FIELD-NOTES FROM AFGHANISTÁN: (No. 3), TURKISTÁN.

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Introduction.

The geological reconnaissance which I carried out in the spring of this year was limited to the confines of Afghan-Turkistán and the district of Bamián, which embraces the area north of the Tirband-i-Turkistán with the mountainous country stretching north of the Koh-i-Baba to the Oxus valley.

Geographical features.

The broad geographical features of Afghan-Turkistán are very simple. There are two distinct areas: a mountainous tract which occupies the southern part, and wide-stretching low lands which skirt the hills northwards. The mountain area consists of a succession of parallel flexures of varying widths which strike west to east or nearly so; generally speaking the folds increase in absolute height and decrease in width as they approach the main water-parting of Afghanistán. Along a line roughly defined as running south of Maimana to Sar-i-Púl, south of Balkh and Mazar-i-Sharif and thence south of Tashkúrghán to Badakhshán, an unsymmetrical flexure terminates the hilly tract of Turkistán. This flexure presents a steep side towards the north, where it disappears below the tertiary and recent deposits which form the great Central Asian plains.

Principal ranges.

The principal ranges thus formed are: the Koh-i-Baba, one of the links in the chain of the great watershed of Afghanistán. Part of the Davendar and Doshakh ranges of the Herat valley may be western points in this same chain; but which of the great anticlinals between the Davendar and the Koh-i-Baba is to be looked upon as the connecting link, I am unable to say.

North of this main line minor ranges run more or less parallel with the watershed; of these is the Tirband-i-Turkistán with its eastern continuations. South of this range is a wide synclinal basin which belongs to the Murghab drainage. The structural prolongation of it may be found in a wide, undulating table-land, which occupies the space between the upper Balkh-ab (Rúd-i-Band-i-Amir) and the Kara Koh. I have not visited this area, but Captain the Hon'ble M. S. Talbot, R.E., describes it as a table-land, of which the eastern portion of the Kara Koh forms as it were a raised rim. The northern and north-eastern continuation of the Kara Koh forms a high chain against which a number of smaller ridges are ranged in parallel lines, both north and south of it. North of these auxiliary ranges extends a wide undulating synclinal basin with several areas of depressed table-lands; the northern termination of this basin is formed by the outer rim of the Turkistán highlands south of Mazar-i-Sharif.

Drainage.

The drainage of Afghan-Turkistán belongs to the Amú Dariá, or Oxus river, although only one of the streams of this part of Afghanistán actually reaches that river, namely, the Aksarai or Kunduz river, of which only a small branch of the upper portion belongs to Turkistán itself. All the other streams are either used up for irrigation purposes or lose themselves in the loess deposits of the Chúll, which forms the lowlands of Turkistán.

Principal rivers.

The Oxus rises in the Pamir and enters Afghan-Turkistán as a large river north-east of Tashkúrghán. Its valley varies greatly in width,—from about 30 miles near Tashkúrghán to over 80 miles near Akhcha and Kilif. It forms an extensive and in some parts very fertile alluvium, which presents some very interesting geological features.

The other rivers are: the Maimana river with its many tributaries, rising in the higher levels of the Tirband range; the Astar-ab and Sar-i-Pul system of drainage, which, flowing from the mountainous country of the eastern prolongation of the Tirband, loses itself in the plains of Shibirkhan and Akhcha; the Balkh-ab, known in its upper course as the Rúd-i-Band-i-Amir, comes from the Hazaraját and after a grand sweep from east to west, turns northwards and loses itself in the swamps west and north-west of Balkh; the Khulm or Tashkúrghán river, which rises north of the Kara Koh range and after a more or less northerly course is lost in the sandy wastes of the Oxus valley.

Only parts of the upper course of the Aksarai or Kunduz river are within the Turkistán and Cabul Hazaraját, north of the Koh-i-Baba; the Karmárd, Saighán and Bamián streams belong to its drainage.

River gorges.

One of the most notable features in the configuration of Afghan-Turkistán is the erosion, by the rivers, of deep gorges. I found that the inhabitants applied the word "dara" (valley) invariably only to defiles. Some of them are exceedingly narrow, like the Yakh-dara, between Deh-i-Faoz and Faúghan, south-east of Maimana, scarcely wide enough to admit an unladen mule being driven through without considerable difficulty. Many of these defiles surpass in picturesque grandeur anything I have seen elsewhere; as for instance the course of the Astar-ab below Faúghan, where the river flows in a narrow gorge, often not more than 30 yards wide and enclosed by vertical walls of limestone, some 1,500 feet sheer height above the stream bed. Most of the rivers flow from south to north and hence form transverse valleys through the ranges of Turkistán. They have eroded gorges where they cross anticlinals, and formed wider valleys with side-streams when on a synclinal.

Structural features.

System of flexures.

As already mentioned the Turkistán highlands consist of a succession of flexures more or less parallel to each other. Their structure is generally very simple and reveals the following facts: that (1) the lowest beds exposed in any of the sections, not only in Turkistán but as far as is known in Afghanistán generally, belong to the marine carboniferous series; (2) that the latter are overlaid comformably by a long succession of strata, partly marine, partly probably of fluviatile character, which form an unbroken and conformable series from the upper carboniferous to upper jurassic or neocomian age; (3) on the upturned and denuded edges of this base of older rocks upper cretaceous limestone of great thickness rests unconformably; (4) tertiary marine deposits and freshwater beds rest conformably on the upper cretaceous rocks; (5) that the general outlines of the present configuration of the country have existed since pliocene times, and that the force which has brought about the wrinkling of the older deposits is still continuing to add fold on fold in Central Asia.

The width of the belt of flexures appears to vary considerably, though the general lines of structure seem to remain more or less constant. So far as my observation has extended, I found that the belt of hills broadens considerably in the eastern sections.

Independent of minor folds between the lines along which the sedimentary zone has contracted, I believe the following great anticlinals can be identified.

4. Kaisar.	Almar.	Maimana.	Belcheragh.	Sar-i-Púl.	Albúrz.	Tashkúrghán.
3.	Painguzar.		Deh Miran.	Paisnah. (Astar-ab.)	Chahil.	Doab.
2. Main range of the Tirband-i-Turkistán.					Kara Koh range.	
1. Synclinal of the Upper Murghab.			Upper Balkh-ab (unexplored.)		Anticlinals of: d. Bajgah and Karmárd c. Dandan Shikan. b. Ak Robát. a. Palu Kotal.	
Great watershed of Afghanistán.						

First group. North of the system of great folds which form the watershed of Afghanistán is found a wide belt of shallow synclinals to which the Upper Murghab basin belongs. The structure of the latter is explained by the exposures between Kushk and Bala Murghab; the interior of the basin has remained a *terra incognita* to me. Eastwards of this region is the table-land of the Upper Balkh-ab, which Captain Talbot has visited; it is bounded north and south by the anticlinal rims of the Koh-i-Baba and the Kara Koh. The eastern margin of this depressed table-land is puckered into several very narrow anticlinals, across which the principal roads to Cabul lead; difficult passes and deep gorges traverse range after range between the Kara Kotal and Bamián. The headwaters of the Kunduz river rise in these folds.

Second group. Immediately north of this belt, a series of wide arches and anticlinals are ranged in long lines across Turkistán. They form the most important land-marks in the physical geography of this country. I include amongst them the main range of the Tirband-i-Turkistán and the Kara Koh.

Third group. A few well-defined and narrow flexures have been closely pushed up against the high anticlinals of the second group; their general direction may be traced from Painguzar, south of Almar, through Paisnah on the Astar-ab to the north side of the Kara Koh.

Fourth group. To the fourth group I reckon the clearly-defined outer rim of the Turkistán highlands, *i.e.*, a more or less steep anticlinal which dips under a high angle below the tertiaries of the plains. The ranges immediately south of Balkh and Mazar-i-Sharif belong to it. Westward

the Alburz and the long anticlinals of Sar-i-Pul, Maimana, &c., form a similar outer rim.

Between this range and the third group of flexures is a wide synclinal depression with areas of low table-lands in which streams have eroded deep ravines.

The greater part of these folds consist entirely of a thick mass of upper cretaceous formations. The great erosion which has taken place along the north slope of the Kara Koh and within the flexures of the third group has exposed the older base on which the cretaceous cap rests. Similarly north of the Koh-i-Baba, older rocks (carboniferous) have been laid bare of their covering of upper cretaceous limestone by denudation.

The Turkistán plains.

Against the last great fold which terminates the mountain area of Turkistán northwards, the tertiaries and recent deposits are ranged. North of the Maimana province they form low undulating loess hills, in which most of the streams which drain from the Tirband are lost. This widespreading loess area is known as the Chúll, and is found to gradually merge into the great plains south-west and south of the Oxus river, a great part of which is covered with modern aerial deposits.

Flexures in the Oxus valley.

There is good evidence that anticlinals are even now in course of formation within the recent deposits of the Oxus valley. I shall have to recur to this feature when describing the recent formations.

Stratigraphy of Turkistán.

I found the following formations represented in Turkistán and Bamián:

Age.	Formations.	Localities.
Recent . . .	Blown sands; alluvium of rivers; fans.	Chúll, Oxus valley, &c.
Sub-recent and post-tertiary.	Loess with interbedded clays, sandstones, and conglomerates.	Chúll; raised beds on the north slope of hills south of Balkh; patches within synclinals.
Pliocene . . .	Conglomerate and bright red and purple sandstones; bright red and green clays, with brown shales. *Planorbis* sp. *Helix* sp., and plant-remains. Gypsum veins.	Bamián and Mathár valleys; north fringe of anticlinals from Maimána to Tashkúrghán.
Miocene . Upper .	Light coloured shales, sandstones, and clays. Estuarine deposits with fish and crustacean remains. Plants.	Bamián and Mathár valleys; south of Tashkúrghán.
Miocene . Lower .	Sandstones and dark clays with marine shells. *Cerithium* sp.	Ditto ditto ditto.

