PROGRESS REPORT

ON THE WORK OF THE

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DURING 1940.

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PROGRESS REPORT
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GOVERNMENT OF INDIA'S COAL SURVEY PARTY IN AFGHANISTAN
DURING 1940.

BY

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Officiating Superintending Geologist,

Geological Survey of India.

M-23

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1. INTRODUCTION.

History of the Investigation.

In 1936 Dr. C. S. Fox, then Superintending Geologist, Geological Survey of India, was deputed by the Government of India to advise with regard to the opening up of coal mines in certain places in Afghanistan. After visiting a number of localities, including Lataband, Faragard, Ishpushta and Shisha Walang, he wrote a report in which he emphasised that no extensive deposits of good workable coal were likely to be found south of the Hindu Kush, but that in Northern Afghanistan there occurred an extensive coal-bearing formation with thick seams of coal, which, however, were mostly so crushed and disturbed as to be unworkable. He emphasised that it was not sufficient to visit isolated areas, but that it was desirable to carry out a systematic geological survey of this northern area. "By so doing," he wrote, "it will be possible to trace the coal measures clearly and, I have little doubt, locate some area where the conditions for working are relatively attractive". He recommended that the tract of country including the regions of Darra Yusuf, Haibak, Kahmard and Saighan, should be surveyed, the work being spread over three working seasons of 6 months each, during which it was hoped that a promising area might be found, suitable for detailed examination by large scale mapping and boring.

It was as a consequence of this report that in the autumn of 1939 the Government of Afghanistan decided to accept the offer of the Government of India to carry out a survey of the coal-bearing regions of northern Afghanistan, and I was deputed to take charge of the investigation. My original orders were not defined very precisely, so as to allow of latitude as work proceeded. But it was explained to me that the objective of the party was to discover accessible and workable coal deposits, preferably at Ishpushta, in sufficient quantity so as to yield 25,000 tons annually for 100 years; and that the actual development of the mines and the exploitation of the coal was outside the scope of the investigation.

For this purpose I was provided with a mapping party from the Survey of India consisting of a Triangulator (Mr. Chiragh Shah, who was in charge), three Surveyors (Sr. Monawar Khan, Sr. Abdul Rahman and Sr.Mohammed Sadiq), and a small staff of Indian Khalasis. Twelve Afghans were also recruited from Ghorband to work as additional Khalasis. In addition, a hand-driven rotary calyx drill, capable of boring to about 400 feet, made by Ingersoll-Rand, was purchased (and later supplemented by a second drill), and a drilling party consisting of a Drilling Superintendent (Mr. N. Mariano), a Boring Mistri and six Boring Khalasis, were recruited from the Bihar coalfields. Thus

a comprehensive party, consisting of a Geologist (myself), a topographical mapping party, and a drilling party, was provided for the investigation.

As Ishpushta was considered to be a promising area, and as moreover it was within two miles of the main road from Kabul to Mazar-i-Sharif, work was begun in this area to ascertain if it could possibly provide all the coal required. It was already known that the coal here was crushed almost to powder, but the Government of Afghanistan had made provision to overcome this disadvantage by ordering two briquetting machines from England, by which the powdery coal could be compressed into briquettes.

It was decided in the first place to make a topographical map of the coal-bearing measures in the country extending from Doab Mekh-i-Zarin to Tala, on the north side of the Surkhab river, on the scale of 1:25,000 (approximately 2½ inches to one mile). This map was to act as a foundation for the elucidation of the general geological structure by geological mapping, and was regarded as an essential prerequisite for the work to be done. Mr. D.R.Crone, Superintendent, Survey of India, came up to Ishpushta for a few days, and inaugurated the work of the mapping party.

After I had been at Ishpushta for a week or two, it became apparent that so far from the coal outcrops known to occur here being part of a continuous seam, they were

in fact isolated lenticles or lenses of coal, separated from one another by carbonaceous shale. Moreover, it was found that the coal lenses, though fairly thick in places, were very irregular in shape and continuity, and must have an average thickness which was not likely to yield any great volume of coal, and would moreover be difficult to mine except with great care and at considerable expense. It became, in fact, quite obvious at the end of the first month's work that the Ishpushta area could never provide the total quantity of coal required. It therefore seemed desirable that, while the work then taken in hand at Ishpushta was going on, I should visit other coal-measure areas, in the hopes of finding an area that showed promise of providing the minimum requirement of 2½ million tons of coal.

At this time H.E. Mr. Rahimullah Khan, the Minister of Mines, paid a visit to Ishpushta, and urged that, in spite of the Ishpushta area having so far afforded disappointing results, work should be concentrated in this area for the whole of this season, to ascertain once and for all how much coal there really was in this area, before proceeding to examine other areas. The main reasons for this were the proximity of the coal at Ishpushta to the main road, and the desirability of showing early results. As my orders had been to discover an area that would

produce 2½ million tons of coal, and as I had a limited time (three seasons) in which not only to find such an area but also to prove it, I referred the matter to Dr. Fox, now Director of the Geological Survey of India, who discussed the position with the Government of India. After a further discussion with H.E. the Minister of Mines in Kabul, in which H. E. the British Minister also took part, it was decided, with the approval of the Government of India, to modify temporarily the main purpose of our investigation, and to concentrate the whole party at Ishpushta for this season.

Work accomplished during the season.

During the season, the mapping of the area on the scale of 1:25,000 (an area of about 60 square miles) was completed, with the exception of a small area between Tala and the Darra Ashraf. In addition, large scale plans of each of the six main coal lenses on the scale of 1:1,000, and a map of the area embracing the coal lenses on the scale of 1:10,000, were completed. At the same time, Mr. Chiragh Shah carried out a preliminary triangulation of the area to the north of Ishpushta, from Shisha Walang to Doab-i-Rui, as a foundation for next season's more detailed mapping; and a sketch map, covering his observations in this area, was prepared on the scale 1:250,000. A more detailed note regarding the work of the mapping party has been written by Mr. D. R. Crone, and is given at the end of this report.

As the work of the mapping party progressed, I was able to take up the geological mapping of the area, and completed the mapping of the Doab Mekh-i-Zarin - Barfaq area, and of the individual coal lenses on the large scale 1:1,000 plans. The results of this work are given in the geological maps accompanying this report. At the same time the coal lenses were examined in detail, and the thickness of the seams determined after cleaning the outcrops, and samples of coal taken from analysis. In addition, I was able to pay a flying visit up the Kahmard valley to Hajar, and over the Kara Kotal to Aokhorak and the upper part of the Chel valley.

The first drilling machine was installed in a suitable place above coal lens No.3, and the second at Barfaq to bore to lens No.6. A second boring was later put down to lens No.3. The many difficulties that were encountered in drilling are given in greater detail later in this report. It is sufficient to state here that although each of the three borings reached depths of between 200 and 250 feet, the results were indecisive, and this method of proving the coal seams had to be abandoned at the end of the season.

Thus, although it was not possible by the end of the first season to arrive at any estimate of the reserves of coal in the Ishpushta area, a good deal of useful work was completed in the mapping and in the geological investigation,

which will form a sound basis for next year's work, when it is hoped to explore the coal lenses at Ishpushta by different methods. At the same time the mapping and geological examination of more promising areas elsewhere will be taken up.

Acknowledgements.

In concluding this introductory section, I should like to take the opportunity of thanking His Excellency Mr. Rahimullah Khan, now Minister of Mines and Public Works, for the interest he has taken in the work of the party, and for the arrangements he has made for our welfare and comfort. The future prosperity and development of Afghanistan depends so much upon an adequate supply of coal, that it is hoped that the work that we are doing will be to the ultimate advantage of the country; and the friendly cooperation and mutual confidence that was felt by both sides should contribute to the furthering of this end.

I must also particularly thank Lt.Col. Sir Kerr Fraser Tytler, K.B.E., C.M.G., M.C., His Britannic Majesty's Envoy Extraordinary and Minister Plenipotentiary at the Court of Afghanistan, for the help and guidance that he has given to me throughout the year, and for his generous hospitality; while Major R.G. Alban and Capt. P.C.Hailey, successive Counsellors in the British Legation, have been most helpful

2. GENERAL ACCOUNT OF THE GEOLOGY OF THE AREA.

We are indebted in the main for our knowledge of the geology of Northern Afghanistan to C.L.Griesbach, who worked there between the years 1880 and 1888[1]; and to Sir Henry Hayden, who carried out a tour through the Ghorband valley, and over the Shibar pass to Bamian, Saighan and Kahmard, during the year 1906[2]. As far as the area dealt with in this report is concerned, Hayden's memoir, published in 1911, summarises all that was known up to that time. Mention should also be made of a confidential report written by Hayden in 1907 dealing with the mineral resources of the country, with special reference to the coal occurrences.

Subsequently nothing new appears to have been published relating to this area until Dr. C.S.Fox visited the country in 1936, and spent two months examining the chief coal occurrences. Perhaps the chief value of the confidential report which he wrote, from the present point of view, was the fact that he drew the attention of the Afghan Government to the coal seams originally discovered by Griesbach in Darra Yusuf, and which he was able to

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[1] C.L.Griesbach, Rec. Geol. Surv. Ind., XVIII, p.57,(1885); Idem, XIX, p.48, (1886); Idem, XIX, p.235, (1886); Idem, XX, p.17, (1887); XX, p.93, (1887).

[2] H.H.Hayden, Mem. Geol. Surv. Ind., XXXIX, Pt.1, (1911).

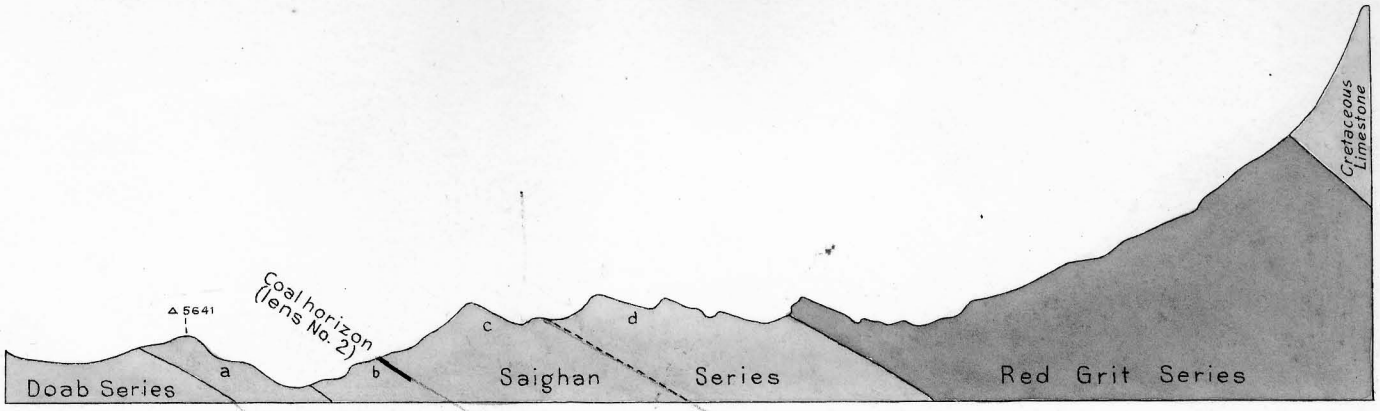
relocate; and to the emphasis that he laid on the probability of this area providing the main coal requirements of the Afghan Government, and to its being worth detailed investigation. It was, in fact, as a result of this report that the present investigation was initiated.

The Geological Structure.

The geology of the country around Ishpushta, that is between Doab Mekh-i-Zarin on the west and Barfaq on the east, to the north of the Darra Surkhab, is comparatively simple. Along the southern side of this belt there occurs the Doab series, of supposed Triassic age, which is overlain, with a marked unconformity, by the Saighan series, the coal-bearing Jurassic rocks. These latter pass up conformably into the Red Grit series and the massive Cretaceous limestone, both these latter being regarded by Hayden as Cretaceous in age.

The general strike of the rocks of this area is in the direction N.E.-S.W., the direction followed by the Darra Surkhab. The dip of the rocks above the Doab series is almost uniformly to the north-west. There are of course slight variations from this direction.

These four main rock groups - the Doab series, the Saighan series, the Red Grit series and the Cretaceous limestone - all give rise to strikingly different scenery.

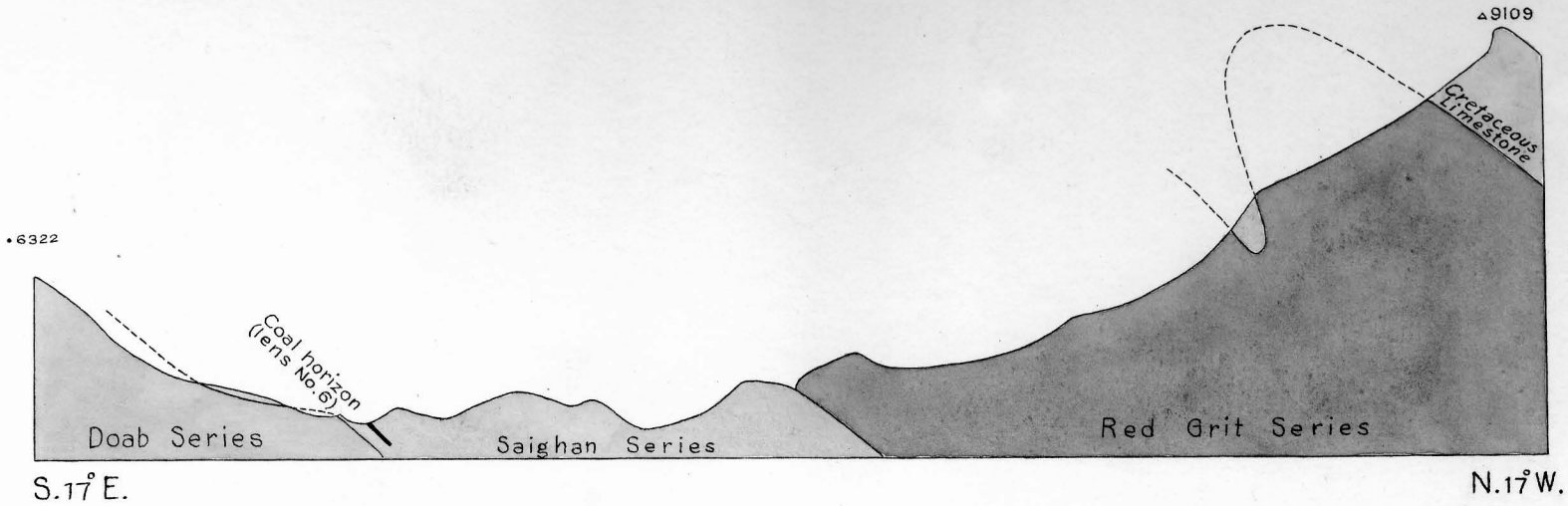


Section across the strike, west of the Darra Ishpushta.

