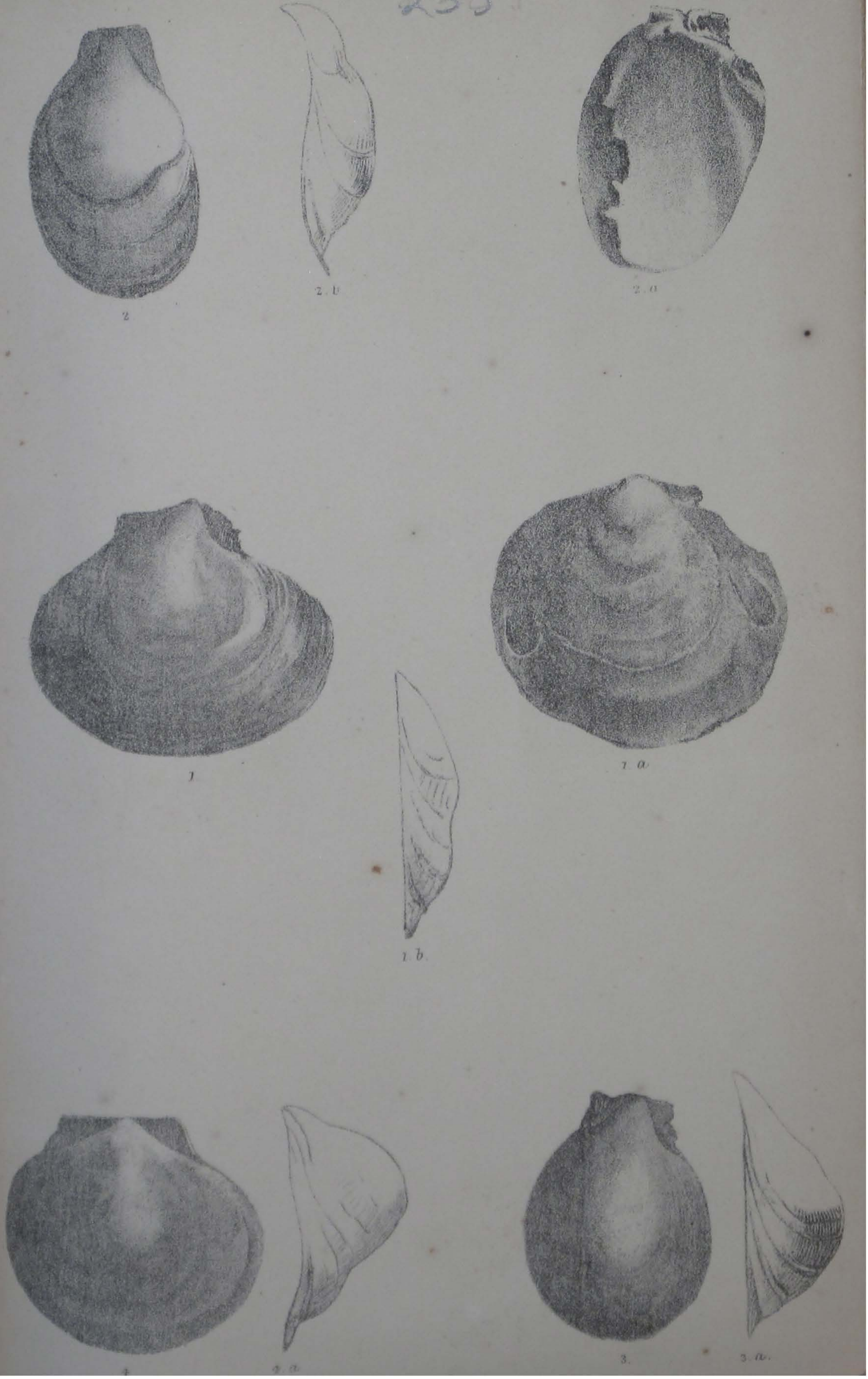