Age.	Formations.	Localities.
Eocene ?	Great thickness of light coloured sandstone and impure earthy limestone. *Exogyra* ?	Mathár, Bamián.
Cretaceous — Upper	White chalk with flints. *Inoceramus* sp. *Exogyra* sp., many bivalves.	Tirband-i-Turkistán range and anticlinals north of it.
Cretaceous — Upper	Thick beds of white limestone with *Exogyra* sp. *Janira quinquecostata.*	Main mass of the Kara Koh and folds between Saighán and Tashkúrghán.
Cretaceous — Lower	Clays, shales, shell limestone, and beds with *Trigonia* sp.	Middle course of the Astar-ab and of the Almar stream.
Jurassic	Densely red grits and sandstone, shales with plant-remains; Trap. Dark bluish grey grits and sandstone; plant-remains. Ash-beds.	Upper Almar stream near Painguzar; Astar-ab below Paisnáh. Khorak-i-Bala north of the Kara Koh.
	Sandstone and black alum shales with plant-impressions; marine fossils.	Doab north of the Kara Kotal.
Upper Trias or Rhætic.	Light coloured sandstones and shales with *coal seams.*	Kotal-i-Sabz (north slope of Kara Koh), Shisha Alang.
Upper Trias — Upper	Great thickness of marine sandstone, limestone, and shales with *coal-seams.* *Schizoneura* sp., &c. Bivalves.	Chahil; Shisha Alang.
Upper Trias — Middle	Brown sandstones and shales with *coal-seams.* *Equisetites columnaris.*	Chahil, north slope of Kotal-i-Sabz.
Upper Trias — Lower	Marine sandstones and limestone beds. *Halobia lommeli.*	Chahil.
Permo-Carbon	Altered shales (mica-schist, &c.) with graphitic and anthracitic seams. Clay shales with impure *coal.* The whole traversed by hornblendic granite.	Saighán; Ak Robát Kotal north.
	Coarse conglomerate in greenish matrix, altered by granite.	Palú Kotal and gorge; Ak Robát.
	Massive dark limestone with brachiopod casts.	Ditto ditto ditto.

Description of Formations.

Permo-Carbon.

Locality.

The only section in Turkistán in which I have met with strata older than trias was within the greatly disturbed area between Saighán and Bamián. With few exceptions most of the beds in that section have been altered by contact with intrusive rocks, amongst which a hornblendic granite is most conspicuous.

Between Saighán (8050′) and the north entrance to the Bamián valley lies an elevated and undulating mass of hills, which consists of the Ak Robát synclinal (9800′) with the anticlinal of the northern Ak Robát pass (10750′) on its north side, and ending on its southern flank with two smaller anticlinals, which form the passes to Bamián, the southern Ak Robát pass, and the Kotal-i-Palú.

The main mass of the hills which close the Bamián valley on its north side, and over which the above passes lead, is composed of upper cretaceous rocks, which rest *unconformably* on the underlying older formations.

Exposed in the southern flank of the Ak Robát pass.

One of the branches of the headwaters of the Bamián stream run through a defile, which leads from the Ak Robát Kotal, south to the Bamián valley; this gorge has been eroded not only through the upper cretaceous rocks, which form the Pali Kotal east of it but also through the strata below, which belong to the carboniferous system.

Description of section south of Ak Robát. Fossils.

The prevailing rock seen on both sides of the gorge is a dark blue very hard splintery limestone, traversed by white calcspar veins; on the weathered surfaces of it I noticed badly preserved and distorted casts of brachiopods (*Productus* ?). The beds of this limestone formation dip under a high angle (from 50° to 70°) to north-west, and are overlaid a short distance higher up the valley by a semi-altered conglomerate or boulder-bed. A few irregular layers of a similar conglomerate are seen to alternate with the limestone beds below. It remains *in situ* a considerable distance up the south slope of the Ak Robát Kotal, and is apparently conformable to the dark limestone with brachiopods. The rounded boulders and pebbles of the conglomerate consist of limestone, and the matrix in which they are imbedded is likewise calcareous, and of a greenish colour. Near the southern entrance to this defile this section disappears below the upper cretaceous and tertiary formations of the Bamián valley.

Intrusive trap.

Large masses and dykes of trap traverse this section, and near the contact I found the limestone and conglomerate greatly altered. It has also penetrated the cretaceous limestone above and is therefore shown to be posterior to the upper cretaceous epoch. Similar traps are also seen in other sections in Afghanistán; the outburst may belong to the same which has broken through and altered the hippuritic limestone of Kandahar.

The kotal (pass) which leads to the Ak Robát synclinal is partly formed by upper cretaceous rocks, which rest unconformably on the older limestone and conglomerate series.

Section between Ak Robát and Saighán.

Between Ak Robát village and Saighán the older series crops up again and is strongly developed. The section runs from south to north and is formed of rocks closely resembling the limestone and conglomerate series south of Ak Robát. The succession of beds dips to north-west and is intersected by intrusive hornblendic granite, near the contact with which the sedimentary series is highly altered. I found in descending order:

Unconformably overlaid by cretaceous limestone.

7. Micaceous altered shales with thin *anthracitic* seams near the entrance into the Saighán valley, where the entire series is *unconformably overlaid* by the cretaceous limestone.
6. Mica schist and gneiss layers traversed by numerous quartz-veins.

} Permo-carbon north of Ak Robát. Dip north-west.

Here a mass of hornblendic granite traverses the section, near which the adjoining strata are entirely altered into a semi-metamorphic series.

The granite encloses many angular fragments of rock, derived apparently from the neighbouring shaly group; in some places it becomes almost a breccia, cemented together by granitic rock.

5. Gneissic beds with mica schist.
4. Micaceous shales with several thin beds of *anthracitic coal*, partly graphitic.
3. Great thickness of altered shales or schists; micaceous.

} Permo-carbon north of Ak Robát. Dip north-west.

2. Greenish altered conglomerate.
1. Massive dark limestone with brachiopod casts.

} Carboniferous. Gorge south of Palú Kotal, both south and north of Ak Robát. Dip north-west.

Three distinct groups.

It will therefore be seen that the series consists of three distinct groups of rocks, which are in descending order:

3. Shaly group with *carbonaceous seams*.
2. Conglomerate.
1. Limestone (*Productus*?)

The whole succession of strata dips to north-west, where they disappear below the cap of cretaceous rocks. All three groups of rocks form one structural whole conformable to and passing gradually from one into the other. The massive dark limestone with brachiopods in particular is closely connected with the greenish conglomerate above, with which it alternates partly. The dark limestone I may without risk identify and correlate with the carboniferous limestone so largely developed westwards in the Herat province and Khorassan, and thus the greenish conglomerate will also have to be included in the carboniferous group.

Similarity of the Herat section with Bamián.

Near Herat[1] I observed an analogous section, although there the thickness of the entire series of beds is very much less than that of the Bamián rocks. The general character of the rocks composing both sections is very similar. On the north slope of the Davendar greenish beds with conglomerates and a thin coal seam rest

[1] Records Vol. XIX, pt. 1, page 54.

conformably on true carboniferous marine limestones. At Bamián the conglomerate and the brachiopod limestone are even more closely connected, and cannot be separated from the carboniferous series.

Talchirs in the Herat section.

I expressed my belief last year that the greenish sandstones with conglomerate of the Herat province may represent the Talchir horizon of India, and if that view is correct, then the latter is of carboniferous age. I am still hoping again to traverse these rocks near the Hindu Kush range at some point where the alteration through contact with eruptive rocks has not quite obliterated all organic remains, and so may finally decide the question of age of the anthracite shales.

Links between palæozoic and triassic series hidden by cretaceous cap.

The continuation of older rocks towards the north and below the cretaceous cap seems likely, as is proved by the fact that at 27 to 30 miles north of Saighán middle triassic rocks crop out from under the overlying cretaceous limestone. Below the latter and in the belt between Saighán and Chahil I expect all the connecting links between the anthracite shales (3) and the middle trias will be found. It is even possible that these links may be exposed at some point where the denudation has worked through the covering skin of cretaceous rocks.

Permo-carbon age of anthracite shales.

This being the case both permian and lower trias are hidden, the former perhaps only partially. At present I must look upon the anthracite shales of Ak Robát and Saighán, connected as they are with the underlying carboniferous series,—as being passage beds between the carboniferous and permian.

Granite and trap intrusions.

The intrusions of the hornblendic granite north of Ak Robát and the trap of the Palú-kotal belong to a subsequent epoch and may possibly be of late cretaceous age, to which the granite intrusions of Kandahar belong.

According to former observers[1] a syenitic granite enters largely into the composition of the Hindu Kush range near the pass of Hindu Kush. It is very probable that the rock I observed south of Saighán is only a spur of the granite masses which have penetrated the limestone of the Hindu Kush.

From stray notes given by Drummond,[2] Lord,[3] and others who were in Afghanistan during our first campaigns in that country 48 years ago, it appears that a formation of schists, traversed by granitic veins and enclosing fragments of limestone, extends between the Hindu Kush passes and the Koh-i-Daman. Along the latter even the seams of graphitic coal are not wanting, and so one may assume that at least the older Saighán beds, *i.e.*, the palæozoic series, occurs also south of the Hindu Kush. The strike of the beds in that district is approximately from south-west to north-east, which is also the strike of the Paghmán range and its south-western continuations. Taking into consideration the report that coal-seams have been found near Ghazni, the inference may be drawn that

[1] Lord, P. B.: Journ. As. Soc. Beng. Vol. VII., 521—1838; and India Review, etc., III. 315—1839.

[2] Journ. As. Soc. Beng. Vol. VII, p. 521, and India Review, etc., Vol. III, p. 315.

[3] Journ. As. Soc. Beng. X, p. 74.

the Ghazni coal, if such exists, belongs to the same formation as the graphite of the Koh-i-Daman and the anthracitic coal of the Ak Robát pass, and Saighán. In that case we may fully expect to meet with the older coal-measures, equivalent to our best Indian horizon (Karharbari-Talchirs) within easy reach of our Indian frontier.

Trias and Rhætic.

Locality.

Most of the streams which denude the north slope of the Kara Koh and the anticlinals immediately parallel with it, have at several places entirely removed the thick cap of cretaceous limestone and so uncovered a series of strata which I found to represent horizons extending from the middle trias to upper jurassics. Most probably this is the case in all the deep valleys north of the Kara Koh range, but I have only been able to examine a few of them, in which, nevertheless, I was rewarded with good sections through the lower and middle mesozoic groups. I found the best sections in the Shisha Alang and Chahil (Chil) valleys, where both triassic and rhætic beds are exposed. The streams which drain these valleys rise on the north side of the Kara Koh, and run eventually into the Balkh-ab.

The area of triassic rocks exposed at Shisha Alang is quite detached from that of Chahil, that is, the intervening high ranges crossed by the Shaúbáshak and Bala Gali passes (8,800′ and 9,330′), are formed by upper cretaceous rocks which hide the triassic section below.

Section at Chahil.

