NOTES ON INDIAN GEOLOGY, INCLUDING A VISIT TO KASHMIR.

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INTRODUCTION.

ANYONE wishing, like myself, to make a few remarks on Indian Geology, as the outcome of a recent tour through part of the country, could not find a more fitting occasion than the present, when the Chair of the Association is occupied by a distinguished Indian geologist, who, though not a professional, has contributed valuable original work to the literature of the Indian Survey. Indeed, it is mainly because an Indian geologist occupies this chair that I venture to put before you this evening a few remarks, based upon my recent tour; not, indeed, that I could hope to contribute anything original of real importance, but simply to bring to your notice some facts in the geological history of that country to which my attention has been especially drawn in one way or another.

Outside Europe, and some portions of North America, there is perhaps no country in the world which has been more systematically surveyed, in a geological sense, than India, and the condensed result of all this work may be seen in the map which accompanies the second edition of Medlicott and Blanford's *Manual*, which has been edited and brought up to date by Mr. R. D. Oldham. The geological features of this map, on a reduced scale, are reproduced in Plate VII. As a matter of curiosity, and by the way of comparison, it may be interesting to exhibit a geological map of India, compiled by Greenough and published by Petermann, of Charing Cross, in 1854. The Geological features of this map would, no doubt, be severely criticised by a modern Indian surveyor, nor is the topography in all cases accurate.* The publication of Greenough's map may be said to mark the close of the first era in the geological investigation of India, an era mainly of non-professional enterprise, but one which was rendered famous by palæontological discoveries of Crawford on the lower Irrawaddy, of Falconer and Cautley in the Siwalik Hills and of Fulljames and others in the Gulf of Cambay. These discoveries relate exclusively to Upper Tertiary fossils, and will be dealt with more especially when we come to consider that group. Meanwhile it is interesting to note that two years after the publica-

* He makes the Jhelum, for instance, a portion of the Pūnch River, FEBRUARY, 1896.]

tion of Greenough's map, namely in 1856, the *Memoirs of the Geological Survey of India* first made their appearance, whilst the *Palæontologia Indica* was at the same time commenced by Stoliczka; the *Records of the Geological Survey of India*, did not appear until 1870. Thus, during the last forty years, the work of the Indian Geological Survey has been progressing, under the able management of men like Oldham, Medlicott, Blanford, Valentine Ball, Wynne, Lydekker, R. D. Oldham, and a host of others, amongst whom we note with pleasure the name of C. L. Griesbach, formerly known to many members of our Association, who is now at the head of affairs in this department at Calcutta.

Before venturing to narrate any of my own experiences, I will, with your permission, sir, give a brief outline of the physical history and geological divisions of India, taking as my principal guide the latest edition of the *Manual*, where references to special papers in the *Memoirs* and the *Records* may be found. Nor should I forget to mention in this connection the work of the late Valentine Ball, whose recent death at a comparatively early age, is so much to be regretted. If we wish, on the other hand, to obtain an insight into the views and operations of the earlier geologists, these may be found in the *Palæontological Memoirs of Hugh Falconer*, edited by Charles Murchison, and published in 1868. The first volume of this work bears the title "*Fauna antiqua Sivalensis*," and it carries us back to the period of the thirties, when Falconer and Cautley were making their memorable discoveries in the Siwalik Hills.

Many of these discoveries were announced at the time in the publications of the Asiatic Society of Bengal, of the Geological Society of London, and of other learned institutions. I merely mention these things to remind you that the study of Indian Geology is by no means a thing of yesterday, and that there is a large and interesting literature bearing on the subject.

The most superficial glance at the Survey Map to which I have referred will serve to show that, physically, India consists of three distinct regions, namely, Peninsular India, the Indo-Gangetic plain, and Extra-Peninsular India. This important geognostic feature cannot be realised on an ordinary map, but on a geological map we at once perceive that the great alluvial flat which curves round Peninsular India, from the mouths of the Indus to the mouths of the Ganges, consists of one formation, which has filled up a sort of gulf or strait between the Arabian Sea and the Bay of Bengal. It is just possible that at one time this may really have been a marine strait, in which case Peninsular India must have been an island. However, the deposits of this great flat give evidence, it is said, for the most part, of fluviatile action, and it is certain that the strait, if ever it existed, has long since been filled up by the spoils of the

Himalayas from the North, and to a lesser degree by the deposits of the Central Indian rivers. Although practically a plain, this great flat has a slight east and west slope towards the Ganges and Indus respectively. Roughly speaking, the watershed, if such a term can be applied to what seems a dead flat, runs from the last spurs of the Arávalli mountain system near Delhi, almost along the line of the Delhi-Kalka Railway, to Umballa, which latter place is about 1,000 feet above sea-level. The Jumna flows parallel to this railway for many miles, and evidently marks debatable ground, since General MacMahon, in his presidential address, states that this river at one time belonged to the Indus system. At present the river Markanda, which immediately succeeds the Jumna on the west, is lost in the sands of the Indian desert, though apparently with the intention of reaching the Indus, if it could. The head waters of the Markanda are famous for great finds of Siwalik fossils.

But to return to the tripartite division of India; for the present I have said enough about the Indo-Gangetic plain and its monotonous alluvium. It is time to consider the more interesting subject of the Peninsular and Extra-Peninsular areas, which exhibit a more or less complete sequence of the great geological systems. But these systems differ so much in each area that it has been found necessary to describe them in duplicate. The geology of Peninsular India, judged by European standards, is the most abnormal, and marine fossiliferous strata are very scarce, and occupy but a small extent of surface. The geology of Extra-Peninsular India, omitting the region east of the Ganges delta, of which I do not profess to speak, may be said to consist of an immense horse-shoe of mountains, which curve round the plains of the Upper Punjáb. Notwithstanding the complications produced in such a region by the existence of an alpine facies in many of the deposits, these conform, on the whole, to the European standard better than do the formations of Peninsular India.

PART I.—EXPLANATION OF THE MAP AND SUMMARY OF INDIAN GEOLOGY.

Section A.—Peninsular India.—An immense proportion of this area is occupied by crystalline rocks, such as granites, gneisses, and basalts, which, with the exception of some inter-trappean beds in the basalts, are, of course, wholly unfossiliferous. Hitherto the Transition rocks have proved equally so, and, strange to say, the great sedimentary series known as Vindhyan has never yielded any fossils, although its unaltered and almost horizontal beds seem to be just the sort of place where one would expect to find them. Consequently palæontology has given but

little aid in the classification of these rocks, and it is only when we come to deal with the Gondwana system that anything approaching a chronology based on fossils can be attempted. But as regards the relative age of the lower rock groups there can be but little doubt, and the crystalline system at the base may be fairly regarded as Archæan.

Crystalline (Gneiss, Granite, etc.).—It is possible that many systems may be comprised under this heading, but on the whole the Surveyors divide the series into an older and a newer gneiss. The older gneiss is largely developed in the northern part of Central India, in the district known as Bundelkhand, and may almost be looked upon as the *omphalos* of the entire Peninsula. It is distinguished by its massive structure and obscurely developed foliation, whilst accessory minerals are rare. Quartz reefs occur in this older gneiss, but they are non-auriferous. The district round Jhansi, which we visited on our return journey, may be taken as typical. A specimen of the rock is described in the Appendix.* In the field the Jhansi rock behaves very much like granite, as may be seen in the Jhansi cantonment, where an undulating area is full of protuberances like the tors of Dartmoor on a small scale, whilst the rock on which the fort is built offers a larger example of the tendency to form protuberances.

The newer gneiss, which is well developed south of the Vindhyan basin, presents greater variety in its mineral composition. Thus we read of limestone, dolomite, massive corundum, and magnetite occurring in conjunction with quartzite, quartz-schist, hornblende rock, and mica-schist.

We cannot doubt that large areas, both in the older and newer gneiss, but especially in the former, may be regarded as granite, and it is probable that much of the area coloured as "Crystalline" in the map would come within the definition of granite.

Transition Systems.—This is admittedly a generalised grouping, capable of being broken up into more than one subdivision. The several areas are only approximately similar, and their connection more or less conjectural. The beds of this system in N.W. Mysore are interesting as carrying the paying gold reefs, and many of them are rich in hematitic iron. The iron industry, however, for the present, may be regarded as almost extinct; as much, says *The Manual*, in consequence of the reckless destruction of forests as owing to the competition of imported iron.

In Rajputana and the neighbouring districts the Transition beds attain to great importance in connection with the Aravalli system of upheaval, the effects of which may be traced as far as Delhi. This mountain system is one of the oldest in India, and I shall have occasion to refer to it again in connection with the subject of Mount Abu.

* No. 1, p. 262.

*Vindhyan.**—The Vindhyan Beds represent the upper portion of a great sedimentary series, vaguely referred to the older Palæozoic, but which is quite as likely to be pre-Cambrian, possibly of the age of the Torridon sandstone. The almost horizontal Vindhyan are supposed to bear the same relation to the upturned Transition formations of the Arávali mountain system that the modern deposits of the Indo-Gangetic Plain bear to the Himalayas: that is to say, the horizontal series in each case is contemporaneous with the upheaval of the mountain range with which it is associated, and of whose *débris* it is, to a great extent, composed.

Although the Vindhyan are described as consisting mainly of fine grained sandstones, there are some shales and limestones, and towards the base conglomerates. It is not proposed to deal with these lower sedimentaries, so as to emphasise distinctions between Vindhyan and Cuddapah; but there are certain points of general interest to which reference may be made. We have already seen that they are wholly unfossiliferous, although their aggregate outcrop is the third largest in Peninsular India. But there is one feature of considerable interest in connection with this system, viz., that the beds are the chief, if not the only, home of the diamond in India. For not only are the workings in the solid rock entirely in beds of this system, but even the alluvial diggings for that gem can, in nearly all cases, be traced to them.