Scale, horizontal and vertical,=1:25,000.

W. D. W.

Fig. 1.



Section across the strike, east of the Darra Ishpushta.

Scale, horizontal and vertical,= 1:25,000.

W. D. W.

Fig. 2.

The Doab series are monotonously drab and gloomy in colouring, while they often appear to be quite structureless; the Saighan series are notable for the variegated colour they display, and for the well-bedded character of the component rocks; the Red Grit series, as their name denotes, are bright red and give rise to very steep cliffs almost entirely devoid of vegetation; while the highest rock of all, the massive, cream-coloured Cretaceous limestone, occurs as a mantle over a great part of the area to the north, and forms unscaleable vertical cliffs above the Red Grits. These last two rock groups, the Red Grits and the Cretaceous limestone, are responsible for the remarkable southward-facing escarpments, which stand out like giant bastions along the north side of the Kahmard and Surkhab valleys.

The whole succession of rocks, referred to above, is shown in the photograph forming plate 2, which is a general view of the west side of the Ishpushta valley. On the extreme left comes the top of the Doab series, the highest bed of which is a bright red rock, shown as a dark line in the photograph. The greater part of the view, however, is formed of the Saighan series, while to the right come the Red Grits overlain by the Cretaceous limestone forming the topmost precipice. In plate 1 more of the Doab series are seen on the left of the picture.

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The remarkable escarpments of the Red Grits and Cretaceous limestone above Barfaq are shown in plate 5, while in the foreground of this picture is a small hill of the Doab series, cut by two vertical dykes of quartz-porphyry.

The general succession of rocks is shown in the vertical section given in figure 1, which is drawn to true scale (1:25,000) across the strike of the area, through coal lens No.2, as viewed from the east, the line of the section being S.40°E.-N.40°W.

The angle of dip of the rocks above the Doab series in the vicinity of Ishpushta varies between 18°and 40°, but is for the most part between 27°and 35°. The direction of dip is generally about N. 35°W. The direction of angle of dip are shown in a number of places on the geologically coloured maps.

In the view up the Darra Ishpushta, the Red Grits and the Cretaceous limestone forming the cliffs of the main escarpment appear to be horizontally bedded. This, however, is because the view is almost exactly in the direction of the dip. In reality these rocks also partake of the general north-westerly dip of about 30°.

A Line of Dislocation.

Although the geological structure of this area is thus seen to be comparatively simple, there is one line of dislocation traversing the area which is important, and must be

referred to.

To the N.N.E. of Ishpushta there is seen a prominent peak, shown on the map as 'Seoch', with a height of 9109 feet. It is formed of the Cretaceous limestone, and is underlain normally by the Red Grits. These Red Grits, however, are themselves underlain by more Cretaceous limestone, which forms the ridge .8023 and .7911 (Surkh Kamar), while below come again more Red Grits, underlain by the main outcrop of the Saighan series. Examination of this area by geological mapping shows that this repetition of the Cretaceous limestone and Red Grits is due to a large recumbent fold, whereby the Cretaceous limestone recurs as a syncline overfolded to the S.S.E. The structure is shown in the section forming figure 2, which is a vertical section drawn to true scale (1:25,000), extending from the peak 'Seoch' in the north to the hill .6322 in the south, as viewed from the east, the direction of the line of section being about N.17°W.-S.17°E. On the geological map this lower outcrop of Cretaceous limestone is seen as an elongated outcrop surrounded on all sides by the Red Grits. On plate 9 are given two photographs of this mountain. The upper one shows the south face of the mountain, while the lower one is taken from the west, and shows clearly the overfolded syncline of the Cretaceous limestone.

A second overfolded, but much smaller, outcrop of the

Cretaceous limestone is seen further west by .6464.

Further west still, on the west side of the Darra Ishpushta, it will be found that the overfold has been replaced by a thrust fault, thus :-

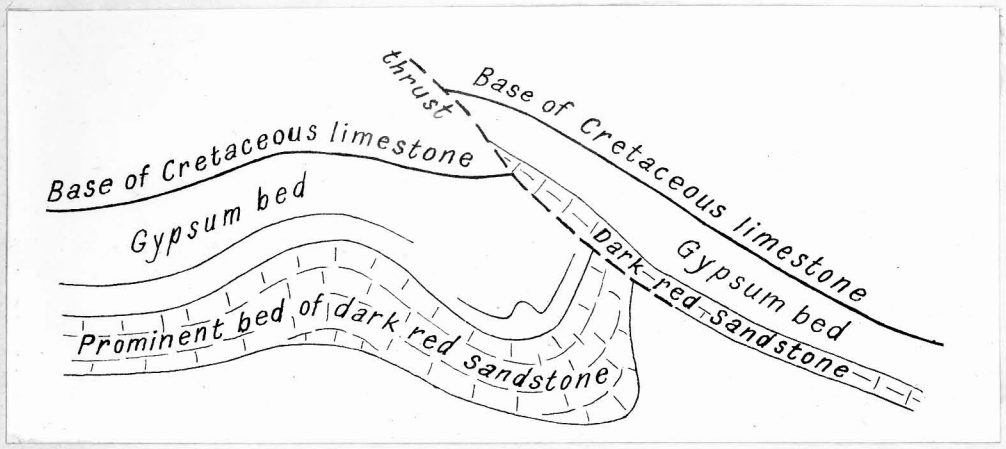


Fig.3.- Section seen in the cliffs on the west side of the Darra Ishpushta.

The lower photograph of plate 10 shows this thrust fault.

On the same line further west, a clear cut thrust fault is seen in the precipitous cliffs forming the west side of the Jar Karimak, whereby the beds to the north have been thrust over the beds to the south, thus:-

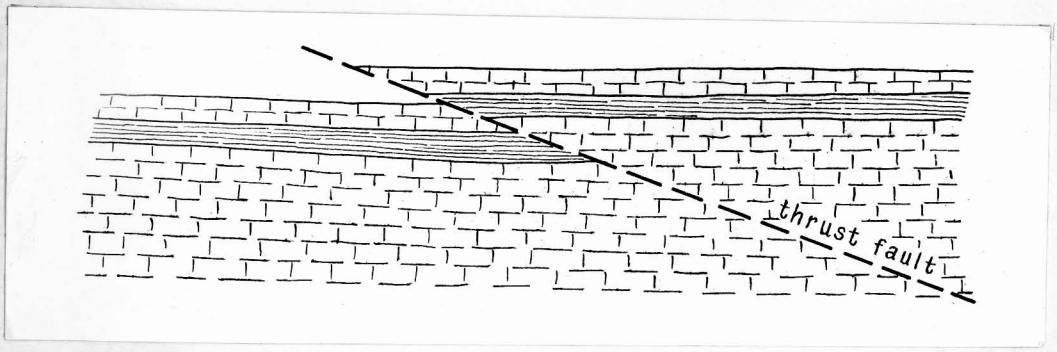


Fig.4.- Section seen in the cliffs on the west side of the Jar Karimak.

This structure is shown in the upper photograph of plate 10.

Returning once more to the main overfold of Cretaceous limestone forming the southern slopes of the mountain 'Seoch', to the east the Saighan series appear in the centre of the anticline of Red Grits, at first as a thin band and later opening out into a rather wide outcrop. The mapping of this outcrop was rendered difficult by the occurrence of thick screes and gravel terraces which obscure the underlying rocks, and the boundaries on the geological map are somewhat speculative. This outcrop of the Saighan series spreads out to the east as a thin covering overlying the flat-topped hill known as Surkh Kamar, which overlooks Barfaq. An additional thrust has developed here, for these Saighan beds rest directly (in inverted order) on top of the Cretaceous limestone, with no Red Grits between. To make this clear a diagrammatic plan of the area is given below:-

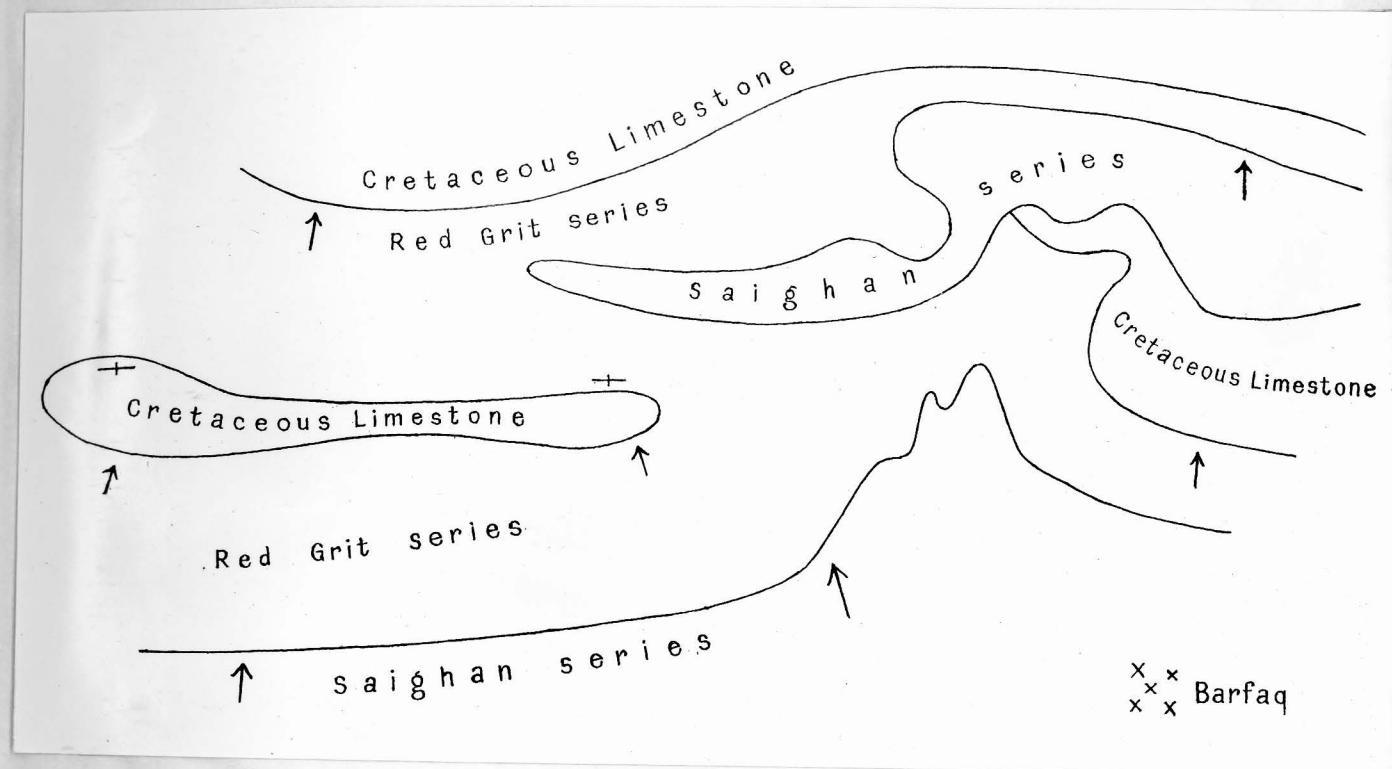


Fig. 5.- Diagrammatic geological plan of the area between the Darra Ishpushta and Barfaq.

The following is a vertical section from N.E. to S.W. across the eastern end of the plan given in figure 5 , and shows the repetition of the beds due to thrusting. There are other complications, but these will be described next year, after the mapping has been completed.

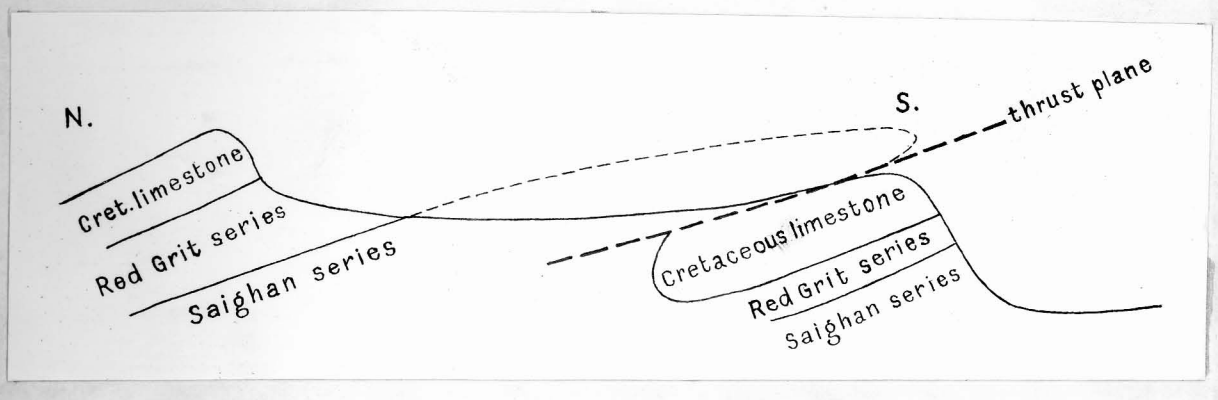


Fig.6.- Vertical Section across the east end of figure 5.

This is as far east as the geological mapping has so far been done.

The importance of this zone of dislocation is that it suggests a reason for the intense crushing to which the coal seams have been subjected.

The Doab - Saighan Unconformity.

It was mentioned above that while the Saighan series, the Red Grits and the Cretaceous limestone lie perfectly conformably one upon the other, the Saighan series rest with marked unconformity upon the Doab series. This unconformity is apparent almost everywhere along the junction of the two series, but is very strikingly seen in some places. On plate 7 are given two photographs showing the unconformity very clearly. The upper photograph is a view of the west

side of the Qol Hotapurak, about two miles north-east of Doab Mekh-i-Zarin. It shows the Doab series on the left, dipping E. by S., with the Saighan series on the right dipping N. by W. The line of unconformity is clearly seen. The lower photograph is a close view of an even clearer example. It shows the junction between the two series at a place about 1¼ miles south-west of Ishpushta camp, north of .5576. Nearly horizontal beds of the Saighan series are seen above, resting unconformably on steeply dipping beds of the Doab series below. The soldier is standing on the junction.

As already stated, the unconformity can be seen almost everywhere along the boundary. For example, by coal lens No.6, it is seen just below the path at the western end of the lens, the brown Saighan beds resting unconformably on the pale, almost white Doab beds. Frequently the Doab series are seen to have very variable directions of dip, while the overlying Saighan series have a very uniform dip. This will be seen in a number of places on the geological map, where the dip arrows on either side of the boundary between the two series are seen to be variable in the case of the Doab series, and fairly constant in the case of the Saighan series. Particular reference may be made to the boundary where it runs north of Doab Mekh-i-Zarin.