The Chahil area exposes the lower strata of the upper triassic group of modern European geologists, or beds which closely represent horizons from the zone of *Halobia lommeli* to the plant-bearing Lunzer beds of the Alps. The section forms a wide arch, the beds of which dip generally south-west and north-east. Part of this arch is overlaid (near its highest point) by the upper cretaceous limestone of the Chaúli Khán. On nearer examination I found the Chahil section greatly disturbed and in some places crushed. But I was able to determine in general outlines the following horizons in descending order:

12. Grey and bright coloured sandstones, with shales and a few limestone partings. They weather nearly everywhere to a bright brown ochre colour, reminding me in that of the Himalayan trias. A few *thin coal seams* occur near the top. Lower down *coal* occurs at regular intervals of about 80 to 100 feet; several of these seams are upwards of 6 feet thick. Plant-impressions, mostly of stalks with some marine remains (bivalves), but in a poor state of preservation. Thickness not less than 1,800 to 2,000 feet.
11. Fine-grained greyish brown sandstone in thick beds.
10. *Coal-seam*; thickness 10 feet and quality apparently excellent.
9. Impure *coal*, with partings of bituminous shales and thin beds of ferruginous clays.
8. Thick beds of fine-grained brownish yellow sandstone with grey shales. *Equisetites columnaris*, Sternb.
7. Grey clay shales.
6. *Coal-seam*, thickness 1′ 6″ and very friable.
5. Brown shales with plant-remains.
4. Coarse grey sandstone and grit; fragments of plant-remains and casts of marine shells.
3. Gritty white sandstone, very friable and sandy, in thick beds containing marine fossils.
2. Same as 3, but alternating with friable light grey shales with bituminous layers, which yield a few fragments of plants.

1. Hard calcareous dark brown sandstone, containing numerous marine remains, amongst which *Monotis salinaria* and *Halobia lommeli* are very common. The lower part of this section, beds 1 to 11, cannot be less than 2,000 feet in thickness, and is probably much more.

Exposed in valleys of denudation only.

This section is only exposed where the upper cretaceous limestone has been completely removed by denudation; consequently the base and sides of the entire Chahil valley with the upper Chahil basin, including the steep south-west slope of the Sabz Kotal, are made up of folds of the triassic group, while the great mountain masses which crown the sides of this valley with inaccessible cliffs belong to the upper cretaceous limestone.

Dip and strike. Distribution.

The principal fold of the triassic series runs nearly due north and south, and at the northern end of the Chahil valley, where it forms a steep anticlinal, is dipping 80° east and about 60° west from its centre. The direction of the fold gradually bends to the south-east and the arch widens as the dip lessens. So east of the second village of Chahil on the right side of the valley I found the lower beds of the series (1 to 4) dipping about 50° north-east below the cretaceous rocks which form the Chaúli Khán peak. West of this same village rises the very steep and almost inaccessible left side of the valley where I found the upper beds of the series to dip about 55° to 60° west and south-west. The same beds form the lower slopes of the upper Chahil valley, left side, on which the third of the Chahil settlements has been built. The steep cliffs on the left side of the valley, above the spot where the stream emerges from the old moraine which divides the basin, belong to the upper part of the beds 12 and contain numerous plant-remains.

The left side up the valley above the village of Chahil is not only very steep but where accessible almost entirely covered with loose debris from the cretaceous rocks above, so that I was not able to obtain a detailed section of the uppermost beds of the series.

The lower portion of the ascent to the Sabz Kotal is hidden under a thick deposit of glacial debris, and the triassic strata only become visible in the stream valley, where they show a dip of about 60° to south-west.

The thick coal-seam (10) with its adjoining strata is *in situ* in that locality, and may be traced for a considerable distance up the slope of the Sabz Kotal.

Last ascent of Sabz Kotal.

Near the last ascent of the Kotal the north-eastern shoulder of the anticlinal is seen to dip 40° to 50° north-east-by-east. The beds exposed belong to the upper part of the group and rest on the main *coal* seam (No. 10). I observed the following succession in descending order:

16. Grey and light coloured clays and clay shales with yellow ferruginous partings.
15. Whitish grey soft sandstone, very friable; weathers rusty brown.
14. Same as 16.
13. Whitish soft sandstone in thick beds.
12. Bad shaly *coal* 1′ thickness.
11. Brown fine-grained sandstone in thick beds.
10. Coal-seam, 10′ thickness (No. 10 in section).

The beds 12 to 16 represent the lowest portion of bed 12 of the entire section.

So far as I am able to determine in the field without closely examining the fossil contents of this locality, it appears that at least three horizons can be made out, which correspond with foreign zones.

Three horizons, comparable with foreign localities.

1. The beds at the bottom of this series represent a well-marked horizon, which occurs not only in several distant parts of the world, as for instance both in the eastern Alps, Transylvania and California, but also is well represented in the Himalaya of Kumaon, Gharwál and Spiti, and this portion of the Chahil section may therefore be identified with the lower horizons of the upper-trias.
2. The next higher horizon which contains plant-remains, amongst which *Equisetites columnaris* is most frequent, may be compared to the Lunzer beds of the eastern Alps, which also occupy a position over strata with *Halobia lommeli* and *Monotis salinaria*.
3. The lower beds of (12) contain plant-remains, amongst which a *Schizoneura* seems abundant. Whether these plants will be found to agree with any of the Gondwana species is impossible to say at present, but the group in which they occur have a strong resemblance to upper Barakars in lithological character.

It appears therefore that the section exposed in the Chahil valley must be placed in the upper trias as now understood by Alpine geologists; the lower portions of it seem to belong to the Hallstadt horizon of the Alps, which has been traced from Central Europe through Asia to California and New Zealand.

The upper portion of the Chahil beds is mostly plant-bearing, and yields characteristic upper triassic (Lunzer) forms, of which some are common in the eastern Alps and others have a strong likeness to middle Gondwana species.

It is clear from this section that the triassic rocks, in common with the upper palæozoic strata of Bamián and Saighán, have undergone crushing and disturbance long before the deposition of the upper cretaceous formations which rest unconformably on the former; I believe the lower-trias will be found below the enormous limestone cap of the Kara Koh and its southern extensions. Perhaps some of the deeper valleys, for instance the upper Balkh-ab gorge, may have cut through this overlying mass of younger rocks and may thus have exposed the most interesting of triassic strata.

The headwaters of the Chahar-Aulia stream, which unites with the Kashindeh valley some distance lower down its course, are made up of numerous small rivulets and springs which rise in the high regions on the northern side of the Kara Koh. They have excavated an area of about 20 square miles in the cretaceous limestone, and exposed the underlying folds of older rocks.

Section at Shisha Alang.

Beds in this section disturbed before cretaceous times.

The beds in this basin have been folded and crushed before the deposition of the cretaceous rocks, which rest unconformably on the former.

The Shisha Alang triassic series forms an anticlinal whose axis has been bent into a horse-shoe shape, the toe of which points towards the south-west. Some of the higher portion of the anticlinal

Strike.

has been denuded away, and I found, therefore, the oldest beds of the section exposed about half way between the southern entrance to the Said Dád Mirgánd gorge and the ascent to the Shaúbáshak pass, whereas the higher horizons of Shisha Alang are seen near the headwaters of the stream of that name and close under the high cliffs which enclose the Dara Shaúbáshak.

Character of rocks at Shisha Alang.

The general character of the section is that of a succession of sandstones and shales with coal-seams, which contain chiefly land-plants, although a few marine remains (brachiopods) are also found in some of the beds associated with the former. There are also several horizons of concretionary limestone containing marine fossils only.

Resemble upper Chahil beds.

The lithological character of the group of beds is very nearly that of the upper portion of the Chahil section, and both seem to contain similar plant-remains. I believe therefore that the Shisha Alang rocks form simply a western continuation of the upper Chahil group.

Repetitions of coal-measures.

The remarkable feature of the Shisha Alang beds is a coarse, gritty, light grey sandstone, which contains fragments of plant-remains, besides a few marine bivalves. This sandstone forms well-marked divisions between the several groups of coal-measures, each of the latter being about 300 feet thick. I cannot say how many of such repetitions may exist in that area, as the beds are far too much disturbed to enable me to form an accurate estimate. But along the low ridge, which forms the right side of the main valley of Shisha Alang, I counted 7 separate groups of coal-measures, each of about 300 feet thickness, which, for this portion alone, would give 2,100 feet total thickness.

Thickness.

Similarity of groups of coal-measures.

There is a remarkable uniformity in the composition of these groups of coal-measures; the only difference seems to be the varying thicknesses of individual beds and coal-seams. The general lithological character remains the same,—in all cases showing a close likeness to middle Gondwana rocks. The shales are generally dark grey with particles of mica scattered throughout.

Details of section.

One of these minor groups of coal-measures north of Shisha Alang I found to dip 40° south-west and to be in descending order as follows:—

	Ft.	Ins.
14. Thick beds of coarse, gritty, grey sandstone with numerous fragments of badly preserved plant-remains and a few marine bivalves (*Ostrea* sp.)	60	0
13. Good *coal*	5	4
12. Bituminous clay	0	4
11. *Coal*	6	6
10. Coarse white calcareous sandstone in thick beds,—a few marine bivalves	50	0
9. Dark grey, micaceous shales, plant fragments	7	0
8. Fine-grained flaggy sandstone	8	0
7. Coarse-grained sandstone, divided by grey plant-shales, and alternating with them	40	0
6. *Coal*	6	0
Carried over	183	2

	Ft.	Ins.
Brought forward	183	2
5. Bituminous clay with ferruginous concretions	2	0
4. *Coal*-seam, divided by a few very thin partings of clay; the latter of from ½ inch to 3 inches thickness. Coal rather leafy. Total	12	0
3. Bituminous shales	25	0
2. Friable *coal*, with plant-impressions, consisting of closely packed leaves (*Schizoneura*, &c.,) alternating with seams of good black *coal*. Total	30	0
1. Coarse calcareous sandstone in thick beds, much jointed	80	0
Total thickness	323	2

Further up the stream I noticed that the dip increased rapidly to 50° south-west-by-south. Several of the beds of shales yielded good specimens of plant-remains, which will have to be determined hereafter.

Marine fossils.

On the opposite side of this valley where the beds dip to the south-east at an angle of from 40° to 50° I found some brachiopods in concretionary nodules which occur near the base of No. 14, in a shaly bed; they seem to bear a close resemblance to upper triassic forms (*Rhynchonella semiplecta* of St. Cassian ?).

Right side of valley.

The same succession of strata may be traced on the right bank of the principal valley of Shisha Alang, and there shales seem to predominate over sandstones. At the same time I found that the thicker seams of coal split up into numerous thinner ones, divided by bituminous clays and micaceous shales. As many as 18 or 20 separate seams may be seen within about 300 feet of thickness.

West of first village of Shisha Alang.

West of the first village of Shisha Alang the coal-series crops out again and shows a similar succession of dark grey Barakar-like shales and sandstones, associated with leafy coal-seams, the whole set of beds being enclosed between thick-bedded massive sandstone and grits.

Distribution of fossils in the groups.