Where is Golconda? That is a question I never could get anybody in India to answer, whilst the name is not mentioned either in *The Manual* or in Ball's work.† At present there are three principal diamond districts in India. In the Madras Presidency there are certain beds in the Vindhyan (Cuddapah) system which are regularly worked for diamonds; these beds consist mainly of sandstones, but the diamonds are said to occur in the more clayey and pebbly layers. However, the most historical diamond district in India is probably that of the Mahánadi valley, though here the diggings are alluvial. The Mahánadi, according to Ball, is the river "Adamus" of Ptolemy, and the neighbourhood of Sambalpur may be roughly taken as the centre of a diamond district, which furnished the Mogul emperors with some of their most celebrated stones. The third diamond district is near Panna in Bundelkhand, where according to *The Manual*, "the original home of the diamond is in the lower part of the Upper Vindhyan series, though the possibility of its derivation from Lower Vindhyan beds has been indicated."

* In the index to the map, attached to *The Manual*, Upper (Vindhyan) and Lower (Cuddapah) = Older Palæozoic.

† Since this paper was read a friend has called attention to the following: "Golconda, a fortified and ruinous city of Hindostan, Nizam's dominions . . . on a hill 3 miles west of Hyderabad; lat. $17^{\circ} 15' N.$, long. $78^{\circ} 32' E.$ It has been noted as a *dépôt* for diamonds, which are, however, only brought hither from the plains at the base of the Neela Hulla mountains, on the banks of the Krishna and Penaar rivers, no mines existing in the vicinity. . . ." *A. K. Johnston's Dictionary for Geography*, 1845.

It seems to have been the opinion of Ball and other writers that the diamond really did originate in the Vindhyan rocks, although no attempt to account for its genesis in connection with these rocks has been made. On the other hand, Mr. R. D. Oldham considers that the diamonds are derivative, that is to say, they occur, like any other pebble or stone, in its matrix. In the absence of any theory to account for the genesis of the diamond in connection with the Vindhyan rocks we must regard this as the most reasonable supposition, although it is indeed a remarkable circumstance that a particular horizon should be the sole repository of the gem in a country of such great extent. The primal origin of the diamond in India seems to be as obscure as ever.

Gondwána (Upper and Lower).—Between all the beds previously described and the system now under consideration there must be a great gap in time, since the Gondwánas are completely unconformable to all the underlying beds. The Gondwána beds, in their present distribution, occupy a number of separate basins, and those in the north-east angle of Peninsular India are the best known and of great economic importance. The fossils of this system, of freshwater and terrestrial origin, afford the earliest signs of life which have hitherto been made known in Peninsular India, although the age of the beds only dates from Carboniferous to Trias, or, if we include the Upper Gondwána, to Jurassic.

The sandstones and shales of this great freshwater formation include Labyrinthodonts, Fishes, Insects, Crustacea, Mollusca, etc.; whilst the Plant remains are abundant, and afford evidence of several successive floras. These are regarded as ranging from Upper Palæozoic to Middle Mesozoic, and the Lower Gondwánas approximately correspond to the Carbon-Trias of extra-Peninsular India. There is considerable lithological variety in the several districts. The Rajmahal group, for instance, consists of a succession of basaltic lava flows with inter-stratification of shale and sandstone; and it is noteworthy that the most characteristic sandstones throughout the series contain abundance of undecomposed pink felspar. The celebrated Talchir boulder-bed occurs towards the base of the formation. The indications of glaciation, which it is thought to present, are also noted in the Carboniferous beds of the Salt Range, and elsewhere in the extra-Peninsular area.

The Gondwána Beds contain practically all the workable coal in that portion of India which is included within the accompanying map. Of 2,750,000 tons raised in 1894 the Bengal coal-fields contributed 2,000,000 tons, and the Nizam's territory accounted for 250,000. The Tertiary coal of the Punjab, from which so much was at one time expected, only yielded 66,000 tons. There can be little doubt that the development of the great Gondwána basin in Chotia Nagpore, is only a question of

time, and with increased railway facilities, such as have been lately proposed, a large output may be expected. At present Bombay and Western India are mainly supplied by seaborne coal from abroad, an unfortunate circumstance for the railway companies in those parts. This is the great advantage which the East Indian Railway Company possesses over all other lines, that its wants are entirely supplied by two collieries in Bengal, which are worked in connection with that line.

Cretaceous.—No marine beds of Jurassic age being recorded in Peninsular India we pass on to the Cretaceous. There is a very interesting strip in the neighbourhood of Trichinopoly, which has yielded, probably, the oldest marine fossils in the Peninsula. Three horizons are indicated—viz., Cenomanian, Turonian, and Senonian. It is interesting to note that there are extensive coral reefs towards the base of the system. Another feature of importance is the ever-increasing number of Gasteropods, including many genera of Siphonostomes, which are especially well-developed in the very highest beds. These have been described in Stoliczka's classical memoir, which forms the introduction to the *Palæontologia Indica*.

Deccan Trap.—This formation occupies the second largest area, but is not so thickly bedded as the Vindhya and Gondwana. The period of its eruption is held to occupy the interval between Middle Cretaceous and Middle Eocene. There are intertrappean fossiliferous beds, such as might result from the covering up of marshes and lakelets. Their facies (not marine) is thought to be more inclined to Cretaceous than Eocene. The Great Indian Peninsula Railway runs through the Deccan Trap for 500 miles from west to east. Throughout a large portion of the area the horizontal terrace formation prevails; the beds in the Deccan being flat and rather thin. The terrace formation is noticeable also in the Western Ghâts, but between this elevated platform and the Indian Ocean, there is a strong westward dip in the beds, which increase in thickness, those nearest Bombay being highest in the series.

Within certain limits the lithological character of the rock is tolerably uniform. In some places blocks of scoria may be seen weathering out, just as they do in old volcanic cones, this phase being very noticeable in the Ghâts and around Poonah, also in Bombay Island and Salsette. In texture the rock varies from an anamesite to highly vesicular beds containing various amygdaloids. Zeolites in such beds are especially numerous, the crystals of stilbite and apophyllite being celebrated for their size and beauty.

The origin of such an immense mass of basaltic rock has been the subject of much discussion. It was probably due to subaerial eruptions, since most of the intertrappean fossils are of freshwater species. It is stated that no vents have been dis-

covered ; but dykes are tolerably abundant throughout the coast region, and older rocks are seen to be pierced in Cutch and Kathiawar. By some this extensive extravasation is supposed to have been connected in some way with the disappearance of the hypothetical Lemuria.

The Tertiary Beds may be considered along with those of the extra-Peninsular area.

Section B.—Extra-Peninsular India.—Crystalline (Gneiss, Granite, etc.). Following the same order we take the crystalline rocks first. These, of course, constitute large areas in the Himalayas, but there they have been so much twisted about and injected with granite that their true nature is not easy of interpretation. General McMahon, in his presidential address (1895), described the character and position of many of these rocks, which usually occupy the most elevated position in the Himalayan ranges. As regards the term "Gneissic," the editor of the second edition of *The Manual* admits the difficulty of distinguishing between granitoid gneiss and gneissose granite. He is also alive to the difficulties which arise from apparent sedimentation, difficulties which the earlier surveyors probably did not sufficiently appreciate.

Transition Systems.—These include the Vaikrita system of Griesbach—micaceous schists, talcose-rocks, phyllites and gneiss—occupying the cores of highly compressed synclinal folds in Hundes and Spiti, not indicated by colour on the map.

Cambro-Silurian.—This must be held to include a wide scope of beds. In the Salt Range, for instance, it will be found to include both pre-Cambrian and Cambrian beds ; whilst under the general term of "Attock Slates," is a great series, coloured pale-blue on the map, corresponding in the main to Lydekker's Panjal system in Kashmir. The older Palæozoic fossils are barely in evidence throughout the Himalayan region, and we must turn to the Salt Range for more conclusive proofs.

The Salt Range, though only 150 miles in length from east to west, contains a sort of epitome of nearly all the marine fossiliferous horizons of extra-Peninsular India. In a country where all fossils are scarce (the Siwalik beds excepted), this is a point of great importance. In the eastern portion of the Salt Range the sequence is not so full, and we miss especially the really abundant Carboniferous fauna of the central and western portions.

Taking the Salt Range as a whole, we obtain the following horizons below the Carboniferous :

(1) The Purple Sandstone group of pre-Cambrian age. This series contains the Salt deposits. The base is not seen, so that no Transition or Crystalline rocks are exposed. It is thought to be of the same age as the Vindhyan, both being equally

unfossiliferous, though there is said to be considerable lithological similarity.

(2) The Lower Cambrian. The fossils are contained in a dark shaly series, which underlies a rock locally known as the Magnesian Sandstone. Subsequent to the publication of Mr. Wynne's memoir, Dr. Warth has extended our knowledge of this fauna, and he claims to recognise the following sub-divisions in descending order: *Olenus*-fauna, *Paradoxides*-fauna, *Olenellus*-fauna, *Neobolus*-fauna. This last assumes considerable importance as the oldest recognised fauna in India, or possibly in the world. With one exception it consists of Brachiopoda, having shells of a horny calcareous nature. The genera differ from those previously known, excepting *Lingula*. There are two species of *Neobolus*, one of which is rather plentiful.

(3) The Magnesian Sandstone and Salt-pseudomorph zone, which overlies the shales, containing the Lower Cambrian fauna, may in part represent the Upper Cambrian and Silurian. The Salt-pseudomorph zone was originally regarded as Trias by Wynne.

Carboniferous to Trias.—Mr. Wynne's original divisions of the Carboniferous have undergone some modification, and the following grouping is now adopted, viz.:

Productus-limestone,
Speckled Sandstone.

There is much that is interesting in connection with the "Speckled Sandstone," especially as regards the boulder-bed, and the striated and even faceted rock fragments, which are held to be indications of glaciation, as in the Talchirs of Peninsular India. To the boulder-bed of the "Speckled Sandstone" the underlying Magnesian Sandstone has largely contributed, and certain crystalline rocks are identified with masses which occur *in situ* 750 miles to the southwards. Some would identify this boulder-bed with the "conglomeratic slate" of Blaini in the Simla district, and with other slaty conglomerates of the Himalayan region. It is interesting to note that the fauna of the "Speckled Sandstone" has Australian rather than European affinities.

The overlying *Productus*-limestone, which for India seems to have yielded a very respectable number of fossils, possesses a fauna whose general facies is Upper Carboniferous to Permian, nor is there a single species identical with those in the bed towards the base of the "Speckled Sandstone." The connection now is rather with Europe and other parts of Asia, whilst there is a singular mixture of typical palæozoic and mesozoic forms.

