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Note on the Tertiary Zone and Underlying Rocks in the North-West Panjáb,

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The object of these notes is to give some account of the westward continuation of the tertiary band which forms the subject of Mr. Medlicott's paper on the Jamú Hills (Records, Vol. IX, p. 49), and is also referred to in Mr. Lydekker's paper on the Pir Panjál (same volume, p. 155).

Both of these papers deal with the tertiary rocks about the valley of the river Jhelum and to the south-eastward of that region, while I propose to consider those forming the Ráwalpindi plateau and stretching westward to the Afghán Frontier.*

* Besides the two special papers mentioned, there are several others, amongst which those included in the following condensed list are of more or less importance, each containing some information about the district:—

1.	Vicary	Upper Panjáb and Peshawar	...	Q. Jl. Geol. Soc. Lond., Vol. vii., p. 38.
2.	Fleming	Salt Range	...	Jl. As. S. Beng., Vols xvii—xxii.
3.	Theobald	Ditto	...	Ditto do. do., Vol. xxiii, 1854.
4.	Ditto	*Chelonian* from Potwar	...	Records, Geol. Sur. Ind., Vol. x, pt. 1.
5.	Falconer	Terty. fossils of E. Salt Range, &c.	...	Jl. As. S. Beng., Vol. xxiii, 1854.
6.	Murchison	Salt Range	...	Q. Jl. Geol. Soc. Lond., Vol. ix, p. 89.
7.	Verchere and de Verneul	Himalaya and Afghan Mountains	...	Jl. As. S. Beng., Vols. xxxv and xxxvi.
8.	Lyman	Report on Panjáb Oil-lands	...	Public Works Dept.; Lahore, 1870.
9.	Waagen	Carboniferous Ammonites, Salt Range		Mem. Geol. Sur. Ind., Vol. ix, pt. 2.
10.	Ditto	Murree Hills	...	Records, Geol.Sur. Ind., Vol. v, pt. 1.
11.	Warth	Salt Range	...	Reports, Inld. Revenue, 1869 *et seb.*
12.	Waagen and Wynne	Sir Ban Mountain	...	Mem. Geol. Sur. Ind., Vol. ix, pt. 2.
13.	Lydekker	Tertiary *Mammalia*	...	Records, ditto ditto, Vol. ix, pts. 3 and 4.
14.	Ditto	*New Vertebrata* (*a*)	...	Ditto, ditto ditto, Vol. x, pt. 1.
15.	Ditto	Ditto	...	Pal. Indica, Vols. 1 & 2, Ser. x-2.
16.	Wynne	Upper Panjáb (*b*)	...	Q. Jl. Geol. Soc. Lond., Vol. xxx, p. 61.
17.	Ditto	Trans-Indus Salt Region (*c*)	...	Mem. Geol. Sur. Ind., Vol. xi, pt. 2.
18.	Ditto	Mt. Tilla, Salt Range	...	Records, ditto ditto. Vol. iii, pt. 4.
19.	Ditto	Pt. of Upper Panjáb	...	Ditto, ditto ditto, Vol. vi, pt. 3.
20.	Ditto	Murree	...	Ditto, ditto ditto, Vol. vii, pt. 2.
21.	Ditto	Kharián Hills	...	Ditto, ditto ditto, Vol. viii, p. 48.

(*a*.) In this paper a specimen of *Myliobatis* is said to have been sent by me from Kach: it is apparently from Katwár on the Salt Range, and was, I think, collected by Dr. Waagen.

(*b*.) Advantage may be taken of this opportunity to amend a few passages in this paper by knowledge since obtained: p. 62, the Siwaliks being miocene is now doubtful (Mr. Lydekker's papers, cit.). Table to face p. 63, last column:—the Tagling limestone is, according to Dr. Stoliczka, liassic; but in comparing the Sir Ban section with the Himalayan series it is placed as triassic, p. 64. The Púnch limestone has been since thought carboniferous, not Krol, p. 70. The conjecture as to there being hill-nummulitic beds near Uri in Kashmir was not supported by a subsequent observation, p. 74. In the section at Dandli, the beds *d*3 have been found to overlie *o*1 (Records Vol. ix, p. 53).

(*c*.) Alterations necessary from subsequent information are mentioned in Mr. Medlicott's paper on Jamú.

I do not at present intend to pass beyond the subject of the tertiary zone further than to indicate briefly the rocks forming its supporting trough; and my notice of the newer formations will require less detail, because the rocks of the Salt Region beyond the Indus have been already described by me* as well as those of smaller areas in other parts of the district,† while a Memoir on the Geology of the Salt Range is in the press.

I must refer to Mr. Medlicott's paper, just now mentioned, for an account of the important changes affecting the tertiary zone on its passage from the country in which it was first examined by himself towards this district. Following out the geological features, he finds nearly every stratigraphical peculiarity of the Simla area vanish to the west. Though the upper and lower members of the great tertiary formation continue, the close identification of the intervening groups is still somewhat conjectural owing to the changes referred to.

The discovery that the whole zone was subject to such extensive modification as the total disappearance of marked unconformities, great boundary faults dying out by conversion into axes of contortion, or disappearing amid parallel stratification, was wanted to reconcile the earlier observations made in the Simla area with my own later ones in this district. The diversity of structure in the two regions will account for my having found it impossible to say which portions of the great conformable series in this part of the Panjáb represented each of the more clearly defined *discordant* groups of the Simla area; particularly as there is a prevalent general similarity throughout all the upper groups.

One of the local changes within the tertiary zone which may be analogous to the lateral variation affecting the whole formation as it passes westward, is the almost total absence of the very lowest beds of the sandstone series (as developed to the north) along the southern or Salt Range side of the trough. On the Himalayan side the uppermost nummulitic beds pass by alternation into the lowest part of the Murree group. On the Salt Range the junction is sharply defined, the parallelism of the stratification being the same in both cases.

Bordering this range there is a band in the sandstone series remarkable for the predominance of red clays, which, from its colour and nature, led me to suggest its being representative of the lower beds to the north. Below this zone, often close to the limestone, fossil exogenous timber is frequently found associated with reptilian remains. Similar petrified wood occurs in less quantity at a considerable distance upwards among the Murree beds on the northern side of the trough and Trans-Indus; but the red zone of the north, if present towards the Salt Range, is not sufficiently marked to be distinguishable. If this fossil wood can be relied upon to fix an horizon, it shows that a large part of the basal sandstone and clay series of the north side of the trough had died out in south and south-westerly directions.

In the Journal of the Geological Society of London,† I have discussed one of the most peculiar features of the country—the marked abnormal contact which forms the main northern boundary of the detrital tertiary rocks: it is not a single continuous fracture, but composed sometimes of several contiguous lines of displacement, amounting to more than ordinary faulting, inasmuch as it is generally attended by strong inversion of the outer rocks; and whether the ground it traverses be at an elevation of only one or of six thousand feet, nearly the same group of the upper nummulitic beds is always exposed along its southern side. On the other side of the line both nummulitic and Jurassic formations are in contact with these upper beds, which occasionally transgress its limits.

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* See Nos. 17, &c., of list. † See No. 16 of list.

From its evident connexion with the Himalayan hills, I have attributed this abnormal contact to the out-thrust of the mountain mass on settlement, producing complicated inversion or oblique displacement. Although I do not think there is concealed unconformity present between the nummulitic groups on each side, I am not prepared to say there is absolutely none, nor can I venture to decide at what post-eocene period the dislocation took place.

The sub-division of the upper part of the great tertiary zone to the east has been carried out chiefly on the basis of slight lithological differences, or marked physical breaks, without collateral aid from the fauna so long known to exist abundantly in the newer beds. In this western district, these breaks being absent and fossil bones and teeth occurring also at lower stages than the usual horizon, the separation of groups has been still more tentative. It remains to be seen how far these divisions may be supported by palæontology, for the stratigraphical distribution of the fossils has not yet been fixed.

Amongst the lowest tertiary beds, the greater limestone groups of this district are conspicuous. The intervening band between these and the sandstones, &c., has been identified as Sabáthu (in part), but the upper members of the triple Sirmur group, peculiar to the middle Himalayan area, have their nearest equivalent in the "Murree beds," transitionally overlying the upper nummulitic rocks here. The higher portion of these Murree beds would also seem to occupy the place of the Nahan group, and they pass upwards into the Siwalik sub-divisions, continuous with those of the adjoining Jamú country.

The local characters of each of the four large nummulitic areas of this country present themselves strongly: the great limestone covering the Salt Range differs entirely from the even more largely developed nummulitic limestone of the outer Himalayan hills, and the upper transitional nummulitic group on that side of the basin shows both affinities and differences compared with the limestones beyond the Indus. These last are distinguished from all the rest by their close association with the great rock-salt deposits of that country and its overlying gypsum, a rock, however, frequently occurring in smaller masses among the upper nummulitic beds conterminous with the outer Himalayas.

The question has been raised whether the whole of the great nummulitic limestones of this country are not merely equivalents of parts of the Sabáthu zone of the Simla and Jamú areas.* I have concluded that these massive limestone groups occupy a lower place or places in the series than the variously-coloured and mixed calcareous and earthy (Sabáthu) deposits, for the following reasons:—These beds of limestone, clay, and sandstone (here recognised as Sabáthu) enter and leave the district as a more or less distinct band, external to the hill nummulitics, and passing into the overlying sandstone and clay series. These mixed beds, as an assemblage, differ from the mass of the limestones on the inner side of their boundary-fault or line of abnormal contact. That feature and the disturbed condition of the ground prevent the sequence from being seen, but towards the same side of the trough, in the Khaire Múrut ridge, I have found a section at a place called Chorgali clearly showing the whole of the local upper group resting conformably upon the more massive and clearer limestone of the older part of the series (see p. 118). Both groups being present in the same section, one cannot be the representative of the other.†

* Messrs. Medlicott and Lydekker's papers alluded to at commencement.