I noticed that the sandstones yielded generally only marine fossils (mostly bivalves), whereas the shales and coal-seams contained numerous Gondwana plants.

Estimate of available quantity of coal.

If I assume the average thickness of the best coal-seam at 6 feet only, which could be worked over an area of 9 square miles in the immediate neighbourhood of Shisha Alang, I find that the available quantity of coal would be no less than 50 million tons. In this estimate I have left out of consideration the fact (1) that triassic coal-measures with large seams of coal are actually exposed over a large surface in the Chahil valley and the north-west slope of the Sabz Kotal, and (2) that permo-carbon strata with anthracitic seams appear between Saighán and Bamián, and that therefore the conclusion is evident that the whole lower trias and permian strata, *i.e.*, the equivalents of our lower Gondwana series, must be buried below the upper cretaceous limestones of the intervening country. It is consequently almost certain that the entire northern Hazaraját is one vast coal-field, which is partially hidden by superimposed cretaceous limestone.

Jurassic series.

Localities.

Rocks lithologically closely resembling the jurassic deposits of Khorassan and Herat crop out from below the cretaceous cap in several localities north of the Kara Koh and north of the Tirband-i-Turkistán.

Valley of the Doab stream.

East of the triassic sections of Shisha Alang and Chahil I found the jurassic series in great force in the valley of the Doab stream, which rises west of Khorak-i-Bala on the slopes of the Sabz Kotal.

Sabz Kotal.

The ridge which forms the Sabz Kotal is formed by a crushed fold of upper triassic rocks, overlaid on each side of the pass by upper cretaceous limestone. The beds dip towards the south-east and disappear finally below the cretaceous *Exogyra*-limestone, which composes the east slope of the pass. Below this cap of younger mesozoic deposits the uppermost trias (with rhætic and lias?) is probably hidden, for I found the head of the valley of the Doab stream near Khorak-i-Bala occupied by formations which I believe to belong to the upper half of the jurassic series.

Section of Khorak-i-Bala.

The section through these rocks near Khorak-i-Bala, as seen from the heights of the Sabz Kotal, is very clear. Successive belts of dark brown, bluish grey, and bright red rocks which compose the jurassic series are seen to dip at an angle of about 40° to 45° to the south, where they are unconformably overlaid by the white *Exogyra*-limestone of upper cretaceous age, which forms the steep scarp of the Kara Koh. These successive belts are traversed by a small stream, which joins the Doab valley from the right near the village of Khorak-i-Bala. To ascend the Kara Kotal I had to go up this side valley and thus traversed the upper jurassic series nearly at right angles.

Dark alum-shales left side of valley.

The left side of the valley near Khorak-i-Bala is formed by very friable dark grey to black alum-shales with a few badly-preserved plant-impressions. The shales weather on the surface and on the upturned edges to a bright rusty brown, and often show a bright coloured metallic lustre on their planes, derived from decomposed iron pyrites. The deposit seems to remain very steady in its lithological aspect, and is generally found at the base of the "red-grit group" wherever I have met with the latter. Along the north side of the range called the Koh-i-kat-i-Shamshir in eastern Khorassan, as far as Zorabad on the Hari Rúd, and again on the north slope of the Tirband-i-Turkistán, the character of this deposit is the same. I believe the horizon will be found to be middle oolite; certain it is that the shales rest conformably on deposits with recognisable lower oolitic fossils in several localities.

Occurrence elsewhere. Age.

Dip below "red-grit group."

The shales dip about 40° south and below rocks which I believe to belong to the widely distributed "red-grit group" or upper jurassics; the passage from the shales into the overlying group is quite gradual.

Dark bluish grey sandstone; a local development of "red-grit."

The first division which I could distinguish in the "red-grit" group rests conformably on the dark alum-shales, and consists chiefly of a dark bluish grey sandstone and grit; the latter encloses grains of black limestone, probably derived from the carboniferous rocks south of the Kara Koh and Bamián. It appears to be a local development of the "red-grit group;" a rock closely resembling it I found last year near the Kala Sard, about 35 miles south-east of Máshhád. The blue grits are not sharply separated from the alum-shales below. Thin irregular layers of the latter occur between thick beds of the blue grey grits, and no doubt some beds of the latter will be found within the alum-shales; such I found to be the case along the north slope of the Baréli hill in the Koh-i-kat-i-Shamshir. The total thickness of the bluish grit and sandstone may be about 1,000 to 1,200 feet near Khorak-i-Bala.

Red grit.

It is concordantly overlaid by the typical red sandstone and coarse grits with strings of conglomerates which seem to compose the upper jurassics in every section which I have hitherto seen in the Herat province, Turkistán, or Khorassan. I found both in the bluish grey grits and the "red grit" some poor remains of plants, mostly only impressions of straight stalks and carbonized matter.

Thin coal-seam.

On the left side of the Doab stream, near the upper boundary of the alum-shales, I found an irregular and impure coal-seam of about 2 inches thickness.

The total thickness of the "red grits" is not seen, as it is discordantly overlaid by the cretaceous limestone of the Kara Koh.

Jurassics of Doab.

Rocks of the same character and horizon may be traced along the Doab valley to the valley of the Tashkúrghán river; the Kara Kotal north of Doab presents steep scarps of upper cretaceous limestone towards the north, resting unconformably on the upper and middle jurassic groups. The sections south of the village Doab reveal the jurassic deposits dipping 35° to 40° west to south-west below the cretaceous limestone, and I found them to be composed of the following groups in descending order.—

3. Red grit group with volcanic breccia and tuffaceous beds.
2. Greyish blue grit and grey micaceous sandstone.
1. Dark alum-shales.

The red grit group (3) is of the usual and almost invariable character. I found also here some igneous beds associated with it, which consist of hard breccia and tuffaceous beds interstratified with the grit.

Below the "red grit" I found (2) grey micaceous sandstone and thick beds of greyish blue grits, alternating with friable black shales; this formation seems of very great thickness and composes all the lower slopes of the surrounding hills.

In lithological character this group is perfectly identical with the similar rocks which I saw near Khorak-i-Bala, about 10 miles west of Doab. Fragments of plants are very common in all the strata of group (2), but a bed of ferruginous, rather concretionary sandstone 1 mile south of Doab, yielded, besides numerous plant-fragments, some marine fossils of distinctly jurassic types.

North of Doab, on the way to Rui, I found the lower group (1) of the jurassic series, a grey sandstone with alum-shales containing a few plant-remains; they form all the lower slopes of the hills on both sides of the valley. The cretaceous limestone rests quite unconformably on the plant-bearing shales (1), and the grits and sandstones of groups (2) and (3) are wanting.

In the Tirband-i-Turkistán.

The general outlines of the geological structure of the Tirband-i-Turkistán range and its eastern continuations I have already given.

Mesozoic strata along third anticlinal.

The third anticlinal (see page 237) which runs almost unbroken from Painguzar to Doab on the Tashkúrghán river exposes lower and middle mesozoic deposits at several points below the capping cretaceous formations; I have described the older mesozoic and jurassic beds of the Hazaraját in the preceding paragraphs. The only other localities where I have noticed rocks older than cretaceous are situated south-west of Maimána and south-west of Sar-i-Púl.

Novel features.

In some respects these localities present altogether novel features, inasmuch as (1) any unconformity between the jurassic plant series and the cretaceous formations is doubtful, and (2) if such unconformity exists, then the overlap of the cretaceous formations must have begun during earlier neocomian times. I believe, however, that the apparent unconformity which I noticed south-west of Maimána can be explained differently, and that therefore the change of sea-level which occurred after jurassic times did not affect the area north of the Tirband range.

South-west of Maimána.

The great anticlinal of Painguzar, 16 to 18 miles south of Almar, exposes some of the upper jurassic horizons; the overlying strata being a succession of deposits, amongst which I could determine both lower and upper cretaceous horizons.

Seeming unconformity above plant-shales.

At first sight of the section an unconformity seems to exist between the red-grit group and the plant-shales below, but there are reasons which are against the assumption of any actual break between these two formations: (1) in sections west of this locality, *i.e.*, in Khorassan, the red-grit group and the black shales of the plant-group (jurassic) are always closely associated, and in fact alternate near the contact, and the same feature may be observed in all the eastern sections, as for instance near Khorak-i-Bala (page 248); (2), seeming unconformities are often observable where rigid thick-bedded formations resting on softer and yielding rocks have undergone lateral disturbance. In such cases, whilst the overlying rigid formations have only been bent into wide curves, the softer shales below have undergone greater crumpling and hence an appearance of discordance has been produced.

It is different with the unconformity between the older mesozoic formations and the upper cretaceous limestone in the Hazaraját; there the same very well-marked feature can be observed in every section, and the direction of the flexures of the underlying rocks differs entirely from that of the cretaceous limestone above.

Section of Painguzar.

The cliffs on the left side of the valley, between Painguzar and the Ziarat Khwaja Diwána, show the following section in nding order:—

Upper / Lower } Cretaceous group.
Red-grit group with enclosures of gypsum; the passage from this into the overlying lower cretaceous beds is gradual.

Bedding nearly horizontal near top of the anticlinal.

pushed over the beds below.

6. Dark shales with partings of ferruginous sandstone and strings of nodular clay iron ore. The general character of this rock is completely that of the dark alum-shales of the Estoi hills.
5. Dark grey micaceous sandstone, weathers rusty brown; plant-remains.
4. Dark shales, same as 6.
3. Sandstone same as 5.
2. Shaly sandstone.
1. Thick-bedded grey sandstone.

Beds dip about 20° to 25° to north-west, the direction of the general dip a few miles further on.

In the Astar-ab.

Along the same flexure and nearly due east of Painguzar, I again met with upper jurassic rocks. The locality is near the villages of Paisnah and Deh-i-Surkh in the Astar-ab valley, about 38 miles south-west of Sar-i-Púl. The river makes a sweep to the east near these villages, and turns again abruptly north and north-east some 6 or 7 miles below Paisnah, where it cuts through the entire cretaceous and part of the jurassic groups along a line which now coincides with the crest of the third anticlinal (see table page 327). The flexure of the rocks has apparently taken place after the greater part of the valley had been eroded out of the mesozoic series, and in that particular locality the bend into an anticlinal naturally took place along the line of least resistance, where the thick mass of the upper mesozoic series had previously been cut through by the river. The strata are now seen to dip away from the centre of the valley—north and south.

I found the section a continuous one from the upper cretaceous (*Exogyra*-limestone) down to the black alum-shales with plant-impressions. There is not the slightest unconformity traceable throughout the series of strata either in this locality or in the transverse portion of the Astar-ab valley between Deh-i-Surkh and Turghan.