In the Himalayas a fair number of marine Carboniferous fossils have been found in the mountain mass which lies immediately north of Kashmir city. The general facies differs considerably from that of the Salt Range, but if the fauna is rather older than that of the *Productus*-limestone, the circumstance may

be thus explained. Associated with the Carboniferous beds, and possibly with older beds, in Kashmir, is an important series of igneous rocks, held to be contemporaneous lavas. Reference will be made to these in Part II.

In the Simla district there are no marine fossils, and the beds are spoken of as "Carbonaceous," yet without coal. The famous Blaini Conglomerate occurs about half-way between Kalka and Simla—a "conglomeratic slate" in association with carbonaceous shales. A large series of quartzites succeeds, and there seems to be a considerable amount of indefinite rock which is held to belong to this system. In the Dalhousie district, lying between Simla and Kashmir, General McMahon has described some carbonaceous beds with associated basic volcanic rocks, underlain by a conglomeratic slate, all held to be of Carboniferous age.

The upper portions of the area, mapped as "Carboniferous to Trias," are, no doubt, mainly of Triassic age, and in the Salt Range are represented by the Ceratite-beds. Lamellibranchs, such as *Megalodon* and *Dicerocardium*, are held to be characteristic, along with *Spirifer* and some curious Ammonites. The Trias in the central Himalayas is characterised by a great thickness of limestone, and there is an abundant Cephalopod fauna in the lowest beds. The equivalents of these beds, so largely developed in Spiti, may be found at either end of the Vale of Kashmir, and in the Hazara (Abbotabad).

Jurassic.—Marine beds of this age are well developed in Cutch and the adjacent islands, whilst there are numerous isolated exposures in Western Rajputana. In Cutch the base is constituted by the Lower Oolites, succeeded by Oxfordo-Kimeridgian, Portlandian, and Tithonian. Limestones are not particularly abundant in the series, which also seems poor in corals. The Ammonites are the principal indicators of European relationships, and such well-known species as *Am. macrocephalus* and *Am. perarmatus* are recognised. Marine Jurassic beds are also found in the western portion of the Salt Range, whose lithology and palæontology are said to incline towards the types in Cutch; in both areas the Kellaway's fauna seems well represented. The Spiti shales of the Himalayas are stated by Dr. Waagen to contain a very different fauna. Some of the Ammonites from this quarter, it is well-known, have been invested with a sacred rather than a scientific character.

Cretaceous.—Beds of this age are well developed in Afghanistan, beyond my sphere of observation. There is also a development near Abbotabad, to which attention will be directed in Part II. Of course, the never-failing Salt Range presents us with its special series. The authors of *The Manual* observe that it is not possible to separate the Cretaceous and Eocene on any but palæontological grounds.

Eocene Volcanic of Himalayas.—Associated with the Lower Tertiaries in the valley of the Upper Indus are some very basic eruptives which are regarded in the main as contemporaneous.

Lower Tertiary.—According to the grouping adopted by the Indian Survey, the Lower Tertiaries comprise the Eocene Nummulitics and their equivalents, together with beds of Miocene age, such as the Nahan, or Murree beds. The arrangement is not altogether satisfactory as regards Northern India. In fact, there would seem to be no analogy whatever between the marine fossiliferous Nummulitics of Eocene age and the unfossiliferous sandstones, etc., referred to the Miocene period, thus grouped together.

The Lower Tertiaries are strikingly exhibited by the long strip of beds in the valley of the Upper Indus near Leh. A portion of these beds consists of a coarse blue limestone containing numerous discs, which are supposed to represent Nummulites, and two species of Nummulites have actually been recorded, also indications of other shells. Stoliczka took these beds for palæozoic rocks, a conclusion not to be wondered at when we bear in mind the rarity of fossils and the vicissitudes which the rocks themselves have undergone. As proof of the changes of level since early Tertiary times, these Eocene beds rise to a height of 21,000 feet in the Stok Peak opposite the town of Leh.

On the opposite or south-west side of the central crystalline axis of the Himalayas there is a long strip of Lower Tertiaries, narrow in the Simla district, but widening out towards the north-west in the neighbourhood of Murree. The Lower Tertiaries are also well developed in the Salt Range and in the Rawal Pindi plateau. The Simla area having been the first studied, the names of the several series are derived from that district. The Sabáthu group at the base is obviously of marine origin and Nummulitic age as shown by the numerous fossils it contains. The two upper groups, which go to make up the Lower Tertiary of the Survey, are really of Miocene age. They possess a variety of Indian names, but are best known in the far north-west as the Murree beds; they are probably on nearly the same horizon as the "Nahan" of the Mount Tilla section. These beds are composed almost entirely of mechanical sediments and contain no fossils other than plant remains, and are held to be of freshwater and to some extent of subaerial origin.

There can be no doubt that a great physical change had taken place between the period of deposition of the marine Nummulitics and of these unfossiliferous mechanical deposits. That change was no less than the upraising of the Himalayan mountain system, which, *as it now exists*, must be regarded as mainly, if not wholly, post-Nummulitic. Doubtless, as our President has so well pointed out, the Himalayan area had a previous history, but to this I need not at present refer.

Upper Tertiary (Siwalik).—These are by far the most interesting and fossiliferous of all the Indian formations, and they are distributed in strips over an immense area. Falconer pointed out that the Siwalik beds may be regarded as forming three points of a triangle, viz., the foot of the Himalayas on the north, the Gulf of Cambay on the west, and the Irawaddi valley in the far east. As I indicated in the Introduction these far off points have been rendered famous by great finds of fossils. Omitting Lower Burmah and Perim Island, let us confine ourselves to the sub-Himalayan region.

The Siwalik Hills, as developed between the Ganges and the Sutlej, have a length of about 270 miles. The structure and composition of these hills was described by Cautley in *The Transactions of the Geological Society of London* as long ago as 1836. We learn also of their structure from Falconer in the *Fauna antiqua Sivalensis*, and more recently from *The Manual of Indian Geology*. The annexed diagram (Fig. 1) is a sort of compound of sections by Falconer and R. D. Oldham.

FIG. 1.—HIMALAYAN FOOT-HILLS.—After Falconer and R. D. Oldham.

- r. Recent alluvium of the Indo-Gangetic Plain.
- r'. Recent deposits of the Dehra Dun.
- A. Upper Siwalik conglomerate.
- B. Middle Siwalik Sandstones.
- E. Pre-Nummulitic rocks.

One point of interest in this Section arises from the circumstance that, owing to the interposition of a longitudinal valley or "Dun," the Siwalik Hills stand out as an independent range. There is every variety of junction section between the Himalayas and the plain, but as a rule the beds first encountered dip inwards—in this case at an angle of about 35 degrees. Moreover, it will be observed that in this section the whole of the Lower Tertiaries are faulted out, as seems to be the case everywhere between the Jumna and the Ganges.

Lithologically the Lower and Middle Siwaliks are characterized by a great thickness of fine grained grey micaceous pepper-and-salt sandstone, interbedded with clay bands near its lower portion. The Upper Siwaliks consist largely of soft, earthy clays (very like the alluvium of the plains) mixed with coarse conglomerates, formed of rounded pebbles and boulders of crystalline and metamorphic rocks derived from the Himalayan ranges.

The subject of the Siwalik fauna is far too large to admit of more than a passing allusion. The mollusca are scarce and belong to freshwater and terrestrial forms, identical, or nearly so, with living species. But, of course, the greatest interest attaches to the vertebrate and especially the mammalian fauna. For an account of these I must refer to the *Fauna antiqua Sivalensis*, and to Mr. Lydekker's recent publications in the *Palæontologia Indica*. Falconer and Cautley often collected their fossils at the foot of the cliffs, thus reaping the harvest of centuries of waste. It is true they had been anticipated to a certain extent, for as far back as the middle of the fourteenth century (1360 A.D.) bones of elephants, and of what were supposed to be men, had been discovered in digging through a big hill, and were thus brought to the notice of the Emperor at Delhi. We are not told whether the Great Mogul possessed a museum, like the Maharajahs of our own days. In the present century the work was done in a very systematic manner, and we read that the collection of fossils which Captain Cautley presented to the British Museum amounted to 200 chests, each averaging about a hundredweight of contents, the whole amounting to ten tons.

Falconer pointed out the analogy between the existing vertebrate fauna of India, as far as it goes, and the extinct Siwalik fauna; of which the existing fauna is held to be a mere remnant. Besides the mammalia, there are abundant remains of crocodiles and chelonians, and some birds, including species of *Grallæ* of immense size. All these creatures lived on the land and in the rivers of a region fairly analogous to the Indo-Gangetic plain. Indeed, the Siwalik beds may be regarded as representing the Pliocene portion of that depression, which after having been lowered to immense depths (these beds are 10,000 feet thick) became involved in the Himalayan uplift. It seems probable that Falconer regarded this assemblage of animals as covering a longer period than the Pliocene, and if we were to be guided by purely palæontological evidence, much might be said for this view of the case. But a careful study of the local evidence, and relations of the Siwaliks to preceding and succeeding beds has brought about the conclusion that they are mainly of Pliocene age.

PART 2.—BOMBAY TO SRINAGAR.

Having briefly sketched some of the leading features of Indian Geology in its dual aspect, I will now narrate some of my own impressions, though still continuing to borrow largely from the constituted authorities. It must, however, be admitted that such impressions are merely superficial, and truly, if such a geologist as Murchison was called to account for practising his profession in gigs, how much more difficult is it to read the features of a country from a railway carriage or a tonga.

Our party, that is Professor Blake, my wife and myself, landed at Bombay on the morning of the 27th of January last. The city is built on a tongue of low-lying land with basaltic supports, which are especially obvious in the Colába Peninsula (the southern extremity of Bombay Island), and still more so on Malabar Hill, a much higher promontory, where are situated the Government House and the villas of the Bombay fashionables, both native and European. In the clear air of a winter's day, as seen across the rippling waters of Bombay Harbour, the picturesque outline of the basaltic hills in the direction of the Gháts adds much to the beauty of the landscape. It will readily be understood that, having much to do in making arrangements for our up-country tour, we did not pay any special attention to geological matters, though I regret not having made the attempt to inspect the celebrated inter-trappean bed on Malabar Hill, which has yielded some interesting fossils. I console myself with the reflection that the site is now most probably built over, and consequently no longer accessible. With regard to collections, it must be remembered that Bombay is a city of merchants, and the geological surveyors reside mainly at Calcutta. I never heard of any Government museum here which contained any fossils, and the same must be reported of every town visited by us throughout the journey. Hence I never had an opportunity for examining any collection of fossils, though there are a few in the museum of the Bombay Natural History Society.

