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Section *along the* Indus *from the Peshâwar valley to the Salt-range, by* W. Waagen, Ph.D., F.G.S.[1]

Having just returned from a little trip from Kálabágh up the Lun Valley to Kohat, and from there over the Kotal Pass into the Peshâwar valley, then back over the Meer Kulan, Pallosi, and Sundully Passes to Shadipur and down the Indus to Kálabágh, I hasten to communicate to you some of the results, as far as I am able to point them out here in the field.

[1] The figured section, with the brief description now published, was communicated to Dr. Oldham in the form of a letter some 12 years ago, when Dr. Waagen was attached to the Geological Survey of India. As an accurate representation so far as the scale would admit, of a most inter-

One of the most interesting parts of the whole excursion certainly was the returning road down the Indus, as this exhibited an uninterrupted section from the oldest to the youngest formations of the whole country, and it is principally this section, of which I send you enclosed a drawing, which I intend to describe more accurately.

Starting from Julozai in the valley of the Cabul river, one has to traverse first a rather extensive plain, consisting entirely of debris, mostly of a red sandstone and marl mixed with fragments of black slate and quartzitic sandstone. As soon as one reaches the skirts of the hills down in a little ravine, a yellowish limestone with great masses of greenish flaggy shales and slates below crops out. The slates continue, changing their colour slowly into black, and then mixed with dark, extremely hard quartzitic sandstones. After about 2 or 3 miles marching, down in a deep glen, suddenly a light-coloured limestone appears, as if dipping under the slates, which are exposed to an enormous extent on both sides of the glen. After a short search, nummulites were detected in this limestone, which is, however, not more than about 10 feet in thickness, being then already followed by red sandstones and shales, nearly quite vertical. Though the red colour prevails in these rocks, there are also some thick pale green bands in it, which, however, do not influence the general red aspect of the whole formation. The thickness of this formation is very great, though not so much as that of the slates, and at several horizons in it thin bands of nummulitic limestone are to be met with. The road winds then up out of the bottom of the ravine, and then again nummulitic limestone appears, here nearly horizontal, forming a crest, and apparently lying regularly above the red formation. The nummulitic, however, is lost soon again, and the red sandstones and shales, here locally almost vertical, are the rocks, over which the path winds up further on. Descending into the glen on the other side of the pass, the red formation is replaced by dark shales, in some layers filled with the impressions of fossils, among them very numerous impressions of nummulites. They rest upon thick hard grey limestones, in which nummulites could not be detected, though they may yet belong to this formation. The bungalow lying on the scarp of the glen is built on these limestones. Below them follow first again dark shales, then a light-coloured flaggy limestone, contorted like the Flysch along the northern base of the Alps, then again shales, and then a thick zone of white and light grey quartzites, resting on a formation of greenish or greyish slaty shales of several hundred feet in thickness. No trace of fossils could be detected in all those layers. Below this, grey limestones in thick banks are sticking out, but also here fossils are extremely rare, and no characteristic species was obtainable. Sections of shells are visible on the weathered surfaces, and in some places I saw Entrochi of a little sharp angular Pentacrinite. Under these again a thick mass of brownish coloured slaty

esting section, it is well worthy of record; showing a continuous section of the immense sequence of tertiary rocks lying between the Himalayan elevation and the outlying remnant, now left in the Salt-range, of what were probably the ancient fringing deposits of peninsular India. The interpretation given of some points of the section may perhaps be open to question, but this scarcely interferes with the admirable view presented of the prodigious movements that have affected this enormous accumulation of tertiary strata. The elevation of the Peshawar plain at Attock is only 1,100 feet, and that of Kálabágh about 700.—H. B. M.

shales is lying, with lenticular portions of a beautiful oolitic grey limestone in it, then, just above the village follow white lithographic limestones without any fossils, then again slaty shales.

After having crossed the valley of a little river the way again ascends to the Pallosi and Sundully Passes, which both in reality form only one Pass, crossing the range of mountains of which the Niláb Gash is the highest point in British territory. On the north foot of the hills, yellow marly limestones, dipping at a low angle to the north, and containing casts of a large Lucina and some Gasteropods appear, then follow compact nummulitic limestones in great thickness, dipping here to the south, but further on much contorted. In fact the whole range chiefly consists of these limestones, and only in the deeper cuttings of valleys or ravines, older formations appear. So, looking down from the height of the Sundully Pass, a rather thick system of limestones, sandstones, and shales, on the whole of a brownish-yellow aspect, is observable. We were prevented by rain and the short daytime from going down and examining the beds closer. But from fragments found before in the river, and from the beds observed by Mr. Wynne at another locality, it seems that cretaceous and jurassic, certainly mesozoic, deposits are here represented. On the other side of the valley nothing of those formations is observable, but instead of that a red band runs along the foot of the steep scarp of the nummulitic limestone.