† Accepting Mr. Wynne's use of the term "Sabáthu," any argument in the matter would be needless, for it is perfectly evident that the coloured and mixed deposits west of Murree to which he restricts the word "Sabáthu" do overlie, and cannot represent, his hill limestone. But this name is one of our oldest Indian group-names: for many years the name "Subáthu" has stood to mean the nummulitic rocks of the outer Himalaya; and in its typical region, and very well marked through the Jamú hills, there is a bottom band of clear limestone under the coloured clays, and having, if possible, a higher claim to the name than they have. It has been reasonably suggested

The fault or contact-line, by its existence, proves the same thing: if there be displacement, the groups on each side cannot be exactly identical: if no displacement, there is no room for lateral transition; and if there should be unconformity, the groups must be even more distinct. The great limestones overlie, with conformity, actual in the Salt Range and apparent in the northern hills, cretaceous and Jurassic rocks, a relation in which the upper nummulitic beds are never found; on the contrary, these are united by intercalation with post-nummulitic rocks.

Notwithstanding, there are places in the other areas in which a certain resemblance to the upper nummulitic character is found. The Salt Region beyond the Indus is one of these, and at the eastern end of the Salt Range (near some typical "Murree beds") there are a few layers at the top of and above the nummulitic limestone which have an "upper" aspect.

Some of the local distinctions between the four nummulitic areas above mentioned coincide with marked variety in the *facies*, the size, or the abundance of their fossils. I am unable to state how far specific differences may exist, the collections not having undergone palæontological examination; but the impression of both vertical and horizontal distribution was gathered in the field. If this be the case, the conditions of one province may have invaded another, and thus blended the characters of deposits, generally contemporaneous no doubt, though perhaps not strictly synchronous one with another.

All the tertiary rocks under notice are, so far as is known, conformable and consecutive. The most distinct demarcations between the different groups occur:—at the top of the Salt Range nummulitic limestone where in contact with the Murree beds; and, between the upper and lower nummulitics, by reason of dislocation, at the northern side of the trough. Beyond the Indus the upper boundary of the limestone is frequently as distinct as in the Salt Range, but there are also obscure indications of transition by alternation upwards. All the other junctions are more transitional and indefinite. To such an extent is this the case, that it is impossible to say exactly where the change took place between the older marine and the newer fresh-water conditions.

Although stratigraphical conformity is obvious throughout the tertiary series, there are traces at several horizons of local breaks not otherwise apparent than by the presence of derived pebbles belonging to older portions of the same series, in some instances accompanied by small fragments of still earlier rocks. It is only at the upper limits of the Salt Range and Trans-Indus limestone that these derived nummulitic and other pebbles are coincident with the boundaries of any of the sub-divisions; they are elsewhere not limited to particular horizons.

A sketch map of the country herein referred to is annexed. It is on the same scale as that to accompany Mr. Medlicott's paper, and has the same colouring for the tertiary groups, the distinction now suggested of upper and lower nummulitics being also indicated. Both maps, joined at the meridian 74°, will convey a comprehensive view of the tertiary region of the Upper Panjáb.

Physical form of the ground.

The space referred to in this paper may be spoken of as lying between the Salt Range to the south and the outer Himalayan hills to the north, and extending from the river Jhelum

that this rock specifically represents the "Hill limestone;" and that its greater development to the west may have so taken place, that, partly at the expense of the upper deposits, the two would be in part representative of each other in the different regions. But this latter part of the conjecture is quite independent of the former, which scarcely admits of question: if the distinction of an upper and a lower nummulitic zone holds good, as is not unlikely, it will have to be carried out in the Jamú hills as well as in Hazára.—H. B. M.

westward across the Indus to the Kohát frontier. It includes the whole of the Ráwalpindí plateau, or "the Potwár," a name strictly belonging to an eastern portion of the plateau, but sometimes used even by natives of the country in a more comprehensive sense.

This ground, having an area of about 7,000 square miles, forms an undulating expanse edged by the northern slopes of the Salt Range, and lies about 1,000 feet higher than the alluvial plains and desert south of that range. It appears analogous to the Dúns of the Southern Himalaya, and is in reality one of the most strangely broken tracts I have seen, intersected by numberless deep, ramifying ravines called "*khadera*," the rapid extension of which is attested by the isolated remnants of the neighbouring "*maidán*" (or plain) included amongst them. The heads of all the streams not in the hills issue from such a fretwork; and along the larger water-courses, though wide flats of auriferous sand and quicksand form their lower levels, ordinary alluvial border tracts are rare.

From this plain or plateau rise a few reefs of bare rock, often only narrow, jagged, vertical walls, and one more considerable mural ridge called "Khaire Múrut" (over twenty-two miles long and reaching to 1,500 feet above the adjacent country) runs west-by-south from the neighbourhood of Ráwalpindi.

The Murree hills, twelve to twenty-eight miles distant from the same station in an opposite direction, culminate in heights of over six, seven, and eight thousand feet, declining in successive nearly parallel ridges towards the direction of Jhelum cantonment. They have a general south-west north-east trend, which is also that of most of their numerous, sometimes sinuous, axes of contorted stratification, the folds being most compressed northwards. All the ridges are united by a zigzag subordinate backbone, forming the Cols, and rudely conforming to the adjacent course of the Jhelum.

Ridges at their eastern ends parallel with these, then bending more to the west, form high mountains immediately north of the Murree hills. Towards the plateau they decline; and the Grand Trunk Road passes through gaps near their western termination at the Márgala Pass. Beyond these again rise the Hazára hills, and the fine range of Gandgarh partly bordering the Upper Indus.

From the Márgala pass two ranges run westward south of Attock; gaining in elevation they unite to form the lofty Affrídi hills overhanging Kohát; then passing south of the Peshawar valley they culminate in the Khybur mountains and Suféd Koh of Afghánistán. The most southerly of these, called the Chita Pahár, edges the Ráwalpindi plateau on the north.

In the Kohát district the part of the ground under notice presents a series of long ridges, closely clustered, running more or less east and west, often crooked and of varying but not insignificant height. Viewed from the plateau, they assume the appearance of a connected range. The valleys between these are for the most part rugged; but some flat cultivable patches enhance the sterility of their generally treeless surroundings. A few high summits occur near the Indus, and the whole cluster lies between the Afghán hills and the Shíngarh chains to the south.

The Salt Range which edges the Ráwalpindi plateau southwards and is sinuously prolonged Trans-Indus, in both places presents wild and mostly unfertile tracts. Cis-Indus it forms a precipitous escarpment overlooking the "Thal" (or desert) and lower plains. Further west, with numerous disturbances and dislocations, the northern inclinations of its strata rise to steeper angles, and the stronger beds support a mass of tertiary rocks, whose deeply serrated outline, Trans-Indus, and the silvery sheen of its bare sandstone summits, betray the presence of the upper tertiary series, making the Pushtu name *Shíngarh* as suggestive in its half English sound as in its vernacular meaning of "Grey mountains." The

northward extension of these rocks, however, in the direction of the dip is interrupted by faulting; most of the lower ground and hills towards Kohát being occupied by older parts of the series.

Drainage.—Crossing this whole tract of tertiary rocks, the Jhelum river is a racing, rapid torrent, hemmed in by mountains; the Indus (or Abba Sín), larger and more powerful, flows from among lofty and picturesque ranges, across an expanding and highly cultivated plain, till it receives the Lúnda or Kábul river at Attock. It then cuts its way through every one of three intervening ranges, and has formed for itself a deep narrow gulch through the rocks of the plateau, running swiftly, with occasional rapids, until it reaches and escapes into the lower plains at Kálabágh. The minor drainage of the district mainly seeks the Indus, some smaller portion reaching the Jhelum. It is everywhere distinguished by its cross-country character, preferring, in many cases, to intersect the hilly or mountainous ranges rather than to follow the larger depressions of the surface. Even the Soán, the most considerable local stream, rises in the hills at Murree, not very far from the Jhelum, yet wanders away westwards to the Indus, by a part of the plateau-land which itself sends affluents to the Jhelum river through ridges of the Salt Range. The Haró, too, in the Hazára valley to the north, does not take all that drainage to the Indus, for the Dore, which would otherwise form one of its upper tributaries, turns aside, crosses through part of the lofty Gandgarh range, and finds thus a shorter way to join the great river at Turbela. The Tíri (Teeree) Towey, another tributary of the Indus, from the Kohát district, changes its course from one depression to another, intersecting the ridge between.

These peculiarities of the drainage tend to show that its course was initiated more directly by agencies of elevation than by the results of atmospheric denudation acting, at different rates, upon rocks of varying texture. The valleys of the ground are not always those of the rivers; both are now valleys of denudation, but the directions of the streams were decided by much older contours of the surface than now exist. The rivers have maintained their courses, even though the wasting agencies in carving out prominent features have at the same time lowered the "divides," in some localities to hardly noticeable undulations.

The antiquity of the courses of the larger rivers Jhelum, Indus, and Kurram is proved by the Himalayan transported detritus, brought to form late tertiary (Siwalik) boulder beds and conglomerates, being thickest near their banks.* A later phase in their history is marked by the occurrence of the same hard detrital and stream-worn blocks lying upon the adjacent mountains at heights of about 2,000 feet above the present bed of the Indus;† and a still later period of the river action is indicated by the same pebbles and boulders interstratified with the superficial deposits of the country along this river. Such hard boulders now form its bed at Attock, and are doubtless still travelling downwards from the Himalayan regions.

Classification.

The rocks found in the district may be classified as follows:—

Natural order.

Post-tertiary—*Unconformity.*	Conglomerates, pebble beds, silt and alluvium.
Upper Siwalik—Pliocene (Lydekker),‡ about 4,000 feet.	Brown, drab, and reddish clays, mammalian and reptilian remains. Soft grey sandstones, conglomerates, and orange or grey clays. Mammalian remains, &c., not abundant.

* This feature was pointed out for the Mid-Himalayan rivers long since by Mr. Medlicott.