This museum is kept in excellent order by the secretary, Mr. Phipson, to whose interesting demonstrations we were greatly indebted. His live snakes, including cobras, pythons, etc., are a remarkable feature of the collection. Birds, birds' nests and eggs, shells, and some few fossils were also passed over in rapid review, and we thus obtained, in something less than an hour, a considerable insight into the natural history of the district. Mr. Phipson had lately procured a portion of the jaw of a rhinoceros from the Siwalik beds of the Gulf of Cambay. This is a well-known locality, whence Captain Fuljames, as before stated, obtained a large series of mammalia now in the museum of the Geological Society, which were specially described by Falconer in *The Quarterly Journal* forty years ago. The best fossils were found in a conglomerate bed on Perim Island, at the entrance of the gulf. This bed lies below high-water level, and, as in all other Indian localities for fossil bones, yielded to the first collectors a rich harvest. Owing to the erection of a lighthouse on Perim Island the principal fossil bed may no longer be blasted, and collectors will have to confine their attention to an extension of the horizon on the mainland. The fauna comprises ten species of mammals, and is thought to be a little older than that of the Siwalik Hills, though the absence of *Elephas* and its subgenera may have been the result of local accidents.

As regards the basalt of Bombay most of the exposures exhibit a dark aphanitic rock, and this, as far as I remember, is the character of the basalt at the Caves of Elephanta, where the pillars and sculptures are hewn out of the living rock, which is close grained and exceedingly tough.

After leaving Bombay, on arriving at Surat we already found ourselves on the alluvium surrounding the Gulf of Cambay. Consequently there is no geological observation to record until we reach Baroda. This town is also on the alluvial plain, though within sight of a hill called Pawargha, which may possibly be the southern termination of the Arávalli mountain system. The new museum at Baroda is a really fine building, though, perhaps, somewhat deficient in light: here we left our friend, Professor Blake, duly installed as the organising curator.

From Baroda the railway runs through a rich alluvial country, past Ahmedabad, half-way between the Gulf of Cambay and the Run of Cutch, and on the confines of Guzerat and Rajputana it enters the rocky district connected with the Arávalli Range. I have already explained that this mountain system consists to a large extent of the rocks described as "Transition," whose north and south strike and high angle of dip may be traced even as far as Delhi. It is the most ancient mountain system in India, and what we now see are the mere stumps of a chain, whose denudation largely contributed the material for the Vindhyan rocks—themselves, as I shall presently show, of pre-Cambrian age.

We quitted the train at the Abu Road Station, where the line passes through a long north and south upland hollow at the junction of the "Transition" and "Crystalline" systems. This hollow, or valley, is, perhaps, a dozen miles across, it is bounded on the east by the peaked and irregular ridge of "Transition" rocks, which constitute the Arávalli proper, and on the west by the granitic range of Mount Abu, which attains an elevation of about 4,000 feet.

The ascent of this mountain, which contains an important sanitary station towards the top, is one of the chief features of a tour in Western India. Gentlemen ride up on horseback, and ladies are drawn in rickshaws by coolies. The distance is sixteen and a-half miles, of which the first four miles are on the almost level surface of the upland hollow. The range of Mount Abu rises very steeply from this level, and, as far as I could judge, consists entirely of granite. No doubt this is bedded to a certain extent, and in one place I noticed some schistose rock, but almost all parts of the mountain to which I had access consist of a very felspathic granite showing little or no foliation.* The scenery is peculiar; there are some curious peaks and knobs of rock; those knobs which are close to the plain having a re-

* No. 2 in Appendix, p. 262.

markable *moutonnée* appearance. The knobs, like the tors of Dartmoor, are no doubt due to the superior hardness of certain portions of the rock—a feature so very characteristic of granite. Altogether the scenery and physical structure of Mount Abu and its surroundings are exceedingly interesting, and seem to invite further investigation, more especially as to the relation of the Crystalline to the Transition series. Moreover, I may mention that the character of the vegetation attracts the attention of travellers coming from the alluvial plains. Here it was that we saw the only approach to anything that could be called a forest throughout the whole journey between Bombay and Peshawur. The deficiency of timber, other than ornamental, in India has been remarked by many people besides ourselves. Nor is this deficiency confined to those parts of Western India visited by us, for Valentine Ball, the Geological Surveyor, mentions that railway sleepers had to be imported in large quantities owing to the deficiency of native timber. Amongst the causes of this deficiency are frequent jungle fires, intermittent cultivation, and the ravages of stock, more especially of goats.

We must now pass over a considerable tract of country, and I draw your attention to Jeypore, the interesting capital of one of the principal Rajputana states. This city exists in duplicate: the modern town is on the alluvium, whilst the ancient and more picturesque town is partly built on the slopes of Transition rock of the Arávalli system, which occupy a large extent of country hereabouts, though nowhere attaining to any great elevation. Throughout this district are a number of rugged, ridge-like hills, which, as far as my own observation goes, consist of quartz schist and rocks of a similar character. But at some little distance from Jeypore in the same Transition system are marble quarries, which I regret that we were not able to visit. Much of the marble employed in building the Taj at Agra is said to have been obtained from here. Before quitting Jeypore I should at least refer to the museum, which is really a magnificent building, and contains many curiosities, though I could find no fossils.

The next place of interest is Agra, where we at last reached the Gangetic plain. Here the Jumna flows between steep banks of alluvium, past the walls of the Taj, which if not built of marble are certainly veneered with it. This marble is perfectly white, and appears to be as good as the best Italian in quality. The buildings in the Fort at Agra are likewise of remarkable interest, and we perceive the same kind of material and architecture at Delhi and Lahore. The stone used in these buildings consists largely of a peculiar purplish-red sandstone, which is obtained from beds belonging to the Vindhyan system situated at Futtehpoore Sikri, some eighteen miles to the west of Agra.

At Delhi the alluvial plain through which the Jumna flows is about 700 feet above sea level. But immediately on the west of

the city rises the celebrated ridge, which is in reality the northern termination of the Arávalli system, consisting of the same sort of quartz-schist, quartzite, etc., tilted at high angles with a northerly strike. Truly, there is no more interesting spot in all India, replete as it is with memories of the Mutiny. For it was the existence of this ridge which enabled a small band of heroic soldiers to conduct the siege of Delhi to a successful issue. The besiegers made this ridge their fortress, and thus, fairly secured against attacks, were enabled to establish batteries, from which the walls were breached and the city ultimately stormed. If the capture of Delhi saved India to the British, as is by no means improbable, the proximity of this old quartzite ridge to the capital of the Mogul Emperors may be truly said to have determined the fate of an Empire.

A railway journey of a hundred and twenty miles enabled us to cross the Indo-Gangetic plain in a northerly direction, and we found ourselves at Umballa, which is within view of the Himalayas, as we saw a snowy mountain about 12,000 feet in height, probably the Chor peak. Continuing our journey northwards, night fell before Kalka was reached, so that we passed through the Siwalik Hills without seeing them; and in the morning found ourselves in the sub-Himalayan region, 2,400 feet above sea-level.

The distance from this place to Simla by road is fifty-seven miles, or about double what it is in a straight line. The route crosses the strike of the beds, and in this way goes right against the grain of the country, the beds being for the most part tilted at very high angles. This route also may be said to follow the water parting between the Ganges and the Indus. If it is difficult to geologise in a gig, matters are not much mended by being in a tonga; consequently I can only give very superficial impressions. It was obvious to me that we passed through two totally different rock systems, and I afterwards learned that the first rock-group is the classical ground of the Lower Tertiaries, whence the names Sabáthu, Kasauli, etc., are derived. Near Kalka almost vertical beds of hard siliceous rock are interwoven with shaly beds, and about six miles from that town these rotten shaly beds, or mud-stones, have caused a landslide, which is continually giving trouble. We shall see presently, when dealing with the Murree beds, that this tendency to form landslips is rather a characteristic feature of the Lower and Middle Tertiaries. The true Nummulitic horizon, or Sabáthu beds, I cannot say that I recognised. These are said to consist principally of greenish-grey and red gypseous shales with merely lenticular bands of impure limestone. Consequently, there are no fine limestone escarpments, such as one would see in the Alps in an analogous position, and the scenery is on the whole disappointing. Indeed, our verdict on the Lower Tertiaries of the Himalayas may be

summed up as follows : a confused mass of precipitous slopes, but no distinguished peak and no commanding precipices.

Beyond Solon, which is a sort of half-way house, there is a complete change in the character of the rocks, and hereabouts we must have passed close to the celebrated Blaini-conglomerate. These are the Carbonaceous beds of the Simla area, utterly unfossiliferous and with a very indefinite lithology. At Simla itself quartzites and beds with some mica are chiefly in evidence. The position of Simla on a rocky and well-wooded amphitheatre, whose crest lies 7,000 feet above sea level, is magnificent in the extreme, and the view of the central snowy range, from the Mall on a clear winter's evening, leaves nothing to be desired.

Having thus had a peep at the Himalayas in winter, we returned to the plains of India as fast as the tonga could carry us, and after a detention of some days at Umballa set out by rail for the Punjab. There are only two points I would notice in our journey to Lahore : first, that the Sutlej is almost deprived of its water at this time of the year by the immense drainage canal which taps it higher up ; and secondly, that the alluvium of the plains through which we were travelling was obviously of a more sandy nature than that farther to the south. The Museum at Lahore is pretty well patronised by the public, but the natural history department as usual is rather weak. I saw no fossils, but there is a specimen of coal from the lowest Eocene strata at Chittheadand (?) in the Salt Range. The seam is stated to be 24 inches thick and the "present excavation" 700 tons per annum, delivered at Khewra Station at 9 Rs. per ton : this specimen was presented by Dr. Warth. There is also a sample of coal found in the Chamba Hills presented by Mr. B. Powell.