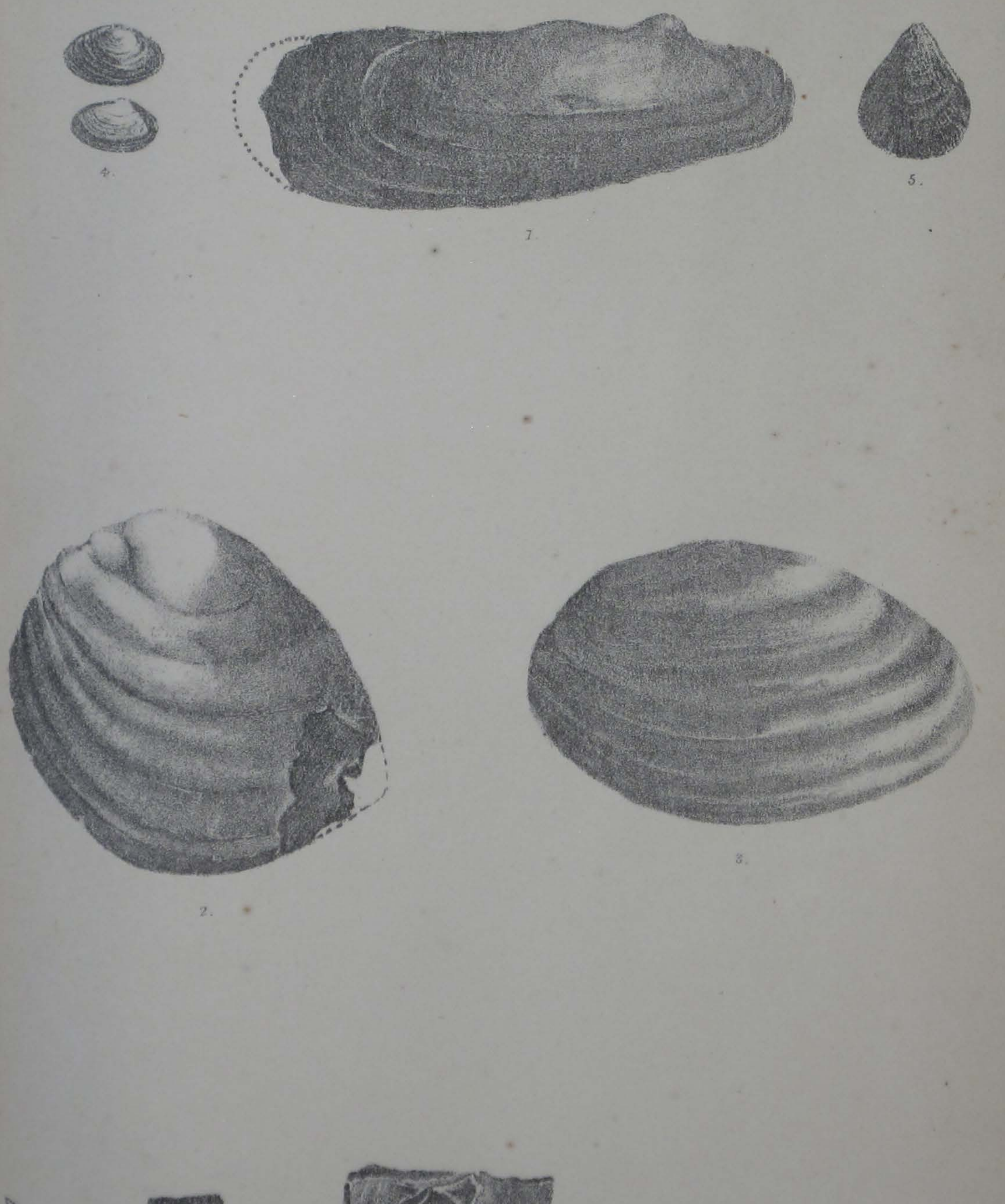