The southern slope of the range is very steep, and the first descent is entirely occupied by nummulitic limestone; then there is a sudden change in colour, and the whole country appears as if looked at through a red glass. In the beginning just at the foot of the hills, between the purplish-red layers, a few bands of yellow marly nummulitics are still observable, but they are only few in number and very thin. Further on purplish-red sandstones and marls compose exclusively the rocks along the road, only sometimes there appears a greenish zone; the layers are fearfully contorted and dipping in every direction. A short distance before reaching Shadipur the red colour is lost again, thick soft grey sandstones here cropping out, only seldom interrupted by a purplish marl band.

At Shadipur I took a boat, and during four days going down the river I observed the following section. At Shadipur the grey sandstones appear along the river bank, dipping to the south, then the purplish-red series comes in again inexpressibly contorted, and two or three miles further down a band of nummulitic limestone, with vertical bedding, crosses the river. Behind this a little valley, filled up with unconformable conglomerate, comes down to the river, and conceals the junction between the nummulitics and the next series, the same grey sandstone with a few purplish marl zones, upon which Shadipur is built. The layers, however, are here nearly all vertical, sometimes inclined a little to one or the other side. This again lasts for several miles, the contortions become less strong and so better visible; suddenly thick marly layers of a red colour appear, mixed with rather thin beds of grey sandstone. To mention all the contortions of these and all the following layers is utterly impossible, and I can in this respect only refer to the drawing, which I have made after nature, and which may give a general idea of the features of stratification. A comparatively short distance further on, the red marls and grey sandstones are checked by a fault against a

very extensive series of purplish marls with subordinate but often very thick grey sandstones, about in the middle of which Kushialgurh is built on a sandstone reef.

This purple series lasts yet for a long distance below Kushialgurh, but then it finishes at a little valley which comes down to the river, on the other side of which suddenly red marls appear, dipping under a rather low angle to the south. The sandstones between these marls are grey, as elsewhere in the Indus section. The colour of the marls, going further down the river, rapidly changes into brick-red, and near the rapid at Kasab the red colour is most striking. A short distance below Pres, the river turns to west 30° south and runs for about 6 miles in a beautiful channel nearly in the strike of the beds, which is with a very remarkable constancy from Shadipur down to Mirzapur at the mouth of the Sohán river, west 20° south —east 20° north. The river flows for a very long way through the red series, only at the short turn before arriving at the last rapid, the colour of the marls changes suddenly into orange and green, and then follows a very thick pale yellowish-grey sandstone in enormously thick beds, only rarely interrupted by orange marls. In the upper region the sandstone contains layers of conglomerate, consisting of pebbles of beautiful crystalline, metamorphic or eruptive rocks. The conglomerate beds become more and more numerous, and at last the rock changes into a very extensive mass of conglomerates, in which limestone pebbles are nearly entirely unknown.

Further on the thick sandstone, which I shall call Dungote Sandstone, after the Dungote Hill, which is entirely formed of it, comes out again, and below it the orange series, both dipping to the north, then a short span of very contorted orange beds, and then again the conglomerates, faulted against the former. The bedding now quickly changes to nearly horizontal, about Makhud. Below Makhud the Dungote sandstone comes a third time above the level of the river, sometimes containing a bed of conglomerate, the decomposition of which has covered the whole country with a rather thick sheet of perfectly rounded pebbles of crystalline rocks.

Coming near the mouth of the Sohán river in the vicinity of the hill tract in connection with the Salt-range, the stratification of the rocks is again disturbed, the layers are turned up, dipping to the north, and the orange series appears below the Dungote sandstone in a broad zone. A fault just below Dungote Hill brings the sandstone again down to the level of the river; a little further on, after several faults, the orange series forms the sides of the cutting the river has made through the hills, down to the Lun river valley. Below this, the rock-salt, gypsum, and red marl of the Kálabágh and Mari hills form the river bank. In the Kálabágh hill a part of the orange series lies unconformable upon the salt and gypsum, and above this again unconformably a thick conglomerate, consisting nearly exclusively of calcareous pebbles. Kálabágh itself stands upon highly tilted layers of sandstone with conglomerates of crystalline pebbles.