Our next point was Jhelum, a small town and civil station on the river of that name (the ancient Hydaspes), where at length the great plain of India with its monotonous alluvium may be said to terminate. The situation is remarkable and if the day is clear may to a certain extent be realised, though in hazy weather nothing particular can be seen. But this is really the gateway leading to the plateau of the Northern Punjab, and is situated in the wide gap between the easternmost spurs of the Salt Range on the left, and on the right the slopes of the north-west Himalayas culminating in the snowy Panjal. The axis of the Salt Range is almost at right angles to that of its gigantic neighbour, so that its eastern spurs point directly at the Himalayan slopes, but never reach them. The stratigraphical facts in connection with this circumstance are important, since they show that a failure of the elevatory forces in the intervening space was the initial cause of this wide flat, through which the waters of the modern Jhelum and its predecessors have passed.

It is now time to say a few words about the Salt Range itself, which I have already indicated as the most important in all India

in a palæontological sense. Indeed I don't know what the Indian Surveyors would have done without the Salt Range, which epitomises the geological history of the country in a way that no other mountain range does in any part of the world. And yet, in this region of gigantic ranges its dimensions are very moderate, the usual elevations being about 3,000 feet, though in its western bulge as much as 5,000 feet is attained. The length of the chain from west to east is about 150 miles, with a marked escarpment towards the south, and more gradual slopes in most cases towards the north Punjab plateau; this plateau is sometimes known as the "Potwar," and I shall subsequently designate it as the Rawal Pindi plateau. You perceive that the Salt Range is very much doubled up in two places, being compressed, as it were, between the Sulimán range, west of the Indus, and the north-west Himalayas. Consequently the strike is sometimes twisted and the dip transposed, but, on the whole, there does not seem to be much inversion, so that the beds are usually in their proper places, and often lying at moderate angles. This peculiarity lends itself to the formation of mural cliffs and cañons, which one does not often see in the outer Himalayas.

Much more might be said as to the orography of the Salt Range, but to us, as geologists, its composition demands attention. I have already mentioned that the oldest fauna in India, perhaps in the world, has been yielded by the Salt Range, but there is a still lower bed, viz., the Purple Sandstone, in which the salt is found. This constitutes the base of the system. It would occupy too much time if I were to detail the entire composition of the Salt Range, and must therefore limit myself to the beds below the Carboniferous, which are more especially seen towards the eastern end. The reader is referred to Part I. for particulars.

Nowhere are the Crystallines reached, but the Purple Sandstone group is clearly pre-Cambrian, and Dr. Waagen is disposed to correlate it with the Vindhyan of Peninsular India, the presence of so much rock-salt and gypsum being regarded as a mere local accident, whilst the lithology of the sandstones is said to correspond closely. The total thickness of the pure rock-salt at the Khewra Mines is about 250 feet, occurring in five beds; the impure salt, gypsum, marl, and sandstone bringing the whole group up to about 1,500 feet. Respecting the age of these beds there can be no longer any dispute, but as to the origin of the rock-salt there are at least three theories afloat. The most natural explanation is that of evaporation, as was undoubtedly the case with the salt of Triassic age in our own country; but, whatever the cause, we find the usual accompaniments of rock-salt, viz., gypsum, marl, and dolomite. Hence some people advocate a theory of replacement, so that the salt is not regarded as contemporaneous with the beds in which it occurs, and may be of

any age ; whilst others regard the salt as the result of some form of volcanic action.

In the Magnesian Sandstone group we have seen that the dark shaly beds at the base contain the lowest Cambrian fauna, and it is thought by some that the *Neobolus*-beds pass slowly, by intercalations of sandstone, into the Magnesian Sandstone. As regards the so-called "Salt-pseudomorph zone," this is now attached to the Magnesian Sandstone, and the whole can scarcely be regarded as newer than Cambrian. The total thickness of the Magnesian Sandstone group, including the Lower Cambrian shales, may be about 1,500 feet.

I have been thus particular in detailing the oldest beds of the Salt Range (1) because of the economic importance of the salt ; (2) because of the interest attaching to the *Neobolus*-beds ; and (3) because of the grand escarpments produced by the Magnesian Sandstone ; which, together with the *Productus*-limestone and the Nummulitic limestone, contributes so abundantly to the formation of those mural precipices for which the Salt Range is famous.

It would be satisfactory, if I had time, to give details of the higher beds, but this cannot be done, and I must now proceed to a particular description. For this purpose I have selected Mount Tilla, in the hope that the study of this mountain may give us some idea of the orography and composition of the Salt Range. Before dying out to the eastward, as previously described, the Salt Range gives off three fingers, the Bakrála Ridge on the north, the Tilla Ridge in the centre, and the Kharian Ridge, which lies mainly south of the Jhelum.

We approached Mount Tilla by way of the curious old town of Rotás, for which Dina, rather than Jhelum is the most convenient railway station. The Tilla Ridge is stated by Wynne to have a total length of twenty-six miles, and its eastern termination just reaches as far as the grand trunk road, which lies a little to the east of the railway. It may be said to consist of two very distinct parts, viz. : an eastern portion where the uplift has not thrust the lower beds through the Siwaliks, which here form the principal rock of the low-lying districts. This portion is about twelve miles in length, and is mainly distinguished from the rest of the Siwaliks by the higher pitch of the beds ; these are nearly vertical, and being more compressed produce a low secondary ridge, which is obvious enough as one rides over the country. Suddenly, in the neighbourhood of Mongli, about eight miles west of Rotás, the uplift becomes very pronounced, and the lowest beds of the Salt Range are thrust up through the upturned Siwaliks in the manner indicated in the accompanying diagram, which is extracted from Mr. Wynne's Memoir. The effect is to produce a mountain 3,242 feet at its highest point, which, as seen endways from the low position of the railway at

Dina, is exceedingly picturesque and effective, and continually increases in interest as one rides along the low crest of the secondary ridge towards the actual base of the mountain. All along this low ridge the upturned edges of the Siwalik conglomerates are very accessible and considerable finds of mammalian remains have been made by Dr. Aitchison, F.R.S., the well-known botanist, to whom I am greatly indebted for information and assistance rendered.

It would be difficult to select a spot which exhibits so much variety as Mount Tilla. Towards the south, beyond the Jhelum, are the monotonous plains of the Punjab, here about 800 feet above sea level; this kind of prospect may be followed, in the mind's eye, to Kurrachee on one side, and to Calcutta on the other. Westwards is the prolongation of the Salt Range, and

FIG. 2.—EASTERN SPURS OF THE SALT RANGE.—After Wynne.*

2. Purple Sandstone (Upper).	11. Nummulitic Limestone.
3. Lower Cambrian— <i>Neobolus</i> -beds, etc.	12. Nahan (Murree beds, Miocene).
4. Magnesian Sandstone.	13. Lower Siwalik.
8. Salt Pseudomorph-zone.	

* *Mem. Geol. Surv. India*, vol. xiv (1878), p. 125.

northwards is the curious country known as the "Potwar," or, as I prefer to call it, the Rawal Pindi plateau. This plateau shows the widest spread of Siwalik beds anywhere to be found; but here the Siwaliks instead of forming a range of hills, as in the typical district, constitute an upland region of moderate elevation, with the beds tilted at high angles and often lying in well marked synclinals and anticlinals. In the far east, across the broad vale of the Jhelum, are seen the slopes of the north-west Himalayas culminating in the heights of the Pir Panjal, which attain elevations of about 15,000 feet.

We must now consider the structure and composition of Mount Tilla itself, by the aid of Mr. Wynne's excellent diagrammatic section (reproduced in Fig. 2). The numbers refer to his original sub-divisions of the Salt Range, but these sub-divisions have been somewhat modified of late. For instance, the "Salt-

pseudomorph zone," which he doubtfully referred to the Trias, is now classed as part of the Magnesian Sandstone group, and may therefore be regarded as of Cambrian age. Of the missing numbers, 5, 6, and 7 represent the Carbon-Trias so splendidly developed in the western portion of the Salt Range; 9 and 10 represent the Jurassic and Cretaceous, also absent here. It follows, therefore, that the Nummulitic Limestone (11), here exceptionally thin, finds itself in some way or other in juxtaposition with the "Salt-pseudomorph zone" of Cambrian age. No. 12 represents the Miocene Tertiaries, or equivalents of the Murree beds, which gradually pass further north into the Pliocene Tertiaries or Siwaliks (13). These latter are seen to encompass the mountain on either side, forming the country of the plain.

Of course, this must not be accepted as typical of the structure of the Salt Range generally, where the roll over is less pronounced and the beds more regular. We must remember that the Tilla ridge is only one of three fingers given off by the Salt Range as it dies away before quite reaching the roots of the Himalayas. The remarkable series of step faults, whilst it adds greatly to the interest of the scenery, is also exceptional. Nowhere in India have I seen such mural precipices as are caused by this repetition of the Magnesian Sandstone resting on the Lower Cambrian shales. As one stands on the low platform of almost vertical Siwalik beds, and looks up at the apparently horizontal tiers of cliffs overhead, rising one above the other into clear blue sky, it is difficult to realise that, owing to results of this great upthrow, the oldest beds of the earth's crust that have a history look down upon the youngest, with whom they are thus strangely brought into juxtaposition.

The throw of this fault, then, you would say, must be tremendous; yet this is apparently not the case, and, if Mr. Wynne's calculation as to the thickness of the beds composing Mount Tilla be correct, the dislocation is not so great as one might suppose. It seems probable that in one part or other of the Salt Range there is a complete sequence of all the marine fossiliferous horizons—Palæozoic, Mesozoic, and Eocene—and that the aggregate volume of these is exceedingly moderate. But towards the close of the Eocene period this style of deposition underwent a complete change, so that in Middle Tertiary times enormous sandy, earthy, and conglomeratic accumulations, now no longer marine, became the order of the day. Whilst the entire palæontological column, up to and including the Nummulitic Limestone, does not exceed a few thousand feet, the aggregate thickness of the Middle and Upper Tertiaries is probably not less than 15,000 feet, thus indicating that an important physical revolution had occurred within the area since the close of the Nummulitic period.

