12. *Observations on some FEATURES in the PHYSICAL GEOLOGY of the OUTER HIMALAYAN REGION of the UPPER PUNJÂB, INDIA.* By A. B. WYNNE, F.G.S. &c. (Read December 17, 1873.)

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1. THE geographical position of the Upper Punjab is too well known to require detailed description; and it will be sufficient to say that the country to which the following observations mainly refer is that part of "the land of the five rivers" in which the Jhilam* (Hydaspes of the ancients) and the Indus or Abba Sin ("Father of Waters") flow rapidly through rocky channels before finally leaving the hills. (See Map, Pl. VII.)

The principal British stations in the country are those of Jhilam, Rawul Pindi, Abbottabad, Fort Attock, and the Hill Station of Murree†.

2. The geological structure of the ground with reference to the points to be noticed may be generally stated thus:—This section of the Outer Himalayas consists of a varied assemblage of rocks. The crystalline, granitoid, syenitic, and schistose rocks, with abundance of greenstone dykes, found far in among the hills, are succeeded by slates and limestones (of possibly Silurian age) unconformably overlain by Triassic and perhaps older rocks, which may be provisionally

* Always pronounced by natives Jhælum.

† Koh Mari, or the Mountain of Mari, from an old Mahomedan shrine, or Zyarut, now a Hindoo temple. The station and locality are very commonly called by the natives Mushæri, a village of that name being situated in the glen below.

called *infra-Triassic*. The Triassic beds are, again, unconformably succeeded by Jurassic limestones, Cretaceous limestones, and a mass of Nummulitic limestone and shaly strata, all three resting conformably, the newer on the older.

From the Trias upwards and inclusive, the rocks consist so largely of limestones that the country formed of these Secondary and older Tertiary strata may be comprehensively spoken of as a zone of limestone hills or "*Hill-limestones*." Exterior to this zone is another of hills (occasionally high) and broken plains composed of a mass of sandstones and clays, with conglomerates, the whole of enormous thickness and of Tertiary age. These sandstones, clays, and conglomerates have been subdivided in this and in other districts into groups, among which Eocene (Nummulitic) and Miocene (*Sivalik*) stages have been recognized.

3. The relation of this outer zone to that of the hill-limestones, is to form one of the principal subjects of the present communication.

4. So far as is known to the writer, the belt of Tertiary sandstones, clays, and conglomerates just now mentioned passes along the whole southern foot of the Himalayan Mountains, beneath the thick alluvial accumulations of the plains, from Assam to Afghanistan, with but one exception, where an outer edge to the belt is seen brought up on the northern flanks of the Salt range in the Punjab and along its tortuous extension trans-Indus. The width of the belt in this part of the Punjab is thus fixed at from 50 to 60 miles; but it decreases westward and turns to the south along the Indian flanks of the Suliman Mountains.

Beneath the outer edge of the Tertiary belt the Salt range partly repeats the systems found in the Himalayan hills, but with very considerable differences as to the number and extent of the formations, and also as to their lithological or petrological and palæontological characters*.

Beyond the Salt range to the southward stretch the flat deserts of the Punjab and Sind, broken only by a small cluster of elevations called the Korana hills, the rocks of which, according to Dr. Fleming (*Journal Asiatic Soc. Beng.* vol. xxii. 1853, p. 444) appear to belong to one of the older groups, perhaps older than any of the Salt-range rocks, and not far removed from the Metamorphic or Crystalline series.

5. Geological information in a published form respecting the district under notice is rather scanty and uncertain; but the whole region lies within the area of Dr. Albert Verchere's map appended to his voluminous paper read before the Asiatic Society of Bengal (1866-67). Dr. Fleming's reports, previously alluded to, treat of the Salt range only; and a small memoir on the Geology of Sir Ban Mountain, near Abbottabad (*Mem. Geological Surv. Ind.* vol. viii.) deals chiefly with the local geology of that mountain. Some official correspond-

* The comparison has not been as yet fully worked out; but enough of evidence has been collected to warrant this statement, the palæontological differences noticed having been confirmed by Dr. W. Waagen's inspection of the rocks, in company with the writer.

ence with the local government, and a Report by Mr. H. B. Medlicott, in 1859, on the subject of coal said to exist in the Murree hills, have been printed; and there are other scattered geological allusions to portions of the district; but in none of these, so far as the writer is aware, are the structural relations between the different rock-groups discussed at length or with any accuracy of detail*.

The nearest places to the Upper Punjâb which have been systematically explored by officers of the Geological Survey of India, are, first, the Himalayan regions for many miles north-west and south-west of Simla, lying between the rivers Ganges and Ravee (which may be called the Simla area), examined and ably reported upon by Mr. H. B. Medlicott (Mem. Geol. Surv. Ind. vol. iii. pt. 2); and, secondly, a region situated further in the interior of the N.W. Himalaya, explored by Dr. Stoliczka† (see Mem. Geol. Surv. Ind. vols. iii. & v.).

These two regions, however, are separated by a wide gap, including the whole of the valley of Kashmere, from the Upper Punjâb, which the researches of Mr. Drew (for some years geologically employed by the Kashmere government) would doubtless, if published, go far to fill up in a satisfactory manner. Something is already known of this intervening country from the papers of Major Godwin-Austen and others published by the Geological Society, from Dr. Verchere's paper already mentioned, and a few other sources, but not sufficient to enable the formations and groups on each side to be connected across so great an interval, though intermediate links undoubtedly exist.

6. In order to present a concise view of the rocks entering into the structure of the Upper Punjâb and N.W. Himalaya, so far as yet definitely ascertained, the local series of the former are placed, in the table opposite, side by side with the classifications of Mr. Medlicott and Dr. Stoliczka, as given in the memoirs referred to.

This table will show that in the outer Himalaya of the Upper Punjâb, as well as in the Salt range, several geological formations are represented. Five of these likewise occur in Dr. Stoliczka's classification of the Western Central Himalayan sections; but in the Simla area, from want of palæontological evidence, while there are eleven groups distinguished, the Eocene and Miocene formations only are identified. There is a suggestion doubtfully put forward by Mr. Medlicott, partly on the authority of the MM. Schlagintweit, that the Krol rocks may be Nummulitic, though his observations tended to negative this; and it has been also thought not unlikely that they may be Triassic; but of the ages of the groups below nothing is known.

