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(SER. XIII.)—SALT-RANGE FOSSILS, BY WILLIAM WAAGEN, PH.D.

I. Productus-Limestone Group: 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.
„ „ 2 (1880). Gasteropoda and supplement to pt. 1, pp. 111 (73-183), pls. 10 (vii-xvi).
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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1882. [August.

Note on the coal *of* Mach (Much) *in the Bolan pass, and of* Sharág *or* Sharigh *on the Harnai route between* Sibi *and* Quetta, *by* W. T. BLANFORD, F.R.S., *Senior Deputy Superintendent, Geological Survey of India.*

When on the way, in October 1881, to examine the hill tracts north of Sind and west of the Punjab, I received instructions to examine two localities at which coal had been found, one on each of the routes between Sibi[1] and Quetta. One of these localities, that at Mach on the Bolan route, had already been visited and described[2] by Mr. Griesbach, but after his examination fresh discoveries were made. As will be seen however, my conclusions as to the value of the coal seams are practically the same as Mr. Griesbach's. The other locality, Sharág or Sharigh on the Harnai route, along which it was at one time proposed to lay a railway to Quetta, and which lies to the eastward of the Bolan pass, had not previously, so far as I am aware, been geologically examined.

My visit to both localities was necessarily very brief, but still I think sufficient to enable me to judge of the probability of their affording fuel on a large scale. My opinion, I regret to say, is unfavourable.

It is unnecessary here to enter at any length into the geology of the beds[3]. Mr. Griesbach has already shown, quite correctly I believe, that the coal of Mach belongs to the lower part of the eocene system. The position of the Sharág beds is not so clear[4], but that they belong to the same system is unquestionable. The similarity in mineral character of the beds associated with the coal[5] in both localities is so great that there is probably very little, if any, difference in age;

[1] The terminus at present of the railway.

[2] Report on the geology of the section between the Bolan pass in Biluchistan and Girishk in Southern Afghanistan, Mem. Geol. Surv. India, Vol. XVIII, Pt. 1, p. 22.

[3] I hope to be able to give a fuller account of the geology of the country in a future report.

[4] I had not time to examine fully the surrounding country.

[5] It may be possibly questioned whether the mineral found at Mach and Sharág should be called lignite or coal, but as the latter term has been generally used, I shall retain it. The substance is certainly not a typical lignite.

but the occurrence of coal or lignite beds in the eocene deposits of Western India appears to be local and occasional, and it is not as yet ascertained that all such deposits are on the same horizon.

It will be well briefly to describe each locality separately, and to commence with Mach.

Mach (Much).—The camp known as Mach, between Sir-i-Bolán and Ab-i-gúm, is four marches (about 45 miles) from Quetta, and six marches (about 65 miles) from Sibi. The elevation above the sea-level is nearly 4,000 feet. Hills occur to the eastward and westward, but for about 2 miles east of the camp, and for a much longer distance to the northward, the surface is nearly a plain, much covered by deposits of gravel, and intersected by deep ravines, in some of which sections of the rocks associated with the coal are seen. A particularly good section is exposed in a stream bed running from the north to join the main Bolan river just opposite the Mach camp. This stream is the Maki Nadi of the map, and is, I think, that called the Mach river by Mr. Griesbach, on the bank of which he measured the sections given in detail in his report[1]. Here several beds of coal occur, but very few, if any, of them exceed a foot in thickness at the outcrop[2].

The beds associated with the coal consist of grey and olive shales, weathering into clay at the surface, sandstones mostly very soft, and a few harder calcareous beds, containing marine (or perhaps estuarine) fossils, chiefly bivalve shells (*Lamellibranchiata*) in great abundance, but not of many species. The sections already mentioned in Mr. Griesbach's report afford a general idea of the rocks.

All the beds are greatly disturbed, and in places irregularly contorted, and the dips are, as a rule, very high, and frequently nearly or quite vertical.

Precisely opposite to the camp at Mach, in the bank of the main or Bolan stream-bed, a thicker seam was found[3] after Mr. Griesbach's visit. Into the outcrop of this seam, at the base of the bank, some holes had been made, from two of which, only a very few feet apart, coal was being dug at the time of my visit. The thickness of the seam exposed was 2 feet 8 inches in one hole, 2 feet 4 inches in the other, as nearly as could be ascertained under the circumstances, the holes being small and irregular, no good face of the coal exposed, and a considerable quantity of water running in from the gravel in the stream bed. But of the thickness named, the uppermost, 6 to 8 inches, was very shaly and impure[4];

[1] *Op. cit.*, pp. 23, 24.

[2] Many of the seams are excessively decomposed at the outcrop, and would perhaps prove rather thicker if cut into.

[3] By Captain Johnson, Commissary of Ordnance. This officer had unfortunately left Mach before I arrived, and I found no officer stationed at the post.

[4] The following is an analysis by Mr. Mallet:—

Moisture	7·0
Volatile matter (exclusive of moisture)	38·8
Fixed carbon	17·6
Ash	36·6
	100·0

whilst the lower, 2 feet or rather less, were of better quality. An analysis of a fair sample by Mr. F. R. Mallet gives—

	Per cent.
Moisture[1]	10·9
Volatile matter (exclusive of moisture)	33·1
Fixed carbon	41·0
Ash	15·0
	100·0

The ash is red, indicating the presence of iron pyrites in the coal.

The seam, where cut into, dips about 50° to the north. Ten or 12 feet above it is another much thinner bed, and 12 feet higher another, consisting of several bands of coal, measuring in the aggregate perhaps 20 inches, distributed through 4 to 5 feet of shale. None of the separate bands of coal exceeds 6 inches in thickness. Several other thin seams occur higher in the section.

There is much reason to suspect that the thickness of the principal seam is not uniform. It appears to vary in the few feet exposed, and so far as could be learned from the native workmen, who had been engaged in digging coal from it, it thins out to the westward. The associated clays can be traced for some distance, but no distinct outcrop of the thick seam is exposed. In the opposite direction to the east and north-east, all outcrops are concealed by the gravel in the bed of the stream.

Sharág or *Sharigh.*—The camp and military post marked as Sharág on the map, but commonly known as Sharigh, lies at a distance of four long marches (about 70 miles) from Quetta, and of five marches (about 80 miles) from Sibi, at approximately the same elevation (4,000 feet) above the sea as Mach, in the middle of a plain extending to a great distance to the north-west and south-east, and broader than usual, being probably 7 or 8 miles from north to south, at the spot selected for the camp.

The principal place where coal occurs[2] is about 3 miles south of the post and close to the hills forming the southern boundary of the plain. A small stream, the Siah Dad, running from the plain, cuts its way through the hills to the southward, and close to the spot where it enters the hills a much smaller stream runs in from the west, and exposes in its bed an excellent section of the rocks, which are imperfectly seen in the Siah Dad itself. As already mentioned, these rocks are similar in character to those of Mach,—soft grey or olive shales, more or less sandy, and weathering into sandy clays at the surface, soft sandstones and hard calcareous bands containing fossils. All are vertical or nearly so. In a measured section of about 370 feet of these strata, there are about thirty beds of coal, the great majority less than 6 inches thick, and many only 1 or 2 inches. Only four beds equal or exceed a foot in thickness, and of these, two are chiefly composed of shales. The thickest seam measures 1 foot 9 inches. Fair samples

[1] Water that is driven off at a temperature of 230° Fahr.

[2] I was more fortunate at Sharág than at Mach, for at the former Major Newport, of the 24th Bombay Native Infantry, the discoverer of the coal, still commanded the post when I visited it. He took me over the ground and gave me all the information in his power.

of this seam (No. 1), the quality of which is superior to that of most of the others, and of a thinner band 8 inches thick (No. 2), have been analysed by Mr. F. R. Mallet with the following result:—

	No. 1.	No. 2.
Moisture	6·8	3·0
Volatile matter (exclusive of moisture)	40·8	42·8
Fixed carbon	47·6	46·1
Ash	4 8	8 1
	100·	100·0

No. 1 does not cake, and yields a red ash; No. 2 cakes to a light porous coke, and yields a red ash.