It is clear that the Doab series must have been considerably tilted and folded before the Saighan series were laid down upon them.

Igneous Activity confined to the Doab Series.

This unconformity, which must represent a considerable interval of time, is also shown in another way. The Doab series are characterised by being full of sills and dykes of igneous rock which in the case of the dykes, cut right across the strata. But where these dykes extend up to the junction of the two series, they are invariably seen to stop abruptly at the junction, and never penetrate the overlying Saighan series. As examples may be mentioned several dykes of quartz-porphyry in the Doab series, close to the eastern end of coal lens No.6; and a dyke of quartz-porphyry which crosses the path from Ishpushta to the Jar Karimak, just over half a mile south-west of the Kotal-i-Sabzak, cutting the Doab series but stopping abruptly against the overlying Saighan series. This phenomenon may be shown diagrammatically thus :-

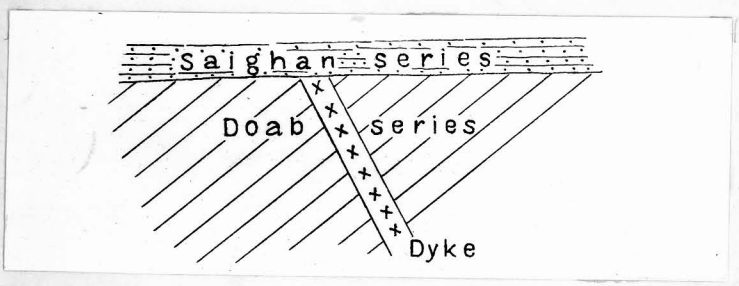


Fig.7.- Diagrammatic vertical section showing a dyke in the Doab series ending at the base of the Saighan series.

Weathering of the top of the Doab series.

One more point should be referred to with regard to the unconformity. The Doab series must have undergone considerable denudation prior to the deposition of the Saighan series, and a characteristic feature of the highest beds of the Doab series is the presence of white and red beds which appear to represent a zone of weathering on the old (?land) surface of those times. These brightly coloured beds are seen at many places at the top of the Doab series, and particular mention may be made of their occurrence in the cliffs on the west side of the Darra Ishpushta, just south of the Ishpushta camp, from where they are clearly seen. Their formation appears to be quite independent of the nature of the topmost Doab rocks, affecting, for example, the intrusions of quartz-porphyry as well as the sedimentary rocks; and sometimes, for example on the west side of the Qol Hotapurak, the zone of colouring, while being parallel to the plane of junction of the two series, cuts across the bedding of the rocks of the Doab series.

This phenomenon has been described at some length, because Hayden was of the opinion that these lightly coloured beds belonged to the base of the Saighan series. This lead him to make the mistake of concluding that the period of igneous intrusion extended up into the base of the Saighan series, for dykes of quartz-porphyry are seen intruded into

these lightly coloured beds. Hayden, however, did not fully recognise the presence of this important unconformity. Had he done so, he would have found that the lightly coloured beds invariably occur below the unconformity, and belong to the Doab series. No igneous rock has anywhere been seen by me penetrating the Saighan series, and it is quite clear that the period of their intrusion was prior to the deposition of the Saighan series.

The Overlap of the Saighan series upon the Doab series.

Not only does there exist this pronounced unconformity between the Doab and Saighan series, but the mapping of the base of the Saighan series across the whole area has revealed that in a north-easterly direction from Ishpushta the lower beds of the Saighan series gradually die out, and the rocks forming the middle part of the Saighan series come to rest upon the Doab series. This phenomenon is perhaps most easily understood from a consideration of the position of the main coal horizon with reference to the top of the Doab series. This main coal horizon may be considered, for this present purpose, as a single horizon, that is the coal lenses occur more or less on the same horizon. West of the Darra Ishpushta, by lens No.2, there occur fully 1,200 feet of strata of the Saighan series below the coal seam. But to the north-east this thickness of the strata gradually disappears, until by coal lens No.6 the coal seam is only a few feet above the base of the Saighan

series. Thus the whole of the lower part of the Saighan series has disappeared in a distance of about three miles along the strike. Further east still, by Barfaq, the Saighan series is largely obscured by recent river deposits. But between Barfaq and Tala these rocks are again seen, and their composition shows them to belong to the upper part of the Saighan series, the middle and lower sections having completely disappeared. This observation is of importance, in that it shows that there is no possibility of the main coal horizon appearing in the Barfaq-Tala area. Any coal which occurs in that area must therefore belong to the upper part of the Saighan series, which, judging by what is known of this part by Ishpushta and Doab Mekh-i-Zarin, is unlikely to contain any important seams of coal. It seems evident, in fact, that Tala is situated at the edge of a basin in which the Jurassic and Cretaceous rocks were deposited, for no more of these rocks is seen further north-east for a very long way.

The following diagrammatic section along the strike explains in a simple way the manner in which the higher beds of the Saighan series overlap the lower beds towards the north-east:-

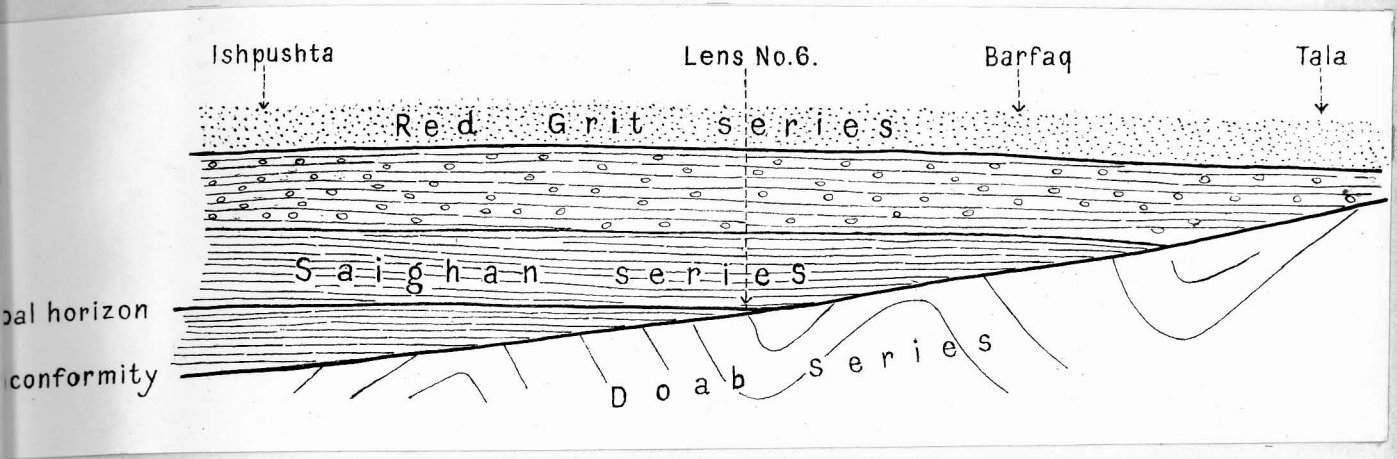


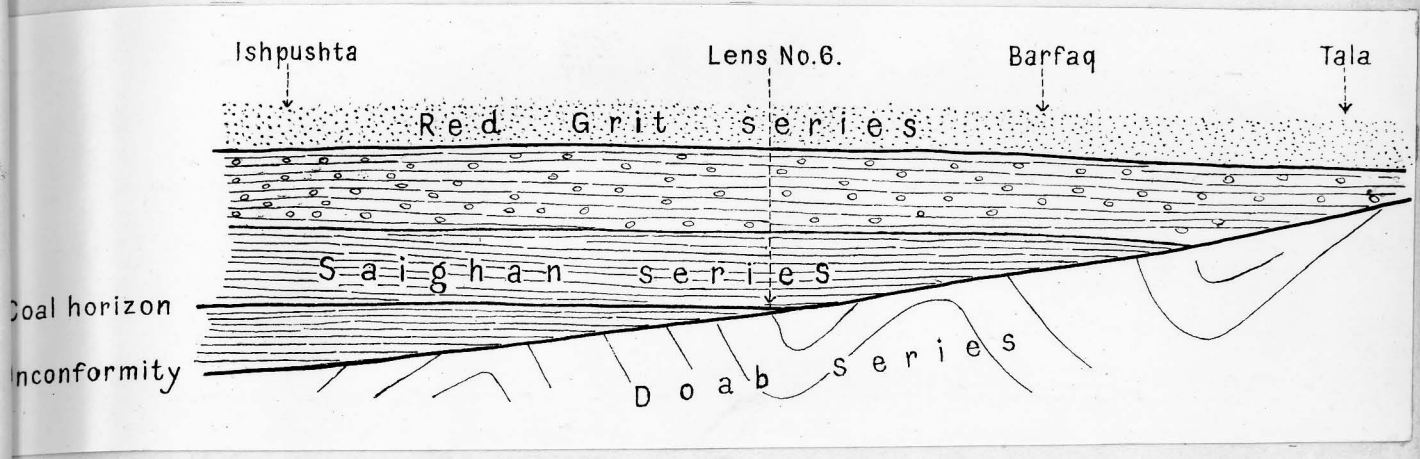
Fig.8.- Diagrammatic section along the strike, showing the overlapping of the Saighan series upon the Doab series.

I will now give a short description of each of the four rock groups present in this area - the Doab series, the Saighan series, the Red Grit series and the Cretaceous limestone.

The Doab Series.

This series is composed of a considerable variety of rocks mostly of sombre hue, into which are intruded dykes of pale yellow quartz-porphyry, laccolitic masses of gabbro, and sills of a dark green basic rock, which may be tentatively termed epidiorite.

Perhaps the most characteristic sedimentary rocks are dark grey, tough, well-bedded grits or sandstones, interbedded with thin beds of dark slates. They are most commonly found at the top of the Doab series, though they are not seen by the Ishpushta camp. They are well displayed in the Jar Karimak,



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The Doab Series.

This series is composed of a considerable variety of rocks mostly of sombre hue, into which are intruded dykes of pale yellow quartz-porphyry, laccolitic masses of gabbro, and sills of a dark green basic rock, which may be tentatively termed epidiorite.

Perhaps the most characteristic sedimentary rocks are dark grey, tough, well-bedded grits or sandstones, interbedded with thin beds of dark slates. They are most commonly found at the top of the Doab series, though they are not seen by the Ishpushta camp. They are well displayed in the Jar Karimak,

where are bedded limestones

below the Saighan series, and on either side of the Surkhab river by Barfaq and Tala. Other types include massive sandstones and quartzites, of varied colours, and conglomeratic sandstones and grits. It should be added that the whole of the Doab series has not been examined in detail. The whole assemblage is rather uninteresting, and has so far revealed no signs of fossils.

The quartz-porphyry dykes are very common, and can be recognised on the hillsides by their lighter brown colour, and by their cutting obliquely across the bedding of the sedimentary rocks. Two such dykes are shown cutting the small hill in the foreground of plate 5.

The best example of the massive gabbro is to be found forming the hills to the south of the path leading from the Kotal-i-khaki to Barfaq, forming the northern slopes of .6322, where they are easily recognised as a distinct feature in the scenery.

The sills of epidiorite are of a similar dark grey colour to the well-bedded grits and slates mentioned above, in which they commonly occur; but they are distinguished from them by their massive character and complete absence of bedding. An example of such a sill is shown in the upper photograph of plate 8, which occurs above the hotel at Doab Mekh-i-Zarin.

These igneous rocks have not yet been examined in detail under the microscope, but it may be mentioned that the gabbros are of interest in containing the rhombic pyroxene hypersthene, while in one variety biotite occurs, this rock being paler in colour, and probably dioritic in composition.

A feature of the Doab series, which has already been referred to, is the occurrence of white and red beds at the top of the series, beneath the overlying Saighan beds. They appear to represent an old weathered surface of the Doab series, the red beds possibly being a variety of laterite formed on the old land surface on which the Saighan series were deposited.

Structurally, the Doab series are considerably folded, a result of earth movements in pre-Saighan times; while, as already noted, the intrusion of the various igneous rocks must have taken place prior to the deposition of the Saighan series. In view of the pronounced unconformity which occurs at the top of the Doab series, they must be considerably older than the overlying Saighan series, which are regarded as belonging to the Jurassic system.

The Saighan series.

The Saighan series, being the main coal-bearing rocks of Afghanistan, have been studied in some detail in this

area. The nature of the sediments which compose them, and the fossil plants which they contain, prove that they are in the main shallow water deposits which must have been accumulated in a large basin or several basins of Doab rocks, upon which they lie both unconformably and with overlap. It is probable that they occur over a very wide area, but the mantle of Cretaceous rocks which overlies them obscures a large part of them, and they are only seen where the Cretaceous has been removed by denudation.

Briefly stated, the Saighan series consist of shales, sandstones, grits and conglomerates of a variety of colours, which are repeated many times throughout the series. In the vicinity of Ishpushta, where the series attains a great thickness, the following sequence has been made out:-

Top.

d. Soft shales, sandstones and conglomerates ...	1400 feet
c. Shales, sandstones, grits and hard conglomerates	1400 feet
Main coal horizon at base	
b. Soft shales and sandstones, with some soft conglomerates	650 feet
a. Alternating hard and soft sandstones ...	550 feet
Base Total	4000 feet

Thus at Ishpushta the series attains a total thickness of about 4,000 feet, and what may be termed the main coal horizon occurs about 1200 feet above the base of the series.

This sequence is shown in the vertical section forming figure 1.

An attempt was made to map each of these four divisions separately. But although this could be done near Ishpushta, it was found that when followed along the strike the boundary, for example between the two lower divisions, gradually changed its horizon as hard sandstone beds came in in lenticular fashion at higher and higher horizons, and the attempt to map the four divisions separately was abandoned. Nevertheless, throughout the area from Doab to Barfaq this sequence is maintained in a general way, and can be readily seen in the landscape.

The lowest division (a), resting upon the weathered surface of the Doab series, consists of hard and soft sandstones, of a light brown to dark reddish-brown colour. The darker sandstones are somewhat ferruginous, and commonly contain hard ferruginous spherical concretions. These rocks are seen on the south side of the path leading from Ishpushta camp to the Kotal-i-Sabzak. The alternating hard and soft rocks cause them to weather in a somewhat step-like fashion.

The second division (b) is readily recognised by its very pale colour, the soft sandstones giving rise to very rounded spurs and hillocks of a mud-like consistency. Occasional beds of a rather soft conglomerate occur here and there, together with a few very thin seams of coal. Large crystals of selenite are commonly seen in these soft beds.