Such is in rough outline what I have seen. The more difficult task, however, is to arrange all the divisions I have distinguished into a chronological scale, and to discuss their relations to each other. I begin with the undoubtedly youngest of them: the

(1) Unconformable Conglomerate. This formation is spread over the whole Rawal Pindi plateau in more or less extensive patches, and I have marked it in the section at several points: at Kálabágh, below Res, below and above Kushialgurh, and below Shadipur. It nearly always consists chiefly of calcareous pebbles. It has partaken in the disturbances of the older beds, so far as I know, only at Kálabágh, where it is erected vertically in some places. Of about the same age, or a little older, may be certain clayey sands of a white or yellowish colour, which I have marked below Kushialgurh.

Undoubtedly older than No. 1, but following immediately below it in the scale of our section, is the

(2) Conformable Conglomerate. This formation shows the best development in the hills above Makhud, where it is exposed to an enormous extent all along the river. It appears again near Makhud itself, but nowhere again to the south or to the north. It is chiefly consisting of crystalline pebbles, and is intimately connected with the underlying sandstone, is disturbed entirely in the same way as this, and actually passes down into

(3) Dungote Sandstone. A pale yellowish-grey more or less soft sandstone of about 2,000 feet in thickness, alternating commonly with layers of conglomerate in the upper and orange marl beds in the lower part. A part of the hills above Makhud and the greater part of the Dungote hill range is formed by this sandstone; its most extensive development is, however, further west from the Indus.

(4) Orange Series. There is a perfect transition from the sandstone above into this series. The principal rocks are grey sandstones interstratified with partly very thick beds of often very bright orange and grey coloured marls. This series is found resting unconformable upon the rock-salt and gypsum at Kálabágh; all the hills between the Dungote ridge and the Lun valley consist of it; it appears north of the Dungote hill, and north and south of the hill range above Makhud: everywhere in intimate connection with the Dungote sandstone. The thickness of this series is only in some parts considerable.

(5) Red Series. By alternation of red with orange beds, the series before described passes into this. The marls are here very much prevailing over the sandstones, and of a bright brick-red colour. In our section this series is only represented north of the conglomerate hills near Res and Kasab, and for a short distance between Kushialgurh and Shadipur. At the latter place it passes down into the

(6) Grey Sandstone Series, consisting of thick grey sandstones with rare marl beds of grey and purple colour. This series occurs at Shadipur, and to a greater extent below this village. Its relations to the next bed are nowhere sufficiently clear to determine from a stratigraphical point of view the age of this series, but as in the next division already nummulites occur, there is no doubt that it must be older than all the rocks as yet mentioned, and one can therefore safely suppose that the grey sandstone with purple marls passes down into the

(7) Purple and Murree Series. I put these two series down together, though their appearance is not entirely identical, as both series contain in small bands nummulitic limestone. Their chief difference consists in the sandstones, which are in the former grey, in the latter purple. The purple series as developed in

the country round Kushialgurh shows no nummulitic band; but in the direct strike of the beds, in the vicinity of Goorgoorlot Sir, I collected a great quantity of nummulites in them. The Murree series with purple sandstones is developed north and south of Shadipur, and in the centre of the Mir Kulán Pass. The stratigraphical relations of this series to the nummulitic limestone are extremely difficult: its layers stand vertical at the side of nummulitic limestone south of Shadipur; they seem to dip under the latter at Sundully Pass, and lie above the oldest nummulitics on the Mir Kulán Pass. That their position is certainly not below the great mass of compact nummulitic limestone is shown clearly by the Pallosi Pass, where the limestone lies immediately above the mesozoics without the Murree series between. It is therefore for me no doubt that the Purple and Murree series are the youngest nummulitics passing up without interruption into younger tertiary and diluvial deposits.

(8) Nummulitic Limestone. Developed to a great extent in the Niláb Gash range, the southern part of which is pushed over the Murree series in a very similar manner as the Alpine limestone is pushed over the Flysch along the northern foot of the Alps. The lowest division of the nummulitics consists of brown shales, which are exposed at the Mir Kulán Pass. In this latter range the lower nummulitic limestone (above the shales) does not come into the section, but is well developed further to the west.

(9) Mesozoic. The rocks and whole development of these formations is so strange in this country, that I must abolish for the present any attempt to go into particulars about them. That those beds are mesozoic is not doubtful, as the want of nummulites and the fragments of belemnites in fallen pebbles in the Pallosi pass very strongly indicate.

(10) Attock Slates. As neither fossils are found, nor do the stratigraphical relations reveal anything, I am utterly at a loss as to the determination of their age. About the age of the last formation, the

(11) Rock Salt, I shall report another time.

SKETCH SECTION FROM JULOZAI IN THE CABUL RIVER VALLEY TO SHADIPUR AND FROM THERE ALONG THE INDUS TO KALABAGH