† Over Kálabágh, and again on the Chita Pahár (Mountain) near their highest elevations above Bág and Choi.

‡ Records, Geol. Surv. Ind., Vol. IX, p. 87.

Lower (red and grey) Siwalik—Pliocene (Lydekker), about 10,000 feet.		Soft grey sandstones and brown or grey clays, slightly harder grey sandstones, many red clays; mammalian remains, bones, teeth, &c., locally abundant. Ossiferous throughout.
Murree Beds—Upper Miocene (Lydekker), 7,500 feet average.		Harder grey sandstones, with soft zones, red or purple clay. Fossils—reptilian and other bones not numerous, some fossil wood. At Salt Range, purple and grey harder sandstones, red and purple clays, a few green sandstones (locally); reptilian remains, exogenous wood, bones scarce, and fragmentary teeth rare.
Nummulitic—Eocene to Miocene (Lydekker).	Upper 800 feet average.	Greenish-grey and purple sandstones, grey, olive-brownish, red and variegated clays with masses of rock gypsum. *Foraminifera*, (*nummulites*, &c.), *Gastropoda*, Bivalves, fossil mammalian bones occasionally. Crustaceans rare.
	Lower ... Trans.-Indus 1,700 / Salt Range 500 / Himalayan 3,000 } Average 1,066	In Salt Range, Trans-Indus, and part of Chita Pahár. Whitish or usually pale limestones, coaly shales, &c., below. In Kohát district are sandy limestones, olive shales, and red clays also, as well as gypsum and rock salt. Fossils, *Foraminifera* (*Alveolina* locally numerous), large *Gastropoda*, Bivalves, Echinoderms, &c. Northern or hill nummulitic, grey limestone weathering pale, dark fœtid limestones, olive shales: *Foraminifera*.

Obs.—Series parallel and conformable from the pale limestones upward to top of Siwaliks. The boundaries of the groups are transitional and indefinite.

The downward continuation of the series, so far as now known, includes the following formations:—

Southern or Salt Range series.

Cretaceous (?)	... Sandstones, conglomeratic clays, shales.
Jurassic	... Sandstones, limestones, oolite, &c.
Triassic	... Limestones, shales, red sandstone and clays.
Carboniferous	... Limestone, sandstone, shale.
Speckled sandstone	... Sandstones, clays, conglomerate.
Magnesian sandstone	... Dolomite, pseudo-limestone, shale, sandstone.
Obolus beds (Silurian)	... Dark, clunchy, shaly and sandy beds.
Lower or purple sandstones ...	... Purple sandstone, replaced by conglomerate.
Gypseous series	... Scarlet marl, gypsum, rock-salt.

N. B.—The series differs at either end of the range by absence of, or changes in, certain groups.

Northern or Himalayan series.

Cretaceous	... Limestones, some rusty and sandy.
Jurassic	... Limestones, sandstones, black (Spíti) shales.
Triassic	... Limestones, magnesian in part, shales, sandstones.
Infra-triassic	... Silicious and dolomitic breccia, shales, sandstones.
Silurian (?) Attock slates (azoic) ...	... Black and grey slates chiefly, limestones, magnesian in part, trap.
Metamorphic	... Part of the Attock slates usually slightly altered.
Crystalline	... Syenite-gneiss, trap rocks, and granitoid rocks.

N. B.—Carboniferous rocks are unknown in the northern series of this district, but occur in Kashmir and to the east of the Jhelum (see Mr. Lydekker's paper on Pir Panjál).

In describing the rocks belonging to the different tertiary groups, I shall follow what is known or appears to be their chronological order, commencing with the earliest.

Nummulitic Limestones.

Hill Nummulitic beds.—Of the four local kinds of nummulitic limestone the oldest perhaps is that of the outer Himalayan hill region: its position and general aspect, with its less fossiliferous character and the manner of its association with the mixed groups, are points giving sufficient grounds for a strong inference that this is the case. It is, generally speaking, dark-coloured, fœtid and massive, with nodular or lumpy bands, the whole irregularly and locally interstratified with masses of brownish, olive or darker shales.

Strong zones of paler grey splintery limestone also occur, and towards what appears to be the upper part of the group, the limestone, though still darkish, weathers of a lighter bluish-grey colour. Stratification is sometimes most plainly seen, sometimes nearly impossible to detect, and disturbance, compression and dislocation have left the succession obscure.

Those beds overlying the next older rocks are either unfossiliferous or only contain black specks that may have been organic, with occasionally minute sections of discoid foraminiferous organisms, having a single tier of cells arranged as a helix; or else cross-sections of another minute form less than semi-circular, with an obtuse angle midway opposite to the curved side, subtended by three or four concentric chambers equally divided by a closely set group of radial septa. I have only found this form in the lowest beds, and have not been able to get it determined. In the shales much higher up in the group are sometimes clumps of very small clustered and branched corals with occasionally numerous little *Foraminiferæ* (similar to the discoid form just mentioned) referred conjecturally by Dr. Waagen to *Rotalinæ*.

Many of the limestones enclose nummulites, whose sections are generally small in size, varying from that of the longest to the shortest diameters of grains of rice or wheat. The whole assemblage of organisms in these hill-beds is distinguished by scarcity and minuteness as compared with the other nummulitic rocks.

Westward, the darkest-coloured limestones are less common, the shales thinner and not so frequent. Strong grey limestone, weathering lighter, occurs along the Chíta range; still the dark shaly variety, with lumpy bands and a few layers crowded with small oysters, appears in the more central, northerly, and western parts of the range, also in the Niláb Gash mountains beyond the Indus. Yellow ferruginous, magnesian-looking bands are occasionally present, and there are black alum-shales in one or two places at the base of the series which may be of an older formation. At one place (Choi), apparently much higher in the group, is a lenticular pocket of bright coal and coaly shales, amongst the ordinary dark limestones and brown shales. Thin carbonaceous shale also occurs locally between these limestones and the Jurassic beds at Chamba Peak north of Murree, but are not constant in that position.

North of Niláb-Gash, at Pullosi Pass, grey limestone contains casts of large *Lucinidæ* similar to those of the Salt Range; and near Shaladetta I found, loose, one of the great Gastropod casts (*Cerithium ?*) peculiar to the Salt Range limestone. These indications are, however, too slight to establish any close identification of the northern limestone group with that to the south. They are lithologically different accumulations, although they appear to be generally contemporaneous as upper and lower parts of the same formation.

The Khaire Múrut ridge is a mass of solid, contorted, grey nummulitic limestone (of the same kind as that found in the eastern part of the Chíta Pahár opposite), flanked by the upper nummulitic group faulted, overthrown and concealed by talus deposits, yet well exposed where it forms the western and lower extension of the ridge. The stronger limestone, and indeed the whole ridge, appears to have had an anticlinal structure greatly modified by compression and faulting. At the eastern end in the lower ground are some indications of the conformable succession of the newer nummulitic group to the hill limestone, and again westward at Chorgali* I found the succession and conformity of the two groups distinctly displayed. (The section will be noticed when writing of this newer zone.)

Under the conditions of disturbance and dislocation it is hard to conjecture what may be the correct thickness of these hill limestones and shales. An attempted estimate carefully

* A pass infested by robbers in the Sikh times.

taken from one of the most detailed sections I have got near Murree* shows thicknesses for parts of the formation of over 2,150 and 2,700 feet; this is, however, but a partial result, and the whole may much exceed 3,000 feet. There is a large group of light-coloured evenly bedded limestones in the Hazára hills which appears intermediate between the hill nummulites and the cretaceous rocks.

Salt Range Nummulitic Limestone.—In this region the formation is made up almost entirely of limestones presenting a greater unity of character and uniformly a much paler colour than the northern group. Intervening clay or shales are rare or absent, and where any occur, they partake of the light colour of the limestone. Nodular or lumpy beds, made up of solid portions surrounded by a softer coating, are not uncommon; compact and cherty limestones often predominate in the upper portion. Many of the beds are highly fossiliferous, containing numerous imperfect casts of large Gastropods more than 8 inches in height, or large Bivalves, and also Echinoderms frequently as large as small melons. One small fossil, *Ostrea Flemingi*, seems exceptionally well preserved. *Nummulites* are numerous, and *Alveolinæ* also occur, as well as other *Foraminiferæ*.

In the Eastern Salt Range layers of pale purple and yellowish limestone conglomerate, with limestone and flint nodules and pebbles, the matrix charged with small *Nummulites*, have been found to form the very uppermost few beds, conformably overlaid by the sandstone and clay series. In the somewhat outlying Diljaba and Bakrála ridge these beds re-appear at Goragali, but separated from the limestone by a mass of greenish shales several feet in thickness, and having much the appearance of the upper nummulitic beds on the north side of the tertiary belt. Some red flakey clay or shale is also associated.

At the base of the Salt Range nummulitic formation dark shales are very commonly present, frequently overlying white, sub-conglomeratic, coarse and fine sandstones interstratified with pale red sandstone bands and red or lighter grey (rarely gypseous) shales.† The dark shales are often coaly or contain a single or divided layer of bright coal averaging three feet (the Salt Range coal). Mottled red and white unctuous or lateritic clay occurs as an accessory in thin or thicker beds. These lateritic and hæmatitic layers sometimes occur at the very base of the limestone, and sometimes below the coaly shale or among the white sandstones. They vary a good deal as to the amount of iron present, are sometimes pisolitic (when the grains are used as shot or bullets) or replaced by white clay, and they are sometimes altogether absent.

The coaly shales are not the very lowest nummulitic layers. At places in the East Salt Range, where most carbonaceous, one or two underlying calcareous beds contain nummulitic fossils; and to the west, as in the Bakk ravine (Músakhel), a considerable thickness of nummulitic limestone separates them from the lower formations. This variegated and mixed band below the main limestone has in the eastern region a probable thickness in some places of more than 200 feet, but parts are often concealed by talus deposits. It is less prominent to the west.