In another spot, three quarters of a mile further north, and consequently nearer to the camp at Sharág, the outcrops of several thin coal seams are seen in the banks of a stream bed. The coal-bearing rocks are probably the same as those to the south, repeated by a roll of the strata. Again, the dip is nearly vertical. One bed of coal was seen a foot thick, and of good quality. It was possible to trace the outcrop of this seam on the surface of the ground for about 350 yards by the aid of a conspicuous band of highly fossiliferous sandstone abounding in bivalve shells, and occurring just above the coal. Within the distance named, the thickness of the coal seam diminished, until it was only represented by a layer or two, scarcely an inch thick, in carbonaceous shale. This was the only instance in which the outcrop of a coal-bed could be traced more than a few yards, and it affords strong presumption of the inconstancy in thickness of these seams,—an inconstancy which has been observed in similar deposits amongst the eocene rocks of other parts of India and Burma.

The country around Sharág has been searched in all directions by Major Newport without any other outcrops having been found. But about 7 miles east-south-east of Sharág, on the road to Harnai, three little seams are exposed 200 or 300 yards north of the road in a small stream running from the north. One of the seams is 7 inches thick, the others 1 to 2 inches. A little further on the Harnai road, a thin coaly layer is seen by the road side. Again, on the same road, about 3 miles east-south-east of a small village called Nasuk, and 12 miles from Sharág, in a section cut by a small stream close to the road, and on the north side of it, four little seams are seen,—the two upper mere layers, the third 8 inches thick, and the fourth, separated by 5 inches of clay from the third, 3 inches in thickness. In all these cases the beds are nearly horizontal. These outcrops, all observed in the course of a single march along the road, render it highly probable that many more would be discovered if a thorough exploration of the country were undertaken; but at the same time they do not add to the probability of thicker beds of coal being found.

The details given above lead to the following conclusions:—

1. Not a single seam has been discovered, either at Mach or Sharág, thick enough to pay for mining on a large scale, even if the thickness of the seam were known to be constant, and if other circumstances were favourable to mining,—neither being the case.

2. The evidence is very imperfect, but so far as it extends, it appears probable that the seams are inconstant in thickness, and thin out within short distances.

3. The conditions under which the seams occur at Mach and Sharág are unfavourable to mining, though not such as to render it impracticable. In the first place, the beds dip at high angles and are often vertical. There is, however, much probability that by search other localities might be found where the dips are moderate, as in the case of the little seams noticed between Harnai and Sharág. Secondly, the associated rocks are so soft that mining would involve the necessity of heavy timbering or of masonry to protect the means of access to the mine.

4. The analyses given above, and especially those of the Sharág coals, show that the mineral found would be of considerable value, if it could be procured in sufficient quantity. It should be remembered that the specimens analysed are taken from the outcrop, and that at a little depth below the surface the quality of the coal would in all probability be better.

A railway could be worked with such fuel, although the work done would be less than that yielded by coal containing a larger proportion of fixed carbon. The quantity of iron pyrites in the different seams is probably variable, but in those especially examined, it does not seem sufficient to prevent the coal being used for a railway.

It is evident that a considerable quantity of useful fuel for local purposes can be procured from the outcrops of the seams. So far, however, as can be judged from the facts hitherto known, the supply obtainable is insufficient for a large work such as a railway.

New faces *observed on* Crystals *of* Stilbite *from the* Western Ghâts, Bombay; *by* F. R. MALLET, F.G.S., *Geological Survey of India.*

During the construction of the Great Indian Peninsular Railway, when very heavy cuttings and tunnels were being driven through the trappean rocks of the Bhor and Thul Ghâts, magnificent specimens of zeolites were brought to light in great profusion. The species occurring most abundantly were stilbite, apophyllite, heulandite, and scolecite, all of which were represented by splendid crystallizations[1]. Large collections were made at the time by Mr. W. T. Blanford for the Geological Museum, where the finest specimens are now included in the systematic collection of minerals.

Most, if not all, of the stilbite specimens fall under one or other of four types[2]:—

1*st.*—Salmon-coloured crystals, generally of considerable size—very commonly, for instance, an inch, and sometimes two inches across (in the direction $\infty \breve{P} \infty$). They have the faces $\infty \breve{P} \infty$. $\infty \bar{P} \infty$. P., and are not uncommonly somewhat (but not highly) sheaf-like, from the aggregation of simple crystals into compound ones. They are generally (but not always) implanted by one end, and hence usually present only one pyramidal termination. Crystals of this type are frequently thickly grouped, occurring either alone, or with apophyl-

[1] Manual of the Geology of India, p. 304.

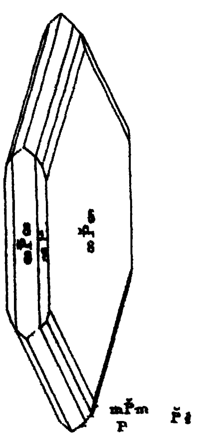
[2] Excluding lamellar specimens, in which the crystallization is obscure.

lite, which not uncommonly takes the form of minute crystals implanted on the surface of the stilbite. Quartz, &c., is also found in the same association, but not so frequently. In other cases the stilbite occurs in isolated crystals of the type in question, being then very usually associated with large, thickly grouped, crystals of apophyllite.

2nd.—Highly sheaf-like forms, sometimes so much so that viewed on the face $\infty \bar{P} \infty$ they have the appearance of a fan, or in the comparatively rare cases where both ends of the crystal are free, of two fans with the points together: the crystals are commonly of considerable size, averaging say one-half to one inch across. They are generally thickly grouped, but sometimes occur singly. They occur either alone, or associated with heulandite, apophyllite, scolecite, or with crystals of the third type.

3rd.—Thin tabular crystals of comparatively small size (more commonly a quarter to an eighth of an inch across, sometimes much less); non-sheaf-like, or very slightly sheaf-like in form, and exhibiting the combinations $\infty \breve{P} \infty$. $\infty \bar{P} \infty$. P. and $\infty \breve{P} \infty$. $\infty \bar{P} \infty$. ∞ P. P. They occur alone, and with apophyllite, heulandite, scolecite, and perhaps other minerals. In one case small crystals of this kind were observed implanted on large ones of the first type, showing that the former were of later formation. The crystals of the second and third types are white.

The crystals of the fourth kind, which are by far the least common, occur on the surfaces of cavities which are lined by minute crystals of quartz. No other zeolites are associated with them (except in one specimen which includes apophyllite). They are salmon-coloured; of considerable size, averaging say half an inch across; generally tabular and non-sheaf-like, or very slightly sheaf-like in form. Generally they present the faces $\infty \breve{P} \infty$. $\infty \bar{P} \infty$. ∞ P. P., but in some there is also a face replacing the edge between $\infty \breve{P} \infty$ and P. The parallelism of the edges between this face and $\infty \breve{P} \infty$. & P., respectively, shows that the formula for the face in question is m $\breve{P}$ m. Striæ and irregularities on $\infty \breve{P} \infty$. and P. prevent more than roughly approximate angular measurements. For m $\breve{P}$ m $\wedge$ P. the value $152°\frac{1}{4}$ was obtained. A more reliable result, however, can be deduced from the observation that the plane angles formed by the edge between m $\breve{P}$ m. & ∞ P. with the edges between m $\breve{P}$ m. & $\infty \breve{P} \infty$. and m $\breve{P}$ m. & P. (all of which edges are straight and sharply defined) are either right angles or extremely close approximations thereto. Assuming them to be actually right angles the calculated value of m $\breve{P}$ m $\wedge$ P. is 154° 35′, giving a value for m of 2·5098, or a close approximation to $\frac{5}{2}$. Taking m at $\frac{5}{2}$, the value of the angle m $\breve{P}$ m. $\wedge$ P. is 154° 41, the plane angles formed by the edge between m $\breve{P}$ m. & ∞ P. with the edges between m $\breve{P}$ m. & $\infty \breve{P} \infty$. and m $\breve{P}$ m. & P., respectively, being 90° 8′ and 89° 52′.