At the top of this division comes what I have termed the main coal horizon, and lenses 1, 2 and 3, west of the Ishpushta valley all occur at this horizon. The horizon can be seen as an almost continuous line, for where there is no coal there is carbonaceous shale, which shows up as a dark bed amongst the lighter rocks.

To the east of the Darra Ishpushta, lenses 4 and 5 seem to be located on a very slightly higher horizon, say 100 feet higher; but in a general way it may be said that the important coal outcrops in this area all occur at approximately the same horizon.

The third division (c) is the most prominent. It is formed of hard conglomerates, grits and sandstones, interbedded with softer shales, and it forms the highest peaks of the Saighan series. This rapid alternation of beds given the rocks a striped appearance, in various shades of brown, buff and grey. In addition to the main coal horizon at the base, there are numerous beds of carbonaceous shale higher up, occasionally slightly coaly, but of no economic value.

It is in this division that the large variety of fossil plants occur, which may be found in any of the shale bands, but are most abundant near the coal horizon. Those collected are described by Dr. Jacob at the end of this report.

A feature of many of the harder sandstone and conglomerate bands is that they are often markedly lenticular;

and though it may be possible to trace individual bands over several hundred metres, most of them sooner or later die out, and others appear at different horizons. This feature is in keeping with the essentially shallow water nature of the deposits, and must be an original feature of deposition. Everywhere, however, strong tectonic forces have had a shearing effect on the beds, but this is only to be regarded as a modifying factor, the main reason for the lenticularity being original irregularity of deposition, a characteristic of shallow water deposits.

The fourth and highest division (d) is composed of rather soft rocks, sometimes full of plates of selenite (crystalline gypsum) the most characteristic feature being the very loose conglomerates which occur interbedded with the soft sandstones and shales. So loosely cemented are these conglomerates that they might almost be described as pebbly sands. They are similar in texture, though not in colour, to the basal beds of the Red Grit series, up into which they pass quite conformably. Interbedded with these loose conglomerates are occasional beds of harder sandstone, which weather out as ledges.

These four main divisions of the Saighan series, as found around Ishpushta, are clearly seen in the view of the west side of the Darra Ishpushta given in plate 2, while the three lower divisions and the underlying Doab series

are seen in plate 1.

The age of the Saighan series was determined by A.C. Seward from their fossil plant contents to be approximately Jurassic[1]. This has since been confirmed by Dr. K. Jacob as a result of his examination of the fossil plants collected by me during 1940. A preliminary note by him is given at the end of this report, in which he states that "the flora as a whole certainly indicates a Jurassic age. Whether the beds are to be referred to the Lower, Middle or Upper Jurassic will be discussed fully in the detailed account which is under preparation".

The Red Grit series.

As stated above, the Red Grit series follow perfectly conformably upon the Saighan series, and it is only the sudden change in colour which marks their beginning, the basal beds being red loose conglomerates, about 10-15 feet thick, which pass up into a massive rusty-red conglomerate, 80-100 feet thick, which forms a prominent feature in the topography, giving rise to an almost vertical precipice. These basal Red Grit beds are shown in the lower photograph of plate 6, the massive dark red conglomerate referred to above being clearly shown. The latter is overlain by a lighter coloured reddish-brown pebbly sandstone, the

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1 Mem. Geol. Surv. Ind., Pal. Ind. N.S.IV, Mem.4, (1912)

highest beds seen in this photograph. The uppermost Saighan series, below the Red Grits, are also shown.

Above these beds there comes a considerable thickness of fairly soft sandstones, grits, pebbly sandstones and conglomerates, with some interbedded shales, the whole of varying shades of red, purple and occasionally green. The conglomerates and grits predominate, and form the steep cliffs that overlook the Ishpushta valley, below the Cretaceous limestone. The rocks of this series give rise on weathering to rather characteristic structures, appearing either as horizontal ledges protruding on the cliff face, as in the upper photograph of plate 6; or as vertical, organ pipe-like columns, the latter so well seen in the cliffs opposite Barfaq, at the left side of plate 5.

Towards the top of the series massive conglomerates give way to a cream or pink coarse-grained limestone, full of shell fragments; while above this comes a zone of massive gypsum, a thin bed which forms a gentle slope beneath the vertical cliffs of Cretaceous limestone, easily recognised in the view looking north-west from Ishpushta. The middle and upper part of the Red Grit series, the light-coloured gypsum horizon, and the Cretaceous limestone are shown in the upper photograph of plate 6.

Hayden concluded, on the evidence of fossil hippurites which are found at the top of the series in the Ishpushta

valley, that the age of this series is Cretaceous. I also found these fossils in the same place, but apart from these I found no further evidence as to the age of the rocks.

From evidence obtained elsewhere, Hayden also concluded that there was an unconformity at the base of the Cretaceous limestone. This is not evident in the Ishpushta area, where the limestone appears to lie conformably on the Red Grits. This, however, may be a purely local feature, and not of regional significance, for Hayden points out that in Saighan the Cretaceous limestone rests on the lower part of the Saighan series, the upper part of the latter and the whole of the Red Grit series being missing there.

For convenience I have taken the gypsum horizon as the topmost bed of the Red Grit series in my mapping of the boundary. But I am prepared to alter this if I find any evidence of an unconformity lower down, as Hayden suggests there may be. It will make little difference to the mapping. Grouped in this manner, the thickness of the Red Grit series by Ishpushta is about 4,500 feet.

The Cretaceous Limestone.

This formation covers a very large area north of the Hindu Kush, and the underlying rocks are only seen where

the Cretaceous limestone has been denuded away.

The dominant rock is for the most part a hard, fine-grained, cream-coloured, calcitic limestone. I have not yet had it analysed, but in places it may be partly dolomitic. Again it is sometimes full of very small grains of quartz, but this is not common. Elsewhere it is so fine grained that it might almost be called a lithographic stone.

It is comparatively devoid of fossils, and I have not found any well enough preserved for identification. But from the few fossils collected by Hayden it was possible to deduce that the limestone belongs to the Middle or Upper Cretaceous.

The Cretaceous limestone is overlain conformably by the Tertiary rocks, which occupy the synclinal valleys such as at Dasht-i-Safed and Ruisang, and occur at the head of the Ishpushta valley, above the narrow 'tangi' which cuts through the Cretaceous limestone. They do not, however, concern us here.

3. THE COAL LENSES.

It is proposed in this section to give a brief description of each of the coal lenses, to accompany the geological maps of the lenses. Most of the information required is given on the maps, and on the plans (placed at the end of the report) showing the thickness of the coal along the outcrop of each lens.

When the work of making the large scale topographical maps was undertaken, it was thought that six main lenses existed in the Ishpushta area, and these lenses were numbered 1 to 6 from west to east. Of these six, lenses 1 to 3 occur west of the Darra Ishpushta, and lenses 4 to 6 east of that valley. Subsequently a seventh lens was discovered to the west of lens No.6; and in order not to have to change the numbering of the lenses already mapped, it was decided to name this lens No.5A. The mapping of this extra lens and its detailed examination will be taken up at the beginning of the 1941 season.

The Lenticular Nature of the Coal Seams.

As is clearly seen from the Geological maps on the scale of 1:25,000, the coal in the Ishpushta area does not occur as a continuous seam, but in lenticular fashion, and it is

for this reason that each such 'lenticle' of coal has been termed a lens. The lenses vary considerably in length and thickness, and moreover each lens itself has a very variable thickness, the seam sometimes even dying out completely for a short distance, as will be seen from the 1:1,000 maps. It is this peculiarity which makes it so difficult to estimate the reserves of coal in the area without detailed exploration of each lens. For just as the lenses are seen to die out each way along the outcrop, so they must also die out in the opposite direction below the surface. The problem is to determine how much of each lens of coal has been left as a reserve within the ground. It may be that only a small portion of a particular lens has been removed by denudation, and the major portion still remains; or alternatively most of the lens may already have been denuded away.

The reason for this peculiar lenticular character calls for some consideration. Examination of the whole area from Doab Mekh-i-Zarin to Barfaq, shows that while what may be termed the main coal-bearing horizon can readily be recognised throughout the eight or nine miles, exploitable coal is only found in a few places, totalling in all less than three-quarters of a mile, or about 8% of the whole length. In the intervening tracts the place of the coal is taken by carbonaceous shale, which can be readily recognised by the dark colouration on the hillsides. There are two

possibilities to account for this intermittent occurrence of the coal, (1) that it was originally deposited in separate basins, or (2) that as a result of the intense shearing that the rocks have suffered, what was originally a continuous seam has been broken up by thrust faulting, and the coal cut out from some places. As regards the second possibility, although it is clear that the coal has been subjected to great shearing, it is inconceivable that thrust faulting could account for the complete disappearance of the coal over a matter of five miles or more, as is the case to the north and north-east of Doab Mekh-i-Zarin. Moreover, it can be observed in many places that the coal when followed along the hillside actually changes into carbonaceous shale with occasional thin streaks of coal. In my opinion, therefore, the coal must have originally been deposited in separate basins, though this intermittent deposition has been subsequently modified by intense shearing, which was crushed the coal and has been responsible for the minor irregularities found within each lens. The shearing is, in fact, only to be regarded as a modifying factor, superposed upon the main factor of patchy deposition.

Whatever the cause may have been, however, it is quite clear that the coal is very patchily distributed, and it is evident that the reserves of coal in this area cannot be considered great.

The Coal-bearing Horizon.

Detailed examination of the rocks of the Saighan series between the Darra Ishpushta and the Jar Karimak shows conclusively that the three coal lenses Nos. 1 to 3 all occur at the same horizon, for between the lenses, and also to the west of lens No.1, the horizon of the coal is marked by a continuous bed of carbonaceous shale, which joins up the coal lenses one with another. When, however, the coal horizon to the east of the Darra Ishpushta is examined it is difficult to be certain whether the two coal lenses Nos. 4 and 5 occur at exactly the same horizon as Nos. 1 to 3, or at a slightly higher horizon. Between the two areas there comes the gap of the Ishpushta valley, across which no rocks are visible, while to the east of the valley the various horizons of rocks - carbonaceous shale, sandstone or conglomerate - which are found in a particular order on the west side of the valley, cannot for certain be recognised again on the east side. Nevertheless, a general view of the cliffs by coal lenses 4 and 5 gives one the impression that the coal on this side of the Ishpushta valley occurs at a slightly higher horizon than it does on the other side. At the same time it has to be admitted that there is a certain amount of disturbance along here, and this may have affected the position of the coal. It is to be noted, however, that on the ridge leading up from

the Kotal-i-Khaki to coal lens No.5, a thin seam of coal is seen about 75 feet below the main coal lens (see large scale map), and these two horizons of coal can be traced intermittently to the east for nearly a mile, the thick but short lenses of coal in the stream coming down from the north-west belonging to the upper horizon. A somewhat similar thin seam of coal is seen below lens No.2; and if this is taken to be the same horizon as the thin seam seen below lens No.5, then it may be concluded that all five coal lenses occur at the same horizon, and the same conclusion probably applies to lenses 5A and 6.

The Absence of Normal Faults, and the Prevalence of Shearing.

Perhaps one of the most striking structural features of the area is the absence of normal faults, or even thrust faults of small hade. This is apparent from the continuity of all the coal seams as shown on the large scale maps. On the other hand thrusting or shearing of the coal seams has clearly been in operation.

In the section on the geological structure, it was described how the Cretaceous limestone and Red Grit series above are overfolded or thrust-faulted on a considerable scale, and it was suggested that this movement must have been responsible for the crushing of the coal seams in the Saighan series, although the latter show no folding in the Ishpushta

The Coal Lens Maps.

On the 1:1,000 maps of the coal lenses, the outcrops of the coal seams have been mapped, and are shown as a dark grey colour. In addition, all along the outcrop the thickness of the coal is shown in feet from place to place. These figures indicate the total thickness of the coal at each point, excluding shale and sandstone bands. Further, in order to make the thickness of the coal in each seam apparent at a glance, sections have been drawn (included at the end of the report) showing this information in graphical form. In these sections the positions of shale or sandstone bands within the coal have not been shown, since these vary so rapidly both along the strike and to the dip that to have given them would have been quite valueless. The only lens for which information has not been given as completely as might be desired is lens No.4, the first lens east of the Darra Ishpushta. Here the coal seam is for the most part covered up by immense boulders of rock; and although a number of men were employed for about ten days cleaning the face of the seam, it was only possible to obtain information as to the thickness of this seam in places where the overlying debris was thin. Nevertheless, sufficient information was obtained to give a preliminary idea of the distribution of the seam, and it is given on the map of this lens.

With the exception of the map of lens No.6, the maps have not been coloured apart from the coal seam, since the whole of the area included within each map is formed of the Saighan series. In the case of lens No.6, however, as already explained in the section on the geological structure, the coal seam comes very close to the top of the Doab series, and the Saighan and Doab series, together with a prominent quartz-porphyry dyke, have been shown in separate colours.

On all the maps the dip of the strata is shown by dip arrows, the larger figure representing the direction of the dip in degrees, and the smaller figure the angle of inclination of the dip measured from the horizontal. The dip of the strata is not always easy to determine, owing to the lenticularity of the harder bands. But considerable care was taken to obtain a good average result for the area within about ten yards of the point of the arrow, and it is thought that the figures are fairly dependable.

Coal Lens No.1.

This lens, though the longest of all the six lenses, is rather discontinuous, as can be seen from the 1:1,000 map, and in places the coal is full of shale bands, often highly contorted.

The best coal occurs in the centre of the lens, where

in one place it is 13 feet thick, and in several places 8 feet thick and over. Constantly, however, it thins out to less than a foot thick, which would not, of course, be worth mining. Towards the north-east end of the lens, by the spur leading down to the Kotal-i-Sabzak, the seam is best described as a shaly coal. But further north from here, where the seam descends sharply, there are several lenticles of coal, up to six feet thick.

This lens, for the reasons given above, will probably prove rather troublesome to mine.

The average dip of the more massive rocks above the seam is about 35° to the north-west, or a little west of north-west.

Two samples of coal were taken from just north of the seam line peg .5578, where the coal is about 8 feet thick, and they gave the following analyses. The first is the analysis of an average sample taken from the full width of the seam, while the second is the analysis of specially selected hard pieces from the same place.

why only ~~two~~ one analysis? profile without analyses have not very much value

	Average sample.	Picked pieces.
Moisture	10.11	9.11
Volatile matter	34.73	33.33
Fixed carbon	47.38	54.04
Ash	7.78	3.52
Total	100.00	100.00
Total sulphur	0.84	0.66
Caking property	Nil	Nil
Specific gravity	1.54	1.55
Calorific value:-		
Calories per gramme	5,610	n.d.
B.Th.U. per pound	10,098	n.d.