In all about 1,860 feet of strata are exposed below the upper *Exogyra*-limestone, of which about 1,050 feet belong to the red-grit group. The black allum-shales below are only partially exposed, their base being hidden below the alluvium of the Astar-ab.

Cretaceous series.

Change of physical conditions after jurassics.

With the close of the jurassic period seems to have begun the most marked change in the physical conditions of this part of the world; the jurassic seas began to shallow, and the greater part of Turkistán and Khorassan became most probably part of a continent which extended towards India. The forces

which are traceable to the present day in Turkistan folded and crumpled the older and mesozoic formations until they were raised above the jurassic sea-level. This shallowing and partial isolating of certain sea-basins may even be traced in the lithological character of the upper jurassics; the "red grit" which keeps wonderfully constant over the whole of Khorassan and Turkistán has most probably been deposited in a shallow and confined sea, and—as the gypsum layers in the sections of the south-western districts of Maimána show—possibly in land-locked basins.

Sub-aerial denudation during early cretaceous times.

The greater part of the upper jurassic rocks became subject therefore to sub-aerial denudation during early cretaceous times. Only near certain points along the cretaceous land deep bays existed; certainly in two localities, namely, in the sections west of Púl-i-Khatun in Khorassan and south-west of Maimána some marine deposits rest conformably between the upper jurassics and the upper cretaceous limestones which must have been laid down in such arms or firths of the lower cretaceous sea.

Lower cretaceous deposits.

The rocks which I believe to belong to this horizon in Khorassan I have described in former notes [1]; the Maimána province offers a very similar section through the lower cretaceous horizons, and I met the series fairly well developed in the Painguzar (Almar) neighbourhood.

Painguzar section.

Between the outer range of the Tirband, *i.e.*, the most northern flexure, and the synclinal of Farad Beg, extends the third great anticlinal (see page 327), which has been transversely cut through by the Almar stream, thus exposing the entire section. Both on the right side of the valley, east of Painguzar, as also immediately south of that village, the cretaceous series is seen to rest conformably on the red-grit group, and in spite of local crushing a fairly complete section can be obtained. I found the following beds in descending order:—

7. Thick-bedded whitish grey hard coral limestone with *Exogyra* sp.	Upper cretaceous.
6. Greenish earthy limestone with *Exogyra*; total thickness of these two groups about 2,000 feet.	
5. Considerable thickness of greyish beds inaccessible, but conformable on the beds below.	Lower cretaceous about 1,000 feet.
4. Shell limestone, with numerous Foraminifera.	
3. Do. do. containing *Trigonia* sp.	
2. Dark grey earthy shales.	
1. Greyish green soft sandstone in thick beds with concretionary layers, shaly towards the base.	
d. Red sandstone with gypsum beds.	Upper jurassics.
c. Parting of calcareous sandstone.	
b. Coarse brownish grey sandstone.	
a. Red-grit group.	

Further eastwards and along the same flexure lower cretaceous strata are seen to rest conformably on the red-grit group and pass upwards in the upper *Exogyra* limestones.

[1] Records Vol. XIX, pt. 1, pp. 59, 63.

Section in the Astar-ab.

The succession of strata between Khamdán and Deh-i-Surkh in the valley of the Astar-ab is in descending order as follows: About 1,500 to 2,000 feet of upper cretaceous limestone with *Exogyra* sp. resting conformably on—

	feet.
5. Greyish earthy calcareous sandstone in thin flaggy beds	60
4. Light grey impure limestone with bluish green shaly calcareous sandstone	80
3. Same as (5) with *Exogyra* sp.	80
2. Rusty brown, coarse sandstone in thin beds with *Trigonia* sp. and alternating with shell limestone	250
1. Bluish green earthy shales and clay	80
b. Light reddish grit with shaly partings	200
a. Thin bedded shaly red grits.	60
Total	2,810

passing gradually into and resting conformably on the red-grit group, which is here at least 1,000 to 1,200 feet in thickness.

Maimána sections identical with Takht-i-Gaúzak.

The sections at Painguzar and near Khamdán will therefore be seen to be very similar and to correspond in general characters with the succession of beds west of Púl-i-Khatun, as shown in the range of the Takht-i-Gaúzak (see Records XIX, p. 63).

I believe the beds 1 to 5 will be found to be of lower cretaceous age and to be identical with the light-coloured marls of Zulfikár.

It appears certain that none of these strata reach further to the east, as I have found everywhere in the Hazaraját and Afghan-Turkistán only upper cretaceous formations resting directly on older groups.

Upper cretaceous.

The greater part of the province of Maimána and of Afghan-Turkistán is covered with a wide-spread cap of upper cretaceous rocks.

Rocks of the upper cretaceous.

With few exceptions the beds belonging to the upper cretaceous horizons consist of white thick-bedded limestones. Here and there a few layers of sandstone occur, which in that case often contain a few badly-preserved plant-remains. But by far the greatest thickness of the upper cretaceous formation is made up in ascending order of (1) hard white splintery limestones, (2) concretionary earthy white or brownish white limestones, occasionally dolomitic, (3) chalk with flints.

The general character of the group seems the same in all cases, that is, it is formed in massive beds, the total thickness being about 1,800 to 2,000 feet. Towards the northern sections the thickness of this group increases, and I found that south of Balkh the total thickness cannot be less than 3,500 to 4,000 feet. In common with its overlying tertiaries it is folded and bent in wide anticlinals with occasional elevated table-lands between. The present rivers have excavated deep ravines and picturesque gorges through the rocks of this group, with steep, often vertical, sides. The general character of the group closely resembles that of the Quader of Bohemia, with which it shares approximately the same age.

Fossils.

The commonest fossils found in this group are *Exogyra* sp. and *Janira quinquecostata*, besides numerous others which have not been determined yet.

The fossil contents, not less than its stratigraphical position over lower cretaceous beds, assign an upper cretaceous age to the group I believe that a more detailed study will possibly reveal that at least two European horizons are represented in it, but I have not been able to distinguish any divisions on my map.

Age, probably two horizons of upper cretaceous.

Exogyra sp. I found in all horizons of the upper cretaceous; but it seems probable that the lower portion of it is chiefly characterised by harder limestones, frequently a pure coral limestone, whereas the more earthy varieties seem to contain principally *Exogyra* sp.

The uppermost portion of the upper cretaceous is composed of white chalk and shell-limestone with flints, and contains *Inoceramus* sp., *Exogyra* sp., &c.; it forms about a third of the total thickness of the group. The best sections were found in northern Turkistán, between Haiback and Tashkúrghán, and south of Balkh, where the white chalk forms precipitous cliffs.

White chalk with flints.

The same horizon is found to form the upper portion of the cretaceous deposits between Chakau and Kalanau north of Kushk in the Herat province; it also caps the cretaceous series of Zulfikár.

Localities of the upper beds of the cretaceous west of the Tirband.

Tertiary formations.

The tertiary series of Turkistán is composed of the following groups:—

Composition.

Post-pliocene	Aerial and freshwater deposits.
Pliocene	Freshwater.
Miocene	Marine and freshwater.
Eocene (?)	Marine formations.

Of these groups only the post-pliocene deposits occupy large areas in Turkistán; the lower groups are confined to narrow strips exposed in deep folds of the upper cretaceous formation and in a few localities in the Oxus basin. In the highlands of Turkistán, and the Hazaraját I have met the older tertiaries in Bamián and Saighan, where they are of small thickness, and along the northern edge of the hills of Turkistán, *i.e.*, resting on the chalk beds of the upper cretaceous series which dip below the plains south of Balkh and Mazar-i-Sharif.

Localities.

It is probable that during eocene times a large portion of the upper cretaceous sea began to shallow and here and there even to recede from its old coast-lines. The force which compressed the sedimentary formations into a narrow and folded belt north of the great Afghan watershed, dates from early tertiary times, when it had forced a great part of the area, now occupied by the Turkistán hills and the Hazaraját above sea-level. From that time date the extensive denudations which these tracts have been subjected to. In succession eocene and miocene formations, marine and freshwater were removed by subsequent and later

Changes of coast lines after cretaceous times.

erosions, until at the present day only a few remnants of the older marine beds are found compressed in elevated synclinals high up on the northern slopes of the Koh-i-Baba and Hindu Kush,—and the remainder of the area only shows the blown sands and fluviatile formations of much later date.

After the deposition of the lower miocene formations the sea seems to have withdrawn finally from the area now occupied by the high anticlinals of the Turkistán hills and retreated to the regions now occupied by the great Central Asian depressions. Lacustrine and fluviatile deposits began to spread over the gradually wrinkling surface of Turkistán and filled the wide synclinal basins with vast accumulations of sands, shales, and sandstone, which continue to the present day.

Section at Mathár.

At Mathár, south of the Kara Kotal, the cretaceous limestone with Exogyra sp. forms a wide synclinal trough, which encloses a fairly complete tertiary series, which I found in descending order to be:

9. About 150 to 200 feet of concretionary green clays with small ferruginous concretions and rust-coloured mud beds, containing fresh water gasteropods; partings of clay and ferruginous sandstone of bright orange colour. Towards the base some purple-coloured sandstone. The whole intersected by thin veins of gypsum.	*Pliocene freshwater series.*
8. 200 to 300 feet of chocolate-brown sandstone with shaly partings. This group shows fine mud deposits or clays towards the base, of yellowish-brown colour, containing fragments of vegetable matter and leaves; thin partings of pure light grey clay-shales. Towards the upper part gritty chocolate-brown clays and sandstone predominate, which, from thick banks in the centre of the group, changes into thin-bedded strata. A few thin partings of olive-green clays are very conspicuous in this mostly chocolate-coloured mass.	
7. Great thickness of grey micaceous sandstone alternating with grey and green clays and chocolate-brown sandstone, which contains some gritty layers false-bedded.	
6. Bright bluish green and yellowish brown clays with some sandstone beds. Contain plant-remains and freshwater shells; gypsum in layers and veins; great thickness.	
5. Deusely red sandstone with a few purple clay beds, towards the top great thickness of bright red sandstone and conglomerate, consisting chiefly of pebbles of cretaceous limestone cemented together by a red calcareous matrix.	
4. Greenish dark clays and shales with partings of brown sandstone with concretionary structure. Thickness about 600 feet, with veins of gypsum and yellowish-brown earthy shales. The shales contain some fucoids and other plant-impressions, besides rather badly preserved remains of fishes and crustaceans.	*Upper Miocene (estuarine).*
3. Towards base of group 4, dark clays and soft clay shales predominate; the shales contain plant-remains and marine shells, *Cerithium* sp.; thickness about 500 feet.	*Miocene (marine).*
2. Bed of greenish clay at the base with layer of gypsum.	
1. Thick beds of sandstone and shales with greenish earthy shales; *Exogyra* sp. Rests conformably on upper cretaceous limestone.	*Eocene ? (marine).*

Eocene group at Mathár.