The value of the following angles therefore are—

$$\tfrac{5}{2}\breve{P}\tfrac{5}{2}. \wedge P. = 154^\circ 41'.$$
$$\tfrac{5}{2}\breve{P}\tfrac{5}{2}. \wedge \infty\breve{P}\infty. = 145^\circ 41'.$$

On one crystal there is also a face $m\breve{P}m$ replacing the edge between $\frac{5}{2}\breve{P}\frac{5}{2}$ and $\infty\breve{P}\infty$. The value of m is much greater than $\frac{5}{2}$, but owing to the position of the crystal in a cavity, it is impossible to get even a rough measurement of the angles between $m\breve{P}m$ and the adjacent faces, without destroying the specimen.

Professor Heddle has noticed the occurrence of a face replacing the edge between $\infty\breve{P}\infty$. and P. on crystals of stilbite from Dumbartonshire, and from near Mount Nombi in Australia. He obtained the value 149° 45′ to 150° for the angle $m\breve{P}m. \wedge \infty\breve{P}\infty$. in the Scotch specimens, and 152° 32′ to 153° in the Australian. These results, however, he considered little better approximations, and he felt little doubt that the face was the same in the specimens from both localities[1]. The angles 149° 45′ and 153° respectively give a value for m of 2·9266 and 3·3497, the angle when m equals 3 being 150° 22′. The probability therefore would seem to be that the face noticed by Professor Heddle is different from that on the Indian specimens.

The total number of faces, which, as far as I have been able to ascertain, have hitherto been noticed on stilbite, are, $\infty\breve{P}\infty. \infty\bar{P}\infty. \infty P. P. 0P.$, which are given in all mineralogical works; $\frac{3}{2}\breve{P}\infty$. noticed by Des Cloizeaux on crystals from Bergen Hill (New Jersey)[2]; $m\breve{P}m$ ($3\breve{P}3$?) recorded by Heddle; $\frac{5}{2}\breve{P}\frac{5}{2}$ and $m\breve{P}m$ (m having a high value) on crystals from the Western Ghâts.

On the traps *of* Darang *and* Mandi *in the North-West Himalayas,—By Colonel* C. A. McMAHON, F.G.S. (*with two plates*).

The occurrence of intrusive traps in the lower Himalayas is mentioned at pages 21 and 70, Vol. III, Memoirs, Geological Survey, and at pages lvii and 606, Manual of the Geology of India, whilst notices of the trappean rocks of Darang (Drang) and Mandi will be found at pages 58, 59, and 61 of Vol. III Pt. 2 of the Memoirs.

Doubts have at different times been expressed regarding the origin and nature of the traps described in this paper. At one time there was a tendency to regard them as metamorphic rocks; and although in the passages referred to they are spoken of as 'traps,' and are described as occurring along a definite horizon, they do not appear to have hitherto been recognised as true lavas. The microscope, I think, enables us to set any doubts upon this point at rest.

I have examined 26 slices[3] of the trap, of which the ridge to the east of Darang is composed, and 9 slices of the trap, in the same line of strike, exposed in the bed of the Suketi at Mandi.

[1] Mineralogical Magazine, Vol. IV, p. 44.

[2] Manuel de Minéralogie, Tome I, p. 416.

[3] Prepared for me by Mr. F. G. Cuttell, 52, New Compton Street, Soho, whose workmanship leaves nothing to be desired.

It would be wearisome to the reader were I to describe each of these slices, but I think it desirable to describe several typical specimens in some detail, and this I now proceed to do.

No. I.—A greenish-grey rock: specific gravity 2·89. It has rather a mottled appearance under the pocket lens, owing to the alteration of a portion of its mineral contents into delessite, or a mineral approximating to delessite. A portion of the rock is soluble in hydrochloric acid, and the dissolved portion contains both ferric and ferrous oxide. A few crystals of iron pyrites are to be seen.

Appearances under the microscope.—This slice may be described as a net-work of felspar and augite crystals set in viridite, which in part appears to represent the original glassy base[1].

There are numerous crystals of augite scattered through the slice. Portions of each of these crystals have been altered into brownish-green granular matter. The portions which have escaped alteration are clear and colourless in transmitted light and polarise fairly well. They are not dichroic; several of the crystals are twinned, and many of them exhibit the orthodiagonal cleavage lines very distinctly.

Most of the felspar crystals exhibit the characteristic twinning of triclinic felspar in polarised light, and their optical properties agree with those of labradorite. Alteration has been set up in the felspar, and has declared itself by the presence of granular matter in the body of the crystals.

The grouping of the felspar crystals, and the general effect of the slice when seen by transmitted light, is illustrated in fig. 1, plate I. It is very characteristic of an eruptive rock.

The viridite, in this slice, is of pale green colour. It is feebly dichroic in patches, and, for the most part, remains dark between crossed nicols. It exhibits little or no fibrous or radiating structure.

Scattered through the mass is some white mineral matter that is perfectly opaque in transmitted light, and which, from its appearance and mode of occurrence, is I think, leucoxene, a product of the alteration of ilmenite.

No. 2.—A greenish-grey rock. Specific gravity 2·90. It has a slightly mottled look under the pocket lens, but minute prisms and irregular crystals of felspar are visible in it here and there.

Microscopic aspect.—The most prominent objects in the slice are the crystals of felspar, of various sizes and shapes, starred about in the field of the microscope. The great majority are distinctly seen to be crystals of triclinic felspar, and the others appear to belong to that system also. They are in fairly fresh condition. Fig. 2, plate I, is a representation of a portion of this rock, as seen under the microscope by transmitted light.

Those who are not familiar with the subject of microscopic petrology, may be surprised to find that the prisms of felspar, represented in these illustrations, do not present more regular forms. It must be remembered, however, that the principal axis of crystals in an igneous rock usually point indifferently in all directions,

[1] This supposition is confirmed by an examination of the basalts of Bombay, to be described in my next paper. In the Bombay lavas the conversion of the *base* into viridite can be distinctly traced.

and a slice made at random cuts the crystals contained in the matrix in every conceivable direction. For instance, in fig. 10, plate II, supposing a slice of the crystal therein represented were made in the direction from *a* to *b*, the outline of the section, as seen in the field of the microscope, would present a considerable modification of the true shape of the crystal.

Other causes also operate to produce irregularities of shape. Crystals forming in the proximity of other crystals appear to be sometimes stunted in their growth owing to crowding; whilst the different degrees of crystallographic energy with which the constituents of different minerals come together appear to exercise more or less influence on crystals forming in their vicinity. The want of perfect molecular freedom, when an eruptive rock is rapidly cooled at the surface of the earth's crust, must also affect the results. This freedom of molecular action becomes less and less as the cooling proceeds; hence crystallisation is often arrested before the outward form of a crystal is finished; portions of the magma are cooled before the chemical elements contained therein have had time to combine to form crystals—leaving here and there what is termed a "glassy base." The molecules of other crystals, again, coming together with energy, and being, so to speak, pressed for time, catch up portions of the glassy base and small crystals of other, previously formed, minerals, and enclose them in their own substance.

Another cause to which irregularities of outward shape are due, is the alteration which minerals undergo, after the consolidation of the rock, by the passage through it of acid and heated water. Cracks are formed both in the body of the rock, and in individual crystals, by the contraction due to cooling and to crystallisation, and along these fissures heated and acid water, or steam, penetrates; chemical action is set up, and, amongst the results, the outward form of crystals is often much altered.

The slice under consideration contains a good specimen of those radiating and cruciform groups of felspar crystals which are so characteristic of eruptive rocks. Some of the radiating prisms exhibit the twinning characteristic of triclinic felspars. The twins appear to be arranged in groups, in each prism, and the whole combined as penetration twins. A sketch of one of these groups is given at fig. 1, plate II.