The whole southern nummulitic group frequently shows itself in high cliffs and varies in thickness from about 500 feet to nothing, being entirely absent in places at either extremity of the range Cis-Indus.

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* The observations for this section were mapped on a scale of 300 feet to an inch and carried along the clear cuttings for the new road between Murree and Abbotabad for over 23 miles. I look upon its information, as far as it goes, as reliable.

† At one place south of Chel hill, East Salt Range, a layer in such shales not far below the limestone contains narrow, pointed leaves.

Upon the evidence of the arenaceous, argillaceous, and rarely gypseous layers below this Salt Range limestone,* or the small local development of layers with an upper character at top, I can scarcely venture to assert that the whole group is the counterpart of the upper nummulitic beds of this district or elsewhere; still I think there may be sufficient reason to suppose that similar conditions recurred at intervals, and that this Salt Range series may at least be, generally speaking, newer than the greater part of the northern hill nummulitic limestones.†

Nummulitic Limestones, &c., beyond the Indus.—I have so lately described these rocks, (in Vol. XI of our Memoirs,) where as yet I am best acquainted with them, that a short notice will suffice. The most striking and constant band is one of hard grey and often variously tinted pale compact limestone 60 to 100 feet in thickness. This in colour and texture has some resemblance to bands in the Salt Range: it contains *Nummulites* and *Alveolinæ*. Below it are other grey lumpy and sometimes cherty limestones, with various nummulitic fossils; some peculiar to this region, and none possessing the great size of some Salt Range forms.

Underneath these limestones there is a zone of deep red clay, having subordinate sandstone and hæmatitic layers; it varies from 1,500 to 400 feet in thickness, and in places contains small fragments of fossil bones. Locally this clay gives place to olive sandstones partly conglomeratic; greenish clays and impure limestones with *Alveolinæ* and *Nummulites*. This mixed group reaches a thickness of 100 to 350 feet. Below all are the alum shales, the massive layers of gypsum, gypseous clays, and the enormous accummulation of rock-salt, often distinctly and regularly stratified. In the upper part of the series there are appearances of alternation with some of the overlying purplish sandstones, &c., but the folding and inversion of the rocks is so intense over the district that appearances cannot be always trusted.

The united thickness of the Trans-Indus nummulitic rocks, including 700 or 800 feet for the rock-salt and 300 for the gypsum, is estimated at from 1,600 to 1,700 feet, and may be more.

There are points of resemblance between this series and that of the Salt Range, but also many differences. Where the limestones are thick, pale, and fossiliferous, the resemblance is strongest; and junctions between the limestone and overlying sandstones, though often *locally* resembling the sharpness and definition of the same in the Salt Range, have here and there more similarity to the transitional nature of the newest beds of the whole nummulitic formation. The Trans-Indus nummulitic area has therefore general characters intermediate between those of the Salt Range and upper nummulitic groups, and is most nearly allied to the last.

The Upper Nummulitic group of this country, coming from the eastward, appears first in the Murree hills, then passes westward, edging the outer Himalayan region, crosses the Indus at Báhtar, continues close along the south side of the Niláb Gash mountain, and leaves the district as a continuous zone to enter the Jawaki Affrídi hills. A spur from these hills to Dandi on the Indus has beds upon its flanks which may belong to the group: it re-appears, at Khaire Múrut ridge, deeply faulted into the *khuds* and mountains of the Hazára district north of Murree, and similarly placed in the Mírkulán pass south of the Peshawar valley.

* The coaly shales afford no point of comparison, no similar zone occurring in the upper nummulitics of this district, nor any band that could be safely referred to the same horizon among the northern hill limestones.

† The East Salt Range nummulitic group presents a most striking resemblance to the bottom beds of the nummulitic series throughout the Jamú hills.—H. B. M.

places it appears as nearly the highest band of the group underlaid by soft grey sandstones and brown or bright orange clays, but further to the east similar rocks to these overlie it. This sandstone usually contains scattered pebbles, or strings of pebbles, of quartzite, &c.; and where the overlying orange and grey rocks do not interrupt, it passes upwards by increase of the pebbles into the conglomerates of the highest tertiary group. Sections of 2,000 feet entirely formed of it have been met with. Mammalian bones occur but are not numerous in the Dangót sandstone. Similar thick sandstones, occupying the same general position, are found at the Jhelum side of the district, and the pebbly upper portion of the Lower Siwaliks seems to be most developed towards the eastern and western limits of the Potwár country.

Thicknesses of 4,000, 6,000 and 11,000 feet have been observed in this Lower Siwalik group.

Upper Siwalik.

This division includes the great conglomerates and associated beds which terminate the tertiary series of the country. Like all such deposits, these conglomerates are inconstant, admitting intercalations of the same kinds of soft grey sandstones and grey or orange clays as underlie them. Besides these, highly ferruginous and occasionally bright red clay bands appear. The conglomerate is in greatest force near the large rivers, as at Salgráon on the Jhelum, at Makad on the Indus, and forming the cliffs called Káffirkot between the Kurram and Bahádur Khel. The enclosed pebbles and boulders, ranging up to 18 inches in diameter, are almost entirely of metamorphic and igneous rocks, forming an extremely varied assemblage,* the mainly Himalayan source of which is indicated by the same detritus being still carried downwards in the channel of the Indus. Amongst these pebbles a fluctuating percentage of limestone occurs, some belonging to the Silurian (?), triassic, Jura, and hill-nummulitic beds of northern regions, and some few towards the Indus to *Alveolina* or coral-bearing rocks, supposed to have travelled from the westward. Away from the large rivers, as in the Soán Upper Siwalik basin, conglomerate beds, though less prominent, still appear, sometimes formed of limestone pebbles from the ranges to the north, or where the transported fragments are fewer, these include sandstone pebbles presumably derived from the Murree group.

For the advantage of obtaining the newest European names of some of these pebbles, I submitted duplicates of a quarter of a hundred to my friend Mr. Kinahan as an authority on the subject of rock names. The following are their designations according to him, quartzites predominating :—

1. Red and grey brecciated jasper (silicified shale).
2. Black pisolitic hornstone.
3. Red and grey pisolitic quartzite.
4. Purple felstone ("euyte") withblood-red specks, white and green silicious amygdala.
5. Black compact dolerite (aphanyte).
6. Red and green blended compact "slightly ophytic" felstone.
7. Purple granular quartzite.
8. Quartzose amygdaloidal euryte.
9. Granular purplish gray quartzite.
10. Hard green felsitic amygdaloid, tufoid.
11. Green amydaloid, white infusible amygdala.
12. Purple amygdaloid.
13. Gray and black speckled felspathic rock.

(To 13.) "These are all passage rocks between euryte and felstone, the 'Hybrid rocks' of Durocher."

14. Flesh-coloured quartzite.
15. Black hornstone with thin parallel lines of quartz (riband argillyte, silicified shale).
16. Hard purple felsitic trap (tufoid part of a euryte ?)
17. Coarse granular subcrystalline quartzite.
18. Saccharoid white quartzite or "greissen."
19. Banded purple and flesh-coloured quartzite.
20. Black argillyte.
21. Olive fine-grained quartzite.
22. Flesh-coloured and green mottled silicious rock (with nests of Olivine ?).
23. Compact green felstone, harder than a file.
24. Coarse flesh-coloured quartzite.
25. Fine-grained black pyritous quartzite (Itsberyte ?).

These must fall very far short of all the varieties of hard rocks among the pebbles of the Siwalik conglomerates. They were collected chiefly at the Jhelum side of the district.

In some parts of the district, the Upper Siwalik conglomerate masses are replaced by clays. This occurs south of the Bakrála ridge, and thence nearly to the Jhelum in a north-westerly direction. Again, in the valley of the Soán the group is represented by a mixture of very recent-looking sandy rocks and dull reddish clays, with an occasional dark, almost carbonaceous band; and numerous layers of gravelly conglomerate, or the limestone pebble beds already mentioned. To the westward near the Indus a thick deposit of drab and pinkish clays clearly overlies the conglomerates; it has furnished the Emydine described by Mr. Theobald, and other fossils (*ante*, 4 of List). Here, too, grey soft sandstones and orange clays are so intimately associated with the characteristic conglomerates as to have taken a considerable place in the upper group.

Siwalik mammalian remains are found in this upper division less frequently than below, and they often present a rolled or worn appearance as if derived from older beds.

In these Upper Siwalik beds, measurements of 3,600, 3,700, and 5,000 feet have been estimated from sections made to scale, and observations on the ground.

It will be seen from the foregoing descriptions that while different stages can be recognised in these tertiary rocks, their boundaries are somewhat conventional. The separation of the marine nummulitic rocks as the representatives of those in other parts of India or Asia, and the recognition of one great fresh-water series succeeding, would have marked the progress of more or less regular accummulation. Some of the beds, however, being clearly in continuation with sub-divisions of regions to the east (where more definite distinction exists), I have extended the classification to this ground as far as practicable.

Upon the estimates given, the whole series presents an aggregate depth of between 25,000 and 26,000 feet, or nearly five miles, of tertiary rocks. What terrestrial changes the time represented by the successive accumulation of such vast deposits may have witnessed, is beyond consideration here.

A few sections taken across the country, to show the manner in which the rocks occur, are appended. It should be remembered that the necessity for reducing their length to suitable compass renders them very diagramatic.

Unconformable Post-Tertiary and Superficial.—Large tracts of this district are covered by superficial accumulations resembling the alluvium of its present great rivers; indeed, owing to the rapid fall of these they are rarely depositing streams. Ordinary alluvium does, however, occur along their banks in places, particularly near the Lower Jhelum and Upper Indus. The older alluvium or silt very frequently predominates on the higher plateau ground, often cut through by intricate "*khudderas*" so as to show the underlying rocks. Sometimes it prevails in open depressions. Nearly all of it is more or less impregnated with soda salts (*Kuller*), rendering large areas difficult of cultivation, and, by facilitating the action of rain-water, increasing the rapidity with which "*khudderas*" are formed or extended.