Major Godwin-Austen, Messrs. Davidson, Etheridge, S. P. Woodward, Dr. Verchere, and M. de Verneuil have shown that Carboniferous Limestone occurs in Kashmere, and, according to Drs. Ver-

* Since the above was written, a short paper by the writer on the geology of this region has appeared in the Records Geol. Surv. Ind. vol. vi. part 3, p. 59.

† Dr. Stoliczka's deputation with the present expedition to Yarkand, will, it is expected, much extend his former valuable researches, with which his new observations will form an interesting and connected series.

	SALT RANGE, UPPER PUNJÂB.	OUTER HIMALAYA, UPPER PUNJÂB. Mount Sir-ban * &c.	OUTER HIMALAYA, SIMLA COUNTRY. Ganges to Ravee. (Medlicott.)	N.W. CENTRAL HIMALAYA, SUTLEJ TO UPPER INDUS. (Stoliczka.)
Post-Tertiary	Kunjure post-tertiary or drift. —— Unconformity ——	Kunjure post-tertiary or drift. —— Unconformity ——	Indo-Gangetic-plains deposits. <i>Sub-Himalayan Series.</i>	
Miocene.....	Tertiary sandstone-and-clay zone, viz.:— Conglomerate sandstone and clays: bones &c. &c. Soft grey sandstones and red clays	Tertiary sandstone-and-clay zone, viz.:— Conglomerates and clays and sandstone: bones Soft grey sandstones and red clays: bones and obscure plants.	Tertiary sandstone-and-clay zone, viz.:— Sivalik conglomerates, sandstones, clays: bones. —— Unconformity —— Nahun lignite sandstones and clays.	Mammaliferous deposits of Tibet.
Eocene	Thick red clays and grey sandstone. Greenish sandstone: crocodilian remains and fossil wood. Nummulitic limestone. (That of the hills absent in the Salt range?) ...	Gray and purple sandstone and purple clays: bones and obscure plants. (Murree beds.) Variegated and gypseous clays and limestone: fossils, as bones and Nummulites &c. —— Abnormal junction or fault —— Nummulitic limestone and shale of hills.	Subathu { Kasauli grey and purple sandstones. Dughai purple sandstones and red clays. Subathu fine silty clays with limestones. (Nummulites.) —— Unconformity —— <i>Himalayan Series.</i> Krol Limestone. Nummulitic † ?	
Cretaceous.....	Olive sandstone: few fossils.	Thin-bedded limestone; no fossils known. Impure ferruginous limestone: fossils	{ Infra Krol. Carbonaceous shale or slates, age unknown. Blini. Limestone and conglomerate, age unknown.	{ Chikkim shale. Chikkim limestone. } Cretaceous.
Jurassic.....	Sandstone, limestone, and shale (fossils).	Limestone (fossils) and Spiti shale (fossils). Unconformity		{ Gieumal series. Spiti shale. } Jurassic.
Triassic	Green shales, limestones, &c. (fossils), and red sandstones and shale. Salt pseudomorphs.	Thin-bedded limestone and slaty shale: fossils. Dolomite and <i>Megalodon</i> -limestone.		{ Tagling limestone. Para limestone. } Triassic.
Infra-Triassic		Siliceous dolomite over red sandstone and shale. Unconformity		Liling series ?
Carboniferous ...	Limestones, dolomite, &c.: fossils.	(As yet undiscovered.)		Kuling series ? } Carboniferous.
Silurian ?	Upper sandstone, age unknown. <i>Obolus</i> - or <i>Siphonotreta</i> -zone, dark shale. Lower or purple sandstone. Red gypseous marl and rock salt, precise age unknown.	Dark Attock slates &c.; no fossils known.	{ Infra Blini. Slates, age unknown.	{ Muth series ? Babeh series ? } Silurian.
Metamorphic		Metamorphic.	Metamorphic.	
Crystalline		Syenite and Trap.	Crystalline and subcrystalline, &c.	

* Pronounced Seer-bun.

† Doubtfully referred by Mr. Medlicott to this age.

NOTE.—It appears from a paper by Mr. Medlicott (Records Geol. Surv. vol. vi. part 3, p. 52), that the Sivalik rocks may be either Older Pliocene or Upper Miocene.

chere and Stoliczka, very possibly Triassic rocks also. In this territory, too, the presence of the granitoid and schistose rocks of Hazára in the Upper Punjáb has been ascertained, and likewise that of the outer Tertiary belt of sandstones, clays, &c., while the Krol limestone has been conjecturally identified in the feudatory state of Poonch, to the south-west of the Kashmere valley, by Mr. Medlicott.

7. There can be scarcely a doubt that several of Mr. Medlicott's divisions of his sub-Himalayan series are present in the Upper Punjáb; indeed we have the advantage of his personal identification of some of them in this district, and also, among the next older rocks, his provisional recognition of the Krol limestone near Murree. To attempt a further comparison of the lower rocks of the Upper Punjáb with those of the Simla area, until organic remains have been found, would be little better than guess-work; they have therefore been bracketed in the table; but the Infra-Blini rocks seem, from description, to resemble those we have called the Attock slates. If this could be established, resemblances might also be found among the Metamorphic and Crystalline groups.

With respect to the part of the series older than Tertiary, it appears strange that the more central Himalayan regions traversed by Dr. Stoliczka should present a closer analogy to the outer Himalaya of the district under notice than the Simla area does; but from the table given it will be seen that such is the case.

8. The physical conditions of the Upper-Punjáb rocks, both in the Salt range and in the outer Himalayan hills, include contortion and faulting; but the disturbance, in part at least, of the Salt range has been much less than in the latter hills, and differs somewhat in kind. For instance, in the Salt range most of the complexities are produced by extensive land-slippage of ground previously more or less the scene of disturbance, while in "the hills" intense contortion, inversion, and faulting have taken place. A feature common to both localities is the prevalence of dips towards the more elevated masses of the Himalaya and Hindoo Koosh Mountains*.