No. 3.—A greenish-grey compact rock. Specific gravity 2·93.

Microscopic aspect.—This slice contains numerous felspar prisms pointing in all directions. Most of them are distinctly seen to belong to the triclinic system. Numerous instances of stellate grouping of felspar prisms occur in this slice. One of them is depicted at fig. 2, plate II. Alteration has been set up in the felspar, and shows itself by the formation of granular matter and patches of viridite in the interior of the crystals.

Fields of pale amorphous viridite are abundant in the slice, and in them are located multitudes of epidote crystals, many of them presenting good characteristic crystallographic forms. They are principally located round the margins of the viridite fields.

The remains of augite crystals are to be distinctly made out, but they have all been, more or less, converted into a greenish-brown non-dichroic substance.

Portions of the slice here and there are obscured by an alteration product, white in reflected and purplish black in transmitted light.

Nos. 4 and 5.—A dull greenish, or greenish-grey, compact rock, weathering light brown. Specific gravity 2·83. Under the pocket lens it has a somewhat mottled appearance.

Microscopic aspect.—The slice consists of crystals of felspar and augite starred about in what represents the original base or magma. This probably, as seen in many basaltic rocks—in the Bombay basalts and some Vesuvian lavas for instance—was originally full of minute grains of magnetite or ilmenite and imperfectly crystallised matter, and this has been changed into an alteration product which exhibits no crystallographic form. It is white in reflected and opaque in transmitted light.

Augite in this slice is very abundant; twinning is common in it; sometimes the orthodiagonal cleavage lines are very distinct, whilst in other crystals the characteristic intersection of the prismatic cleavage lines is well seen.

The unaltered portions of the augite are fresh and polarise well, but much of it has been transformed into a brownish-green substance.

Fig. 4, plate II, is an illustration, taken from slice No. 4, of the way in which the augite crystals have been eaten up and converted into this substance. The fragments shown in the illustration appear to represent the remains of a group of augite crystals originally in close juxta-position to each other, but which have now been split up into a little archipelago of augite fragments. The alteration which has taken place in these cases can be distinctly traced to the passage of water along cracks, and the alteration can be seen in all its stages in the slices under consideration.

Fig. 7, plate II, represents a twinned augite in slice No. 4, in which great irregularity of outward form has to some extent, at any rate, been produced by the corrosive agency of acid water, but in which internal alteration through cracks has not proceeded as far as in fig. 4. Under the microscope the dark lines which traverse the crystal are distinctly seen to be little canals filled with the products of aqueous alteration.

In many cases the alteration of the augite has resulted in the formation of mica. Fig. 5, plate II, is an illustration of a case, taken from the slices under consideration, in which part of an augite crystal (*a*), the external outline of which has been rendered irregular by its change into a greenish substance, has been converted into mica, as at *b*; whilst another portion (*c*) appears to be in process of conversion into this mineral. Another illustration is given at fig. 6, plate II, also taken from one of these slices, in which small fragments of augite are seen to be encased in mica. Doubtless the latter is an alteration product, resulting from the change of a large augite crystal, small fragments of which escaped conversion. The little canal-like cracks through which the corroding liquid originally gained access to the heart of the augite, are still visible, and an attempt to represent them has been made in the sketch.

Mica is scattered about rather plentifully in these slices, and in transmitted light, it varies in colour from red to green.

Bischof[1] alludes to the conversion of augite into a brownish, or leek green, mica. Some augites contain as much as 11·05 per cent. of alumina (J. D. Danas' "System of Mineralogy"); whilst, according to the same authority, some micas contain as little as 9·27 per cent. of that constituent. All that seems essential for the conversion of the one mineral into the other, is a removal of a large proportion of the lime from the augite and the introduction of the alkaline element—a process which one can readily understand taking place in the "wet-way."

The felspar crystals have been so kaolinised and altered that all trace of twinning has been obliterated.

I have detected one small prism of hornblende. It is probably an alteration product.

No. 6.—A compact grey rock faintly tinged with green. Specific gravity 2·92.

Microscopic aspect.—The base has been converted partly into an amorphous substance, bluish-white in reflected and olive green in transmitted light, and partly into granular viridite. In this base felspar crystals are scattered about in immense profusion, some in minute needle-shaped prisms, and others in prisms of some size. A large proportion of them exhibit the characteristic twinning of triclinic felspar. Some of the medium-sized crystals have caught up portions of the base in the act of crystallisation, and the portions so included conform to the shape of the felspar prisms.

The slice contains some good-sized crystals of epidote.

No. 7.—A grey, compact, amygdaloidal rock. Specific gravity 2·88. The centres of the amygdala consist of quartz, the inner lining being sometimes composed of epidote. Epidote is also seen to line cracks and to abound in the vicinity of the amygdala.

Microscopic aspect.—The slice consists of countless felspar prisms, starred about in a felspathic cryptocrystalline base. A large proportion of the felspar exhibits the twinning peculiar to triclinic felspar. A considerable amount of epidote is seen dotted about in small granules and in meandering lines. Here and there patches of viridite are seen throughout the base.

Amygdaloidal cavities occur here and there, filled with quartz, epidote, and delessite. The quartz is greatly crowded with a fine dust of opaque matter, which, on the application of high powers, is seen to consist of a multitude of extremely minute gas and liquid cavities.

A sketch of one of the stellate groups of felspar crystals before alluded to, contained in this slice, is given at fig. 9, plate II. The illustration shows the appearance of the group in polarised light with crossed nicols.

For the sake of comparison, I have given at fig. 8, plate II, a sketch of a triclinic felspar group taken from a slice of domite, in my possession, made from a specimen collected by me on the Puy de Dome, Auvergne. All the radiating prisms are seen in polarised light to be many times twinned, but they are arranged in groups which simulate the twinning of the Carlsbad type.

I have often observed this peculiarity in plagioclase, and it appears to be produced by one set of twins being thick at one side of the prism and thin at the other side; whilst the second set of twins are thick on the side in which the first set are thin, and thin on the side in which the first set are thick. The

[1] Chemical Geology, Vol. II, p. 326.

effect of this peculiar arrangement therefore is, that, when viewed in polarised light, one-half of the prism appears almost wholly dark, whilst the other half exhibits an almost unbroken sheet of colour; the twins which at that azimuth suffer extinction of light being very thin relatively to the twins which at that azimuth polarise in more or less brilliant colours.

This arrangement may be traced in fig. 8 sufficiently, perhaps, to make my meaning clear; but I have attempted in this sketch to reproduce the general effect, as far as that can be given in black and white, rather than these minute details of structure.

Throughout the base are scattered granules of black opaque matter that appears to be magnetite arrested in the act of crystallisation. A sketch of one of these granules, as seen with the aid of somewhat high power, is given at fig. 11, plate II. Forms of this kind appear to me to indicate that the rock cooled rapidly under conditions that interfered with the molecules of the ferriferous mineral coming together in the form of a regular crystal. As pointed out by Dr. Sorby, there is a strong tendency on the part of crystals formed in slags to assume skeleton forms, and I have noticed that salts crystallised rapidly on a glass slide very frequently assume the sort of skeleton form shown in fig. 11, instead of regular crystals; each salt, speaking broadly, having its own pattern. Skeleton crystals of magnetite, similar to those occurring in these rocks, appear to be very characteristic of volcanic rocks and furnace slags[1].

A few flakes of a reddish mica are to be seen in this slice.

No. 8.—A grey, compact, amygdaloidal rock. Specific gravity 2·84. A reddish mica is seen here and there in amygdaloidal cavities, associated with the other minerals therein.

Microscopic characters.—Prisms of felspar, much of which is distinctly seen to be triclinic, are scattered about in a felspathic base. Amongst the felspar a striking case of cruciform penetration twins is to be seen. The two arms of the cross intersect at an angle of 85°.