With the exception of an *Exogyra* sp. I have not discovered any fossil remains in the lowest beds of the tertiary rocks. The passage from the upper cretaceous limestone of the anticlinal north of Bajgah to the miocene *Cerithium*-clays (3) is gradual and continuous, and I would naturally infer a representation of the eocene horizon in the section, even if eocene fossils had not already been described from that locality. I believe Captain Hay [1] describes eocene fossils from beds which rest on cretaceous rocks north of the Bajgah anticlinal, but unfortunately his paper is not available to me whilst I write this in the field.

Thickness.

In the Mathár valley this group is of considerable thickness, probably not less than 800 to 1,000 feet. The strata composing it are highly raised up, but perfectly conformable to the upper cretaceous *Exogyra*-limestone.

Eocene beds south of Tashkúrghán.

A very similar group of sandstones and shales lies between the upper cretaceous and the dark miocene clays, south of Tashkúrghán, where the tertiary rocks dip under a steep angle below the recent deposits of the Oxus valley.

Miocene.

Of great interest is the group of partly marine partly freshwater strata which rests conformably on the marine eocene beds at Mathár.

Marine clays. *Cerithium* sp.

Towards the top of the group of sandstones and shales (1) beds of a dark clay or clay-shales with subordinate sandstone beds appear, which finally merge into a thick group (about 500 feet) of dark friable clay-shales, which contain a few indeterminable plant-remains and some marine shells, amongst which a *Cerithium* sp. is the commonest. The form is probably allied to a species also found in the miocene salt-bearing group of the Adarbaijan province of Persia. The clay-shales are associated with gypsum layers and veins, which occur not only in this horizon but throughout the overlying strata.

Estuarine formation. Fish remains.

This group passes upwards into sandy shales, with concretionary brown sandstone and yellowish brown earthy shales. The passage from the *Cerithium*-clays into the group (4) is so gradual that I must assume the latter to have been deposited under estuarine conditions near a gradually shallowing sea. Of marine fossils I have found none in the group, but some plant-impressions, mostly fragments only, besides badly preserved fish and crushed crustacean remains are common. Veins and irregular layers of gypsum are found throughout the group, which is well exposed on both sides of the Mathár valley in which the tertiary series forms steep cliffs.

Freshwater series.

Group (4) is overlaid conformably by a series of beds, which all pass gradually from one into the other, and evidently form one structural unit. They are all freshwater deposits, probably of fluviatile origin, and remarkable for the bright deep red, brown or green colours prevailing.

The lowest stratum of this series is a coarse conglomerate which is chiefly made up of rolled debris from the cretaceous limestones cemented together by a red-

[1] Journ. As. Soc. Beng., IX, 1840, p. 1126.

dish calcareous matrix. It is well seen on both sides of the valley and near both ends of it, but perhaps may best be examined north-west of the village of Mathár, on the right side of the stream, where I observed it to rest seemingly conformable on the underlying upper miocene rocks. With this conglomerate and above it are thick beds of densely red coarse sandstones, alternating with a few thin earthy purple layers. The total thickness of this group is very great; at Mathár not less than 800 to 1,000 feet are exposed of it, but in other sections this figure is largely exceeded, and is most probably several thousand feet. The group is of wide-spread extent north of the central Afghan watershed, and may be seen in all sections below the more recent Chúll deposits.

The groups 6, 7, 8, and 9, which form with 5 a structural whole, are, of course, not divided from each other in any defined manner, but pass from one into the other very gradually.

Tertiaries in other localities.

It only remains to trace these groups in other localities.

In the Bamián valley itself the conditions are very similar; in a synclinal of upper cretaceous rocks, an apparently complete series of tertiary rocks is enclosed. I was unable to examine the Bamián section closely, as I was at the time suffering from severe fever, but fortunately Captain Hay (see footnote on preceding page) has given a description of that locality.

Bamián. Complete series.

The only other section where unquestionable lower tertiary rocks crop up is that of the Oxus valley, which presents altogether very interesting features.

Oxus valley. Lower tertiaries.

Conformably on the northern flank of the cretaceous anticlinal, south of Tashkúrghán and Balkh, I found the older tertiary clays and sandstones more or less identical with the groups as described from Mathár, and they pass here also gradually into the bright red and green clays and sandstones of the lower pliocenes.

South of Tashkúrghán

The whole series dips under a gradually lessening angle below the aerial and fluviatile deposits of the Oxus plains to crop up again at their northern margin. The tertiary series seems strongly developed on the Bokháran side of the valley, but political reasons prevented my visiting the right banks of the great river. Between Kilif and Kham-i-ab the Oxus cuts an outcrop of the tertiaries and luckily exposes some of the marine miocene strata, and perhaps some portion of the group 1 (page 255).

Re-appears on the Oxus.

The cliff above the head-land of the Kilif ferry (Afghan side) is composed of sandstones with alternating shell-limestone, dipping at an angle of about 60° below the blown sands of the great plain which stretches south of the river. The shell limestone contains some *Ostrea*, *Pecten*, and *Bryozoa*, which all bear a strong resemblance to species figured by von Abich from the salt-bearing miocene of north-western Persia.

Kilif. Shell limestone.

This complex of fossiliferous strata rests on irregular beds of white limestone, which forms the cliff west of the Kilif ferry; alternating with it and replacing the limestone laterally are large deposits and irregular masses of gypsum of reddish and black colour. The limestone yielded a few badly preserved fossils.

Limestone with gypsum.

The same gypsum group crops up again some 30 miles further west in the cliffs of Kham-i-ab on the Afghan-Bokháran frontier, where the formation forms a bold scarp facing north and gently dips below the recent deposits of the Chúll south of it. In one of the irregular layers of soft white limestone of Dev-Kala, a prominent hill south of Kham-i-ab, I found a few marine remains (bivalves) which await determination.

Kham-i-ab.

Fossils at Dev-Kala.

I venture to identify this group of rocks on the Oxus with the typical miocene formation of Persia and Armenia, which seems identical with the gypsiferous series of Loftus.

Identification with gypsiferous formation of Persia.

I am told that at the western slopes of the Koh-i-Tan in Bokhára, some 35 to 40 miles north of Khwaja Salar, some good rock-salt occurs in beds similar to the gypsiferous group of Kilif. The rock-salt is mined and largely used by the inhabitants on both sides of the Oxus. It is of a fleshy pink colour.

It remains now to describe the pliocene formations which occupy a very large area in Turkistán.

Pliocene formations in Turkistán.

The Mathár section shows an apparently perfect conformity between all the strata composing the tertiary series; that, however, is not the case everywhere. Not only in the area between Mathár and the Oxus valley, but in all sections westwards of the Balkh-ab, I found the easily recognised bright coloured rocks of the pliocene series resting directly upon strata of the upper cretaceous group, and in most cases with apparent conformity.

After the close of the miocene period the conversion of a great part of the Central Asian sea into wide plains and isolated lake basins was finally accomplished, and the wrinkled and folded surface of marine deposits was gradually covered with a huge thickness of sandstones, clays, and sands during the pliocene and recent epochs.

There is nowhere a marked lithological difference between the pliocene deposits and the recent accumulations of sands and gravels. The passage from the former into the latter is very gradual in most localities.

No marked lithological difference between the pliocene and recent deposits.

The lower beds of the pliocene formations are only seen near the contact with the cretaceous limestones, or where the beds have been sufficiently raised to bring them above the surface, and they therefore show in most cases the characteristics of great fans, accumulations of river gravels, and intercalated beds of sands and clays. The whole lower portion of these deposits is nearly everywhere of a dense brick-red colour, with occasional thin clay bands of bright olive green. This formation seems of a perfectly uniform character over the greater part of Afghanistán and Persia, and underlies everywhere the vast accumulations of blown sand of the Chúll which fringes the Turkistán low-lands.

Occurrence and composition.

The cretaceous limestones formed probably an undulating table-land in pliocene times, in the wide troughs of which the sandstone and gravels of that period were laid down. Subsequent wrinkling of this table-land into the compressed area we see now has also crushed the later tertiary beds into narrow synclinals. This feature can be observed in every case, where the tertiaries and recent formations are exposed.

Pliocene strata deposited prior to the general wrinkling of the Turkistán table-land.

The valley of the Belcheragh-Maimena[1] stream shows this structure exceedingly well. The greater portion of the synclinal along which the stream runs must once have been filled by pliocene gravels, clays, and conglomerates, which in this case were unconformable to the cretaceous limestone anticlinals on both sides of the valley. The force which completed the folding of the Turkistán rocks after the deposition of the pliocene gravels affected the latter also, and the section of these rocks near Katar Kala, between Maimena and Belcheragh shows now a high arch into which the pliocene rocks have been crushed, and which stretches across the synclinal trough of the valley. The present stream has since then worked its way through the great thickness of gravels and sandstone beds, leaving at some points only portions of the latter on each side of the valley. They seem now to dip below the cretaceous limestone at several points owing to the partial inversion the strata of the latter have suffered in folding.

Crushing of the pliocene deposits near Katar Kala.

The best exposures of the pliocene group may be seen along the northern margin of the Turkistán high-lands, *i.e.*, along the north slope of the last anticlinal. Densely red grits, conglomerates, and clays may be traced uninterruptedly from the western corner of the Tirband, near Bala-Murgháb, to Tashkúrghán in Afghan-Turkistán. The coarser deposits (old fans) of the group rest usually conformably on the cretaceous limestone below, and with the latter they have now been highly raised, and in some cases been bent vertically. Northwards the dip gradually lessens and apparently becomes nearly horizontal.

The northern margin of the Turkistán hills.

There seems to be no great lithological difference between the pliocene accumulations and the more recent deposits, and I believe the passage from one into the other is very gradual. The greaterpart of the recent accumulations are of aerial origin,and consist of unstratified loess deposits. I noticed similar masses of loess within the pliocene group, and I believe therefore that the physical conditions of this part of Central Asia have not changed materially since the close of the miocene times.

Physical conditions of Turkistán much the same since pliocene times.

Some of the smaller and isolated areas of pliocene deposits within the great synclinals of Turkistán have probably been laid down in lake basins and river valleys, and so no doubt were some of the lower parts of the pliocene gravels and conglomerates near the northern edge of the high-lands, where the drainage from the hills spread over the great plains. But even in pliocene times, as at the present time, the fine dust and sand borne along by the northern air currents used

[1] This name is distinctly written Maimena in Mr. Griesbach's manuscript, but it would seem to denote the same as the equally distinct Maimána of other passages. Available maps of that region do not afford means of correction. The accentuation is defective throughout.—ED.

to meet the river-borne deposits coming from the hills. The sections of the Almar, Maimána, and Astar-ab streams all reveal the same facts: a short distance away from the edge of the hills, unstratified and irregular layers of loess lie between distinctly fluviatile formations, until still further away the former assume larger proportions, and finally the whole assumes the unstratified appearance of typical loess, which forms the wide Chúll north of Afghan-Turkistán.