A view of this lens is given in the upper photograph of plate 12.

Coal Lens No.2.

This is the lens to which Sir Henry Hayden paid most attention at the time of his visit in 1906, while Dr. Fox also examined it in 1936. Hayden described it in some detail in his confidential report, and gave an analysis of the coal taken from what we now call lens No.2, where he found the seam to have a maximum thickness of 13 feet 4 inches. Since then a few attempts seem to have been made to mine

the coal along the outcrop, with the result that in places the overlying rock has collapsed and obscured part of the seam.

From the diagrammatic section showing the thickness of the seam at various points along the outcrop, it will be seen that this lens is quite substantial. Although the thickness of the seam does vary along its length the variation is not so marked as in the case of the other lenses, and nowhere does the seam appear to die out, although the outcrop by the point .5329 is obscured by fallen rock. Thus from a mining point of view, and also from the fact that the lens is fairly accessible to the road, this is probably the most attractive lens, and deserves mining in a proper manner.

Judging by the dip of the rocks in the cliffs above the seam, the average dip would appear to be about 35° in the direction of 325° (N.35°W). In the case of this lens, however, it is easier to determine the average direction of dip from the direction of strike of the seam, for it so happens that the two ends of the seam (and also a point near the middle) are all the same height, and the straight line joining them gives the direction of the strike. This it will be found is in a direction of about 228° (W.41°S), which gives as the direction of dip 318° (N.42°W).

I did not take a sample of this seam, as it had already

been analysed by Hayden. Later on, if the seam is mined, a sample will be taken from well below the surface of the ground, where it will have been unaffected by surface weathering, and it will be of interest to see if the moisture content is any less. The following analyses were obtained by Hayden:-

	Sample.	Picked specimen.
Moisture	8.40	9.00
Volatile matter	30.10	30.33
Fixed carbon	56.00	58.17
Ash	5.05	2.50
Caking property	Nil	Slight
Sulphur	0.68	0.35

A view of this lens is given in the lower photograph of plate 12.

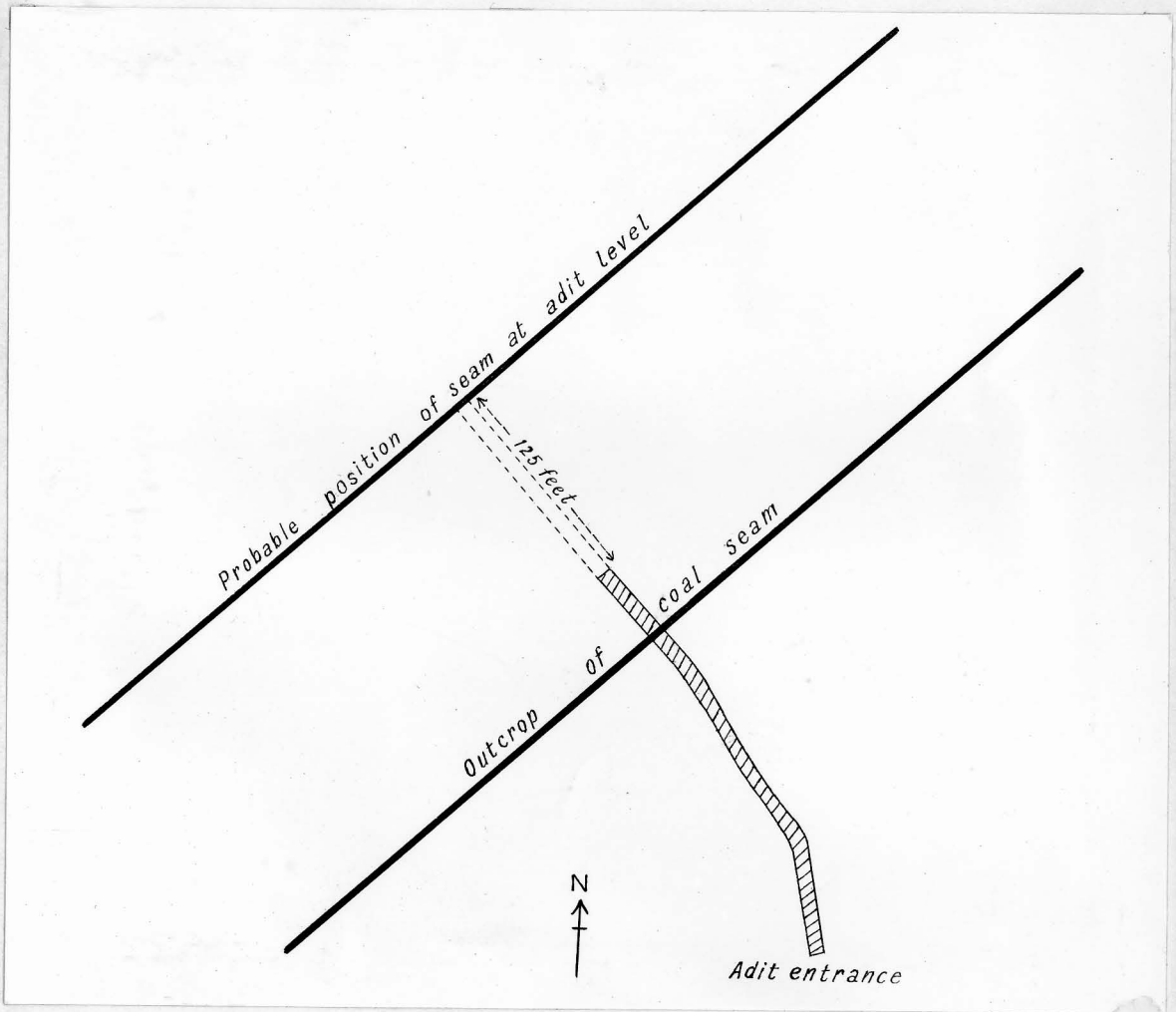
The Horizontal Adit.

In the autumn of 1939 work was begun by the Ministry of Mines on the construction of a horizontal adit, to be used in the mining of coal lens No.2. Owing to the rather steep inclination of the coal seams (28° to 40°), it would be very laborious to bring coal up inclined adits made along the dip in the coal seams, and it had been suggested by Sir Henry Hayden in his confidential report of

1907 that a nearly horizontal adit should be made from below to meet the coal seam underground. The same advice was given by Dr. C. S. Fox in his report of 1936. The Ministry of Mines, therefore, selected a convenient point about 125 feet below the outcrop of the coal, and a horizontal adit was begun in the direction 348° (N. 12°W), 49½ feet being completed in the autumn of 1939.

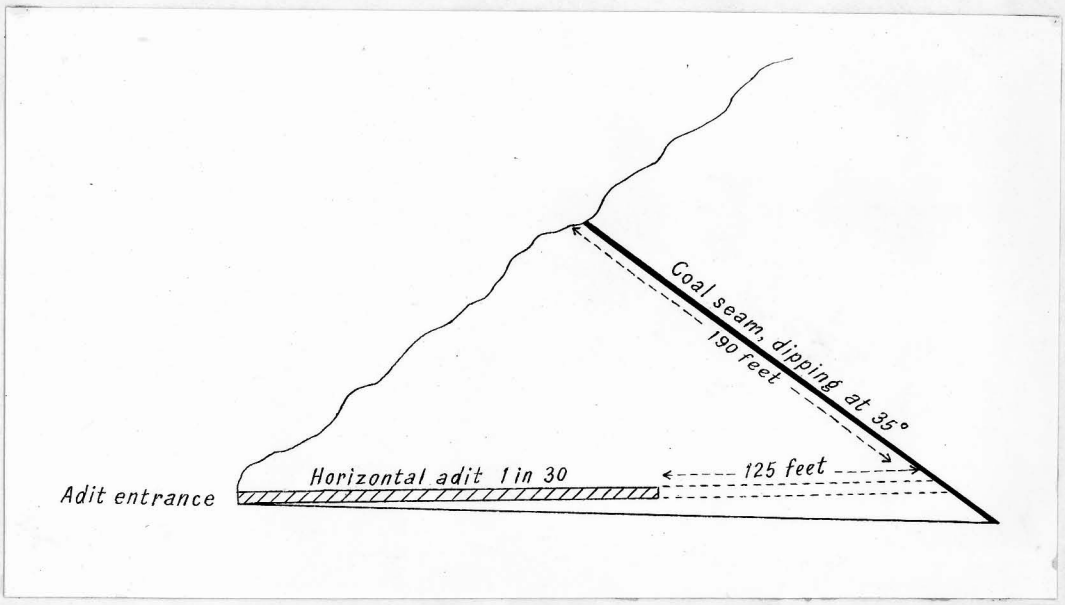
On arrival in Ishpushta in the spring of 1940 I saw that the adit, if continued in the direction selected, would meet the coal seam towards its eastern end. I suggested, therefore, that the direction of the adit be altered so as to run more to the west, and this was done. By thus changing the direction of the adit, not only would the adit meet the coal lens near its centre instead of at one end, but it would also meet it sooner and its total length be decreased. The direction was therefore changed to about 322° (N. 38°W), and a further 142 feet, at an average inclination of 1 in 30, were constructed by the Ministry of Mines during 1940.

The following plan and section on the scale of 1:1,000 show the position at the end of 1940. From these it will be seen that, assuming the coal seam to dip at 35°, there still remain about another 125 feet of adit to be constructed before the coal seam is reached. Further, if an adit be driven along the coal seam in the direction of the dip, immediately above the horizontal adit, it should meet the latter after going about 190 feet.



Scale, 1:1,000

Fig. 9.- Plan showing the position of the horizontal adit. The portion completed by the end of 1940 is shown shaded.



Scale, 1:1,000.

Fig. 10.- Vertical section showing the horizontal adit and the coal seam.

It should be emphasised that the construction of such horizontal adits, before the extent of the coal seam has been proved, is rather risky. For, in the event of the seam extending for only a short distance along the dip into the hillside, the work of constructing the horizontal adit would be wasted. In the present case it is to be hoped that the seam will be found to extend at least the necessary 190 feet.

Coal lens No. 3.

On account of the configuration of the ground, the outcrop of this lens is curved, giving it an apparent length of nearly 1,000 feet. Throughout this length the seam completely dies out in four places, but elsewhere attains a maximum thickness of 10 feet. Such attempts as have already been made to mine the coal at two or three points along the outcrop show that in the direction of the dip also the thickness of the seam, and the presence or absence within it of shale and sandstone bands, is equally variable. The main attraction of the seam is its close proximity to the motor road.

Although, as mentioned above, the seam is 10 feet thick in one place, the average thickness is rather small, and probably not much more than three feet.

The average dip of the southern part of the outcrop is about 28° in a direction of 330° (N.30°W). Towards the north, however, the dip swings round a little to the west and becomes about 320° (N.40°W), at about the same angle. Thus the average dip of the coal seam in this lens is rather less than in the other lenses.

A sample of coal was taken from the trench dug near the seam line peg .5164, where the seam is ten feet thick, and it gave the following results on analysis:-

Moisture	9.40
Volatile matter	35.76
Fixed carbon	50.87
Ash	3.97
Total	100.00
Sulphur	0.49
Caking property	Nil
Specific gravity	1.56

Calorific value:-

Calories per gramme 5,793

B.Th.U. per pound 10,427

Two views of this lens are given in plate 13, the upper one showing the southern part of the outcrop, and the lower one the norther part as viewed from the East. A near view of this part of the lens is also given in the upper photograph of plate 18.

Coal Lens.No.4.

This seam of coal was noticed early in the season by Mr. Gulam Ali Khan. As already stated, the outcrop of the seam is largely obscured by a thick covering of rock boulders fallen from the cliffs above. In places, however, the seam is visible, and these places were cleaned and the thickness measured. Information about the thickness and continuity of the seam is, however, necessarily

incomplete, and for this reason no section showing the thickness of the seam along the outcrop has been drawn for this lens. All the information available, however, can be seen from the map.

As will be seen from the 1:1,000 map, the seam in one place reaches the very considerable thickness of 44 feet. The coal, however, appears to be very unevenly distributed, and for the most part is extremely friable, though it may improve in depth.

The average dip of the rocks above the seam is between 30° and 35°, in a direction of about 335° (N.25°W).

The ground below the seam is steep and uneven, but it should be quite easy to make a motor road up the side valley from Ishpushta to directly below the centre of the seam, and it would only be necessary to transport the coal by hand down the steep slopes to the road below.

A view of this lens is given in the upper photograph of plate 14.

No sample of coal from this lens has yet been analysed.

Coal Lens No. 5.

This lens occurs on the crest of the spur above and to the north of the Kotal-i-Khaki. Although comparatively short in length, the lens is quite thick in places, and contains some good quality coal, though in places there is

much interbedded shale.

Since it occurs round the crest of a spur, the outcrop is curved. But the length of workable coal as measured in a straight line along the strike may be taken to be about 420 feet. In the north-eastern part of the outcrop, the coal displays a tendency to die out and restart at another level.

At the extreme north-east end it is rather difficult to decide what is coal and what is not, owing to its becoming shaly.

The general dip of the rocks above the seam is nearly due north, the angle being rather high and probably averaging at least 35°.

A view of the lens is given in the lower photograph of plate 14.

A sample of this lens was taken from a trench cut a little east of the point .5845, where the seam is 16½ feet thick. It gave the following analysis:-

Moisture	7.72
Volatile matter	33.39
Fixed carbon	54.09
Ash	4.80
Total	100.00
Total sulphur	0.70
Caking property	Nil
Specific gravity	1.50
Calorific value:-	
Calories per gramme	6,092
B.Th.U. per pound	10,966

From this it will be seen that the coal from this lens yields the best analysis of all, being lower in moisture than the others and having a higher calorific value.

Coal Lens No.6.

This lens, though situated within easy reach of the main road to Barfaq, is the least promising of the six lenses. Its length at the outcrop where it is thick enough tp work is only about 365 feet measured in a straight line, while its maximum thickness is only 8 feet. The coal is extremely powdery, and the roof of the seam very rotten, so that it would be difficult to mine. Moreover, the analysis is the poorest of all, having higher percentages of moisture and of ash than any of the other lenses. The dip of the seam is also rather high, being 37° in the mouth of the adit that had been begun by the Ministry of Mines the previous year.

A view of this lens is given in the lower photograph of Plate 15.