A considerable proportion of the base is represented by minute patches of viridite, partly fibrous and partly granular. Scattered through it, there is a considerable amount of opacite in granules, representing, I apprehend, imperfectly formed magnetite. It is similar in character and appearance to that described in slice No. 7.

The amygdaloidal spaces are plugged with quartz and viridite. In some, the viridite is seen by itself; in others an intergrowth of the two has taken place, granules of quartz being surrounded by the viridite in some cases, and in others, numerous patches of viridite of various sizes and shapes being included in the quartz.

The viridite is in some places amorphous, and in others, in radiating or sheaf-like bundles of fibres. I believe it is in part delessite and in part chlorite. Round the margins of the chloritic inclosures in the quartz it passes into the vermicular form of pro-chlorite.

The quartz, which occurs both in the amygdaloidal cavities and filling what were apparently fissures, contains many flakes of a reddish mica. The quartz is

[1] Rutley's Study of Rocks, p. 154.

remarkable for containing numerous very minute rounded liquid cavities with moveable bubbles.

From the fact that the quartz occurs in the amygdaloidal cavities and from its intimate intergrowth with the delessite, I see nothing to support the supposition that it is of fragmentary origin and has been brought up with the lava stream from below. On the other hand, though liquid cavities are very common in the quartz of granite and quartz-porphyries, I am not aware of their having been before observed in quartz plugging amygdaloidal cavities. Dr. Sorby mentions a solitary case of liquid cavities having been found in some trachyte of solid character at Ponza[1] which appears to have been formed under considerable pressure. They are, however, very common in quartz veins, and to their presence principally, Dr. Sorby attributes the usual whiteness of vein quartz. The quartz under consideration is of dull white colour and it probably owes its opacity and whiteness to the same cause. The presence of the liquid cavities in the quartz of slice No. 7, and in that under consideration, may, I think, be explained on the supposition that the lava stream after solidification was covered over for a considerable thickness by other lava streams, or by stratified deposits, and that the plugging of the cracks and the amygdaloidal cavities was accomplished with the aid of highly heated water or steam *under pressure.*

There is a great thickness of trap exposed at Darang.

Nos. 9 & 10.—A greenish-grey rock with numerous amygdaloidal cavities; Sp. G. 2·77[2].

Microscopic aspect.—The amygdaloidal cavities contain scolecite. The inner kernel of some is formed of calcite, whilst fissures in the scolecite are filled with this mineral. The study of these amygdala under the microscope affords an illustration of how one might often be misled by a chemical analysis. Viewed macroscopically the calcite would probably escape observation altogether.

The base is cryptocrystalline, and it contains multitudes of tufts of a fibrous chloritic mineral. Numerous small patches of viridite are also to be seen scattered through the mass. There are patches of a greenish mica both in the matrix and the amygdala.

Granular epidote is plentiful. A fine group of epidote crystals is imbedded in the scolecite.

The stellar arrangement of the felspar crystals may still be traced, but the felspar is a good deal altered, and no distinct indication of the twinning of the triclinic system remains.

No. 11.—A greenish-grey compact rock, Sp. G. 2·81. There are numerous round lumps of delessite plugging what were apparently amygdaloidal cavities. Other such cavities are seen to be lined with a dull reddish-brown mica. The centres of the cavities are filled with quartz.

Microscopic aspect.—The slice consists of numerous crystals of felspar of various sizes starred about in a fibrous translucent ground mass, olive green in

[1] Quart. Journ. Geol. Soc., London, Vol. XIV, p. 484.

[2] This is within the minimum for basalts, but it is probably somewhat under the mark owing to the presence of air in some of the unfilled or partially filled amygdaloidal cavities. The presence of scolecite and calcite in the latter must also affect the result.

transmitted light. More dense and opaque patches of the same material are dappled about in it in a spotty way, whilst, here and there, along what were apparently lines of infiltration connecting amygdaloidal cavities, it assumes a ropy appearance.

Most of the felspar crystals are distinctly triclinic and are in prismatic forms affording rather sharp outlines. In some instances they have caught up portions of the olive green base in the act of crystallization, the base being moulded to the form of the felspar prism.

Fig. 3, plate I, is a representation of a small portion of this slice, as seen in the field of the microscope. Annexed to a group of plagioclase felspar crystals one of the cruciform arrangements of felspar prisms, so often alluded to in the preceding pages, is seen to be attached. The arms of the cross intersect at an angle of 83½°, and they exhibit the twinning peculiar to the triclinic-system. The two long dark lines in the group above the cross are portions of the base caught up in the act of crystallization. The amount so caught up in the present instance is small, but occasionally, in some of the slices described in this paper, the amount is considerable relatively to the size of the prism.

Some of the amygdaloidal cavities are plugged with delessite in fan-shaped and radiating forms; others contain, intermingled with the delessite, a mica, red in transmitted light, and a little quartz.

Epidote is abundant, and occurs either in or connected with amygdaloidal avities.

Mandi Traps.

The traps seen in the bed of the Suketi river at the town of Mandi occur in he line of strike of those at Darang. The outcrop is here much thinner than at he latter place.

I have examined seven sections of the Mandi trap made from chips and two rom slices of the rock. There is no perceptible difference in the character of hese specimens, and it will suffice to describe the two slices.

Nos. 12 and 13.—A dark-grey compact rock with a slight tinge of green in it; Sp. G. 2·88.

Augite is abundant. Some of the crystals are fairly regular in shape and winning is common in them. A little mica is visible in these slices.

A cryptocrystalline or partially devitrified base, forming irregularly shaped paces, is to be seen here and there. The felspar prisms do not present sharp outlines, and they are kaolinised and decomposed. No trace of triclinic twinning s to be seen in them.

The olive green ground mass has been partially converted into viridite, which s only seen, however, in minute patches disseminated through the mass.

The rock is evidently a lava that has rapidly cooled, the augite being the only mineral that has had time to crystallise regularly and perfectly.

Conclusion.

The specific gravity of basalt ranges from 2·76 to 3, its mean specific gravity being 2·90. The specific gravity of the traps described in this paper ranges from 2·77 to 2·93, their average being 2·86. The specific gravity test therefore points to these rocks being classed as basalts.

The microscopical examination of thin slices supports this view. Augite is generally abundant in them; plagioclase forms a prominent component in most of the slices; and, in those in which the twinning peculiar to triclinic felspars is not visible, its absence is satisfactorily accounted for by the kaolinisation and alteration of the felspar.

Olivine is usually one of the first minerals in a basalt to undergo decomposition, and it is often represented by a green product of alteration.[1] Olivine has not been detected. Its presence was not to be expected in a rock which has undergone considerable alteration, and, moreover, though its occurrence is very common, it is not present in all basalts. None of the Bombay basalts I have examined contain any.

Magnetite is plentifully represented in these slices by skeleton crystals arrested in the progress of crystallisation, and also by the secondary products of its decomposition.

Mica often occurs in basalts. Its presence in these slices appears to be due to the alteration of some of the original minerals.

The epidote, calcite, delessite, pro-chlorite, and scolecite, are also the secondary products of the decomposition of some of the original constituents of the rock.

Quartz only occurs in amygdaloidal cavities and cracks, and its presence in such situations is not unusual.

The mineralogical contents therefore of the thin slices examined under the microscope, agree with the specific gravity test, and show that those rocks are altered basalts.

Basalts are classed as volcanic rocks, and the fact that the traps under consideration are abundantly amygdaloidal, and that the microscope reveals the presence in them of a glassy or imperfectly crystallised base, shows that they were consolidated at the surface of the earth's crust. All the details of their structure corroborate this view, and I think they are without doubt altered basaltic lavas.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Portion of a slice of an altered basalt. Darang, in the Mandi State, North-West Himalayas.

Fig. 2. Ditto ditto.

Fig. 3. Ditto ditto.

PLATE II.

Figs. 1, 2, 3, and 9, illustrations of stellate grouping of felspar prisms, characteristic of eruptive rocks, and basalts in particular, taken from the Darang basalts.