Had I only observed the red grits and clays of the pliocene along the southern boundary of the Chúll, I would most probably have looked upon them as being of more recent origin, but the sections of Mathár and Bamián seem to afford a key to a different interpretation. At all events the lower portion of this huge accumulation of conglomerates, sandstones, and loess must be of pliocene age.

Recent formations.

From the preceding section it will appear that the history of the pliocene epoch has been repeated during later times and is still being enacted at the present moment. There is practically no difference in the lithological character of the deposits of these eras. Now, as in pliocene times, huge fans are spread out at the points where the present rivers enter the open plains and finer deposits are laid down further away from the fans. Air currents, probably little changed in direction since later pliocene times, bring yearly vast quantities of fine dust and sand and spread them over the low-lands of Turkistán, in the thick deposits of which the streams lose themselves with few exceptions. The finer particles of this dust is borne further southwards by the hot-weather winds and so find a last resting-place on the high slopes of the northern anticlinals. North of the provinces of Maimána and Turkistán immense deposits of aerial formations extend—formations which date from pliocene times to the present day. Only the southern margin of these deposits belongs to Afghanistán; the remainder covers the greater part of Central Asia and forms the lower reaches of the Oxus with the Aral and trans-Caspian region.

Here also the separation of coarser sand from finer dust is apparent and produces land of quite different nature. The coarser sand falls to the ground first and composes the great Turkoman deserts. Further south the finer dust produces the steppes of Afghan-Turkistán, known as the Chúll, which is still partly irrigated and under the influence of a larger amount of atmospheric moisture, and hence generally covered with good grass. According to Richthofen's observations, who has studied the aerial formations and steppes of northern China, these last two factors—moisture and vegetation—caused the cementing together and partial change of the air-borne particles of sand and dust and so caused the formation of unstratified loess deposits which cover immense portions of Central Asia.

In connection with the recent formations there are chiefly two features which I will notice here; the first is the fact that the folding process is still active at the present time, and the second feature is the accumulation of vegetable matter in certain areas of the Chúll.

Recent flexures.

The first fact seems proved by two observations: (1), at all the points where the present rivers of Turkistán form high alluvial banks,—and this is the case along their lower reaches in the

plains,—it is plainly seen that the beds composing these deposits have undergone considerable disturbance. Near the northern margin of the high-lands, sands and gravels of the younger alluvial deposits are raised high up, in some cases nearly vertically; further away from the older anticlinals the dip of the recent deposits flattens gradually and forms the plains of Turkistán.

(2.) The valley of the Oxus between Akhcha and Tashkúrghán is formed chiefly by extensive and probably very thick deposits of clays, gravels, and loose sandstone. Near the river, and forming a belt of varying width, thick waves of blown sand cover this base of fluviatile deposits. The latter has been formed by the Oxus with its tributaries, the present Khulm, Balkh-ab, Sar-i-Púl, and Maimána streams. At the present time none of the latter reach the Oxus itself, but lose themselves in, and are diverted by, a great swell in the ground which extends more or less parallel with and north of the edge of the hills, and north of the populated districts of the plains. Though I have not seen any section of this 'rise' or swell in the valley of the Oxus, I believe that it is the beginning of an anticlinal which has formed in comparatively recent times. The Oxus itself is a good illustration of the fact known as De Baers'[1] law, inasmuch as it steadily encroaches on its right banks, at the same time depositing detritus on its left side. The river comes in great sweeps from Badakhshan, diverted certainly here and there by far projecting ranges, but on the whole steadily pressing northwards and so removing material from its right bank. It therefore hugs the hills of Bokhára the whole way. If no other agencies were at work, the river, in its endeavours to transgress on its right banks, would have levelled the cliffs of Kham-i-ab and Kilif, instead of, as appears now, having cut off a corner of the miocene group which forms the Bokháran side. The dip of these miocene strata, not less than the partially raised recent alluvial accumulations near the latter, prove that the gradual bending of the tertiaries of the Oxus basin into an anticlinal is going on at the present time. The river is as it were flowing along the crest of a mountain range now in course of formation. Here denudation keeps pace with folding, and hence the excavation of the river channel between the cliffs of Kilif and Kham-i-ab.

I believe the swell mentioned above to be simply another line along which an anticlinal is forming at the present time. The gradually rising fold being paralle with the direction of the river has aided the exertion of the latter to encroach on its right side and so resulted in the Oxus being gradually forced over the miocene deposits of Kilif, into which the river eroded a channel, whilst the left banks continue to bend into a new flexure.

The lesser eroding power of the former tributaries of the Oxus in Turkistán could not keep pace with the steadily rising area of the new fold, aided by the accumulations of aerial formations which collect mainly along the northern curves of this flexure, and hence the streams have now been cut off from the Oxus and are mostly lost in the Turkistán plain or form irregularly shaped marshes.

The second feature which I observed in connection with the modern deposits of rivers seems to me of considerable importance in illustrating certain conditions under which carbonaceous deposits may have been formed. Afghanistán, especi-

[1] Bull. Acad. St. Petersburg II, 1860.

ally the hilly portion of it, is remarkably poor in vegetation; its hill-sides are all but absolutely devoid of any. Trees are very few and far between, and grass exists only as separate tufts here and there. The lower slopes are generally well clothed with fine grass amongst which thistles and camel-thorn species flourish, and in some places altogether replace the former. The scorching dry winds of the summer soon dry every blade of grass and every single thistle, which after a time are reduced to more or less of a vegetable dust. The dry stalks and scrubby parts of thistles and camel-grass become now the sport of the wind, and it is not uncommon to see them accumulated into the shape of large balls or bundles careering over the dry surface of the hill-sides. Most of the smaller rivulets in the hills become quite dry during that season, and others are reduced to quite small runnels. In the spring, however, when the snow melts and tremendous thunderstorms break in the mountains, every little streamlet changes into a violent torrent, whilst the big rivers become altogether impassable, often for months. At that season the channels of all the hill streams, previously choked with vegetable dust and debris, are thoroughly cleaned out. So are the hill-sides and sloping plains, with the result that all this organic matter, representing more or less the entire vegetable growth of the preceding year, is washed down into the big rivers of Turkistán, which then are in flood. They are then more or less completely covered with a thick coating, a floating mass of vegetable debris, which consists chiefly of powdered and broken-up grass, some fragments of scrubby plants, such as thistles, and only a few broken branches or whole trees.

As I had to cross the principal mountain streams during my tour in the spring of 1886 I was forcibly struck with the fact that in a country so bare of vegetable growth as Afghanistán, every stream during spring-time was nothing but a sewer, in which almost everything that had grown the preceding year was washed down to the plains.

Had Afghanistán a climate more moist, and were the hill-sides covered with forests, the vegetable matter contained in the streams during spring-time would probably be very slight in comparison with what it is now. Grasses and annual plants would decay locally, more or less held together by tree-growths and the moister surface of the soil. As it is, however, the scorching and almost persistent winds which prevail in Afghanistán reduce every blade of grass on the hill-sides into a yellowish brown dust before the hottest days of the summer are over.

I was especially struck with this during last spring, when I crossed the Balkh-ab by the bridge at Akhkabrúk. A thunderstorm had broken in the hills to the south and the river came down a seething mass of chocolate-coloured liquid. Its surface was covered thickly with vegetable matter, such as I have described above. It was evidently the result of an extensive 'wash' of the whole hill-sides. So matted and thick was the mass of vegetable matter, that I noticed birds being able to alight on it, though it was floating all the time With it, the water holds in suspension a large quantity of mineral matter and brings down large boulders. The noise of the latter as they rattle down with the current is sometimes quite deafening. I observed the latter fact when encamped at Haiback close to the Khulm river. It happened to come down in flood after a terrific thunderstorm, and the noise of the moving stones in its bed

was far exceeding that of the rushing torrent, and I could only liken it to the clash of machinery.

The mineral matter held in suspension falls gradually of course as the river proceeds, and the water will be almost free from such matter near the end of its course, where the river 'runs to earth' in the plain of Turkistán. Not so the vegetable matter floating along. Only a small proportion of it will find a resting place along the banks, as it is constantly again swept away by subsequent floods. Almost the entire sweepings of the hill-sides of the Tirband, of the Hazaraját, and the Turkistán high-lands generally find their way into the rivers and eventually get stranded in the reedy marshes of the Chúll, where in time the vegetable substance must form vast deposits in isolated areas.

Much of the water is used up for artificial irrigation, and with it no doubt a great deal of the vegetable matter helps to manure the lands of Turkistán; but in times before man helped to shape the course of natural events, the accumulations of vegetable deposits in the marshes of the Central Asian plains must have been very large and seems to me to explain the existence of coal-beds in formations which evidently were deposited in an area and epoch poor in vegetable produce, with a flora poor at least in species, if not in actual quantity.

Glacial formations.

There are no glaciers existent at the present time in Afghan-Turkistán. But that such filled some of the high valleys in former days, probably contemporary with the older alluviums, is proved by huge glacial accumulations in several localities which I have visited. Some of them seem so fresh and undisturbed that it is difficult to believe that behind them glaciers do not still exist.

High boulder bed terraces exist in nearly all the valleys, and some of them may be of glacial origin. Particularly well developed I found such in the valley of the Almar stream near Sarakh-dara and on the north slope of the Kara Galli pass south-west of Maimána.

I have however seen unquestionable glacial formations in several localities, as for instance in the valley of the Yakh-dara, west of Faúghan, near Shisha Alang and Chahil, at Karmard and other places.

In the Yakh-dara and at Chahil the deposits may perhaps be best studied. At both places the old glacier has retired, leaving its moraines perfectly undisturbed. At Chahil the valley is still blocked by the old end-moraine which forms a dam of boulders about one mile long right across the valley behind which the basin of the former glacier stretches, bounded on each flank by side-moraines. The floor of this glacial basin is covered with a fine mud, and half of it is occupied now by a deep lake. The drainage escapes through a narrow opening in the centre of the end-moraine.

Summary.

The sections which I examined this year are about midway between the Himalayan, Indian, and the Persian areas, and naturally show certain affinities with these regions.

Comparison with adjoining countries.