As a mere piece of scenery Mount Tilla is admirable, and an

excursion to the summit will well repay both the tourist and the geologist. One may ride up all the way, and ladies are carried in dhoolies. On leaving the rest-house at Mongli, the path lies along the upturned edges of the Siwaliks, which exhibit in one place a magnificent conglomerate 150 feet in breadth. The path now turns the eastern flank of the mountain, and, amid a mass of talus and loose blocks, gradually and imperceptibly attains the older rocks. Following this path in a direction parallel to the axis of the mountain one ultimately arrives at the summit, which is found to consist of the Magnesian Sandstone, which is so often repeated in the southern cliffs. I submit a specimen from the summit, and also a specimen of the overlying "Salt-pseudomorph" rock, a red flaggy marl which occurs in a sort of synclinal hollow a few hundred feet below the summit. Above this comes a notable pisolite, of which I also submit a specimen. Its true position in the series is unknown to me, and I have sometimes suspected it to be an outlying fragment of Nummulitic Limestone.*

We must now leave the Salt Range and travel over the "Potwar" plateau in the direction of Rawal Pindi. Seldom has one such an excellent opportunity for studying the geological features of a district as is afforded by this railway. As far as the Sohàn Valley nothing is to be seen except Siwalik beds, earthy in some places; but the usual pepper-and-salt sandy beds predominate, along with some conglomerates—a constant succession of synclinals and anticlinals, with here and there a rib of harder sandstone standing out like a trap-dyke. These ribs of sandstone are often charged with fragments of bone, as may be seen at Riwat, which is situated on the summit of the plateau south of the Sohàn River. One thing I learnt on this journey, viz. : how alluvium is formed, and how such a quantity of gravel comes to be mixed with it. Although on the map Siwalik beds only are indicated in this area, the solid geology is often largely masked by a high level alluvium; in railway cuttings and natural drainage sections one sees every stage of decay in the upturned edges of the Siwaliks, until they are literally buried in their own ruins, and earthy alluvium mixed with gravel, in more or less horizontal beds, covers the face of the country (Fig. 3).

In the gorge of the Sohàn, about five miles south of Rawal

* If the prospect from the salient cliff is one that tries the nerves, it also delights the senses. On looking over the edge of the precipice our party surprised a pair of the Salt Range wild sheep, which trotted off very elegantly. No cliffs that we saw in India can vie with these as an appropriate nesting-place for vultures, which are fairly numerous, though occasionally disturbed, I fear, by the crack of a rifle. There can be no doubt that the Salt Range generally, owing to the mural character of its cliffs, affords a home to many species of raptorial birds. But the vultures of Mount Tilla are a favoured race: they look down upon the field of Chilianwalla, only ten miles distant, where their more immediate ancestors must have had a glorious feast. And, indeed, there may be traditions of a still greater banquet, when Alexander the Great crossed the Hydaspes by stratagem, and defeated Porus within a short distance of the same spot.

FIG. 3.—HIGH-LEVEL ALLUVIUM AND GRAVELS OF THE SOHÀN VALLEY.

- a. Soft Sandstones of the Siwalik beds.
- a'. Harder grits of the same series with bones and teeth of mammals.
- b. The soft Sandstones decomposing *in situ*.
- c. High-level (Pleistocene) Alluvium and Gravels.
- d. Recent deposits of the Sohàn river.

Pindi, we have a very instructive section, which combines, to a certain extent, the features of the plateau with those of a river valley, such as originates in the outer Himalayas. The Siwaliks are perfectly vertical at this place, and the harder grits stand up like so many trap-dykes, one of which may be seen in the bed of the Sohàn itself. Between these harder grits the softer Siwaliks are decomposing rapidly at the edges, but the *débris*, being more readily removed, does not accumulate so much as on the plateau. These vertical dykes are certainly fossiliferous, and I exhibit a tooth of *Mastodon* and some fragmentary bones which were lately procured from them. In some places, where the superficial beds are thin, these pseudo-dykes project beyond the general surface-level like the ribs of some gigantic skeleton. The strike of the beds here is W. half S., and at Riwat, on the plateau, about S.W. These strikes, it should be observed, are nearly at right angles to the normal strike of the North-western Himalayas, the roots of which are only a few miles distant.

The superficial deposits in the Pindi district are of great interest and importance. In places they are so thick as to bury the Siwaliks on which they rest. This is particularly the case in one of the tributaries of the Sohàn, where the appearances are so striking that I induced the local photographer to take two pictures, copies of which are now on the table. The alternation and thorough inosculation of bedded alluvium with gravels is a feature which I have noticed not only in the Pindi district, but also in the valleys of the lower portion of the Hazára. In the Sohàn and its tributaries the bulk of the gravels consist of hill-limestone of Lower Tertiary age, and of the harder parts of the Murree beds, which are of Middle Tertiary age. It should be borne in mind that the farthest sources of the Sohàn do not extend beyond the Murree Ridge, and are therefore wholly within Tertiary or Mesozoic rocks, which, as far as I know, are completely free from igneous intrusion within the basin. The presence of pebbles of Diorite is therefore not easy to account for.*

The general opinion with regard to these high level river gravels is that they are of Pleistocene age, and certainly they must be of considerable antiquity, when we bear in mind how deeply they are excavated by the present rivers, which have been denuding rather than depositing in this area for a long period. Though not very fossiliferous, remains of the elephant are occasionally found in them, and I am able to exhibit a portion of a tusk which Dr. Aitchison and myself disinterred from gravels about 70 feet above the bed of the Sohàn. The breadth of the base of this tusk seems to distinguish it from the existing elephant of India. Portions of the ivory in this case are much silicified, thus indicating remains of considerable antiquity.

There is also another point for consideration in connection with these horizontal Pleistocene beds, viz., their striking unconformity to the highly-tilted Siwaliks. This circumstance is by no means accidental, as one finds it to be the case in nearly all places where the two are seen in juxtaposition. The horizontality of these beds seems therefore to afford indisputable evidence that the oscillations which resulted in the upheaval of the Himalayas had terminated, in this area, at least, before the deposition of the gravels; probably the cessation occurred towards the end of the Pliocene period. I shall have again to notice this subject in connection with the gravels of the upper Jhelum. There has been an idea in some quarters, shared even by Falconer, that the uprise of the Himalayas still continues, and perhaps this may be so to a small extent, though I know of no evidence tending to substantiate this view. At any rate there cannot have been any material disturbance of the strata since the formation of these river gravels, and if the Himalayan system is still rising it must be *en masse*, so that the results of lateral pressure and differential

* See No. 3 in Appendix, p. 262.

elevation are not produced. It is true that the gravels near Rawal Pindi cannot in strictness be said to belong to the Himalayan system, but the same features are observable in the river gravels of the true Himalayan area, as I shall presently point out. Moreover, it is reasonable to suppose that the tilting of the Upper Tertiaries of the Siwalik Hills and of the Pindi Plateau, notwithstanding the difference of their strike, was due to the same cause, and occurred about the same period.

Rawal Pindi itself (1,700 feet) is situated on the uptilted Middle Tertiaries which are largely obscured in this neighbourhood by the alluvial gravel and earths which cover this upland plain. We made two excursions from this cantonment: one towards the *North-west*, viz., to Attock, Peshawur and Abbotabad; the other towards the *North-east*, which had for its object the valley of Kashmir.

There can be no doubt that the district between Rawal Pindi and Attock is one of great interest to the geologist, and, being traversed by a railway, is quite accessible. The interesting station of Hassan Abdal would form a useful centre. The relations of the upland plateau to the ridges of older rock which intersect it hereabouts, the proximity to the higher ranges which are attached to the Himalayas, and the vicinity of the low-lying alluvial plain of the Indus and Kábul Rivers, constitute a rare variety of subjects which seems to provoke investigation. But to do anything here would have taken up far more time than was at my disposal.

On leaving Rawal Pindi we were told that there was nothing to see at Attock, and from this I drew favourable conclusions; nor was I disappointed, for the gorge of the Indus at Attock, with its surroundings, is one of the finest things we saw on the whole journey. A photograph of Attock lies on the table. Apart from the picturesqueness of the place and its historical associations, as the spot where the Indus has been crossed by almost every invader of India, the physical features are of peculiar interest. Why did the united waters of the Indus and Kábul Rivers, after flowing through the great plain which lies to the northwards, take the trouble to saw through this ridge of "Attock slate"? Of course, it is a question of levels, and the present level of the Indus at Attock is about 800 feet. Doubtless the drainage of the great plain of Peshawur must have escaped in some way, and that way, we may be sure, would be the easiest; yet when one looks at the gorge from the north, there seems to be a failure of the Attock chain to the eastwards, which might have afforded an easier escape for the accumulated waters of the Hindu Koosh and central Himalayas.

As regards the term "Attock slate," this covers a variety of rocks, and is a geological rather than a lithological term. Black, argillaceous limestone, for instance, with subconchoidal fracture,

like the specimen on the table, is not uncommon in the gorge of the Indus, and one sees argillites and even grits. An east and west strike seems to prevail hereabouts, but there is so much twisting of the beds that this could not be laid down as a fixed rule; neither is it clear that the beds correspond on opposite sides of the gorge, although in some cases they appear to do so. The same rocks, which are so blue in the river cliffs, weather buff in the upper parts of the hills. The river is pretty full of sediment, yellow with a greenish-grey tinge, and the bulk of the deposit is fine quartzose sand, with fragments of rock-crystal and flakes of variously coloured micas.

On leaving Attock we went to Peshawur and even as far as Jumrood at the entrance of the Khyber Pass, but the weather was so bad that I was unable to do anything in the way of observation. On our return towards India, after a night at Hassan Abdal, we set off once more in the direction of the frontier, and this time for Abbotabad, 44 miles to the northwards. It is in this direction that the last vestiges of the plains of India extend, running up like a tongue into the mountains of the Hazára, and most interesting sections showing the relations of alluvium and river gravel similar to those of the Sohán Valley may be seen on this route. On crossing a wide river-course, where these Pleistocene beds are displayed to perfection, the road enters a mountainous country which lies between the deep valleys of the Indus and the Jhelum. It is a question in orography whether these mountains belong to the Himalayan system or not. One might say from a geological point of view that they are outside the prevailing north-west strike of the chain, which is deflected at the northernmost angle of the Jhelum Valley near Muzufferabad. Since there is something exceptional in the character of these mountains, I will draw attention to some points in the geology of the Abbotabad district which have been so well elucidated by Messrs. Wynne and Waagen.