[1] Rutley's Study of Rocks, p. 254.

Fig. 8. Another illustration of stellate grouping of triclinic felspar taken from a domite, Auvergne.

Figs. 4 and 7. Augite crystals in process of alteration into a green product by the passage of corroding liquids through the rock.

Figs. 5 and 6. Pseudomorphs of mica after augite, taken from the Darang basalts.

Fig. 10. Illustration showing the modified shape of sections of minerals, as seen in thin slices under the microscope.

Fig. 11. Skeleton form of magnetite taken from one of the Darang basalts.

Further note on the connexion between the Hazára *and the* Kashmir Series—*By* A. B. WYNNE, F.G.S., *Geological Survey of India.*

The recent appearance of Mr. Lydekker's latest paper on the geology of Kashmir (Rec. Vol. XV, p. 14) throws so much more light upon the question of the relations of the rocks in two adjoining regions that I am tempted to offer a few further remarks in continuation of my last papers on Hazára.

We are now enabled to extend the comparison which I applied to the then known Kashmir section (Rec. Vol. XII, p. 128, &c.), so as to embrace the actual continuation of the Hazára rocks as they pass thence into Kashmir and Kaghán as follows, the annexed list including all the main groups of the whole region on both sides of the Kunhar[1]-Jhelum valley which appears to have been the main drainage outlet of the area from an early period :—

HAZARA.	KASHMIR AND KAGHAN.
7. Murree Beds (probably partly miocene).	7. Murree Beds (miocene).
6. Nummulitic.	6. Nummulitic.
PRESUMABLE OVERLAP.	OVERLAP AMOUNTING TO UNCONFORMITY.
5. Cretaceous (feebly fossiliferous).	5. Absent or unknown.
4. { Jurassic. UNCONFORMITY, ? VERY LOCAL. Triassic upper and lower.	UNDETECTED OR ABSENT. 4. Trias and ? Jura.
3. Infra-Triassic and Tanól group.	3. Carboniferous.
UNCONFORMITY (STRONG).	UNOBSERVED.
2. { Attock Slate of Northern Punjab. Trap division absent. } Silurian.	2. { Aqueous. Traps.
1. { Schists. Gneiss (primitive).	1. { Newer gneiss including representatives of 2 and 3. Gneiss (primitive, Central).

This comparison will be seen to present some advance beyond that of my former paper (Rec., Vol. XII, p. 128), in which, as Mr. Lydekker observes, the schists of North Hazára are not separately included, because his Kashmir sections quoted offered nothing with which to compare them, and they could not be introduced as

[1] This Kunhar river is also called the Nainsúk, by which name I first knew it.

Plate 1

1 × 30

2 × 60

absolutely unrepresented, when they were found to pass out of the Hazára district, into then unexamined ground.

They have a position in the list nevertheless, where they are placed together with the Infra-triassic and Tanól series as he partly suggests; the Tanól portion of this set of rocks passing, as stated, into crystalline, *i.e.* metamorphosed, rocks and gneiss.

The identity of the gniess in both areas is now established and that also of the next adjoining beds.

The Attock slates are shown to be those of Kashmir, and their Amygdaloid division is approximately placed.

The carboniferous horizon is not much more clear, but the trias beds are identified, and the Murree beds are now known to be partly miocene, at all events.

The main points of difference appear to be as follows:—

HAZARA SIDE.	KASHMIR SIDE.
1. Presence of a cretaceous horizon.	Its absence.
2. Partial separability of the trias and jura, with a local discordance.	Usual blending of these without discordance.
3. Presence of an infra-triassic or lower division of the trias.	Occurrence at this horizon of a carboniferous group.
4. Presence of a thick group of Tanól beds identical or partly so with the foregoing.	Apparent absence of these beds.
5. Absence of an amygdaloid series in the silurian Attock slates.	Presence of an inferior silurian amygdaloid group.
6. Presence of a complete sub-trias discordance.	Absence of this feature or its imperceptibility.
7. Concealment or obscurity of a sub-tertiary overlap discordance.	Presence of a sub-tertiary break and overlap.

The main points of agreement are these:—

HAZARA SIDE and KASHMIR SIDE.

1.—Similarity of tertiary group in both.

2.—General similarity of the newer or perhaps upper half of the mesozoic rocks with small exceptions.

3.—Similarity of the lower palæozoic silurian-Attock-Kashmir slates.

4.—Similarity of the schists and gneiss.

5.—Universal disturbance.

It seems from the lists that the points of difference are equal in number to the main rock-groups, and those of agreement are rather more than half as many as the differences.

1. The cretaceous horizon established in the Sirban sections in Hazára and at great distances to the eastward in the Himalayas may well be present in other places though unrecognizable, as appears frequently to be possible even in Hazára.

2. The triassic rocks in this region being yet known to present in one place only (at Sirban) all the conditions as to definite zones and sufficiently fossiliferous ones, to enable detailed separations to be carried out, it seems most probable that the mixed character or the unfossiliferous condition of the Kashmir and Kaghán rocks is the general rule in both areas. The definite horizon may

of course exist everywhere, but under impenetrable obscurities, and even the appearance of discordance fairly established between these and the Spiti shale jurassic of Sirban being quite unpronounced elsewhere in Hazára, it may well be lost to sight in Kashmir.

3. The fact that Mr. Lydekker finds the carboniferous group of Kashmir vanishing into obscurity northwards, where its fossils disappear, is strongly indicative of the same unfortunate occurrence in Hazára and the consequent impossibility of defining its position closely, while it may be fairly surmised that the Hazára infra-triassic Tanól rocks or some portion of these are equivalent to the carboniferous group of Kashmir.

At the same time the idea suggests itself that the Sirban trias may really exhibit only a higher portion of the whole great group which may be elsewhere represented by more obscure older developments more widely spread, and that the carboniferous representatives may be found or supposed to exist amongst the lowest layers of these and partly amongst the likewise unfossiliferous strata of the Tanól group.

4. This Tanól group presents one of the greatest difficulties in reconciling the structure of the two regions as at present interpreted. Its thickness renders the absence of its recognition in Kashmir, &c., strange; and its place is peculiar, lying exactly between the now well-identified Attock-Ladák slates and the metamorphic schists (including rocks of different horizons), into which the same Attock-Ladák slates are supposed by Mr. Lydekker to merge by reason of increasing metamorphism.

These Tanól rocks, or their congeners, the infra-triassic, one or both, extend towards and into the lower part of the Kunhar valley, but crossing this no place is found for the group in the series of Kashmir and Kaghán, and a short line, obliquely crossing the valley from the Lachi Kun nummulitics to the Hazára older gneiss near Bálakot, marks the approximate boundary between the Attock-Kashmir slates and their supposed more highly metamorphosed continuation into the "newer gneiss" northwards. South of this boundary, however, between Bálakot and Gharri Habibula on the flanks of the Lachi Kun mountain, the Kashmir-Attock slates are not typical Attock slates at all, but more allied to the metamorphic schists. This point would so far favour the supposition that a northerly transition was taking place from less to greater metamorphism; but not far south of Gharri Habibula the slates possess their normal character, and appear projecting unconformably from beneath infra-triassic or Tanól quartzites and dolomites. The supposition that the Attock slates are the same to any extent as the schists to the north which pass into or are scarcely separable from the Tanól beds would then demand the incredible conclusion that both an unconformity and a transition between the older and newer groups should occur in the immediate neighbourhood of Gharri Habibula,—a view in which I cannot coincide.

Although the Tanól or infra-triassic beds fall readily into none of the Kashmir sub-divisions or have not been admitted into any, I certainly found them on the right bank of the Kunhar at the place last indicated, and saw at least one small tongue of them crossing the river. It seems marvellous if some representative of these dolomites, quartzites, argillaceous and other rocks does not also occur to the east, because, although in discordant relation with the silurian slates on their southern side, they have been found to mingle gradually with the schists to the northwards, which in their eastern extension become the "newer gneiss" of various ages, and also because dolomites and quartzites are mentioned among the rocks of Northern Kashmir.