Its colour varies considerably below, but the upper portion is nearly always a dull pinkish drab, glistening, finely micaceous and often distinctly stratified silt, in which "*kankar*" (carbonate of lime nodules) is locally abundant. Near Jand and Sagri, the silt is locally overlaid by loose blown sand, and it is everywhere undergoing transportation to lower levels. The saline nature and stratified condition of this silt suggest an estuarine deltoid or lacustrine origin; it has only been found to contain land shells of recent species.

Before the time of the deposit just described, certain of the larger depressions in the country existed, and some, such as the Soán, Sil, and Lower Hazára valleys, were unconformably occupied by coarse pebble beds and sand or clay. These pebble beds are not, however,

confined to the valleys; they rise out of that of the Soán on its northern side near Ráwalpindi, and seem to have once overspread a good deal of the country west and north-east of that station with strongly-marked unconformity. They overlie the sides of the Rotás gorge near Jhelum; occur near Nowshera on the Son-Sakesar plateau of the Salt Range; at Namal to the westward; and cap the mountain above Kálabágh on the Indus. In most cases, if not always, they are undisturbed; but rest at locally steep angles of deposition in one or two places (in the Park at Ráwalpindi, and Son plateau, Salt Range). In the Soán valley and towards Ráwalpindi the pebble-beds are chiefly formed of detritus from the limestone hills to the north, but the very layers consisting most largely of calcareous pebbles at the Pindi side of the valley, crossing the river, gradually change into a mass of light-coloured quartzite boulders, the original locality of which is as yet unknown. The unconformity so strongly marked near the Soán bridge on the Trunk Road is scarcely traceable in lower parts of this valley, though of course it exists.

In the Hazára and Chutch (Chaj) plains, the pebble rocks beneath the superficial silt, &c., appear as a coarse conglomerate or well-rounded gravel, chiefly of syenitic and gneiss fragments, overlaid by thick horizontal sands, sometimes consolidated so as to form a sandstone of almost precisely similar appearance to those of the upper tertiary beds, but enclosing subangular and rounded blocks of crystalline rock similar to the pebbles beneath.

Along the Indus and in the banks of the lower part of the Haró river these pebble and boulder beds are again seen, occupying different levels, chiefly in the lower part of the river deposits: similar post-tertiary accumulations form rather a high flat between the Mírkulán and Chíta hills, and the thick sands recur on the Indus near Sújanda.

North of the Mírkulán and Affrídi hills, detrital beds, apparently of the same group, were observed near Ispínhák, as saline yellow, pale pink, greenish, red and white sands, clays, and gravelly beds with bones,* or soft micaceous sandstone.

These coarse deposits, though not always present, seem to be transitional with the lowest layers of the silt, and this has not been observed to overlie the pebble beds in some lofty situations, where it may be doubtful that it ever was deposited.

The heights at which the post-tertiary beds are found range from about 800 to 3,000 feet above the sea; they have much the aspect of river deposits, and may have been formed at different periods.

Another variety of superficial accumulations, dating far back, though still forming, is the "wash" or "fan" detritus edging the Salt Range to the south, the hills near Banú, and those in the neighbourhood of Mírkulán and Pullosi passes towards Cherát.

Calcareous tufa ("kamát") is not an uncommon associate of the newer deposits. Sheets of it are interposed between the "pebble beds" and the underlying Murree group, upon the banks of the river Lé, near Ráwalpindi; others seem to have once overspread the ground near Fatahjang, and it is frequently seen among or near the limestone hills.

Erratics.—Dr. A. Verchere is believed to have first recorded the occurrence of large erratic blocks near Trap village on the Soán, attributing them to flotation by means of ice. These travelled blocks are distributed along the left bank of the Indus from Attock southwards, reaching into the country for ten or twelve miles from the river. They are more numerous between the parallels of Attock and Jand than further to the south, strewing the surface of the ground in patches, some being partially buried in the sand or other superficial accumulations.

* Major Vicary found the bone of a camel (?) in apparently the same beds at Akhora (*au. cit.*).

A group of these erratics occurs on the road between Jand and Kushálgarh; one is of granite, measuring over 15 feet by 9 feet by 3 feet (exposed). Others close by are of syenite, gneiss, hornblend schist, and black slate. For a few hundred yards around the ground is dotted with similar and smaller blocks, and others are numerously distributed over the neighbouring sandy country. Some of these appeared smoothed, but none that I saw showed any signs of striation.

Near the Túral or Rais river opposite to Jand erratics occur again, but fewer. One of grey syenite measured 4 feet by 2 feet by 2 feet 2 inches; and a block of grey gypsum, 18 inches by 12 inches, was precisely of the kind occurring beyond the Indus in the Gúrgúrlot and other hills, or at Báhtar on the left bank of the river, where it crosses the Chíta range.

Two large erratics lie near the hamlet of Kummerallia (Wahlia of the maps) south of Daknér: one of white granitoid rock, weathering dark, has a girth of 50 feet and a height of 6 to 8 feet; the other, of basalt, is 48 feet 6 inches in girth and 12 feet 6 inches high. A block of grey felsite, set on end in the sand half a mile south of Hatti on the Trunk Road, forms a conspicuous monolith: it measures 8 feet 6 inches high by 18 inches by 6 to 10 inches. Not far to the north is a block of the Kyjnág and Hazára porphyritic granite with large twin crystals of felspar; it has dimensions of 9 feet by 3 feet 6 inches, and is much buried. There are others scattered about, but this one only suggests the northern source of these erratics with some certainty and the Indus valley as the direction from which they travelled.*

Far to the south-east near Hoon, Mount Tilla, Rotás, and in the Bunhár river at Ghoragali, smaller and less angular erratic blocks of red granite are numerous. One of these, however, at Narwari, a mile east of the Collector's bungalow at the Mayo salt mines (Khewra), is 7 feet in height, measures 15 feet in circumference at the ground, 19 feet half-way up,† and rests upon the red gypseous marl. These red crystalline boulders are supposed to have come from a peculiar conglomerate in the cretaceous or "olive group" of the Eastern Salt Range, or at least from the same unknown source as its enclosed blocks. One such boulder, polished and striated, apparently by glacial action, was shown me by Mr. Theobald, who found it in a wall near Wahali, on the eastern plateau of the Salt Range, not far from where the conglomerate just mentioned is *in situ*.

By what means these erratics were transported, if not by the agency of ice, is unknown. Their size, sub-angular shape, and the distances they must have travelled, favor this supposition. All do not seem to have wandered so much, thus localising the transporting cause: on one of the river terraces of the Indus gorge between Purri and Báhtar, I measured an erratic mass of unfossiliferous limestone 9 feet high and 74 feet in girth, which may have belonged to any of the neighbouring limestones from the lower nummulitic downwards, and seems to be as truly an erratic block as any of the others.

With regard to the existence of a glacial period affecting the Upper Punjáb in very recent geological times, the only evidence the country seems to offer is in the occurrence of the formerly Indus-borne crystalline fragments at heights some 2,000 feet above the present bed of the river. These would indicate either a very late elevation of the region traversed by the Indus, or that when it ran in a channel so much higher, the hilly country to the northward may have been as much more lofty (or even higher still), and regions of perennial snow much nearer than they are at present. The denudation, which, influenced by earth-movements, or alone, reduced the general surface, would have removed most evidences of

* I have also noted granite and other crystalline erratics at heights of four or five hundred feet above the Jhelum near Chuttur Kalas, the first stage from Kohála on the new road into Kashmír.

† From measurements kindly furnished by Dr. Warth.

glacial action,* and the widely spread, well-stratified post-tertiary silt would indicate aqueous conditions in the vicinity, which might have facilitated the distribution of these erratic blocks.

Supporting Rocks of the Tertiary Zone.

I shall now endeavour to convey as briefly as possible some slight idea of the palæozoic and mesozoic formations bordering the tertiary zone in this district.

Southern or Salt-Range Rocks.

The nine Salt Range groups of palæozoic and mesozoic formations, included in the list (*ante* p. 113) exhibit parallelism and conformity throughout; this, however, may be only a local, yet marked, peculiarity. Another as great is that the strata composing the sections at either end of the range are strikingly dissimilar. One formation or group may be traced thinning away and becoming overlapped by another at various points along it, so that in no place is the full section obtainable. Besides this the whole region has undergone most violent disturbance, resulting in displacement and contortion, sometimes one or both being prominent, and in places, owing to this, the oldest and newest of the groups are brought into contact. The outcrop on the scarped side of the range is thrown frequently into such intense confusion from land-slips caused by the deliquescent nature of the salt-marl that it is difficult to reproduce it on any map, and entirely impossible on the roughly reduced outline given with this paper.

"*Saline Series.*"—The red marl, gypsum, and rock-salt forming the lowest group is as mysterious in its origin as strange in its development and economically important, producing a large annual revenue of about £400,000 sterling. The salt occurs in the upper portion of a mass of red gypseous marl, and underlies massive, white, stratified gypsum. It shows a thickness of 600 feet at the Mayo mines, of which 225 are almost chemically pure salt (Dr. Warth's paper, No. 11 of list).

"*Purple Sandstone.*"—Thick sandstones, earthy below and of deep purple colour, becoming whitish at top, succeed the saline series. This "purple group" extends far to the west, but there becomes thin, and the sandstones give place to dark earthy conglomerates containing crystalline boulders of red granite and other rocks. It contains no fossils, so far as known.

"*Obolus beds.*"—In the next formation, however (also ranging widely westward), a belt of blackish clunchy shale, with sandy layers, was found to contain, at one or two places, the small detached valves of *Obolus* or *Siphonotreta*, a Silurian form, locally numerous, but entirely by themselves.