The intervening Tertiary sandstone, clay, and conglomerate zone, where the ground has a plain or plateau form, frequently presents nearly as much contorted disturbance as either the Salt range or the outer Himalayan hills.

In this Upper Punjáb country too, the normal Himalayan strike of the rocks and ranges alters abruptly in the Jhilm valley (as noticed by Mr. Medlicott) from a bearing of E. 35° S. to N.E. and S.W., marking a change in the direction of the disturbing forces. North-easterly, or more east and westerly, lines of strike prevail elsewhere over the district, except towards Kohat and the Bunnoo

* During a recent visit to Kashmere this dip towards instead of from the great mountain-axes of the Himalaya, so common on the outer flanks, was found to occur also in the chain running along the N.E. side of the valley, where the glens of the Sind and Siddur and other rivers cross the strike, exhibiting strong dips to the north-eastward, and some fine escarpments of Carboniferous Limestone, slate, and other rocks presented the opposite way. Local curves over axes parallel to the range also occur.

frontier, where the westerly run of the rocky ridges is, so to speak, crushed against that of the stronger nearly north and south-run of the Suliman range.

The hills forming the outworks of the Himalaya in this district, may be said roughly to vary from below 5000 to over 9000 feet above sea-level, the higher elevations of 14,000 and 15,000 feet belonging to lofty chains forming integral portions of the above mountain-system. The most lofty peak, perhaps, in view from the higher hills between Murree and Abbottabad is that of Nanga Pârbat (Nunga Parbut), 26,000 and odd feet, situated near Astor, north of the Kashmere valley. The Salt-range elevations reach from 2000 to 5000 feet above sea-level; and the intervening plateau to the north may be taken at 1700 feet, the altitude of Rawul Pindi Station.

9. One peculiarity to be mentioned before passing on is, that a decided difference exists between the physical geology of the outer Himalayan regions and that of the Salt range, akin to the difference between the Alpine and extra-Alpine characters of European rock-groups*. Taking the *Obolus*- (or *Siphonotreta*-) zone of the Salt range and the Attock slates of the Himalayan hills to be both Silurian†, they are marked by characters petrographically entirely distinct, and from the Silurian upwards to the Miocene there is no formation common to both localities which does not present in each strong dissimilarity both in lithological aspect and in the assemblage of contained organic remains, though the latter prove the rocks to be Triassic, Jurassic, Cretaceous, or Eocene, as the case may be, with the same certainty in one locality as in the other.

There appears, then, to be a parallel between the Alpine and extra-Alpine and the Himalayan and extra-Himalayan features of these two distant regions; but the diversity of character in this district has been contended for no further in the ascending series than above the Eocene, because the Miocene forms a part of the great Tertiary sandstone, conglomerate and clay belt, which is in contact on different sides with both Himalayan and extra-Himalayan rocks‡. Even in the Miocene formation, however, some

* The verification of this is due to the Palæontological officers of the Geological Survey of India.

† The reasons for provisionally assuming the Attock slates to be of Silurian age are their similarity of position to those of Dr. Stoliczka's Himalayan sections, and the recorded fact of Dr. Falconer and Major Vicary having discovered the existence of Silurian fossils in the mountains drained by the Cabul river (Quart. Journ. Geol. Soc. vol. vii. p. 38), mountains which may be fairly supposed to be formed by an extension of the slates known to project westward into the Peshawur valley beyond Attock.

‡ Pending the possible discovery of Carboniferous rocks in the outer Himalaya of the Upper Punjab, it may be as well to state that among the Kashmere Carboniferous fossils occurring within the *Himalayan region*, species probably identical with those of the Salt range have been determined; but it remains to be seen whether the whole Carboniferous fauna of one locality is or is not identical with that of the other. The rocks are certainly different: limestones occur in both; but the dark slaty fossiliferous Carboniferous rocks of the Siddur valley in Cashmere have no similarity to any of the Salt-range Carboniferous beds with which the writer is acquainted.

dissimilarity may be traced, inasmuch as the sandstones and clays which rest with apparent entire conformity upon the Nummulitic limestones of the Salt range, differ in character from those beds of the outer Tertiary belt which are brought into violently discordant junction with the hill-limestones of the outer Himalaya*.

The recurrence of these mountain and extra-mountain features, so to speak, at such great distances may indicate a connexion between the former conditions of deposition and the early history of the great chains themselves; at least causes which would affect the distribution of land and water appear most competent to have originated the diversity†.

10. In the table given at p. 63 an effort has been made to correlate the newer Tertiary series of this part of the Punjab with the succession in the Simla area, as gathered from Mr. Medlicott's description; but it may be as well to give a slightly more comprehensive account of these Upper-Punjab newer Tertiary beds, for the sake of comparison with the series recorded by that gentleman (see Report previously cited).

From the sections exposed in the river Indus, and numerous observations over the Pot'war or Sind Saugor Doab (which has been called also the Rawul Pindi plateau), it appears that the only natural base of these rocks of any extent to be met with is along their upturned edge flanking the northern slopes of and rising on to the Salt range. Here, notwithstanding the perfect parallelism of the sandstone and clay beds to the strong underlying Nummulitic limestone, the absence of subjacent erosion of the latter, and the great length of the apparent conformable contact, there is reason to suspect that the conformity may be but local and not general, or else that the Salt-range Nummulitic limestone is not a strictly synchronous extension of the Nummulitic limestone to be found in other parts of the district.

A. The bottom rocks of this region are soft or harder grey or greenish sandstones, in places slightly calcareous, alternating with red, or sometimes dull grey or greenish olive clays. The contained fossils are blocks of petrified timber, crocodilian and chelonian bones and plates, with rarely (derived, or perhaps sometimes contemporaneous?) Nummulites in the lower part.