On the first rise from the alluvial tongue before mentioned, we find ourselves in a confused mass of steeply-sloping mountains, most of which would come within the category of "Attock slates"; but as the road continues to ascend towards Abbotabad, a large mass of grey limestone appears, the true relations of which puzzled me very much at first, as I fancied it must be the ordinary hill limestone of Nummulitic age, which had been faulted into the slates. During the two days we were at Abbotabad, I spent some time in searching this limestone for fossils, but without success, although I was rewarded by magnificent views across the vale of Abbotabad (4,200 feet) in the direction of the northern snowy mountains.

The annexed diagram section (Wynne and Waagen) may serve to convey some idea of the position of this limestone in the ravine below Abbotabad, through which the road is carried. To

anyone going away from Abbotabad, the limestone would appear on the left, as shown in the section (Fig. 4).

On studying their section I found that I had been exploring a great series of Triassic age, consisting of limestones, dolomites, quartzites, breccias, etc. Fossils are said to be by no means numerous, but the forms of *Megaiodon* and *Dicerocardium* may be traced on weathered surfaces; and there are probably other indications of the Triassic age of the beds, though I am not aware that *Ceratites* have been found. Below these Triassic beds occurs an unfossiliferous system, which, it is thought, may be Carboniferous, and the whole series is completely unconformable to the "Attock slates." But the marvels of Mount Sirban are by no means exhausted since we perceive on the other side of the fault, below

FIG. 4.—MOUNT SIRBAN, 6,243 FT., NEAR ABBOTABAD.—After Wynne and Waagen.*

D. Dolomite		
C. Thick quartzites and breccia		
B. Thin-bedded limestone with some fossils		
A. Dolomites		
4. Nummulitic Limestone		Nummulitic.
3. Cretaceous zone (fossils)		Cretaceous.
2. Spiti-shales (fossils)		Jurassic.
1. Limestones		Triassic.

* *Mem. Geol. Surv. India*, vol. ix (1872), p. 345.

the summit, a complete series of Mesozoic rocks, including the Nummulitic. It is thought that there is an unconformity here, between the Spiti-shales (Jurassic) and beds of Triassic age; so that there are two distinctly recognised unconformities. The Mount Sirban section will also serve to show how the formations are broken up in these mountains, and it may help to give an idea of the character of the surface in the Abbotabad district.

Towards the latter end of March our preparations for the long-projected journey to Kashmir were complete, but we were detained by bad weather at Rawal Pindi for three or four days; and when at length we started on the morning of the 26th, there were predictions that we should not get through, as the new cart-

road in the Maharajah's territory was reported to be broken down in many places.

There is a drive of about twelve miles in a north easterly direction across the plateau ere the roots of the Himalayas are reached. This part of the upland plain is formed by the Middle Tertiaries or Murree beds tilted at high angles, but covered with

so thick an alluvium that no rock is visible until within three or four miles of the foot of the mountains, when the usual rib-like structure appears through the skin. All the ridges in the low ground are of sandstone, with hollows representing the softer beds, and the prevailing strike near Shanurpore is S.W., with high dips to the N.W. This, I believe, is the place where Mr. Wynne gives the section (reproduced in Fig. 5) showing the roots of the North-west Himalayas as they emerge from the Pindian plain.

Within short distances a considerable difference might be observed in the junction-sections between plateau and mountain, but they nearly all exhibit this peculiarity viz., that in the neighbourhood of the fractures, whilst the beds of the plain are almost vertical, those of the mountain roll over at comparatively easy angles. Of course, this feature is not maintained in all cases;

FIG. 5.—GENERALISED SECTION AT SHAHKA-NOORPOOR. (Length about 3 miles; highest hills 4,000 feet).—After Wynne.*

- a. Murree Beds.
- b. Limestone bands (Nummulitic), gypseous red and greenish-grey shales.
- c. Jurassic Limestone.
- d. Hill-Limestone (Nummulitic).

* *Quart. Journ. Geol. Soc.*, vol. xxx, p. 71.

moreover, the Murree beds themselves soon become involved in the Himalayan uplift, and are quickly raised to heights of over 7,000 feet, as on the Murree ridge.

I had been at some pains a few days previously to note these facts, but, on the present journey, no delay was advisable, and it was necessary to be content with impressions as derived from the

tonga, which halted at Tret for the night. We were now fairly in the outer Himalayas, amid beds of Lower and Middle Tertiary age exclusively, and when we pursued our journey towards the Murree ridge in the morning we had the Nummulitic Limestone country on our left, and the massive grits of the Murree beds on our right. The contrast in the scenery is fairly well marked, but throughout this immense region of Lower Tertiaries, which attain elevations of not less than 9,000 feet, there is a certain degree of sameness in the landscape, such as we had previously noticed during our drive to Simla. Amidst an endless maze of V-shaped valleys and precipitous slopes, no peak distinguishes itself from its fellows, and no precipice overawes by its mural character. After such heavy rains waterfalls ought to have been conspicuous, but, owing to the want of horizontality in the beds, and, possibly, to other causes, they seem to be very scarce in this region. Two strikes, which I took at Murree, bear S. half W. and S.S.W., so that we are not yet within the true Himalayan system, although the elevation exceeds 7,000 feet. The grits and clays of the Murree beds are naturally well-wooded, although at great elevations even the limestones on the "Gully" ridge carry a considerable amount of timber. As we continued to ascend from Tret towards Murree, it is interesting to notice that *Pinus longifolia* is almost entirely replaced by *Pinus excelsa*, and on Pinnacle Hill, where the exterminating axe of the native cultivator has been restrained for a while, these pines are reinforced by a goodly show of the tall Himalayan spruces. There are no deodars (*Cedrus deodara*) here, and I may remark, by the way, that I never saw a deodar growing on any beds of Tertiary age.

A drop of 5,000 feet brings us to the bottom of the Jhelum valley, which at Kohála is about 2,000 feet above sea-level; the river here is a furious rapid rushing along in its narrow rock-bed. The tortuous course of this river valley we now had to follow in its ascent of about 3,000 feet, to Baramula. The first section of the journey runs due N. as far as the angle of the Jhelum, at Muzufferabad (Domel), and on the east side of the river, where the road lies altogether in the Murree beds. The second section runs S.E. from Muzufferabad to Uri, and also lies wholly in the Murree beds. The third section runs E.N.E. from Uri to Baramula, cutting right across the axis of the Panjal range, and is mainly within the area of slaty and schistose beds—the "Attock slates" or Cambro-Silurian of the Survey, and the Panjal system of Mr. Lydekker.

It was almost fortunate that I did not possess a Kodak, or we should have tried the temper of our tonga-drivers by perpetual halts to photograph the fine sections which this gorge-like valley affords. I am only too conscious that mere verbal description is altogether inadequate to convey a proper idea of these scenes. A few words respecting the Murree beds may not be altogether

out of place. Massive purple grits and clays are the predominating feature, and the grits are often seamed with calcite, as in the case of the specimen exhibited. It is strange that such an immense mass of beds should be so unfossiliferous; but hitherto the only organism identified is a palm of Miocene age—*Sabal major*—found by Mr. Lydekker in the middle section of this route. So much for the palæontology of these beds, which may be held to represent the first deposit within the area after the commencement of the Himalayan uprise, and which themselves now form an outer portion of that mighty range with ridges not far short of 10,000 feet in elevation.

You perceive from the map how curiously the Jhelum is doubled back on itself. I rather think there is a sort of synclinal between these two great arms of the river, and that the river bed itself in the first and second sections lies in anticlinals. At any rate, I noticed, as we were being driven along the Kashmir cart-road, that there is a considerable tendency for the beds to dip inwards, both in the first and second sections, and to this cir-

FIG. 6.—IDEAL SECTION ACROSS THE JHELUM VALLEY, BETWEEN MUZUFFERABAD AND URI.

- A. Murree Beds (Miocene).
- b. Pleistocene Gravels.

cumstance the preservation of the road is to a certain extent due. For we must acknowledge that nature does not altogether look with favour upon this cart-road, and that in places where undercutting has been extensively practised, if the beds happen to be clayey or there is a lot of slippery talus, the pitch of the slopes is so steep that, after heavy rains, a glacier of mud and stones is formed across the track, which is thus either masked or carried away altogether.

The annexed diagram (Fig. 6) may partly serve to illustrate my notion of that portion of the Jhelum valley which lies wholly within the Murree beds, and is more especially applicable to the middle section between Muzufferabad and Uri. It will be seen that the

beds in the lower portion of the section lie at a much higher angle than those in the upper portion. Of course this is only an impression as seen from a tonga, but of its substantial accuracy I have no doubt. Mr Lydekker, in his Memoir on the Kashmir territory, notices that the lower beds in the valley gorges are often more highly tilted than those on the hill-tops; and he goes on to say that this has been explained on the supposition that a considerable amount of the contortion occurring in the strata has taken place since the present hills and valleys were marked out. I cannot quite understand this, and would much rather believe the phenomenon is due to differential pressures acting approximately at the same time, whereby the upper beds being less weighted, and having more room to expand, gaped at the surface, and fell away from the axis of tension in dips of moderate degree. Lower down no such relief could be afforded, and we have the beds standing on end, and in every attitude; though even here they are rarely contorted, and, so far as I know, not in the least degree metamorphosed. If my notion of gaping at the surface is correct, such a feature would largely help to determine future lines of drainage.

The third section of the road, viz., that between Uri and Baramula, running right across the strike of the beds and more especially of the Panjal system with its associated Metamorphic and Igneous rocks, presents totally different features and exhibits on the whole more impressive scenery. This is a transverse valley, due in the main to denudation, yet clearly determined by a weakness in the Panjal axis, since the granitic and other crystalline rocks, which form this conspicuous crest of the Himalayan system fail at the point where the Jhelum crosses, so that the gorge lies wholly within the schistose rocks, which are probably of Palæozoic age. The scenery is truly magnificent, and precipices of the schist* tower above the small station of Rampur in the most impressive manner. Here also deodars figure largely in the hanging forest of the region, flourishing on Palæozoic rocks just as at Simla. This must be an excellent place for examining the effects of strain in rocks, as one of the sharpest and best marked of the Himalayan anticlinal axes has been cut through by the Jhelum at Rampur,† which station lies about half way between Uri and Baramula.