6.

4.

4. a.


2
2. b
2. a
1
1. a
1. b.
3.
3. a.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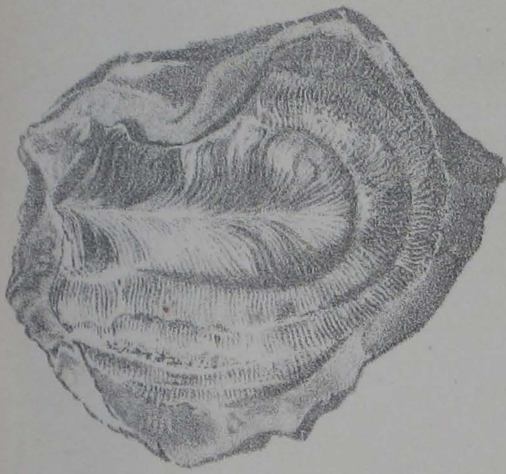
1.
5.
2.
3.
6 b.
6.
6 a.
7.
7. a.



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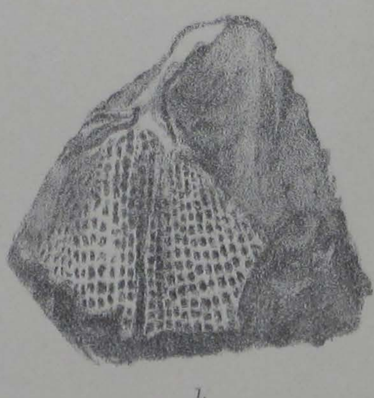
3.



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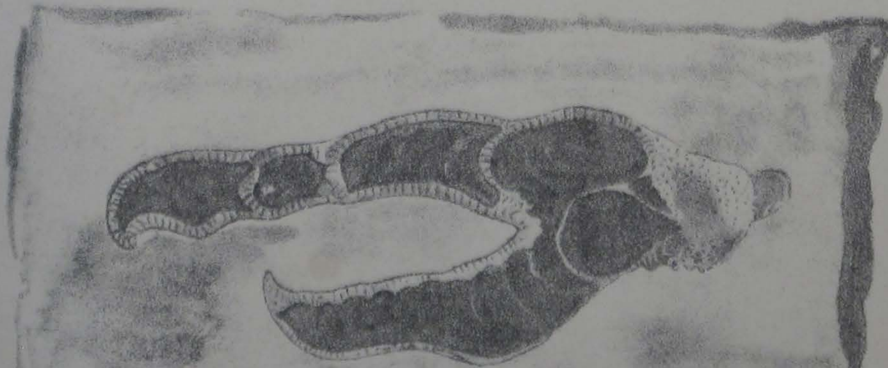

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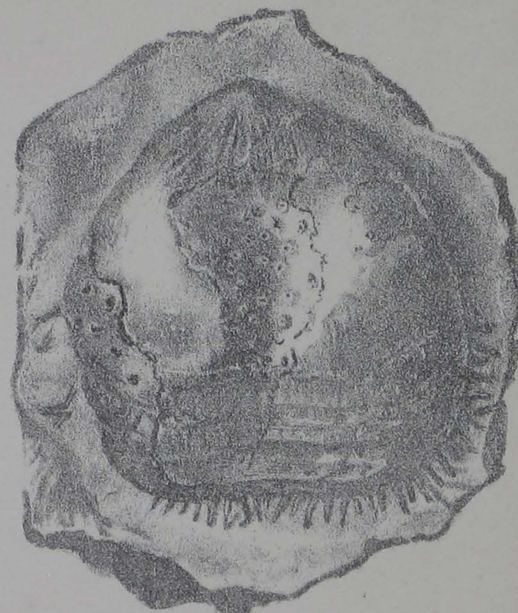
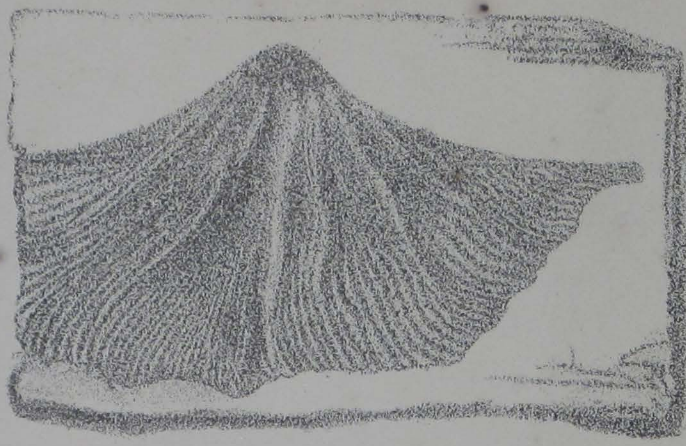


1. a

1. a.

1. b.