B. Where the Nummulitic limestone has thinned out, these beds rest on some of the older groups of supposed Cretaceous or Triassic age, and they are overlain by a strongly marked zone (B) of red

* The rocks of this belt have been stated to possess more or less affinity with those of the Simla area; but they differ *en masse* and in detail from the large Tertiary deposits newer than Eocene (Nummulitic) of the distant province of Kutch. It remains to be seen whether and where a transition between the two types may be found, one of these types belonging to the Himalaya region, the other more nearly associated with the southern extension of the Suliman chain, two great mountain-ranges which inosculate near the frontier of the Punjab, where the whole of the Tertiary rocks resemble in character those of the Salt range and outer Himalaya.

† It is perhaps hardly necessary to note that the features referred to in this section as bearing relation to the mountain-ranges include, in consequence of this relation, more than the common mutability of formations.

clays containing harder slightly calcareous layers interstratified with grey sandstones. The upper and lower boundaries of this group are quite indefinite; and the only fossils found in it besides obscure plant-markings are small fragments of bones. So far as position goes, this zone seems to correspond more or less with another to be presently noticed under the letter E.

C. The upper part of the red band just mentioned passes gradually into a great thickness of soft pulverulent grey or light bluish sandstones, alternating with red clays and occasional bands of light-coloured slightly ferruginous conglomerate, which sometimes contain bones, and pebbles of Nummulitic limestone enclosing small Nummulites. The strong light-coloured sandstones have here and there thin layers of lignite, the carbonized remains of fossil plants or trees; and the zone has been called the "red and grey group."

D. Above these red and grey beds the sandstones continue of much the same character; but the alternating clays are frequently of an orange-drab or pink colour, and towards the top the series gradually passes into a thick set of incoherent boulder- and pebble-beds, sometimes cemented so as to form conglomerates, the pebbles of which are a most heterogeneous assemblage derived from the crystalline, igneous, and limestone rocks of the Himalaya. In the sandy beds associated with this conglomerate portion of the group fossil bones also occur; and from the waste of the softer strata the gold of the Pot'war country is apparently obtained.

Throughout the whole of the foregoing and among the rocks next to be mentioned are numerous beds of a fine pseudo-conglomeratic aspect, composed of a sandy calcareous matrix charged with small clay concretions and sometimes ferruginous nodules. These beds not unfrequently contain fragments of bones.

E. So far the succession has been traced from the Salt-range bottom beds upwards; but on coming to the northern side of the Tertiary sandstone, clay, and conglomerate belt, we find a change in the formation. Here the series may be followed downwards from the group D through C; but in the place of the red zone B is a very great thickness of purple and grey and purplish-grey or blue sandstones, of much harder nature than any of those previously described, with polished metallic-looking films, as of iron or manganese, on joint-surfaces, alternating with purple or reddish clays not unfrequently having a nodular structure. The sandstones are often veined with carbonate of lime and penetrated by obscure plant-impressions; and more rarely they enclose imperfect bone-fragments.

Along the southern edge of this band its beds pass without any abrupt or marked change into the "red and grey series" C; but on the northern side, at the base of the limestone hills (or where all is hilly ground, then contiguous to the hill-limestones), there are many alternations of purple and red beds, with grey and yellow muddy calcareous strata, associated with dark olive, blackish purple, or greenish-grey shaly and sandstone bands, in the vicinity of which a zone of very red clay, including layers, veins, and masses

of white and reddish gypsum, may be frequently observed. The light-yellow earthy calcareous beds are crowded with Nummulites and large *Rotalina*, *Ostrea* and other Bivalves, with a few Gasteropods, while more solid limestone, of a lavender-grey colour, found nearer to the gypsum, contains a few thin-shelled Gasteropoda resembling some species of *Planorbis*, but no Nummulites that could be observed. Near these latter bands, and generally not far removed from the gypseous zone, the beds (most frequently those which are calcareous or limestone), are in places impregnated with petroleum, affording a scanty supply, for some time utilized in lighting part of the station of Rawul Pindi with gas.

11. These varied strata along the inner or mountain margin of the zone E, are subject to some amount of change both as to quantity and composition. At certain localities the dark olive-coloured beds are more largely developed, containing some whitish quartzose gravelly bands; in some parts bright purple clays, in places highly ferruginous, predominate, associated with massive dark bituminous limestones enclosing very small Foraminifera, and closely resembling in character the Nummulitic "Hill-limestones." At other localities the ordinary purple beds have interstratified with them but a few limestone layers, or sandstone, or marly bands, containing, as usual, quantities of Nummulites, *Rotalina*, *Orbitolites*?, and some fragmentary bones, while in yet other places the dark olive and greenish beds are locally absent. The layers just described form the oldest portion of the outer Himalayan Tertiary sandstone and clay zone along its junction with the "Hill-limestones," though to an observer approaching the foot of the hills the almost constant inversion of the strata would make them appear newer than the main mass of the subdivision E, which has been provisionally called the "Murree beds" from its prevalence at the hill station of that name.

This group E, from many of its characters, appears closely to correspond with Mr. Medlicott's Nahun group; but the lower portion would seem to present most of the features of his Subathu division (Mem. Geol. Surv. Ind. vol. iii. pt. 2, pp. 11, 12, &c.)*.

12. The whole of the Outer Himalayan Tertiary sandstone and clay belt, from the limestone hills on the north to the Salt range in a southerly direction, has presented, so far as yet known, no single instance of a clear unconformity or overlap within its limits, while its entire aspect, notwithstanding much contortion, is that of parallel sequence throughout. No erosion of any of its beds prior to the deposition of others upon them has been observed; and yet it must be remembered that some of the layers, and these on different horizons, contain rolled pebbles of fossiliferous Nummulitic limestone, proving breaks to have occurred subsequently to the deposition of this rock. It cannot be asserted with accuracy whence these

* The description of the Nahun group in this Report would answer in a general way for all the Tertiary sandstones &c. below the conglomerates of our group D; and these conglomerates would answer well to the Sivalik beds, with which some of them have been identified by Theobald and Falconer (Journ. Asiatic Soc. Beng. 1854, p. 651).

rolled pebbles were derived; but other fragments associated with them appear to have come from a northerly direction rather than from the Salt range, where apparent conformity has been stated to exist*.