"*Magnesian Sandstones.*"—This group is to the east succeeded by, and connected with, a strong lightly coloured set of beds, the most conspicuous of which are hard, compact, magnesian layers, varying from dolomite to magnesian sandstone, and associated with flaggy and darker shaly bands, often covered with fucoidal and annelid markings. This formation has a more limited extension than the last, and was doubtfully thought by Dr. Waagen possibly to represent the carboniferous limestone of the west. From its position in certain sections, it appears to underlie that group, so I have preferred to keep it provisionally separate, particularly on account of its partial intercalation with the zone below, just where it is least recognisable to the westward.

"*Speckled Sandstone.*"—The next group is a massive succession of speckled light-coloured or reddish sandstones, with purple clays and conglomerate bands, the pebbles of which are chiefly of old crystalline rocks. At the top of the group, pale lavender clays (said to contain small concretions of copper pyrites) are constantly present.

* As pointed out by Mr. Croll would generally be the case (Climate and Time).

"*Carboniferous.*"—Immediately above these layers the carboniferous series commences in the Nilwán ravine, as dull, dark-coloured, impure, calcareous beds of small thickness. Westward the formation developes rapidly into a great mass of clear limestones, with some ferruginous or pale sandstones and dark earthy calcareous layers, the whole often crowded with palæozoic fossils, amongst which Dr. Waagen found the unique carboniferous *Ammonites* which he has described (*l. c.* No. 9 of list).

"*Triassic.*"—Almost united lithologically with this group is a series of thin limestones and greenish shales or clays developed from the Son plateau of the range westward, and containing abundance of *Ceratites*, *Goniatites*, and other forms, of the same genera but of different species from those in the carboniferous group below (as distinguished by Dr. Waagen). On the evidence afforded by these a triassic age has been assigned for the group, to which period also a group of bright red arenaceous and argillaceous rocks in the east part of the range, without fossils, but full of casts of salt-crystals, has been referred. It immediately succeeds the magnesian group before mentioned.

"*Jurassic.*"—Overlying the western triassic group are white soft sandstones, yellowish limestones, oolitic and earthy beds containing *Belemnites*, more rarely *Ammonites*, and other Jurassic fossils. The upper part of this Jurassic group becomes dark and shaly Trans-Indus at the Chichâli pass, where a curiously inverted and faulted section is exposed. Along their Western Salt Range boundary, the uppermost Jurassic and lowest nummulitic rocks present appearances of local transition through alternating bands of limestone, sandstone, and shale.

"*Cretaceous.*"—In some places, however, as in the eastern part of the range and at the Chichâli pass, dark-coloured shales and olive or yellowish sandstone with local beds of peculiar dark conglomeratic clay intervene between the above-named groups, or between the red trias (?) of the east and the coaly, shaly, ferruginous, or white sandy beds near the local base of the nummulitic formation. The shales in the Chichâli pass contain several globose *Ammonites*, recognised at once by Dr. Waagen as cretaceous; and I have found in these intervening beds (to the east) casts of large shells, which, with a few forms discovered by Dr. Waagen near Makrách, led to suggest for the beds a cretaceous age.

From the salt marl upwards, all the formations, as far as the base of the tertiary, seem to be marine; but as some are not fossiliferous, and there is a record of some plants found in the Jurassic group by Dr. Fleming, this is less than absolutely certain.

It will be seen that the contrast is strong between the rocks of this area and the pretertiary series of the outer Himalayan region.

Western Punjáb, Himalayan Series.

"*Crystalline.*"—The oldest part of this series includes the syenitic rocks, granitoid porphyry, and greenstones of Hazára (Pakli valley, Súsúlgali Agrór, &c.), and, from specimens brought down, it seems that crystalline rocks are common in Kaghán also. The granitic porphyry with its twin crystals of felspar, 5 or 6 inches high, is exactly like that occurring as erratic masses (from the Kyjnág range, &c.) near Nowshera in the Jhelum valley on the road from Murree to Kashmír.*

* This porphyritic rock seems to represent the central gneiss of Dr. Stoliczka's Himalayan sections (Mem. Geol. Surv. Vol. V); at least he appeared to identify a block we found together in the Jhelum at Huttí, Kashmír, with his "Albite granite."

"*Metamorphic and Silurian.*"—Over a considerable area outside the Hazára granitoid rocks, slightly metamorphosed, dull, talcose, silky slates were traversed, representing the local "Attock slates" of Nowshéra, Abbottabád, &c. Some of the altered beds (on the road from Manséra to Garhi Habibúlla, for instance) weather to a substance resembling porcelain clay. Greenstone dykes and masses intersect the inner portion of the slates, and syenitic protrusions occur, but no stratified or foliated gneiss nor any mass of quartzites or mica schists was met with, though such were known to Dr. Fleming among these mountains, probably at places which I did not visit.

In the Upper Hazára slates and those of Mianjáni mountain limestones are absent or uncommon, but occur extensively in the Gandgarh mountain north of Hassan Abdál, in the Attock hills and towards Mírkulán. These limestone bands have varied textures, from pseudo-brecciated to compact, and are often magnesian: one remarkable bed, though unaccompanied by other local metamorphism, resembles a clear sub-crystalline and compact white altered marble; it is slightly affected by acid. It stretches along the southern face of the Attock and Mírkulán hills. It is not improbable that several of these limestones, though closely associated with the dark slates, do not belong exactly to that series, but to some newer group. Others are undoubtedly interstratified.

In none of the slates or intercalated limestones have I been able to find a single organism; but in the hard limestones near Dakner, I found obscure traces of small gastropods and other shells, barely recognisable as organic: further west, at Mírkulán pass, these traces are stronger, and a few fossils can be distinguished.

The stratification of the slates is often obscured by a number of cross-cleavages, which render their furnishing slate of economic value unlikely. As a rule, they are very thinly laminated, this structure enabling slab or bedding slates to be raised where the cleavage is less prominent or coincides with the bedding; the material, however, is soft and weathers easily. Bands of dark-greenish, gritty, fine-grained sandstone are not uncommon. The whole group often shows intense folding and compression.

A possibly Silurian age for these slates has been chiefly inferred from the discovery of Silurian fossils by Dr. Falconer and Major Vicary in the Peshawar district, apparently not *in situ*, but traced to the Khyber mountains in Afghánistán. These fossils are stated to have been of lower Silurian age. Major Vicary mentions *Spirifer*, *Orthis*, *Terebratula* (?) and *Polyparia* in limestone. Similar genera occurring in the carboniferous and secondary rocks of the other parts of the country, the evidence as to Silurian age is limited, so far as any information at present available extends, to Dr. Falconer's fossils, as referred to by Major Godwin-Austen (in Quar. Journ. Geol. Soc. Lond. Vol. xxii, p. 29).

The slate group is perhaps older than carboniferous,* and may be a continuation of the azoic slates of Dr. Stoliczka's Himalayan sections.

"*Infra-Triassic.*"—Resting upon the Attock slates with complete unconformity is the series of Sirban mountain in Hazára (see Memoirs, No. 12 of List). The unfossiliferous red sandstones, hæmatitic and silicious magnesian beds, there underlying the triassic formation, are of unascertained age, and have not as yet been found elsewhere.

"*Triassic.*"—The triassic formation of the whole northern region consists largely of limestones often so slightly fossiliferous as to be very difficult to distinguish from those of

* Last season Mr. Lydekker found in a detached block near Hassan Abdál a specimen of *Productus Humboldti*, common in the Salt Range carboniferous formation. I have since searched the place in vain for any evidence of the existence of carboniferous rocks in the locality. It is possible that some may occur among the limestones on the south side of Gandgarh mountain to the north, though I failed to find a fossil of any kind in the only traverse of the mountain I have as yet been able to make.

the Jurassic period. Shales, limestones, silicious breccia, hæmatitic clays, and sandstones are present at Sirban; in other places limestones only are found, or with these a few shales, a sandstone band, or some ferruginous amygdaloidal clay. In one case I observed among other limestone rocks supposed to belong to this formation, a limestone conglomerate enclosing fragments of coralline limestone. The triassic beds are in force among the hills extending from the Mochpúra mountains to the Trunk Road; and a quantity of hard limestone, much of which may be triassic, appears in the Chíta range as well as in the detached hills to the north.

The fossils of the formation are, as a rule, scarce, obscure, and hard to detach: *Nerinæa*, *Neritopsis*, *Astarte*, *Opis*, *Nuculæ*, *Ledæ*, *Ostreæ*, *Terebratulæ*, *Rhynchonellæ*, *Megalodon*, *Dicerocardium*, *Chemnitzia* and *Gervillia* were identified by Dr. Waagen at Sirban, and *Ostrea Haidingeri* near Khairagali. At the western base of the Zyarut hill at Hassan Abdál I found a massive grey limestone bed unconformable upon Attock slates, and full of large *Dicerocardium* (and *Gervillia?*) sections, the fossils being impacted and impossible to separate. Overlying this is a large zone of hard, thin-bedded limestones from which I obtained (loose) a very perfect *Pholadomya*. Sections of *Rhynchonellæ* are seen in the rocks, and on close search little *Retzia* (*?*) and Echinoderms are found weathered out. If the fossils of the upper portion of these limestones prove Jurassic, the unconformity between the trias and Jura of Sirban is absent here.

Thick, amorphous, splintery, nummulitic limestone of the paler hill-type caps the whole, and is compressed between the folds of the older beds, with very doubtful conformity to the thinner limestones below. In another section, near Kamalpur, of similar hard, thin-bedded limestone with some thicker bands, is a layer crowded with very large and thick *Ostreæ*.

The complicated association of limestones, trias, Jura, and nummulitic, extends westwards further than it can be followed into Affrídi territory (Afghánistán). "Large fossil oysters" are reported from a stream near Cherát, and at Mírkulán, not far from this place, there is the following succession, from south to north, a considerable part of which may be triassic:

Mírkulán Section.