Irrespective of these considerations, the locality is full of geological interest. On referring to Fig. 6, it will be seen that, in the second section of the route, the Jhelum has cut through a terrace of Pleistocene gravels. This terrace is perhaps still better developed in the third or Rampur section, though I am not sure

* No. 4 in Appendix, p. 263.

† No such place is marked on the maps. The station bearing this name lies on the south side of the Jhelum, immediately west of its junction with the stream from the south, marked in Lydekker's map as the "Harpatkai" River, but which in Murray's handbook goes by the name of the "Haji Pir" River; the temple of Bhanjar is on the opposite side.

of its having been cut through in all cases. Practically, however, there is more or less of a gravel terrace on the banks of the Jhelum all the way between the commencement of the gorge near Baramula and Muzufferabad. Fine sections of this old river gravel are occasionally displayed by the road cuttings, and it is worthy of note that these sections are, in many places, quite vertical, showing how well the boulders cohere. Occasionally a boulder much bigger than the rest projects from the vertical face and seems to threaten destruction to the tonga and its occupants. This is more especially the case in the second section, near Chakoti, and, although on the whole the cuttings in the gravel were less effected by the recent heavy weather than those in the Murree beds, yet when one of these big boulders did happen to fall out, the appearances were somewhat alarming.*

One cannot help being struck by the contrast between these horizontal boulder beds, and the highly tilted rocks on which they rest. Just as in the Sohàn Valley, this fact seems to me conclusive against any important movements having taken place within the area since the commencement of Pleistocene times. True, the area is an uneasy one, and the earthquake of 1885, which utterly destroyed Baramula and wrought such havoc in Kashmir City, will serve to remind the dweller in the Himalayas of the instability of the ground beneath him. Yet such earthquakes seem to have produced no very obvious results in disturbing the almost horizontal gravels of the Jhelum gorge, at and below Rampur.

A word or two as to the composition of these Jhelum gravels may be interesting. In the second section of the route a cursory examination indicates that the hard parts of the Murree beds have contributed a large proportion; hence the gravels are mainly of local origin. But, when only a few miles above Muzufferabad, I noticed a granite boulder with large porphyritic crystals of white felspar, and this kind of rock became more plentiful as we proceeded up the valley, though I could not pretend to say that it is to be traced throughout. However, when we got to Rampur, I took a stroll, with my wife and General de Bourbel, to the junction of the Jhelum with the Haji Pir River. Here we found an enormous accumulation of these granite boulders, many of them of gigantic size, embedded in a sort of terraced, clayey deposit, which looked uncommonly like a rearranged moraine. The Haji Pir River drains a valley at right angles to the course of the Jhelum, and this valley must nearly coincide with the Panjal axis. Hence we may conclude that there is an important exposure of granite somewhere along this axis which has yielded these boulders. The beautiful old Hindu temple of Bhanjar has been constructed of stone supplied by

* Early in April last, as the Resident of Kashmir and his wife were travelling by this route, one of these big boulders fell just in front of them and greatly alarmed the lady. Undoubtedly they had a narrow escape.

these boulders, and the builders seem to have selected those with conspicuous crystals, some of which are half a foot long. Above Bhanjar one no longer sees this granite in the gravels. Mr. Lydekker notices the granite boulders, but seems disposed to derive them from the north side of the Jhelum.*

One cannot help drawing some inferences from these gravels and their mode of occurrence. In the first place it may be objected that to call them "Pleistocene" is an assumption. Yet they must be of considerable antiquity, when we perceive that the Jhelum has not only cut through them, but also, in some places, through a considerable thickness of the underlying rock. Moreover, the action of the river must have been very different during the period of accumulation from what it has been subsequently; and yet all these changes have taken place since any marked disturbance has occurred within the area. It is by no means improbable that the accumulation of the gravels coincided with the period when there was some glaciation on this side of the Kashmir Valley. This seems to be Mr. Lydekker's opinion. The point is of importance, as helping to fix the date when the movements in connection with the uprising of the Himalayas ceased. There is some additional evidence on this point, afforded by the superficial deposits known as Karéwas, which skirt the interior slope of the Panjal range facing the Vale of Kashmir. Mr. Lydekker, in his map, classes these as Pleistocene; and it is significant that, while the lowest and oldest beds exhibit a certain amount of tilting, the bulk of these Karéwas are nearly horizontal. Hence the movements were dying out when the Karéwas first began to be deposited, just as was the case with the topmost Siwaliks of the outer hills.

As regards the granite itself, it is no doubt derived from a mass on the crest of the Panjal, which has been squeezed through the crystalline axis, and, according to my notions, is most probably of Tertiary age.

Continuing our journey from Rampur, the gorge of the Jhelum gradually becomes less savage, and a wide expansion towards the east seemed to proclaim that some great change in the landscape was impending. We had now got through the Panjal chain, but all view of the land of promise was still blocked by a low range, part of which, probably, consists of the aforementioned Karéwa deposits. There are two ways from here to Baramula. The new cart-road follows the natural cutting afforded by the Jhelum, whilst the old track takes a short cut over a low col. We chose the latter on account of the view which it commands, and which has been celebrated by many travellers. There lay at our feet the western half of the Vale of Kashmir, and owing to the enormous expansion of the Wular Lake, the low ground appeared to be one vast inundation. Right across this depression

* For a description of this granite see No. 5 in Appendix, p. 263.

risers an enormous mountain rampart, forming a portion of the central Himalayas. Exactly opposite are the rocky masses of Haramuk, rising to a height of 17,000 feet, and this chain extends to the right and left as far as the eye can reach. The Tragbal Pass leading to Gilgit is very obvious, and in this direction some of the party fancied that they could perceive the peaks of Nanga Parbat (26,629 feet), the monarch of the North-west Himalayas, which bears nearly due north from this spot, seventy-five miles distant.

We must now consider our position on this low col above Baramula from a physical point of view. Regarding the rocks of the Kashmir basin and of the Panjal range as a whole, Mr. Lydekker says there are two principal anticlinal axes: First, that of the Panjal itself, which exposes disconnected portions of a central crystalline core, and right athwart this axis lies the gorge of the Jhelum that we had just traversed. The second anticlinal is exactly opposite to us, viz., the mountain range on the northern side of the Wular Lake, of which the rocks in the neighbourhood of Haramuk form the south-eastern termination. As regards the chief synclinal axes of the area, these must be sought (1) in the Mesozoic rocks of the outer hills; (2) in the Kashmir Valley itself; and (3) in the district on the other side of the Haramuk range, where beds of the Carbon-Trias or Zaskar system of Lydekker are folded within the older palæozoic series. To put it more plainly, the Vale of Kashmir constitutes an elongated oval synclinal area, about ninety miles in length, where beds of Carboniferous, Triassic and possibly Jurassic age lie within a ring of older palæozoic rocks; these latter have been denominated the Panjal system, corresponding in the main to the "Attock slates," or Cambro-Silurian of the Survey.

There are so many points of interest in connection with the Vale of Kashmir that one might well devote a paper solely to their consideration. To some of these I must merely allude. For instance, the question of the exit of the Jhelum at Baramula, and its bearing on the existence of a former lake has given rise to much discussion. The history of the Karéwas, or Pleistocene deposits of the Vale, which are banked up in large masses against the northern slopes of the Panjal, also affords considerable matter for speculation; fossils appear to be by no means plentiful, and there seems to be a doubt whether the deposits are fluviatile or lacustrine. Perhaps one of the most remarkable features of Kashmir is the oval ring of palæozoic volcanic rocks which, according to Lydekker's map, surrounds the Vale. Those on the northern side come right down to the marshy flat which constitutes the Vale proper, rising out of the plain like islands. The picturesque rock near Manasbal, at the entrance of the Sind Valley is one of these; but by far the most interesting development is at Srinagar itself, whose position has been determined by

a promotory of these andesitic traps, which separates the marshy basin of the beautiful Dal Lake from the plain of the Jhelum. This promotory finds expression in the low hill of Hari Parbat, crowned by the fort and state prison, and by the picturesque and conical Takht-i-Sulimán, which rises a thousand feet above the plain, and is crowned by an old Hindu temple.

I submit two specimens of the igneous rock of Srinagar, both from the lower portion of the Takht-i-Sulimán: the one is close-grained, and the other vesicular. The former has been examined by General McMahon,* who says that the rock has been altered almost out of recognition, but that it was probably in its original state an augite andesite. Both specimens are greatly epidotised, but may fairly be regarded as products of the same magma which have cooled under different circumstances. The period of extravasation is variously stated as uppermost Panjal (Silurian) or Carboniferous, but at any rate Palæozoic. Hence the present thermal activity in the Vale, which was first noticed by Falconer in 1838, can have little or no connection with these eruptions; nor can I ascertain that there is any igneous rock of later date to be found *in situ* in the Vale.

We owe to the traveller, Vigne, in 1842, the recognition that the mountains about Srinagar were composed of amygdaloidal trap, though Mr. Lydekker was probably the first to point out the geological relation of these beds. In the neighbourhood of the Takht-i-Sulimán there is a low col on the east side leading to the Dal Lake, where certain splintery shales may be seen; and these are said to be partly inter-stratified and partly to underlie the igneous rock. The Col itself occurs in these shales, whose softer nature has determined this well-marked hollow. All the steep, eastern side of the beautiful Dal Lake, says Mr. Lydekker, is a mixture of these slates and volcanics. Hence the presumption that the igneous rock is not intrusive; he finds no necks or dykes, and yet doubts their being the result of fissure eruptions. General McMahon has stated his opinion that these rocks are old altered lavas, similar to those found in the neighbourhood of Dalhousie. From this conclusion we can scarcely dissent; and it seems probable, owing to the abundance of amygdaloidal beds, that the lavas were poured out on a terrestrial surface. There is, of course, the usual difficulty as to where the vents existed, and if it were not for the vesicular character of part of the beds, one might be disposed to regard the Takht-i-Sulimán itself as an old volcanic core. However, these and many other points of equal interest must be left for the present, and this brief notice of the Vale of Kashmir must terminate.

* No. 6 in Appendix, p. 264.