13. This state of things seems widely different from that of the Simla area, where Mr. Medlicott, who speaks of the Murree rocks as Subathu, and the beds next succeeding the Salt-range Nummulitic as Sivalik (Memoir previously referred to), has found two strong unconformities or overlaps—namely, between his Sivalik and Nahun, and between his Nahun and Subathu groups; further, Mr. Medlicott has found the whole of the outer Tertiary detrital zone of the Simla area from the base of his Subathu group upwards discordant to the Himalayan and Hill series, and discordant to each other, all three of his divisions transgressively reaching and resting upon the older rocks.

Referring to the Report of the Simla area, it appears impossible to disagree with the author's conclusions as to the relations of the newer rocks in that country. Here, however, the structural features differ from those he describes, and the breaks may not have existed to the same extent; but this supposition interferes with the connexion he would establish between their existence and the mode of elevation of the Himalaya—unless a difference may have existed also in the kind of formative agency which produced the Himalayan extension towards the Upper Punjāb.

14. The junction of these newer Tertiary rocks with those forming the higher of the Outer Himalayan hills, both in the Simla area and in the Upper Punjāb, is one apparently marked by much the same features of disturbance, distortion, and inversion, or abnormal superposition in the Tertiary strata along the contact (characters also known to prevail in the Alps, see Medlicott's "The Alps and the Himalayas," *Quart. Journ. Geol. Soc.* vol. xxiv. p. 34 &c.), the chief resemblance being that in both regions a disturbed and abnormal junction of these Tertiaries with the hill rocks occupies the same geographical and orographical position among the outer hills or at their foot, and the chief difference lying in the fact that in the Upper Punjāb there is but one prominent zone of such abnormal junction (that coincident with the boundary between the Hill-limestones and the outer Tertiary belt), while in the Simla area this feature is said to be repeated at least three times (Report cited).

In the district under notice this junction follows a line describing an arc of a circle having a radius of 60 miles, and its centre some 72 miles N. 20° W. from Rawul Pindi, the western continuation of the line passing with less curvature just north of the station of Kohat, whence it enters the Affreedi and other Afghan hills. (See

* Mr. Medlicott states that the sandstones and clays of the upper sub-Himalayan groups [*i. e.* Sivalik?] rest upon a denuded surface of the Nummulitic limestone of the Salt range (Memoir quoted, p. 91). Nothing of the kind has been observed from end to end of the Salt range by the writer, but the contrary, as above stated. This, however, is no reason for assuming a foregone conclusion on the part of Mr. Medlicott, based upon his observations in the Simla area.

Map, Pl. VII.) Its eastern extension, from the point where the arc touches the Jhilam river, turns abruptly northwards along the right bank of that stream, then, crossing the sharp angle formed by this river near Mozufferabad, bends to the south-westward, lying generally high up on the flanks of the Kyjnâg range in Kashmere. At the village of Oori in this territory it crosses the Jhilam (here called the Vedusta) with a bearing which would take the line along the outer flanks of the Peer Punjal chain.

The rocks of the outer Tertiary belt in the Upper Punjab, and as far as they have been seen in Kashmere, which are in contact with the limestones and other rocks of the hills, unlike those of the Simla area, belong to one subdivision only, namely the Murree beds (E), *i. e.* Subathu or Nahun, as the case may be. On the inner or "Hill" side of the line, however, different groups of the hill-rocks come into contact with these Murree beds. Strong Nummulitic limestone (a portion of which was conjecturally identified with the Krol limestone of the Simla area by Mr. Medlicott, *l. c.* pp. 91, 92) occurs commonly in this position; but sometimes the rocks in junction are of Cretaceous or Jurassic age, as shown by the Ammonites, Belemnites, and *Trigonia* which they contain, while in the Kashmere territory, if any dependence is to be placed on a somewhat distant view, the Murree beds are sometimes in junction with metamorphic or semimetamorphic slates, with crystalline rocks and with hardened and altered-looking limestones, in which, what appeared to be the distorted forms of small *Rotalina* drawn by cleavage were recognized, giving ground for the conjecture that near Oori, where the observation was made, some representative of the Hill Nummulitic beds was present*.

15. The local relations of the contact † are tolerably uniform in their discordance, the hill-rocks being crushed into most complicated folds, while the Murree beds are either less contorted or vertical or inclined, frequently underlying *towards*, seldom *away* from the hills, and then only at high angles. How closely similar these features of the contact may be to those of the Simla area it is not easy to assert without having inspected both; but from the descriptions given they seem to have a general resemblance; Mr. Medlicott's study of the circumstances led to the belief that the junction with the hill-rocks marks a limit of deposition of the Tertiary beds from the base of the Subathu upwards, these having been deposited on a denuded surface of the hill-rocks, and the whole subsequently reduced by disturbance (of both simultaneously) to their present complex condition. In the Upper Punjab country, evidence of any denudation of the Hill-limestones preceding the deposition of the Murree beds (considered as equivalents of the Simla-area Subathu

* Here, as usual, inversion appeared to be the rule, these limestone rocks overlying bright red and green clays and purple sandstones, clays, &c. of the Murree type.

† It should be stated that actual contact is seldom seen along this line of junction, though the rocks *in situ* on different sides frequently approach each other very closely.

or Nahun) has never been detected; and the features which expose Jurassic or other rocks beneath the Eocene limestones and shales of the hills at the line of contact, are those produced by the same action of denudation which has affected the Murree beds themselves. Nor is the line of contact in the Upper Punjab strictly a limit of deposition confining the appearance of either the hill-rocks on one side or

Fig. 1.—Section across the Chita range at Lumbidund, near the Indus.
(Length about 6 miles; hills 1500–2000 feet.)