If the group has an extension to the eastward, there seems, however, not much more likelihood of its being closely identified among the "newer gneiss" series than either the metamorphosed silurian or carboniferous members of that division. Connected with one or both of these groups, rocks of Tanól aspect might occur, though without sufficiently distinct grouping or identity to have urged their separation.

5. Had they possessed this distinctive character, there would only have been the absence of the apparently fugitive volcanic amygdaloids from amongst the Hazára slates to have caused any very prominent disparity between the general series in these two areas. The horizon or horizons of this amygdaloidal silurian group or groups being rather uncertain, but still placed below the slates or in their lower portion, the idea is suggested whether some of these volcanic rocks may not represent the horizon of the Tanól group, but this question I have not sufficient evidence to follow out.

From what I know or can gather of the general aspect of the geology of the whole region, I should rather expect to find the principal portion of the Tanól beds occupying a carboniferous or other intermediate horizon between the uppermost slates and the lowest fossiliferous triassic rocks.

So far the obstacles, as it were, to extending either the full Kashmir colouring of the map into Hazára, or *vice versâ*, have been noticed; the question of the arrangement of the groups is another matter.

In the parts of Kashmir and Kaghán, most adjacent to Hazára conformity real or apparent would seem to be the rule throughout the whole sequence. From an inspection of Mr. Lydekker's map and from his remarks it would appear evident that this conformity of the tertiaries north of Mozufferabad upon the palæozoic rocks assumes the nature of an overlap, amounting to the total discordance which I had already indicated from limited observations (Rec. XII. p. 127).

The unconformity at Sirban, in Hazára, where the infra-trias is not only discordant to but contains derived fragments of the Attock-Ladák slates, is established. It appeared to me to occur again without the derivative feature near the road from Abbottabad to Mánsahra and also on the right bank of the Kunhar river south of Gharri-Habibula, and yet it does not appear to have been detected in Kashmir or Kaghán, where secondary rocks occur within 12 and 32 miles of the Gharri locality, roughly speaking.

This unconformity proves so complete a break between the infra-trias and the silurian that I held myself prepared to find those of the Tanol beds most nearly identical with the infra-trias of Sirban completely discordant to the Attock slates at any place where they might occur in junction with these.

This appeared to be the relation of the groups on the lower Sirun and Dore rivers near the Indus.

The disturbance in most places greatly concealed or quite obscured any identification of this relation in connexion with the silicious and dolomitic bands of the Tanól group, while in many instances they appeared to be simply intercalated with the other Tanól beds; besides, there was always the possibility in consequence of the break at Sirban that infra-trias rocks of other places might exhibit a larger thickness of themselves or of other subjacent conformable beds. I was therefore the less surprised to find great irregularities and sudden development or reduction of the unconformable infra-trias (presumed to be in some degree equivalent of Tanól rocks) in various localities, nor did it appear improbable that the unconformity so clear at Sirban should be obscured by being removed further elsewhere from the dolomites and quartzites, or altogether lost to view in the more metamorphosed area of the schists.

Whatever portion of the Tanól beds may be identical with the infra-trias will carry with it much of the associated and stratigraphically united Tanól rocks not largely developed, if at all, at Sirban. The place of these Tanol-infra-trias beds must lie at the upper side of the discordance there, and it is impossible in so limited an area to place on the same horizon any rocks supposed to form a part of the Attock-Ladák silurians on the lower side of this discordance.

To say that the dolomites and quartzites of the Tanól area are not infra-trias but metamorphosed trias-jura, will provide no escape from the dilemma, for the trias and infra-trias have always been found as part of the same conformable sequence.

In one way it seems still possible to reconcile some of the discrepancy between the Hazára area and that to the east. I offer the suggestion with much reservation on the supposition that the rocks of both regions pass northwards into a metamorphic *terra incognita*, where important divisions become undistinguishable and the clearest indication of stratigraphic arrangement at low or high angles are untrustworthy. This being granted (if possible) it may be that the schistose series (newer gneiss of Lydekker) represents among its other constituents a lower portion of the Attock-Ladák silurian, or even the same beds as are elsewhere unmetamorphosed; that over these the schists passing upwards and uniting with the Tanól group (on an extension of Mr. Lydekker's hypothesis) represent the carboniferous and triassic horizons. Some of the dolomites, &c., of the Tanóls belonging to the former, and others with their associated slates, &c., being the unconformably enfolded representatives of the trias and infra-trias or "trias-jura" division, all in a metamorphosed or sub-metamorphosed state.

At this distance, both as regards time and place from the region and its examination, one is apt to have a less lively faith in his own deductions, and yet after reconsidering the question with the aid of Mr. Lydekker's paper, unless the perplexities of mountain structure will endorse so large a draft upon speculative hypotheses as the above suggestions demand, I am unable to see in what way the interpretations of Hazára Kashmir and Kaghán can be brought into closer concordance.

Notwithstanding that I am ready to admit any reasonable amount of possible misinterpretation not of a glaring nature amongst the obscure stratigraphical features of a metamorphosed and disturbed mountain region, the greater difficulty presents itself that it is not so much obscurity of the stratigraphic relations in Hazára as the reverse which has led to my interpretation of the district, and that no amount of the inversion, which it is now the custom to call in aid so largely, can set aside local deductions from such physical facts as the Sirban infra-trias unconformity.

Notes on the Umaria Coal Field (*South Rewah Gondwána basin*)—*By* THEODORE W. H. HUGHES, A.R.S.M., F.G.S., *Geological Survey of India.*

Owing to the great interest that has been aroused regarding the occurrence of workable coal at Umaria and in the Johilla valley in the Rewah territory, I have no doubt that a short notice relating to it, preliminary to a fuller description in our Memoirs, will be generally acceptable. Under ordinary circumstances the publication of the facts in connection with the coal would not have taken place until next year, by which time the map of the larger area to which this ground belongs would have been completed. So many enquiries, however, have been set on foot, as to the extent of the coal, its thickness, the quality of the coal and the facilities for working it, that it has become a duty to respond to them without delay.

Previous notice.

In a previous volume[1] of the Records of the Survey, I have described the geological position of the Umaria and Johilla coal. Its proper place is amongst the true or older coal-measures of India, and it is not to be confounded with the younger coal of the Mahanadi, Lameta Ghat and Jabalpur. This is a favourable point, and it implies that the coal will be moderately steady both in quality and quantity, features which are not characteristic of the newer coals.

Captain Osborne, 1860.

Many years have elapsed since the original discovery of the coal that I am writing about. The first who drew attention to it was Captain Osborne, the Political Agent of Rewah in 1860. Afterwards some Royal and Civil Engineers reported on it, but their recommendations were not strong enough to induce any active steps being taken to explore the field. Subsequently, and quite recently (1881), it was my good fortune to meet with a gentleman in charge of the Rewah administration[2] who responded cordially to my suggestions that the coal-measures should be tested near Umaria and in the Johilla valley; and within a few weeks of my broaching the plan of operations, boring tools were got ready, and Mr. Stewart, who had previously been in charge of the Narbada trial borings, was appointed, on a salary of Rs. 420 a month, to test the various sites indicated by myself. It is a great satisfaction to be able to say that the word *success* may be freely used. An abundance of coal has been proved; a large area has been determined; the con-

[1] Records G. S. I., Vol. XIV, pages 313—315.

[2] Captain Barr, Political Agent, Baghelkhand, and Superintendent, Rewah State.

ditions for working are favourable; the quality of the coal is fair in the laboratory, and the practical results are satisfactory.

The accident of position has caused much more attention to be devoted to the Umaria than to the Johilla area, the former locality being 14 or 15 miles nearer to the station of Kutni, on the East Indian Railway. The Johilla valley was merely looked at in case the Umaria borings should fail to realise the expectations formed of them. The extra distance would have been a very small drawback, if the only alternative left of procuring coal had been the opening-up of that part of the district; and it was deemed advisable, while means were at hand for under-ground exploration, to make as effective use of them as possible.