It appears probable that nearly all the horizons describ-

ed in this paper are represented in Persia also. With the exception of the formations enclosed between the carboniferous Productus-limestone and the upper jurassic beds, all or most of the horizons of the Hazaraját are also seen in the Himalayan or sub-Himalayan areas.

Eastern Khorassan and the Herat Province.

As might have been conjectured, the likeness between the formations of eastern Khorassan and the Herat Province with Turkistán is striking, and would probably be found still greater, if I had had better opportunities of studying the former last year. The following table will show how the different horizons of these provinces may be correlated :—

Turkistán.	Herat Province.			Khorassan.
Blown sand of Chúll; alluvial deposits.	Alluvial deposits; blown sand of Herat valley and northern Badghis.			Blown sand, north-eastern Khorassan; alluvial deposits; salt-pans.
Upper pliocene and older loess of Chúll.	Loess of Badghis with beds of sandstone and conglomerates.			Loess deposit of lower Jam valley, Nishapur plain, &c.
Lower pliocene of Mathár (plant-beds).	Upper sandstone and plant-beds of Herat valley (Tirpúl beds); north of Shabash, Tirpúl, &c. Red and white clays with freshwater shells of Sakhra in the Murghab valley.			?
Upper miocene (estuarine) of Mathár.	Lower plant-beds of Tirpúl with gypsum. Red clays and grits with *Ostrea multicostata* of Badghis (Nimak-sar and Khwaja Kallandar).			?
Lower miocene of Mathár.				Sandstone with *Ostrea multicostata* Desh., near Khaf.
Eocene of Bajgah, Bamián, &c.	?			Nummulitic limestone with rhyolites, between Nishapur and Madan.
Upper cretaceous of Turkistán.	White chalk with fossils, south of Kila Nao. *Exogyra*-limestone of Darband, south of Bala Murghab.	White limestone with *Inoceramus cripsi* at Zulfikár and Ardewan pass.	Hippuritic limestone of the Doshakh range and Paira. Coral limestone of the Doshakh peak.	White chalk of Kelat-i-Nadri and Zorabad. *Inoceramus*-beds of Zorabad. *Exogyra*-limestone, Takht-i-Gaúzak near Púl-i-Khatun, Kelat-i-Nadri, &c.
Lower cretaceous (Astar-ab, upper Almar stream).	White sandstone and grits with *Ostrea* sp., and plant-remains of the Kashka Kotal. Shell limestone of the Band-i-Baba.	White marls and clay-shales with marine fossils of Zulfikár.		*Trigonia*-beds and shell limestone of the Takht-i-Gauzak; white plant-sandstone of Kelat-i-Nadri.

Turkistán.	Herat Provinces.		Khorassan.	
	Red grits (with volcanic breccia).	Barchut range (Chasma Subz pass, Robat-i-Surkh pass, Ardewan pass, Kurukh, Davendar range, &c.)	Red grits .	Kat-i-Shamshir (S. E. of Máshhád); Madan west of Nishapur; Firaiman S. E. of Máshhád Yaktán range.
urassic group of Astar-ab and north slope of Kara Koh.	Black shales (plant-remains).	Kurukh valley, Robát-i-Surkh pass.	Black shales (with fragments of plants).	Zorabad; Garmab (Kat-i-Shamshir range); west of Takht-i-Gaúzak.
	Brachiopod limestone.	Iaoza.	Limestone and shales (with marine fossils).	Gaukharchang pass (Burj-i-Kalij Khan).
Rhætic? of Shisha Alang.	Brachiopod limestone.	Kholi Biaz east of Herat.	?	
Halobia lommeli group of Chahil, &c.	Plant-shales and sandstone.	Ditto ditto.	Green shales of Yaktán range and Dehrud pass.	
	Green shales .	Ditto ditto.		
Lower trias and anthracite group (permian).	Green plant-shales with coal-seam.	Ditto ditto.	?	
Carboniferous of Ak Robát.	Carboniferous Productus-limestone.	Robát-i-Pai; Doshakh range; Kholi Biaz.	Carboniferous Productus-limestone of Yaktán range, Dehrud pass, &c., &c.	

It will be seen that up to the close of the jurassic group the difference between the lithological characters of the various sections is not great. The carboniferous Productus-limestone was certainly laid down under purely marine conditions. From the close of the carboniferous to upper jurassic times a littoral character prevails in all the deposits from eastern Khorassan to the frontier of Badakshan, and I may conclude that, during permian times, the sea gradually became shallower, even leaving isolated basins and estuaries along the Perso-Turkistán tracts.

While the sea continued to retreat further northwards during jurassic and lower cretaceous times in the eastern portions of Turkistán, other parts of the old coast-line became gradually again submerged and the overlap of the sea reached its maximum extent in upper cretaceous times, when vast tracts of south-eastern Europe, Persia, and Afghanistán with Beluchistán, Sind, and the north-western margin of the Indian continent were covered by an ocean, which was most probably continuous over these areas.

From that time forward eastern Khorassan and Turkistán, and indeed the greater part of Persia, seems to have enjoyed much the same physical conditions. As my work in Khorassan and the Herat province was only of the nature of a reconnaissance, some blanks appear in the foregoing table, where probably whole

groups could be recorded if I had had opportunity of examining certain sections more carefully.

North-western Persia and the Elburz.

The literature which bears on matters relating to Persian geology is very large, but the only connected accounts which we possess, we owe to Abich,[1] Grewingk,[2] Loftus,[3] Blanford,[4] and Tietze,[5] and according to these authors it appears that the geological structure of northern and north-western Persia closely corresponds with that of Afghanistán.

From the upper cretaceous to the youngest formations the resemblance is very strong. The passage from the upper cretaceous into the nummulitics and lower tertiaries is very gradual, as Abich has shown for the north-western Persia. There are also miocene marine deposits, overlaid by great thicknesses of a marine salt and gypsum formation in which densely red rocks predominate, which formation (the gypsiferous group of Loftus) passes upwards into a freshwater group containing plants and mammalian bones, which stratigraphically corresponds with my pliocene freshwater group.

Along the entire Elburz range there appears below the upper cretaceous (hyppuritic) group and the true carboniferous (marine) rocks a great thickness of deposits, which contain in certain localities plant-remains of Gondwana types, and in north-western Persia some marine jurassic fossils in its upper beds. Coal-seams are found in many localities. I think it very probable that this series of deposits represents all the horizons which I found in Turkistán between the carboniferous and the cretaceous group. I hope to find the opportunity at some future time of examining this plant-bearing series of the Elburz and so establish its exact relations with my Turkistán sections.

India and the Himalayas.

Several of the groups of strata which I observed in Turkistán show close relationship to formations found in the Peninsula of India, the Central Himalayas, and Kashmir. All along the northern margin of Persia, through the Herat province and Turkistán, runs a more or less connected line of carboniferous rocks, containing marine remains common in the carboniferous beds of Europe. Formations of more or less identical lithological character and containing the same carboniferous fauna are found all along the Himalayan ranges from Kashmir to the frontier of Nepal. Several of the forms found in Kashmir and in the Perso-Afghan areas are identical, and it appears most probable that during carboniferous

[1] H. von Abich: Vergleichende geognostische Grundzüge der kaukasischen, armenischen und nordpersischen Gebirge. Mem. Acad. Sc. St. Petersb. Vol. VII. 359—536.

H. von Abich, Über das Steinsalz in russ. Armenien; pages 61—150.

Do. Beitr. zur Palæontologie des asiat. Russl.; pages 537—577.

Do. Eine Bergkalkfauna aus der Araxesenge in Armenien. Wien 1878 etc. etc.

[2] Dr. C. Grewingk, Die. geogn. und orogr. Verh. des nördl. Persiens.—Verh. Kais. min. Gesell. St. Petersb. 1853, p. 208.

[3] W. K. Loftus, on the Geology of portions of the Turko-Persian frontier, etc. Quart. Jour. Geol. Soc. 1855. Vol. XI. p. 247.

[4] W. T. Blanford, Eastern Persia. London 1876, pp. 437—506.

[5] Dr. E. Tietze, papers in Jahr. K. K. geol. Reichsanstalt 1875, pp. 129—140; 1877 pp. 1—6, p. 341—430; 1878 p. 169—206; 1879 pp. 565—658; 1881 pp. 67—130.

times these tracts were connected by sea. That connection seems to have continued, partly at least, up to later permian times, for in beds belonging to that epoch on the Araxes are found identically similar forms as in the beds with *Otoceras woodwardi* in the Central Himalayas, which I included in the lower trias at first, with which horizon they are structurally connected.

Whilst purely marine conditions prevailed from carboniferous to tertiary times in the Kashmir and Himalayan areas, the sea began to retreat gradually along the whole Perso-Turkistán line soon after the close of the permian epoch.

No marine beds seem hitherto to have been found in the Elburz lower mesozoic deposits; in Turkistán, however, I found several well-marked triassic and later horizons intercalated between beds of distinctly freshwater or estuarine character. Amongst them I recognized strata with *Monotis salinaria* and *Halobia lommeli*, both good upper triassic (Hallstadt) types. The horizon has been recognized by Stoliczka[1] and Lydekker[2] in the Spiti and Zanskar areas. I found it well represented in the Central Himalayas of Kumaon. In addition to this the Turkistán group contains also some Gondwana types of plants, which probably grew on the triassic land south of the Hazaraját, which may have been connected with the Indian Gondwana continent.

In the jurassic series I have only found one group of deposits which reminded me very strongly of a Himalayan horizon, namely, the Spiti shales. Lithologically the black alum-shales of Khorak-i-Bala and Doab in Turkistán and the Maimána province, no less than similar beds in Khorassan, seem undistinguishable from the Spiti shales, from which, however, they differ in their fossil contents. I found similar shales at the base of the cretaceous group of the Takht-i-Sulimán west of Dera Ismail Khan.

Cretaceous and tertiary.

The tremendous overlap of upper cretaceous deposits with the entire tertiary series of Turkistán seem rather to agree in their broad outlines with similar formations in Beluchistán, Sind, and the north-west frontier than with the Himalayas, with which I have not been able to correlate them.

The upper cretaceous rocks seem to have been laid down in a sea which stretched from the Adriatic to Afghanistán and round the north-western margin of India almost uninterruptedly, for both the lithological characters and the fossil contents of the upper cretaceous group seem very constant over the entire area. With eocene times some changes occurred, for the tertiary deposits of the Perso-Turkistán and Indian seas show some great differences. It may probably be found that the tertiary series of Sind and Beluchistán is perhaps structurally connected with the Perso-Turkistán rocks; there seems at least a similar succession of marine to freshwater series in both these tracts.

Shadian, near Balkh, 1st September 1886.

[1] Memoirs Vol. V. p. 44.

[2] Memoirs Vol. XXII. p. 168.

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