Fig. 2.—Generalized Section at Shahka-Noorpoor, N.E. by E. from Rawul Pindi.
(Length about 3 miles; highest hills 4000 feet.)

the Murree beds on the other. For instance, a mass of grey slaty shales with associated red rocks, both containing Nummulites and possessing the aspect of the Subathu portion of the Murree group, occurs in the hills crossed from the Peshawur valley southwards by the Meer-Kulan Pass, and lying far to the north of the abnormal contact-line situated under the southern foot of Nilab Gash moun-

tain, on the Indus below Attock. Red and variegated gypseous rocks resembling those in the Murree group previously mentioned, occur far down in the ravine of the Haro river near its source, and at Doongagully on the new mountain-road from Murree to Abbottabad, while the possibility of the extension of the hill type of Nummulitic limestone southwards beneath the Pot'war country is supported by its reappearance at the hill of Kháiree Moorut, ten miles south of the junction-line referred to, and west by south from Rawul Pindi.

Although the line of junction presents ordinarily the appearance of a single line of contact (often concealed owing to its position at the foot of hills), this is not a constant condition; for it is accompanied in places by somewhat parallel lines of the same kind situated within very short distances, and traceable into close convergence, if not into absolute unity, with the main one (see section, fig. 3). It also throws off a branch north of Rawul Pindi, having all the characters by which it is itself distinguished, and bringing the same sort of Lower Murree rocks into junction with the Hill-limestones. This branch, diverging at an acute angle from the north side of the line, passes westward along the outer foot of the ridge behind which are the ruins of the ancient Taxila at Shah-ka-deri.

The whole aspect of the contact along this line presents none of the features or irregular outlines which might be expected to result from unconformity, overlap, or limit of deposition; and, further, it might be urged that nowhere along the junction are the newer rocks on one side of the line or its branches made up of any recognizable detritus of the older beds on the other side; nor, indeed, are any prominent coarse detrital deposits, such as might indicate an adjacent shore, to be found in the lower strata of the Murree group, a few minor beds of coarse sandstone at one part of the junction only (in section, fig. 3, *b*¹) having been met with along the whole region of contact from Oori to Kohat, a distance of fully 200 miles. Nor does it appear that the basal beds of the known Tertiary deposits in the Simla area along their inner (and even more extended) boundary, differ in these respects from the junction beds of the Tertiary belt with the "Hill-rocks" in this region.

The contact here, on the contrary, presents straight or but slightly curved lines, like those of fractured dislocation, without sinuosities resembling deep bays, creeks, or promontories; nor are there visible signs of islands lying off the supposed ancient coast, the detached elongated hill of Kháiree Moorut being apparently enclosed between lines of fault.

In a case of ordinary unconformity or overlap subjected to denudation, discordant patches of the Murree beds might be expected to occur resting on the older rocks; but these have not been met with, any detached portions which have been found being apparently let in among the older rocks by faults, rather than folded into contortions.

16. Under all these circumstances it is difficult to recognize in this and the Simla region the same relations among formations or groups, several of which may be fairly considered identical and in

the same orographical position. Even in the Simla area a fault-like character is attributed to the abnormal junction; and had we here the transgressive overlap of different portions of the Tertiary series on to the hill-rocks, it might be easier to assimilate the features of the two areas and to admit for this district Mr. Medlicott's view that the junction-line is not one of fault but of unconformity.

Fig. 3.—Section crossing *Shah-durrah Valley*, N.N.E. from *Rawul Pindi*. (Length about 5 miles; highest point about 5000 feet.)

Fig. 4.—Section at *Chuttur Serai*, N.E. from *Rawul Pindi*. (Length about 3 miles; highest point about 5000 feet.)

Placing the more northern contact-lines as indicated in the foregoing observations, and those of the Simla area also, upon a map of small scale, they seem, thus reduced, to possess considerable irregularity, favouring the idea of unconformity, as in the case of the deep *sinus* coinciding with the bend of the Jhilam at Mozufferabad; but

it should be remembered that the depth of this bay is twenty miles on its shortest side, lying within British territory, on the right bank of the Jhilam, that this side is there nearly a straight line, and as strongly resembles a fault separating highly contorted rocks as any other portion of the contact. Examined in the same way, other parts of the junction lose much of their apparent sinuosity.

17. The sudden change in the direction of the ranges and strike of the rocks in the Jhilam valley has been already mentioned; and in this connexion it is somewhat singular to mark that on the further side of that river from our district, in the tributary valley of the Poonch (Kashmere), occurs the nearest instance of the unconformity contended for by Mr. Medicott, at a place called Dundelee. The strike of the rocks (E. 35° S.) belongs to the same system as that of the Himalaya east of the Jhilam valley; and the section as given in Mr. Medicott's report is extracted (fig. 5) for comparison with those

Fig. 5.—Section at Dundelee, Poonch Valley.
(From 'Mem. Geol. Surv. India,' vol. iii. pl. 2, p. 96.)

c^1 . Krol group. c^2 . Infra-Krol. d . Subathu group.

within our district (figs. 2, 3, and 4) and lying about 45 miles to the west-north-west.

The "hard blue limestone," c^1 , in this section, taken by Mr. Medicott to represent his Krol subdivision, if it is the same as that of Mochipoora Mountain (as may be gathered from a footnote at p. 92 of the Report), is most probably Nummulitic, or might also include some of the Triassic limestones of that range; at any rate it would appear to belong to the Hill-limestone rocks. c^2 is said to be composed of "thin carbonaceous slaty shales," which, if they are the same as those of Shah-durrah, mentioned in the succeeding passage, probably belong to the zone marked d^3 in the section fig. 5; indeed this might be inferred from the parallelism to the latter which Mr. Medicott mentions. d^2 , red sandstone and clays, and d^3 , nummulitic clays (and limestones?), are evidently the same as those of the Murree beds previously described under letter E. If the slaty shales c^2 pass conformably below the limestone c^1 , they probably represent some of the many hard splintery shaly beds of the Mochipoora nummulitic rocks.

Of course, without having seen the Dundelee section, these remarks upon it are given with reserve; still it is much nearer to our district than to the Simla area, and this must be the excuse for an attempt to interpret it according to Upper-Punjab experience.

Independently of the question whether the beds c^2 in this section belong to the central ridge or to the flanking rocks, those marked d^2 and d^3 (the description of which so exactly coincides with the Murree group) still appear unconformable to c^2 , the central limestone; and yet there is only wanting an apparently very probable line of fault on each side to make this section resemble a modification of the same kind of feature as is represented in our Shah-durrah and Chuttur sections (figs. 3 and 4), where the discordance has no similarity to unconformity.