(*North.*)

30. Dark Attock slates, with some harder bands.
    Fault (?).
    Upper Nummulitic.
29. Bright red earthy rocks and soft greenish sandstone.
28. Sandy limestone with large quartz grains.
27. Olive shales.
26. Strong purple sandstones.
25. Very red earthy rocks, cleaved.
24. Grey, slaty, olive and greenish shale, cleaved parts full of *nummulites*.
    Cretaceous (*?*).
23. Alternations of slaty shale and dark limestone with sections of *Cerithium* and *Natica* (*?*). Calcareous bands weathered to a rusty clay full of undeterminable fossils.

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22. Thick limestone.
21. Dark greyish-green, slaty band.
20. Thin dark, flaggy limestones.
19. Greenish and grey limestones, highly contorted.
18. Thin-bedded black limestone.

17. Dark grey quartzite, with black flaggy slate bands, and white flaggy calcareous layers (600 ft.).
16. Silicious gritty beds.
15. Grey and purplish, rippled, thick-bedded slate (1,500 ft. ?).
14. Grey, purple, and greenish flaggy limestone.
13. Dark green calcareous slates, thinly laminated.
12. White flaggy limestone with yellow lines, among grey slaty beds.
11. Dark grey and variegated limestone, magnesian, compact, with ferruginous strings; a black earthy layer and several shale partings, one hard blue band crowded with sections of thin flat bivalves, shelly parts often oolitic, and contain sections of pentagonal crinoid stems.
10. Purple slaty band.
9. Black and greenish shining shale or clay, flaky; layers and nodules of grey oolitic limestone.
8. Black limestone—dolomitic in places, then of brownish grey colour.
7. Green-olive fine slate.
6. Strong grey and variegated yellow and black limestone: no fossils.
5. Brownish grey and purple slaty band, passing up into yellowish and green calcareous slate (about 200 ft.).
4. White flaggy lithographic limestone, thin and flaggy above, alternating with grey bands, like Solenhofen lithographic slate, upper part lavender-coloured.
3. Greenish olive; dark, shaly ferruginous, thin band (same as "Darwáza" limestone on Indus near Dakner).
2. Brownish yellow brecciated limestone, overlying.
1. Olive shales with ferruginous concretions.

The correlation of this section cannot be usefully attempted till the ground has received further examination. The series appears to rise in the direction indicated by the progressive numbers, but may be affected by faults and inversion in part. The southern end would seem to belong to the slate series; further on, the only guess which Dr. Waagen could hazard from the imperfect organisms found, was that the zone (so marked in the section) might be cretaceous; while the upper part, presumably faulted against the slates, is certainly nummulitic and perhaps upper nummulitic. The thickness exposed must be great, but could only be estimated for some of the zones.

"*Jurassic.*"—Jurassic rocks are known to exist in many places beneath the lower nummulitic beds. They, too, are chiefly limestones and not of widely different aspect from those overlying. In the southerly parts of these northern hills they usually contain a well-marked rusty zone, enclosing small grains of quartz, which give a rough appearance to the weathered surface of the rock. This zone is sometimes a mass of fossils, chiefly of large *Trigonia ventricosa*,* of which the matted and intertangled casts can only be obtained. *T. costata* occurs also, but the sections of the larger species give a very marked character to the weathered surface of the rock.

In the hills near Márgala pass, where broken portions of the Trigonia rock occur, the associated beds contain fragments of *Ammonites* and *Belemnites*. Again, to the west near Jang, the latter and *Gryphæa* abound in one or two layers just below the Trigonia bed. *Ammonites* of well-known Himalayan forms† are numerous in the Spiti shales of Chamba

* Determined by Dr. Feistmantel.

† *Oppelia acucincta*, Strachey, *Perisphinctes frequens* Opp.† conf. *Simplex*, Sow., *Belemnites Gerardi* Opp. *Inoceramus*, *Cuculæa* and *Pecten* are the fossils mentioned by Dr. Waagen. Records, G. S. I., Vol. V, para. 1, p. 17.

peak near Khairagali (where they were first discovered by Dr. Beveridge, R.A.). *Inoceramus* and *Ammonites* fragments, a *Pecten* and *Belemnites*, occur in another exposure of the Spiti group at Kondragali on the Abbottabád upper road from Murree; and some of these fossils re-appear in dark-coloured sandy and calcareous rocks far down in the deep ravine of the Haró below this locality.

None of these Jurassic rocks, Spiti shales, *Trigonia* zone, or the harder compact and semi-lithographic limestones in the least resemble the Salt Range Jurassic rocks, nor is there any similarity between the great trias limestones, &c., of the northern region and the *Ceratite* beds of the other locality. The cretaceous horizon of the northern area is chiefly marked by hard sandy limestones forming a thin band at Sirban and in the hills close to Kohát (though thicker limestones without fossils may also belong to the same formation). This band contains several *Ammonites*, a few *Baculites* and large *Belemnites*, generally of uncanaliculate forms. The aspect of the band is also quite unlike the dark shales of Chichali or the "olive group" of the Salt Range.

Palæontological skill only can decide how far the northern and southern fauna are disimilar; to ordinary observation there is a striking difference between the fossils belonging to the formations of all ages from the two areas, corresponding with the lithological diversity, and suggesting much variation of conditions during palæozoic and subsequent times.

Disturbance.

There are abundant instances of most intense disturbance and dislocation in this district, yet they appear to have resulted from but one extended influence, which produced the whole system of its mountain features. Strata belonging to all periods older than post-tertiary are contorted, but as no chronological sequence can be distinguished amongst the countless folds or numerous faults in any of the series, the whole of the disturbance connected with the physical features can only be attributed to a post-Siwalik period. Whether the results are due to one prolonged or to consecutive exertions of force, there is as little to indicate, as there is to show when the action ceased.

The marked line of disturbance, dislocation, and inversion along the outer Himalayan limestone hills has no counterpart in the district (unless a concealed feature of similar kind skirts the Salt Range on the south). It appears to imply special intensity of the disturbing agency. Other developments of extreme results occur;—a complete inversion of the Jurassic and tertiary limestones is seen among the hills between Shaladitta and Khánpur (northward of Ráwalpindi): inversion is common, sometimes extraordinary, all over the Kohát country, and its presence at Chichali pass has long been known.

Although whole ages of apparently tranquil accumulation distinguish the succession in the Salt Range, the limitation laterally of so many of its groups may have been connected with slight or local alterations of level

In the Himalayan area there are traces of palæozoic and mesozoic elevations and denudations, in the unconformities mentioned (at Sirban and Hassan Abdál), however local these may have been; and in the more central area, similar events in tertiary times are indicated by the derived fragments enclosed in the rocks.

The presence of the great tertiary sandstone and clay series of this area asserts the previous existence of an elevated region to the north, and its Siwalik boulder beds point to a west Himalayan elevation in later tertiary times, as plainly as the distribution of the same boulders in subsequent deposits proves that those western Himalayan regions have remained elevated ever since.

The lofty situations of these Himalayan boulders in some localities may either indicate a post-tertiary elevation or be a measure for part of the sub-aëreal denudation of the Upper Punjáb.

Description of the Figured Sections.

These three sections, in consequence of the vertical exaggeration necessary, will show at a glance the general fall of the country towards the Indus from the Murree hills and Salt Range.

It will also be seen that the Himalayan side of the Ráwalpindi plateau is much the most generally disturbed, the folding of the rocks being almost confined in its greatest intensity to the Náhan-Sirmúr band and those groups lying northward of it. The local character of the Salt Range disturbances will also appear, but the sections do not happen to cross where these are most developed.

Section No. 1 is in two parts, from the difficulty of taking a single line over the most expressive features of the ground. In the part of it along the Trunk Road it may be noticed that the upper Siwalik conglomerates at and near the Rotás anticlinal are represented in the Kharián hills and south of the Bakrála ridge by clays. The faulting at the latter locality might be supposed sufficient to account for this, but from the aspect of the neighbouring country it appears equally probable that the formation has changed and the coarser beds have been replaced as at the Kharián ridge. The Náhan beds of Bakrála ridge have been already referred to.

The lower Siwaliks are largely developed from Mount Narh to the southward, giving sections of over 13,500 feet; and the upper Siwalik conglomerate beds have a thickness of 2,800 feet at Salgráon. The Murree hills are all formed of the rocks referred to the Náhan-Sirmúr group, but the contortion is so great that their thickness can only be guessed at about 5,000 to 7,000 feet, with the probability of its being very much greater.

The whole of the Kuldana spur, uniting the Murree ridge with the more lofty ranges to the north, is occupied by upper nummulitic beds, including a quantity of sandstones, &c., so similar to the overlying ones that their identity has been doubted. If the faulting necessary to have produced the present arrangement could be accounted for in detail, these questionable beds might be admitted to have belonged to the series above.

Northward from Kuldana the section has been already described, and its continuation to beyond the Miánjáni slates near Batangi shows alternation of nummulitic and Jurassic or triassic exposures, crushed and faulted beyond recognition of the geological relations. The mass of red rocks at Dungagali are believed to be upper nummulitic beds introduced by faults.