A sample was taken from the back of the above mentioned adit, that is from about 22 feet from the surface of the ground. On analysis it gave the following result:-

Moisture	13.70
Volatile matter	39.21
Fixed carbon	37.99
Ash	9.10
Total	100.00
Total sulphur	0.84
Caking property	Nil
Specific gravity	1.57

4. PROXIMATE ANALYSES OF COAL SAMPLES FROM ISHPUSHTA.

In his confidential report of 1907, Hayden gave analyses of the coal from what we now call coal lens No.2, while Dr. Fox gave two further analyses in his report of 1936. During the present season samples of coal were taken from lenses 1, 3, 5, and 6, and analysed in the laboratory of the Geological Survey of India by Mr. Mahadeo Ram. The calorific values of three of them were determined by the bomb calorimeter method at the Alipore Test House, Calcutta. The results are shown in the accompanying table.

A feature of the coal in this area is its rather high moisture content, and as it is likely that earlier samples were taken from near the surface of the ground, it was thought that the high moisture percentage was possibly due to surface weathering. It was therefore with some interest that the sample from lens No.3 was analysed, for this had been taken from a deep trench cut in the hillside, the back of which was about 15 feet from the surface of the ground. The result, however, was disappointing, as the moisture content was still high, over 9%.

It is well known that there is a close relationship

between the moisture content and the caking property. Thus in India the hard-caking coals of the Barakar coal-measures are low in moisture, having less than 2%, while the non-caking and semi-caking coals of the Ranigunge coal-measures have a moisture percentage of from 3 to 10%. Hence the high moisture content of the Ishpushta coal agrees with its non-caking character, and it seems unlikely that any of this coal will have caking properties.

Though the moisture content is high, due no doubt to the comparative youthfulness of this Jurassic coal as compared with the Gondwana coals of India, the ash content is low.

Perhaps the best indication of the value of a coal is to be obtained from a determination of its calorific value. In this respect the values of 6,000 or less calories per gramme (or less than 11,000 in B.Th.U. per pound) are rather poor, and compare unfavourably with the average Indian Gondwana coals, which according to Dr. Fox vary from 13,500 B.Th.U's. per pound in the best qualities to somewhat more than 11,000 B.T.U's. in the inferior grades, 13,000 being the mean of the coals now being exploited in that country.

One further point may be mentioned, which is in favour of the coal, and that is its low sulphur content.

PROXIMATE ANALYSES OF COAL FROM ISHPUSHTA.

	Picked pieces from Lens. No.1.	Average sample from Lens No.1	Average sample from Lens No.3.	Average sample from Lens.No.5.	Average sample from Lens No.6.
Moisture	9.11	10.11	9.40	7.72	13.70
Volatile matter	33.33	34.73	35.76	33.39	39.21
Fixed carbon	54.04	47.38	50.87	54.09	37.99
Ash	3.52	7.78	3.97	4.80	9.10
Total	100.00	100.00	100.00	100.00	100.00
Total sulphur	0.66	0.84	0.49	0.70	0.84
Caking property	Nil	Nil	Nil	Nil	Nil
Specific gravity	1.55	1.54	1.56	1.50	1.57
Calorific value of dried sample:-					
Calories per gramme upper? lower?		5,610	5,793	6,092	
B.Th.U. per pound		10,098	10,427	10,966	

5. THE DRILLING.

When the Coal Survey Party was first sent from India to Afghanistan it had been hoped that the various outcrops of coal known to occur in the Ishpushta area might prove to be parts of one continuous seam, several miles long. Had such been the case, a few borings put down to the dip at various points along the strike would have proved the extension or otherwise of the coal underground, and if successful might have indicated a large reserve of coal. Unfortunately, detailed examination of the area soon revealed that the coal occurred not as a continuous seam, but as a number of separate lenses of comparatively small extent, the coal giving place to carbonaceous shale in between the lenses. The problem of estimating the reserves of coal thus became much more difficult; for just as the shape and extent of the coal lenses was found to be irregular where actually seen along the outcrop, so their shape and extent underground must also be irregular, and the value of drilling in order to determine the underground extension of the coal became much diminished unless it were possible to put down a very large number of borings. This, however, was impossible owing to the configuration of the ground, and the difficulty of finding suitable sites for the drilling machine and derrick. Thus the method of proving the

reserves of coal by drilling was not altogether satisfactory.

Further difficulties also arose. For a boring by a rotary calyx drill to be successful, a considerable quantity of water is required to wash up the mud and particles of rock produced by the drilling, otherwise the rods jam in the hole. 'Unfortunately the supply of permanent water in such a dry country is limited to the larger valleys, and in this area the only water available was that flowing in the Darra Ishpushta. Consequently it became a matter of considerable difficulty to convey water up to the boring sites, and it could only be done by using horses and carrying the water in specially made leather bags.

A further difficulty arose in that the rocks bored through were found to be full of cracks, with the result that water ran away through the sides of the hole instead of a large proportion of it returning to the top and being used over again. This necessitated the use of a large quantity of water, and four horses were required for each drill, carrying up between them about 1,000 gallons of water a day to each drill.

Considerable delay was also caused by the constant caving in or collapsing of the sides of the hole, which eventually necessitated filling the weak portions of the hole with cement, and reboring through the cement. This difficulty could have been got over by inserting casing

pipes throughout the hole, but unfortunately the right type were not available in India.

The Borings.

A site for the first boring was selected about 145 feet above the outcrop of lens No.3, and a path was constructed up to the site for the conveyance of the machinery, and for the horses to take up the water. Subsequently a second drill was obtained, and after arrival early in August was taken over to lens No.6. A second boring was also put down to lens No.3, and was situated about 270 feet to the north of the first site.

From the beginning the Drilling Crew experienced one difficulty after another. It is unnecessary to recount here all the troubles that were experienced, but they resulted in none of the three borings being completed, in spite of the hard and painstaking work put in by Mr. Mariano and his crew. The two borings that were put down to lens No.3 reached depths of 201 and 218 feet, and their positions are shown on the geological map of this lens. Assuming a dip of 28° to 30° for the coal in this lens, the borings should have met the coal at depths of about 240 and 250 feet respectively. In the case of the third boring to lens No.6, the position of which is also shown on the large scale map, the coal should have been reached at a depth of about 300 feet. Rapid progress was at first made in

this boring, 104 feet being bored in the first 11 days. But on reaching a depth of 250 feet, the hole began to cave badly towards the top, and the boring had to be abandoned on account of the lateness of the season.

Thus, in each case the borings failed to reach the coal, a most disappointing result; and in view of the lack of results obtained, it is unnecessary to go into further details. At the end of this report, however, the sections of rock encountered in each boring are given in tabular form.

6. A NOTE ON THE GEOLOGY OF HAJAR AND AOKHORAK.

Towards the end of August I left Ishpushta for Doab Mekh-i-Zarin, and, after completing the mapping of the country between Ishpushta and that place, I went on tour up the Kahmard valley to Hajar. The purpose of this visit to Hajar was to determine whether the signs of coal previously seen there by Hayden were worth detailed investigation.

The Kahmard Valley.

The geology of the Kahmard valley has been briefly described by Hayden on pages 66-67 of his memoir. After leaving Doab Mekh-i-Zarin, the escarpment of the Red Grit series and Cretaceous limestone, which forms such a striking feature all the way from Tala to here, is seen to cross the Kahmard valley, forming the narrow gorge known as Tangi Moyak and continuing to the S.S.W. towards the Saighan valley. Above Tangi Moyak the Cretaceous limestone is overlain conformably by a thick series of soft Tertiary beds, which fill up the wide valley to the south-west of Dasht-i-Safed. Above Dasht-i-Safed there comes a second escarpment of the Red Grits and Cretaceous limestone. Hayden describes this reappearance as due to thrusting, and it is quite possible that this is correct. But just north of Dasht-i-Safed village there is a fine exposure in the cliffs showing the

brow of a recumbent fold, closing south-eastwards. The Cretaceous limestone occurs both above and below the Red Grits, and the closing of the fold is clearly seen, with Tertiary rocks immediately in front of it. It may be that to the west of Dast-i-Safed, north of the Tertiary beds, the fold is replaced by a flat thrust, but I did not actually examine this area.

Continuing up the valley above Andab, the upper bed of Cretaceous limestone, forming the upper limb of the fold, crosses the river and continues south. But round the bendin the river it rises again and forms a fine arch on the north side. Westwards from here, by Bajgah, Larmush and Pain Bagh, the river flows in the bottom of a syncline of Cretaceous limestone. The south side of the valley is formed of a magnificent dip-slope of bare limestone, while on the north side is the nearly vertical southern limb of an anticline which runs along the north side of the valley. The latter is well seen in the gorge cut by the tributary flowing south from Madar, and also along the path that goes from just east of Pain Bagh up to the Kotal Reg. To the north of this anticline the lower country by Duru, Doshak and Madar is a flat syncline occupied by Tertiary rocks; while still further north the Cretaceous limestone comes up once more to form the high hills over which the road to the Kara Kotal passes.

Westwards from Pain Bagh the narrow valley opens out by Ruisang, Laghaki and Banak, and the Tertiary rocks are once more seen filling the lower ground. Continuing to the north-west past Banak, the Cretaceous limestone is again met in the valley bottom where the Darra Loranj comes in from the north. Further west, however, after passing through a gorge in the Cretaceous limestone, the valley opens out once more to form the wide valley of Hajar. But this time, instead of the Tertiaries appearing in a syncline, the valley is excavated out of a broad dome, and the Red Grit series and the Saighan series are exposed in the centre of the dome below the Cretaceous limestone.

The Geology of Hajar.

Hajar was visited by Hayden, and he has given a brief description of the geology of the area on pages 67-68 of his memoir, while he also refers to the poor coal seams on page 7 of his confidential report on the Mineral Resources of Parts of Northern Afghanistan. In the latter he writes as follows:-

> "In the Khojaghaib dara, on the right bank of the Hajar river, coal seams occur near the foot of the hills on the left side of the dara. The seams are thin and poor. The lowest seen is like the seams in Saighan, and though fairly thick, is composed chiefly of coaly shale, only bands of 8" and 2" being of fairly good coal. Some way above this seam are two more thin seams, each only a few inches in thickness. On the left side of the Hajar river,

> behind the village of Miana and also at Khalak, seams crop out again, but they are mostly carbonaceous shale, with little or no coal. It is possible that better seams may occur below the surface, but the poor character of the seams seen as well as the distance of the locality from Kabul, would not justify the expense of boring."

In view of the poorness of the coal seams seen cropping out here, a view with which I agree, it is necessary to decide whether it is wroth while boring to ascertain if there is any coal in the lower part of the Saighan series which occurs below the valley bottom and so cannot be seen. Before giving an opinion in this matter, however, it is necessary to describe very briefly the geological structure of the area, in so far as I was able to determine it in a stay of only four days.

Hayden has described the Hajar area as a simple anticline, but examination showed that the structure is much more complicated. On the north side of the valley the normal sequence is seen, the Saighan series dipping north beneath the Red Grit series and the Cretaceous limestone. On the south side of the valley, however, the structure is found to be complicated. I will refer only to the main features.

In the Khojaghaib Darra, referred to by Hayden in the quotation given above, the Saighan series are seen on the west side of the valley dipping to the N.30°W. at an angle of about 35°, and there must be a considerable thickness of these rocks. But the east side of the valley is formed

wholly of horizontally bedded sandstones of the Red Grit series, which suggests that something unusual has happened.

Further up the same valley, on the west side, the Red Grit series appear beneath the Saighan series, and the boundary between the two rises to the south-west. This boundary is clearly seen to be a striking discordance, the horizontal red sandstones being obliquely truncated by the Saighan series, which have a pronounced dip, thus:-

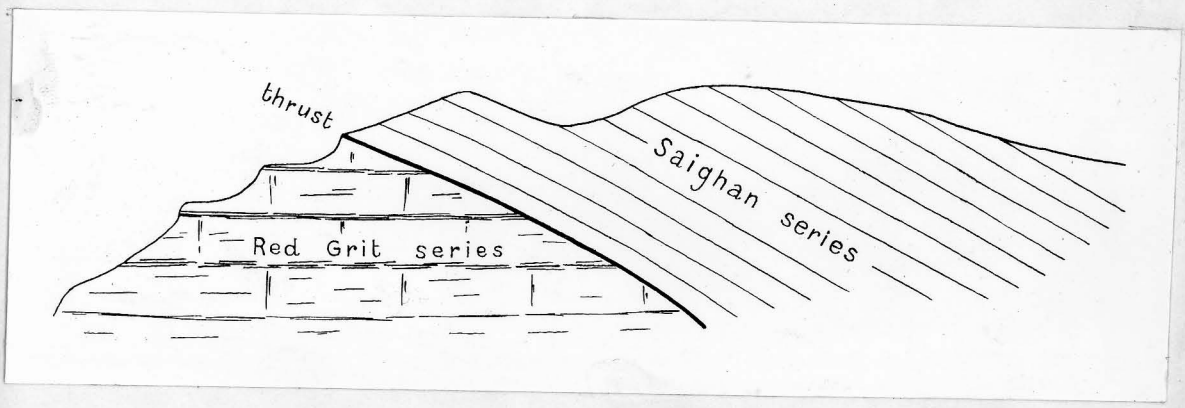


Fig.11.- The Saighan series thrust over the Red Grit series.

It is clear that this line of discordance must be a thrust, for the Saighan series should normally come <u>below</u> the Red Grit series. This supposition that the line of discordance is a thrust is supported by what is seen higher up; for there, above the Saighan series, there comes the Red Grit series resting conformably upon the Saighan series, as it should do. Thus we find the <u>Saighan series here to be both overlain and underlain by the Red Grit series</u>, and

there can be little doubt that the Saighan series are separated from the underlying Red Grit series by a thrust. The structure as thus deduced is shown diagrammatically in the following vertical section, which is taken along a N. to S. line just west of the Khojaghaib Darra:-

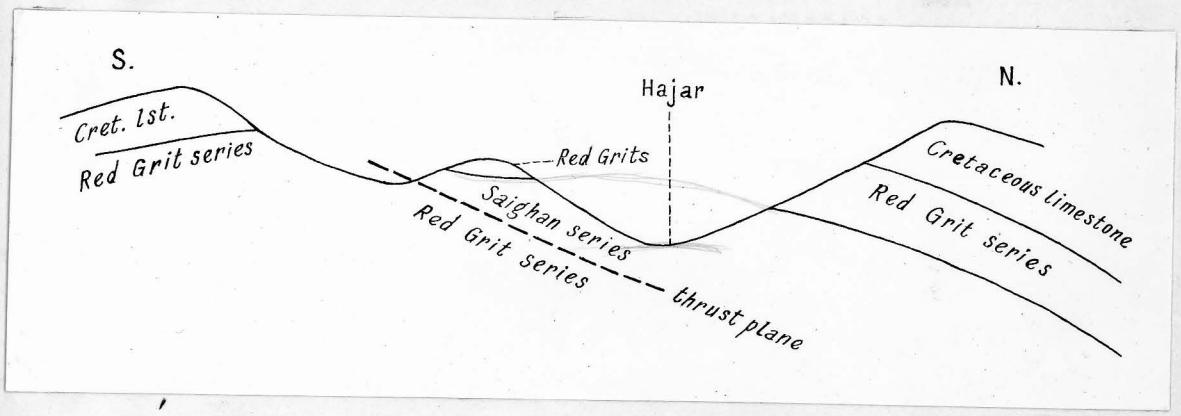


Fig. 12.- Vertical section across the Hajar valley.