It may also be instructive to compare this Dundee section with another in the Pot'war district, some 60 miles to the S.W., taken N.W. and S.E. across Diljubba Mountain, part of a chain of hills which runs from the Salt range almost directly towards Dundee, but vanishes before reaching the Jhilam river. The strike of the beds is parallel to that of the ridge; and the section is given from memory.

Fig. 6.—Section across Diljubba Mountain.

1. Salt-range series, including Cretaceous?, Triassic, Silurian, and Salt marl &c.
2. Nummulitic Limestone. 3. Grey Sandstones, Red Clays, &c. A (bones).
4. Red zone B. 5. Fault.

The Nummulitic limestone in this section has not its full development; but it shows well the parallelism between this and the succeeding strata. The fault shown is the probable extension of a long fracture, most strikingly seen further to the west; and no sign of unconformity appears in the section.

Whether the movements connected with the origin of the Himalaya (as out-thrust produced by settlement, &c.), to some of which Mr. Medlicott ascribes the succession of abnormal junctions of the outer Tertiary zones, may have differed in kind, intensity, or in number as well as in direction here, is as yet mere matter of speculation; but it is at least possible that in the neighbourhood of this region the greater variety in the bearings of the vast mountain masses may be accompanied by greater complexity in their structure.

18. The only attempt to explain the structure of the Tertiary belt in this Upper Punjab region with which the writer is acquainted is that given in Dr. Verchere's paper before the Asiatic Society, where a diagrammatic section occurs at p. 104.

In this the contorted lower Miocene (Murree) beds are made to thin out towards the south, where they are overlapped by the Sivalik or upper rocks, these also thinning out towards the bulk of the Murree series, which latter is shown to rest unconformably upon porphyry, felstone, &c. In support of this section there seems to be nothing to advance. No trace has been found of the overlap of the two series as shown; and the rocks against which the lower group rests are not porphyry and felstone, but limestone and shale. This is the case from Murree westward to Kohat; and even at Oori, in Kashmere, the Murree group was found in junction with limestones, as already mentioned, and the latter with metamorphosed schistose rocks; nor could the representation of the locality given in another of the same author's sections be recognized.

19. The general features of the outer Tertiary junction with the hill-rocks will have been gathered from the foregoing remarks; but the difficulty remains of asserting the non-existence of unconformity along a complex boundary, only because nothing of the kind can be observed. On the other hand it is equally difficult to rest satisfied from the evidence obtainable that the discordant junction marks a limit of unconformable deposition. Reverting to the sections of this district appended, there is nothing in them contrary to the existence of faulting; the crucial-test section of Mr. Medicott near the Markunda river has no parallel among our observations; and though the unconformity which it exhibits (Report cited, p. 108) be unquestionable, there seems to be room left to doubt its applicability beyond the boundary line on which it occurs, which is also that of the newest subdivision beneath the alluvium as well as of the coarsest beds, most palpably formed from detritus of the neighbouring rocks, among the three groups of the Simla Tertiary series.

Nor does it appear reasonable to suppose that the basal contact of these outer Himalayan Tertiary beds must have everywhere occurred along a denuded cliff-line, which is a part of the supposition advanced for the Simla area. If so, the continuous-cliff-line conditions would in all probability have to be extended from the Simla area to the Punjab, a distance of some 600 miles, or, for all we can tell, even to the whole Indian frontage of the Himalaya range, or from this to the Alps. It may fairly be asked, does any coast-line, ancient or modern, present an unbroken cliff-line of this length, or one so little marked by indentations?

The circumstance that the line of abnormal contact is also a geological boundary limiting the *main* development of this part of the Tertiary formation, at first sight greatly favours the idea of unconformity. Supposing the Upper-Punjab contact, however, to have been caused by displacement, there is nothing in this demanding that the newer beds should continue persistently far beyond their present general limits, or if they did even to a greater extent than is known, the denudation of this country would have been amply sufficient to have removed them from all prominent positions*. In

* Notwithstanding this, the writer's impression must be stated that these beds of the Tertiary formation had no widely extended range over the Outer Hima-

the hilly and contorted limestone-and-slate country lying just northward of the line of contact, there are two distinct unconformities (see table) observable without difficulty, notwithstanding local contortion and faulting; and this being the case, it is not easy to conceive why unconformity should be invisible along the sharply defined contact of the hill-limestones with the outer Tertiary zone.

20. Having thus failed to find in this line of contact proof of either conformity or unconformity of the adjacent rocks, it only remains to glance at the general structure of the country, in order to see if there are any points observable likely to aid in arriving at a fairly satisfactory explanation of the facts.

A feature common to the structure of the whole of the Upper Punjâb is prevalence of lateral changes in the series of which it is formed. Thus the great Nummulitic deposits of the Salt range die out to the east, as do also the Carboniferous, the fossiliferous portion of the Trias, and some other groups of that region; while others, again, disappear westward; so that each end of the range presents an almost entirely different section. In the hills to the north also the Cretaceous rocks have a local development, the Trias of different regions differs, and the character of the Jurassic beds is inconstant.

These changes are not, as a rule, connected with perceptible unconformity, the northern Jurassic group being the "exception which proves the rule," but seem to have resulted from gradual thinning out of the beds, their original partial deposition in detached patches, or difference of the rock-forming materials.

The outer Tertiary belt presents a sort of gradation or transition towards the hill-character; for we find among the rocks of the Murree zone harder beds than elsewhere, limestones also occasionally appear, and some of these are dark in colour, as the hill-beds usually are, and contain in places the same kind of minute organisms, chiefly undetermined Foraminifera. The prevalent reddish or purple colour of the group changes too; and grey shaly bands appear of quite the same aspect as those of the hill-rocks, in the part of the series nearest to the latter. None of these shales nor any alternations of the beds with limestones characterize the basal portion of these newer Tertiary layers in the vicinity of the Salt range.