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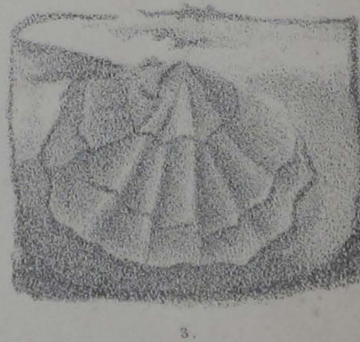

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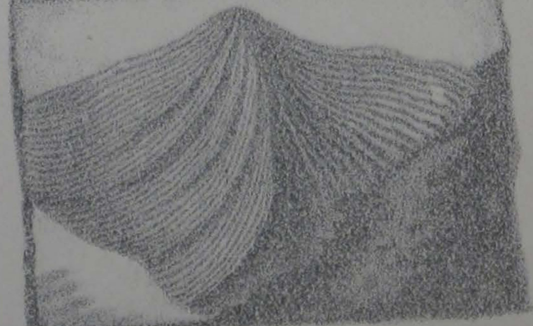


1. a

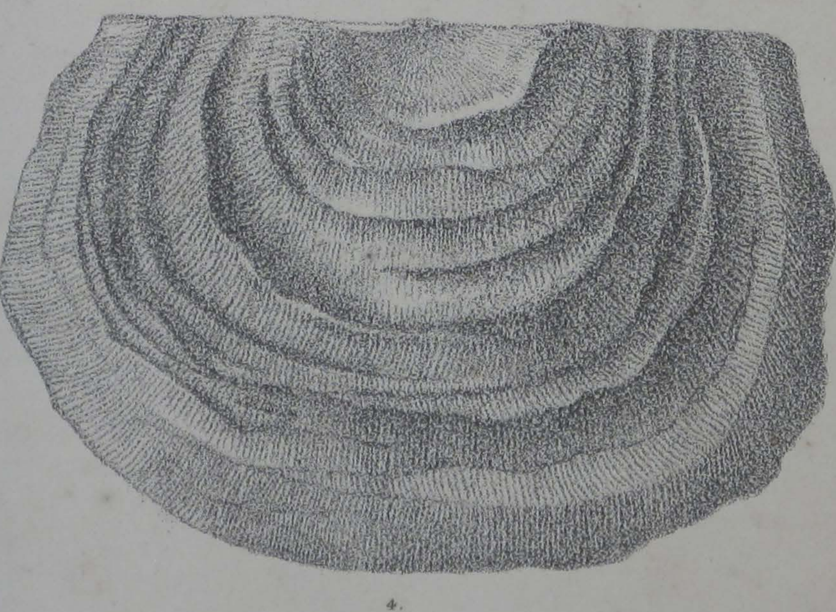
230


1.


1. a


3.


3. a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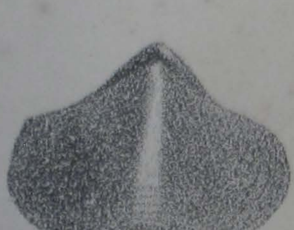
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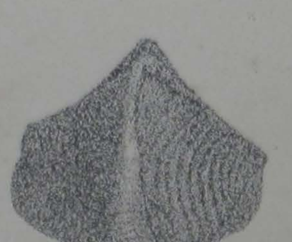
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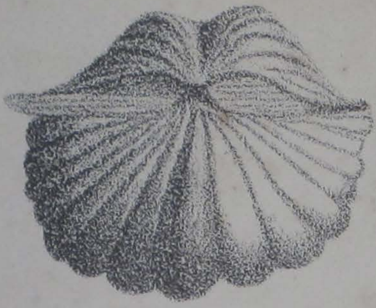
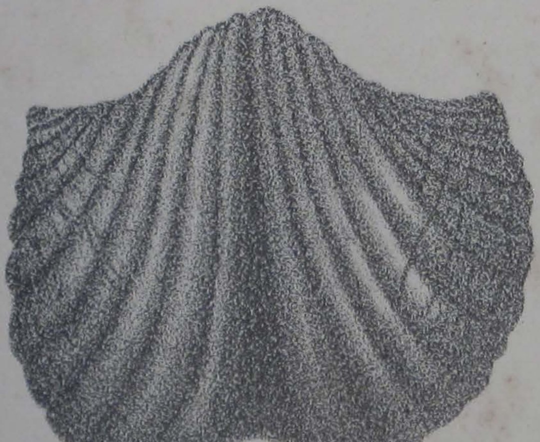
2. b.



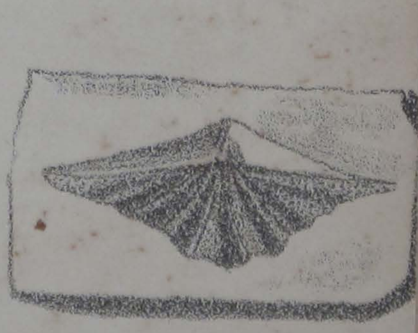
1. a.

1. b.



1.

2. a.



2.

2. c.

2. d.

2. b.