We can now consider the question as to whether it is worth while boring in the bottom of the Hajar valley to determine if any coal exists in the lower part of the Saighan series.

The coal seams which are visible in the Hajar area, both on the west side of the Khojaghaib Darra, and on the north side of the main valley, for example behind the fort known as Bajgah, are really best described as carbonaceous shale with occasional strings of coal, and are economically quite worthless. Now in the Ishpushta area there is one horizon in the Saighan series which contains useful lenses

of coal, while above and below this horizon occur several beds of carbonaceous shale, in places slightly coaly, but of no economic value. Does then the carbonaceous shale seen at Hajar correspond to the main coal horizon of Ishpushta, or does it represent some thinner and unimportant carbonaceous shale band higher up. If the latter is correct, then there is still a possibility of the main coal horizon being found below the valley bottom.

Although it is impossible to be dogmatic in a matter of this nature, especially in view of the shallow water nature of the rocks of the Saighan series, and the probability therefore that their sedimentary nature and sequence vary from place to place, at the same time the succession of rocks seen in the Saighan series at Hajar rather suggests that the seams of coaly shale found there do occur at about the same horizon as the coal lenses of Ishpushta. This view then, so far as it can be relied on, suggests that there is unlikely to be much coal in that part of the Saighan series which occurs below the bottom of the Hajar valley.

Secondly, the fact that the Saighan series are underlain by a thrust plane suggests that the lowest part of the Saighan series is missing, at any rate on the south side of the river, but not in the valley of the river and north of it.

Thirdly, in view of the fact that no workable coal seams are found anywhere in the Saighan series west of the Karimak

valley to the end of their outcrop west of Doab Mekh-i-Zarin; while, according to Hayden, no coal of any value occurs in the Saighan valley further south-west, it appears as though this area of Saighan rocks to the west of Ishpushta is a barren one, and that the coal-bearing areas are confined to Ishpushta and further north in the Darra Yusuf - Qabr-i-Afghan area.

Thus, while none of the above arguments by themselves are of much force, taken together they suggest that there is unlikely to be any workable coal in the rocks of the Saighan series that occur beneath the Hajar valley, and that therefore it is hardly worth while boring in this area.

Aokhorak.

After leaving Hajar, I made a rapid tour over the Kara Kotal to Aokhorak Bala, to ascertain whether this valley would be worth mapping in detail during 1941.

On the south side of the valley by Aokhorak Bala there is a normal undistrubed succession of rocks, the Saighan series dipping south beneath the Red Grit series, and the latter beneath the Cretaceous limestone, which forms the upper part of the high ridge to the south. In the Saighan series on this side of the valley there is no coal just here; but further down the valley, about half way between Aokhorak Bala and the junction with the Zinda Qol, a thin seam is seen just above the road. The whole of this dark band is quite thick, but it is mostly composed of a hard carbonaceous shale, the thickest single bed of coal being not more than 1 foot thick.

On the north side of the valley the structure is more complicated. By Aokhorak Bala the Cretaceous limestone is seen forming the cliffs overlooking the valley (see the lower photograph of plate 11), dipping steeply below the Saighan series which form the lower slopes, there being no Red Grits here. But behind (north of) these cliffs of Cretaceous limestone there is more Saighan series (with traces of Red Grits), while the higher slopes to the north

are of Cretaceous limestone. There must be considerable folding, with perhaps some thrusting, to account for this succession.

Higher up the valley the structure is somewhat clearer. The Cretaceous limestone on the south side of the valley comes round the head of the valley, joining up with the limestone on the north side. The Red Grits also come round beneath the limestone, and evidently continue a little way east along the north side of the valley, judging by the colour of the soil. It seems clear, in fact, that the general structure of the valley is anticlinal, the northern limb being vertical or overturned, with a thrust coming in to cut out the Red Grits and the upper part of the Saighan series, as shown in the following diagrammatic section across the valley:-

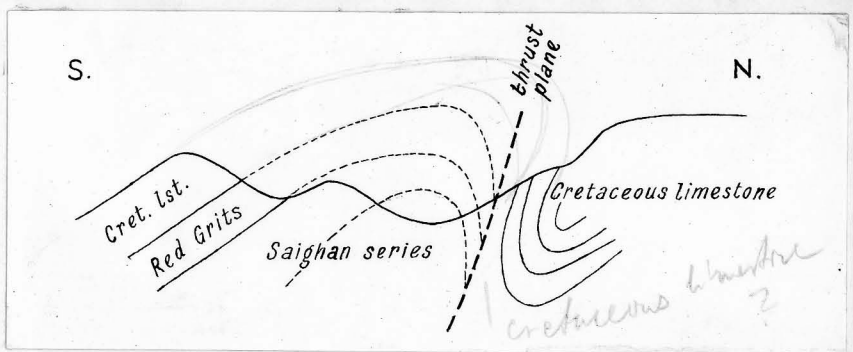


Fig.13.- Diagrammatic section across the Aokhorak valley.

Reference was made above to a thin coal seam on the south side of the valley. On the north side of the valley, however, there are more abundant signs, for in a number of places dark outcrops are seen at the bottom of the valley side. Examination of all these, however, revealed that they are mostly carbonaceous shale, with strings of coal here and there. The most prominent of these occurs just east of the tributary stream by Kalacha. At some time previously this out crop had evidently been excavated, and it was therefore difficult to see much owing to rock-falls obscuring the outcrop. There must certainly be some coal here, but the short length of the outcrop, and the disturbance of the beds, suggest that it is of no importance.

Dr. Fox, in his report, has suggested the possibility of boring to the south of the valley, for example in the side valley of the Zinda Qol, where the rocks are not disturbed but dip steadily southwards, in the hope that the traces of coal seen on the north side of the valley continue southwards beneath the visible Saighan rocks. There would be no difficulty in doing this, for there is plenty of water in the Zinda Qol. But in view of the patchy distribution of the coal or carbonaceous shale where seen, and more especially taking into account the fact that Hayden reported unfavourably on the quality of the coal

which he sampled, and of which he gives an analysis, I think it hardly worth while going to the expense of getting a drill transported here, when the prospects of finding good workable coal are so slender.

While camped at Aokhorak Bala I took the opportunity of going over the Kotal-i-Pechgah (called by Hayden the Kotal-i-Sauzak) into the upper part of the Chel valley. It was only a single day's excursion, and I have nothing to report which has not already been mentioned by Sir Henry Hayden or Dr. Fox. But I am of opinion that the coal seams seen here and there on the way down from the Kotal to Jeh are so disturbed, that they would be difficult to mine. The coal, however, appears to be of good quality, and is not powdery like the Ishpushta coal but breaks up into cuboidal fragments. The following is a proximate analysis of a small sample collected from the west side of the road below the Kotal :-

Moisture	7.62
Volatile matter	35.05
Fixed carbon	52.93
Ash	4.80
Total sulphur	1.48
Specific gravity	1.412
Caking property	Nil

The sample was taken from the outcrop, and so the analysis, and possibly the caking property, may be expected to improve in depth.

On this day's excursion I only went as far as Sar-i-Asia, and so did not see the seams already examined by Mr. Gulam Ali Khan and Dr. Drath, which must occur further down the valley.

7. A NOTE ON THE FOSSIL PLANTS COLLECTED FROM THE SAIGHAN SERIES, ISHPUSHTA.

By Dr. K.Jacob, D.Sc.

Description of the Flora.

The collection of fossil plants made during 1940 by Mr. W. D. West from the Saighan series at Ishpushta, Northern Afghanistan, is important as it throws fresh light on the Mesozoic flora of Afghanistan. In view of the fact that the earlier collections made from this region were either mixed up[1] or represented by only a few identifiable species[2], the present collection is of great significance.

A cursory examination of the specimens reveals that several genera and species hitherto unrecorded from Afghanistan are included in this collection. Most of the specimens are well preserved; while a few are found as carbonised incrustations or compressions which, on maceration, yielded excellent cuticles. Such forms have not been previously known from Afghanistan.

Below is given a table showing the provisional list of genera and species represented in the present collection, and their distribution in the different horizons within the Saighan series. Those marked by an asterisk are now for the first time recorded from Afghanistan.

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1 Seward, A.C., Pal, Ind., n.s., IV, No.4, (1912).

2 Sitholey, R.V., Pal, Ind., n.s., XXIX, No.1, (1940).

Saighan series

Base	Near Coal horizon	Towards top.	
		x	* ?Marchantites sp.
	x	x	Equisetites ferganensis
		x	* E. cf. naktongensis
	x	x	Equisetites sp.
		x	Roots of Equisetites.
	x		* Todites williamsoni
	x	x	Cladophlebis denticulata
	x		* Cladophlebis triangularis
	x	x	Cladophlebis halburnensis
	x		Cladophlebis cf. exiliformis
	x	x	Cladophlebis sp.
	x		Klukia exiliformis (fertile)
	x		Laccopteris sp.
	x		* Coniopteris quinueloba
	x		* Coniopteris cf. arguta
	x	x	Conippteris hymenophylloides (fertile)
	x	x	Coniopteris (Sphenopteris) hymenophylloides.

Marchantiales:

Equisetales:

Filicales:

	x	x	Sphenopteris spp. (fragmentary, and specifically indeterminate)
	x		Haydenia thyrsopteroides
?x	x	x	* Eboracia lobifolia
?x	x	x	* Eboracia (probably a new species)
		x	Dictyophyllum (?Clathropteris) sp.
			Cycadophyta:
	x		* Pterophyllum (probably a new species)
	x		* Ctenis fallax
	x	x	Ctenis cf. falcata
	x		* Nilssonia sp. A (fragmentary)
		x	Nilssonia sp. B (fragmentary, and specifically indeterminate)
			Coniferales:
	x	x	Pagiophyllum (Elatides) curvifolium
		x	* Elatocladus (?Taxites) sp.
		x	Pityophyllum (?Pinites) sp.
	x		Conites sp.
			Caytoniales:
	x		Sagenopteris phillipsi
			Incertae sedis:
	x		Podozamites sp. (fragmentary, and specifically indet.)
	x		* Axis with swollen nodes

In this collection, as in those previously described, there is an abundance of fern remains. At least seventeen forms are recognised.

The Cycadophytes, the common Mesozoic forms, are meagrely represented.

Ctenis fallax and Pterophyllum sp. have yielded excellent cuticles. The upper and lower cuticles of Ctenis show fairly thick-walled elongate cells. The stomata are confined to the lower cuticle.

In Pterophyllum sp. the cells of the cuticle are sinuous-walled and elongate with well-preserved stomata of the Bennettitalean type on the lower surface. A few round to elliptic spores are seen sticking to the lower cuticle.

Sporangia with well-preserved apical annulus distinctive of the modern family of ferns, the Schizaeaceae, are observed in certain fertile fronds of Klukia exilis. Masses of more or less triangular pitted spores with clearly visible tri-radiate marks have been obtained from these sporangia after maceration in Schultze's fluid.

The plant remains from the different horizons in the Saighan series do not reveal any obvious difference in age. As already observed by earlier authors, the flora considered as a whole certainly indicates a Jurassic age. Whether the beds are to be referred to the Lower, Middle or Upper Jurassic will be discussed fully in the detailed account which is under preparation.

The Affinity of the Flora.

The opinion has already been expressed that "the Saighan series belongs to the Angara, rather than to the Gondwana, province"[1]. An examination of the present collection lends support to this view. From a consideration of the species listed above, and those already described previously, it is fairly evident that the plant remains show the greatest affinity with the Angara flora. A certain resemblance to the vegetation of Gondwanaland is also recognisable. It is obvious that intermigration of species had taken place between the two palaeogeographic provinces; but the question of the probable path of migration still remains open.

A detailed account of the specimens is in the course of preparation.

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1 Hayden, H.H., Mem. Geol. Surv. Ind., XXXIX, No.1, p.33, (1911).

8. A NOTE ON THE WORK OF THE SURVEY OF INDIA MAPPING PARTY.

By Major D.R.Crone, O.B.E., R.E.

The task of the Survey of India detachment with the Afghan Coal Survey Party was to produce medium scale topographical maps in the field on which the geological field work could be carried out.

The scale adopted for this topographical mapping was 1:25,000. This survey task involved the establishment of the trigonometrical control, its computation and plotting in the field at the earliest possible moment, the actual plane table survey and the preparation of traces for the geological field work.

In addition to this medium scale mapping, it was desired to carry out small scale mapping over as extensive an area as possible for preliminary geological reconnaissances.

When the party was in the field it was decided that engineering plans of the coal occurrences in the Ishpushta area were required, and trigonometrical control, computation and plane tabling on the 1:1,000 scale of these areas was undertaken.

Organisation.

The topographical survey party was organised as follows:-

Mr.Chiragh Shah (Sub Assistant Supdt.)	In charge and triangulator
Sr. Monawar Khan	Computer and small scale planetabler
Sr. Mohammed Sadiq Sr. Abdul Rahman	Medium scale and large scale planetablers.

Personal servants and 12 khalasis accompanied the party from India, and the remaining instrument carriers were recruited locally.

Major D. R. Crone, R.E., visited the party during the first week and assisted in the inauguration of the control, computation and planetabling.

Technical Work.

The area of work lay on the northern side of the main range of the Hindu Kush. The area was roughly shown on the published degree sheet (1-inch to 4 miles) from ¼-inch reconnaissance surveys of 1884-95. A few peaks whose co-ordinates had been fixed in the survey operations of 1884-86 lay at distance of six or more miles to the south, west and north but were visible from the area required to be mapped on the medium scale.

In order to get the planetabling started with the least possible delay on origin was selected near the Ishpushta camp, its co-ordinates on the Indian rectangular grid system were taken from the Degree sheet 38 A, 2nd (Revised) edition, 1936, and the height obtained from hypsometer readings taken

in the camp.

At this origin an astromonical bearing was observed and a base of four chains (Hunter Short Base apparatus) was laid out and extended on the neighbouring hills and the co-ordinates and heights of the first few points were issued to the planetablers to enable them to commence work on the third day.