Section No. 2.—From Pind Dádun Khán to Gandgarh (or from the Jhelum to the Indus).—In this section one of the most conspicuous faults of the Eastern Salt Range is crossed, bringing a portion of the tertiary Náhan beds against the lower rocks of the palæozoic series. The land-slips and complexities of the Salt Range section here had to be omitted on account of the reduced scale of the section. North of the range the beds having most the appearance of the Náhan rocks may be taken at 1,500 feet, but beyond this the wide expansion of the lower Siwaliks rolling at gentle angles conveys little idea of the true thickness of the beds—a large one, however, in all probability exceeding 10,000 feet. The upper Siwaliks of the Soán basin may be estimated at from 300 to 500 feet, and are generally overlaid by the valley-deposits or loess, both series being in places so horizontal and so similar as to be hardly

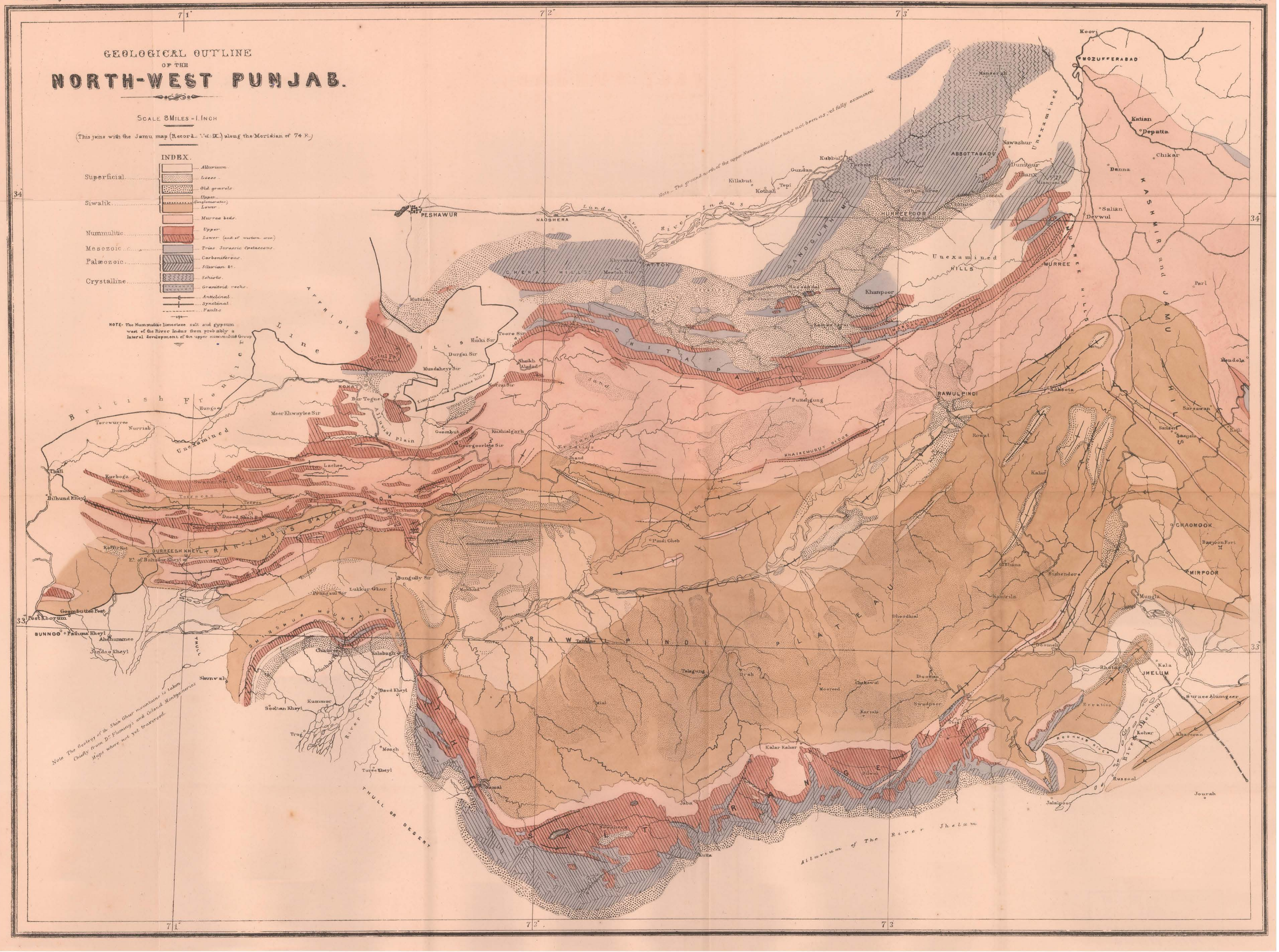
distinguishable. At the northern side of this basin the beds become gradually tilted; the gravelly conglomeratic beds and clays pass down into the red and gray rocks of the lower group to near Khaire-Múrut ridge, where the angles are very highly inclined, or vertical bedding is found in the purple Náhan-Sirmúr group. In places on both sides of this ridge there are traces of the upper nummulitic beds intervening between the limestone of the hill and the purple rocks on its flanks, but the junction on either side as frequently has the appearance of a fault. Hence to the vicinity of Fatahjang numberless steep inclinations towards the north and south in the Náhan-Sirmúr rocks indicate the closely-folded and compressed curves of the beds, which are both disturbed and displaced at the upper nummulitic zone, as may be seen where the alternating limestones, shales, &c., mark the arrangement more distinctly. As an example of the contortion here I may mention that *thirteen* anticlinal curvatures are shown within 3,000 feet horizontally in one of Mr. Lyman's very carefully detailed sections at the Fatahjang petroleum springs, and there are many similar cases.

It not unfrequently occurs along the junction of the upper nummulitic zone with the stronger limestones of the adjacent hills, that there is a small space between the two occupied by rocks resembling those outside that zone. This is sometimes due to combined faulting and inversion, but the contortion is often so great that it is difficult to say whether there are not some intervening red and purple sandstones and clays really present. Sometimes also there are but very few layers of the well-developed upper nummulitic character to be found in their usual position, as at Shaladitta, where the main zone is a mile and a half to the southward, and the usual lower sandstones and clays of the Náhan-Sirmúr group, containing occasional layers of upper nummulitic type, are *faulted against*, rather than rest on, the Jurassic limestone of the hills.*

In this section (No. 2) the solid limestones of the Chíta Pahár range are of unusually pale colour, and sometimes full of nummulites. At the northern base of the range they are in contact with a highly disturbed and faulted zone of upper nummulitic beds. Further north the rocks beneath are concealed by heavy accumulation of valley beds (syenitic gravel and gray sands), until at Khaire Múrut the hard triassic-looking limestones show themselves in a folded state capped by and faulted against nummulitic limestone, below which the *Dicerocardium* and overlying limestones (some of them Jurassic?) of Hassan Abdál rest upon slightly exposed Attock slates, such as are seen with many intercalated and associated limestone masses on Gandgarh to the north.

In section No. 3 the carboniferous limestone of the Salt Range is shown appearing thicker than it is on account of the vertical exaggeration. The groups below it are the "speckled sandstone," "purple sandstone," and "gypseous" salt-bearing series, while the mesozoic formations above include the triassic Ceratite beds and Jurassic sandstones and limestones overlaid by the strong nummulitic limestone. The section continues through the same series as before, traversing the great upper Siwalik conglomerates of the Mokud region, the slightly fossiliferous bone and wood-bearing rocks of Jand and Nara, the upper nummulitic limestone and secondary limestones (probably both trias and Jura) of the Chíta range, then turning eastward in the river Indus traverses the valley deposits of the Kamalpur plains and the slates and limestones of the Attock hills, as shown in the section.

* Compare Records, Vol. IX, p. 156, para. 3.

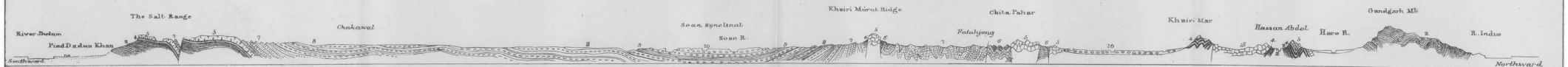

GEOLOGICAL OUTLINE
OF THE
NORTH-WEST PUNJAB.
SCALE 8 MILES = 1 INCH
(This joins with the Jamu map (Records Vol. IX.) along the Meridian of 74 E.)
INDEX.
Superficial
Alluvium
Loess
Old gravels
Siwalik
Upper
(Conglomerates)
Lower
Murree beds
Nummulitic
Upper
Lower (and of western area)
Mesozoic
Trias Jurassic Cretaceous
Palæozoic
Carboniferous
Silurian &c.
Crystalline
Schists
Granitoid rocks
Anticlinal
Synclinal
Faults
NOTE - The Nummulitic limestone salt and gypsum west of the River Indus form probably a lateral development of the upper nummulitic Group
71°
72°
73°
34°
33°
PESHAWUR
NAOSHERA
ATTOK
ABBOTTABAD
MURREE
HURREEPOOR
MOZUFFERABAD
RAWUL PINDI
KOHAT
JHELUM
CHAOMOOK
MIRPOOR
BUNNOO
KASHMIR and JAMU HILLS
RAWUL PINDI PLATEAU
SALT RANGE
CHITA PAHAR
CHERAT HILLS
British Frontier Line
AFRIDIS
Unexamined
Unexamined HILLS
River Indus
Alluvium of The River Jhelum
THULL OR DESERT
Khanpoor
Futtehjung
Pindi Gheb
Kalabagh
Kalar Kahar
Jalalpoor
Pind Dadun Khan
Note. The Geology of the Shin Ghur mountains is taken chiefly from Dr. Fleming's and Colonel Montgomeries Maps where not yet traversed.
Note. The ground north of the upper Nummulitic zone has not been as yet fully examined.

SECTION WEST OF RIVER JHELUM. N° 1.

84. Miles.

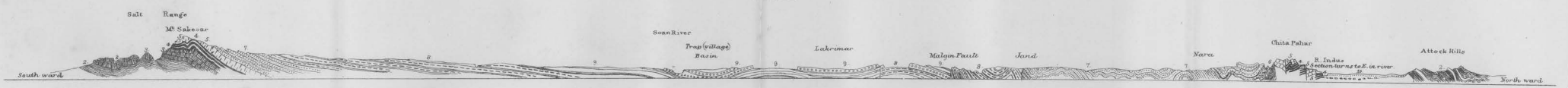
SECTION FROM PIND-DADUN-KHAN TO GANDGARH. N°2.

132. Miles.



SECTION FROM SALT RANGE TO ATTOCK. EAST OF THE INDUS. N° 3.

108. Miles.



References; 2 Palæozoic; 3 Carboniferous, 4 Mesozoic, 5 Lower Nummulitic, 6 Upper Nummulitic, 7 Nahan Sirmur, 8 Lower Siwalik, 9 Upper Siwalik, 10 Old Gravels, 11 Alluvium.