The Nummulitic limestones of the Salt range, with their large Bivalves and Gasteropoda, have the appearance of shallow-water origin, while the diminutive organisms of the hill-Nummulitic Limestone would seem to have inhabited greater depths.

Another common feature of the country is contortion of its strata, this disturbance having affected some of the very newest Tertiary beds, so as to place them in a vertical position, and having almost everywhere thrown the rocks into more or less complicated folds,

layan hill-country. Their great extent along the base of the Himalaya might favour the supposition that they stretched also in other directions; but in a country where we have hills 7000 ft. in altitude, entirely composed of these newer Tertiary rocks, considerable masses of them might be expected to occur in the lower and contorted limestone hilly ground north of the main boundary, if they had ever covered that region. Such masses are almost entirely absent.

which have in many cases been pushed over from the direction of the mountains so as to produce inversion of the strata. As instances of this, may be mentioned the complication near the mouth of the Chichalee pass, westward of Kalabagh (trans-Indus)*, the convolutions along the escarpment or slopes of the Affreedi hills overlooking Kohat, and the well-marked case on the hill road from Shaal-ditta to Khanpoor, northwards from Rawul Pindi, where the Jurassic series behind the outer ridge, with its characteristic band, one mass of a large *Trigonia* (like *T. ventricosa*, Krauss), almost horizontally overlies the Nummulitic limestone.

It must be admitted that, were these numerous foldings and contortions expanded and restored to their original horizontality, or any thing like it, the area occupied by the now contorted rocks would be much greater than it is at present.

21. All geological formations being subject to lateral variability, it would seem from the foregoing remarks that those of this district are no exceptions to the rule, if, indeed, the variability is not unusually pronounced throughout the local formations. Hence it does not seem improbable that the red Tertiary zone of the Salt range may correspond to the Murree group of the northern side of the Tertiary belt, so that, if we could eliminate the line of abnormal contact bounding the latter, we should have an ascending sequence from the Salt-range Nummulitic to the newest rocks of the formation on that side of the belt, and to the north another ascending sequence from the hill-Nummulitic Limestone, but one formed under different conditions of depth of water, contemporaneous with the former, yet only in a general way, neither succession being wholly without evidence of interruption, in the small rolled pebbles of fossiliferous Nummulitic limestone previously mentioned.

It is possible that the hill-Nummulitic Limestones alternated somewhat in their upper portion with the purple and grey Murree beds, in favour of which the similarity of certain of the basal limestones and shales to those of the hill-Nummulitic rocks, may be again noticed as indicating a slow change of condition, although the two groups are now separated by the most abrupt discordance, disturbance, and displacement. This change, too, may have taken place over a much wider area than that now occupied by the rocks, if the lateral expansion caused by restoring the contorted beds to their original horizontality be granted, thus enlarging the space within which thinning out might have occurred.

With regard to a separation from an early Tertiary period between the Salt range and northern hill-regions, this seems possible. The nature of the outer Tertiary belt suggests a shallow-water origin; and yet in the Murree beds alone a thickness (which no reason exists to doubt) of a mile and a half, or nearly 8000 feet, has been observed, while 10,000 or 15,000 feet does not appear at all too much for the whole series: but this means 2500 fathoms; and the impossibility of

* Noticed by Dr. Fleming, who gives a somewhat imperfect illustrative section across the inversion. See his report to Gov. of India, Journ. Asiat. Soc. Beng. 1853, pp. 266, 267.

MAP SHOWING
THE NEWER TERTIARY BOUNDARY
in
NORTH-WESTERN INDIA

associating such a depth with the idea of a shallow sea or lake constrains one to call in the aid of subsidence to account for the accumulation. Subsidence, however, can hardly be universal any more than elevation; so that an idea of limitation is suggested for the area receiving the deposits and consequent denudation round the border. The first clear evidence of this in the case before us dates from a considerable height in the post-Nummulitic series.

22. In conclusion it may be inferred from the foregoing observations that the physical relation between the outer Himalayan limestones, &c., and the adjacent great Tertiary belt are obscure in the Upper Punjâb, and that the local facts hardly warrant the close application of arguments used to explain some similar relations in the Simla area. Palpable unconformity has not been found along the region of contact, nor any positive evidence leading to the conviction that it exists.

Inversion of the lower strata of the outer Tertiary band is common close to the line of contact; but this is not surprising, the violent disturbance which has affected all the rocks having inverted some of the hill-limestones within a comparatively short distance of the junction. It would also appear that the Simla area possesses a structure more easily comprehended from the fact that the outer Tertiary zone has a definite Nummulitic (Subathu) base resting on rocks of uncertain age, while here Nummulitic rocks certainly occur on both sides of the same outer Tertiary abnormal boundary. This abnormal junction-line is evidently a feature inseparably connected with the causation of the great mountain-chains, preserving, as it does, a parallelism to the axes of the outer ranges; and whether it marks an invisible break in the series or not, the conviction is strongly impressed on the observer that it is chiefly due to intensity of disturbance amounting to fracture and dislocation, combined with more or less complicated inversion, the result of lateral pressure along a region which has suffered, and from the same cause, a similar thrust to that affecting the place known as the *spring* of any ordinary arch.

The detailed examination of the upper Punjâb has not been completed; and only the general facts bearing upon the peculiar junction-boundary of a large and important group of the local rocks have been considered, with the impression that it is only by collecting such facts and comparing them with others similarly obtained that the nature and value of obscure points in physical geology can be arrived at.

EXPLANATION OF PLATE VII.

Sketch Map showing the Newer Tertiary boundary in North-western India.

DISCUSSION.

Mr. DREW gave some further explanation of the author's views and of the geology of the district.

Prof. RAMSAY agreed with the author as to the analogy between

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the outer ridges of the Himalayas and those of the Alps, and also as to the difficulty in such cases of distinguishing between an inversion and a fault. From the different conditions as to metamorphism of the Miocene and Eocene rocks in the Alps, he had been led to question the fact of the inversion, and now found that most Swiss geologists had come round to the opinion that the present position of the beds was not due to mere inversion but to actual dislocation. He thought this might also prove to be the case in the Himalayas.