Observation, computation and planetabling then proceeded simultaneously. The triangulation for the 1:25,000 survey was closed at Tala on a similar astronomical bearing and four chain base.

Astronomical latitude and astro-wireless longitude were observed by Major Crone on three nights at Ishpushta camp.

Triangulation.

On completion of the 1:25,000 control, Mr. Chiragh Shah proceeded with a chain of topographical triangulation covering the Kahmard valley and Rui valley as far as Chel and Qabr-i-Afghan. This work was interrupted whilst Mr.Chiragh Shah returned to Ishpushta to carry out the triangulated control for the 1:1,000 engineering plans.

The topographical chain was checked at Yakh Pusht by a third short base and astronomical bearing.

Whilst carrying out this triangulation Mr. Chiragh Shah made reconnaissance surveys on the 1:250,000 scale

of the whole area traversed.

All stations and a number of intersected points were computed in the field.

Small Scale Survey.

During June and July Sr. Monawar Khan surveyed the Kahmard valley as far as Banaq on the 1:125,000 scale.

Results of the Season's Work.

Triangulation. The triangulation has been recomputed in No.18 Party. From the intersected points common to the previous Haibab and Bamian series of triangulation this year's work has been reduced to the same terms as the Haibak series and the correction to be applied to the Bamian series to bring it into these terms has been derived. These terms cannot be considered as final as the Haibak series is connected to the Indian triangulation by a circuitous route and very considerable corrections have already been applied to it which are open to doubt. It is hoped that a direct connection with India will be made in 1941.

Survey. A general map on the ½-inch scale has been prepared and the edges adjusted to the published sheets to enable it to be used as an applique slip for the Degree sheets 33 M and 38 A. This is also being prepared on the 1:250,000 scale with both English and Persian lettering, and metric gridding for use in Afghanistan. The map in both cases is

placed on the grid in Haibak terms.

The 1:25,000 survey is being published in three sheets in Haibak terms on the metric grid with both English and Persian lettering.

The 1:1,000 plans and their 1:10,000 index are also being published in English and Persian in Haibak terms on the metric grid.

9. LIST OF PLATES.

PLATE 11, fig. 1. Pitching anticline of Cretaceous limestone, Madar.

fig. 2. The Aokhorak valley. Cliffs of highly dipping Cretaceous limestone with the Saighan series below.

" 12, fig. 1. Coal lens No.1.

fig. 2. Coal lens No.2.

" 13, fig. 1. Coal lens No.3, showing derrick, from the south.

fig. 2. The same lens from the east.

" 14, fig. 1. Coal lens No.4.

fig. 2. Coal lens No.5.

" 15, fig. 1. Small lenses of coal, between lenses 5 and 6.

fig. 2. Coal lens No. 6.

" 16, fig. 1. Part of outcrop of lens No.3, cleaned to show hanging wall.

fig. 2. Constructing the main adit to lens No.2.

" 17, fig. 1. Near view of coal outcrop (lens No.2), showing contortion of coal and shale bands.

fig. 2. Weathered surface of lava in Doab series.

" 18, fig. 1. Working the outcrop of lens No.3.

fig. 2. Transporting coal by lorry to Kabul.

" 19, fig. 1. Drilling to coal lens No.3.

fig. 2. Near view of drill.

" 20. The Survey of India Mapping Party.

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PVT:

ISHPUSHTA.

The west side of the Darra Ishpushta.

2

The east side of the Darra Ishpushta.

3

1. View west from the Kotal-i-Khak towards the Ishpushta valley.

2. View east from the Kotal-i-Khak towards Barfaq.

The Cretaceous escarpment at Barfaq.

The Doab series cut by two dykes in the foreground.

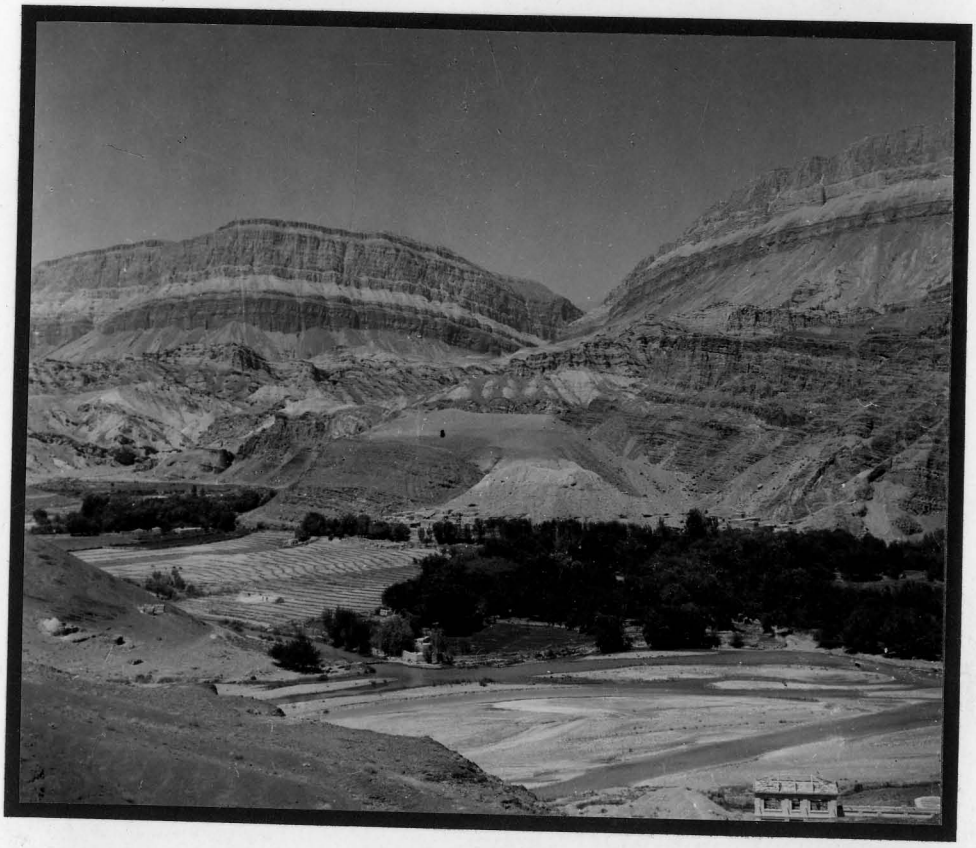
1. The Cretaceous limestone and the upper part of the Red Grit series, with the gypsum bed (white) between.

2. The lower part of the Red Grit series resting conformably on the Saighan series.

1. The Doab series on the left the Saighan series on the right, 2 miles north-east of Doab Mekh-i-Zarin.

2. The Doab series below, the Saighan series above, $1\frac{1}{4}$ miles south-west of Ishpushta.

1. Sill of igneous rock intruded into the Doab series, above the hotel, Doab Mekh-i-Zarin.



2. Doab Mekh-i-Zarin and the Kahmard valley, showing the Cretaceous escarpment.

12

1. Fold viewed from the south.

13

2. Fold viewed from the west.

Recumbent fold of Cretaceous limestone, in the high hills north-east of Ishpushta.

1. Thrust fault in the cliffs on the west side of the Karimak valley.

2. Thrust fault in the cliffs on the west side of the Ishpushta valley.

1. Pitching anticline of Cretaceous limestone, near Madar.

2. The Aokhorak valley.

Cliffs of Cretaceous limestone, with the Saighan series below.

1. Coal lens No. 1.

2. Coal lens No. 2.

21

1. Coal Lens No. 3, showing derrick, from the South.

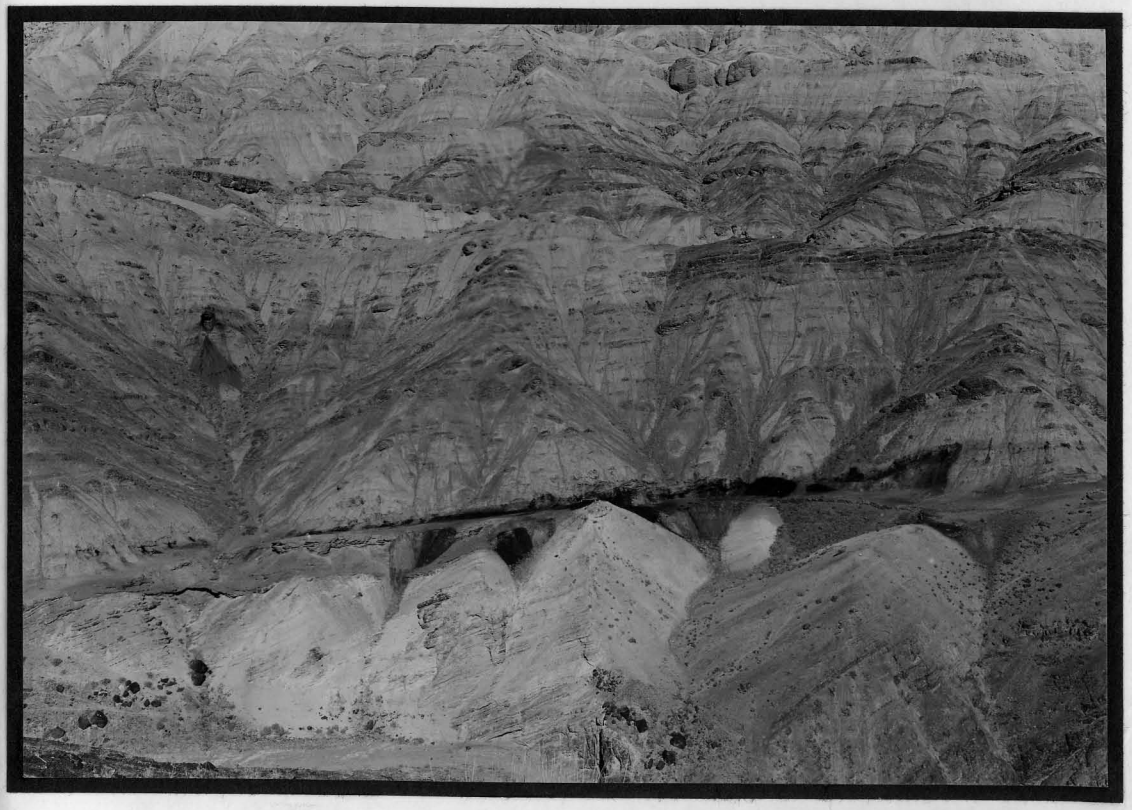
22

2. The same lens from the east.

1. Coal lens No. 4.

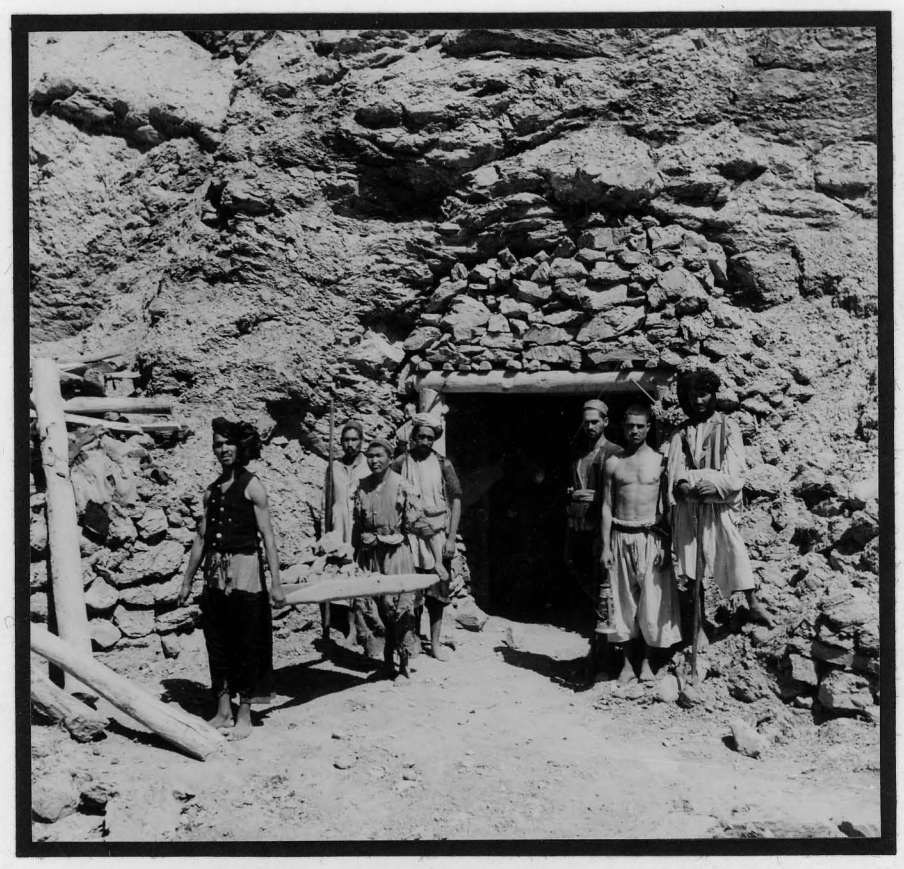
2. Coal lens No. 5.

1. Small lenses of coal, between lenses 5 and 6.



2. Coal lens No. 6.

1. Part of the outcrop of lens No. 3, cleaned to show the hanging wall.



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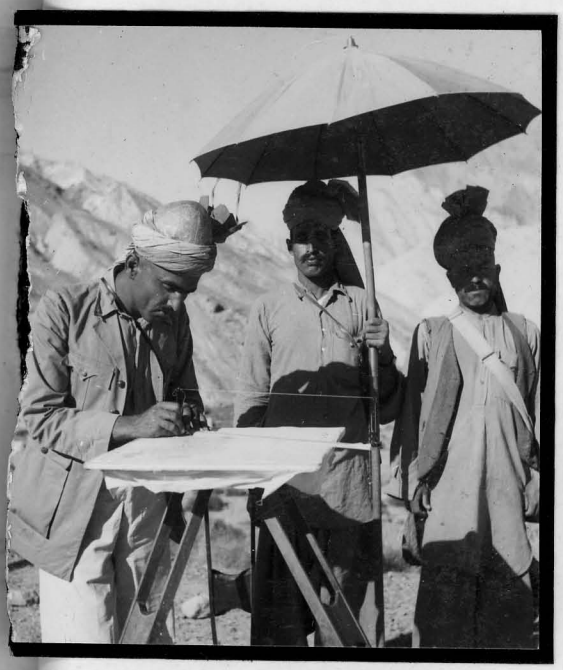
Mr. Chiragh Shah.



Surveyor Monawar Khan.

Surveyor Abdul Rahman.

Surveyor Mohammed Sadiq.

The Survey of India mapping party.