As matters have turned out, there was no necessity to have taken the precaution of examining the Johilla coal lands, but the information that has been gained respecting them is a valuable item added to our positive knowledge.

First boring at Umaria, 22nd January 1882.

The first boring at Umaria was commenced on the 22nd January 1882 on the site selected by myself. It was to the north of the outcrop of the coal seam, and was intended to prove the true thickness of the coal. According to Mr. Stewart's reading of the samples it is 7 feet. This may be accepted as the average thickness of the coal seam, the outcrop of which is seen in the Umrar river, running between the two villages of Khalesar and Umaria.

It would be needless multiplication of details to allude to each bore-hole section. The object with which the various positions were chosen was to test the extension of the coal both laterally and to the deep.

Had more time been at our disposal more ample results could have been achieved, but as the case stands even now enough data have been gathered to show that the seam exposed in the river extends over a *proved* area of 1½ square miles, and that it is fair to assume 3 square miles as probable and easily worked coal lands.

Second seam.

In boring No. 7*a*, immediately on the right bank of the Umrar, a second seam was met with, which is, I fancy, higher in the series than that proved in No. 1. It was again passed through in Nos. 8 and 9, and it was just touched in No. 11. It appears to be a permanent bed, so that we may calculate upon two seams of coal, which at a very low average may be taken as 14 feet thick.

Most of the borings were put down within the limits of the Umaria holding; but in order to learn something of the lie of the land between Khalesar and Lálpur on the other side of the river, I directed Mr. Stewart to start No. 6. A series of misfortunes rendered this hole and two subsequent ones useless as indicators, none of them having been completed. The question therefore as to what becomes of the coal in that direction is an open one, but I incline to think that the coal is there, and that had the borings been carried deeper they would have proved this to be the case. It is unfortunate that there should be uncertainty on the point, as, owing to this circumstance, I have for the sake of being within the mark omitted it from the calculable coal lands.

Available coal at 300 feet is about 28,000,000 tons.

I presume that I am expected to give a few figures showing the amount of coal that I consider to exist in the Umaria field. It is an unsatisfactory task to undertake, as those know who make calculations of this sort. With an average thickness of 14 feet, I think that within the area of 3 square miles there is an available amount of 28 millions of tons at a depth of 300 feet from the surface.

Dip slight.

The dip of the measures is slight, and the coal keeps well up for a long way to the deep, so that it presents great facilities for being readily worked.

With respect to the quality of the coal the only seam that could be tested in the laboratory and tried practically on the railway was the lower one.

About one hundred tons were excavated from the outcrop, and consignments were made to the East Indian and Great Indian Peninsula railways. From Mr. Pont, of the East Indian line, I heard that the working power of the coal was 41 lbs. the train mile.

From Mr. Brock, of the Great Indian Peninsula line, the most favourable result was 33 lbs. the train mile.

The Great Indian Peninsula trials show the coal in a very favourable light, and nearly equivalent to the best and freshest samples of the Karharbari field.

Considering that the coal on trial was merely surface stuff, the result is quite surprising. It is possible also that when the drivers and firemen are better acquainted with it they will be able to get still more work out of it.

Analyses made in the Survey laboratory by Mr. Hira Lal, who has been associated with me in the survey of the South Rewah coal areas, gave the following result:—

Analyses of different bands in the Umaria seam.

	a. °/₀	*c.* °/₀	*d.* °/₀	*e.* °/₀	*f.* °/₀	*h1.* °/₀	*h2.* °/₀	*h3.* °/₀	*h4.* °/₀
Moisture (at 230° F.) . .	5·8	3·6	2·6	3·4	2·2	2·4	2·4	2·6	2·8
Volatile, exclusive of moisture	23 6	30·0	19·6	34·4	24·4	25·8	26·0	29·2	27·6
Fixed carbon	52·4	53·6	57·2	55 0	35·6	59·4	57 8	52·2	59 0
Ash	18·2	12·8	20·6	7·2	37·8	12·4	13·8	16·0	10·6
Caking	...	+	...	+	+	...	...	+	+
Not caking	+	...	+	...	...	+	+	...	...
Colour of ash	white.	pink white.	white.	grey white.	white.	white.	white.	white.	white.

N. B.—The band *f.* yielded about 15 °/₀ of oil and tarry matter.

The samples were taken by myself from the quarry at the outcrop. The index letters refer to the section which is—

Descending.	Inches.
a—Coal hard	6
b—Stony band	1
c—Coal bright	6
d— „ hard	7
e— „ bright	6
f— „ hard	4
g—Stone band	2
h—Coal hard	2 ft. 0
	4 ft. 8

The seam is not so thick at the outcrop as it is farther to the deep. The best coal is the lowest band, lettered *h*. It contains a high percentage of fixed carbon, which accounts for the excellence of the trials on the Great Indian Peninsula railway.

Of the bore-hole sections, I give Nos. 1 and 7*a* to show what rocks were passed through, and the thickness of the two seams.

No. 1.—*Commenced 22nd January 1882, ended 10th February 1882.*

	Feet.	Inches.
Black surface soil	1	6
Brown coarse sandstone	4	0
Grey soft „	1	6
Red coarse hard „	1	0
Yellow coarse hard sandstone	1	0
Grey earthy „	2	0
Yellow hard coarse „	1	0
Red coarse hard „ with clay	2	6
Grey hard coarse „ „	2	6
Mottled coarse earthy „	2	0
Grey hard fine „	2	0
Light brown fine hard „	2	0
Dark brown fine hard „	1	6
Brown hard „	7	6
Grey soft shaly „	1	0
Red coarse soft „	2	0
Brown fine soft „	1	0
Yellow fine soft „	1	0
Brown and yellow mottled clay	1	0
Brown shaly soft sandstone	1	0
Gray and brown shaly sandstone	1	0
Brown shaly soft sandstone	1	0
Grey fine soft sandstone	1	0
Brown clay, hard „	1	0
Grey and soft shaly sandstone	1	0
Carbonaceous shale „	5	0
Coal	3	0
Carbonaceous shale	1	0
Grey shaly sandstone	1	0

	Feet.	Inches.
Coal	7	0
Carbonaceous shaly sandstone	9	0
„ shale	2	0
Coal	2	0
Carbonaceous shaly sandstone	3	0
White hard sandstone	16	0

No. 7a.—Commenced 17th March 1882, ended 30th April 1882.

	Feet.	Inches.
Dark brown sandy surface soil	16	0
„ „ clay and pebbles	5	0
Brown clay and sand	2	0
Light brown mottled shaly sandstone	1	0
„ and red sandstone	1	0
Brown shaly sandstone	1	0
Red „ „	1	0
Yellow „ „	1	0
White „ „	2	0
Brown and white shaly sandstone	1	0
White „ „	1	0
Brown and white „ „	2	0
Red and brown „ „	1	0
White and brown „ „	1	0
Yellow „ „	1	0
Red and white „ „	1	0
Brown and yellow „ „	1	0
„ „ „	1	0
„ and white „ „	2	0
„ „ „	1	0
White and red „ „	1	0
„ and yellow „ „	2	0
Brown and white „ „	3	0
White „ „	8	0
„ sandstone	1	0
Brown „	5	0
Grey „	2	0
Brown „	6	0
Grey „	23	0
Carbonaceous shaly sandstone	5	0
Grey sandstone	1	0
Carbonaceous „	5	0
Grey „	2	0
Carbonaceous „	8	0
Grey „	20	0
Coal	13	0
Carbonaceous shale	25	0
Coal	11	0

Of the Johilla borings I have little to say; one was put down near the junction of the Marjada and Umarha streams and the other on the left bank of the Johila. The sections speak for themselves, and the coal appears to be better even than that of Umaria.

No. 2.—*Commenced 6th March 1882, ended 23rd April 1882.*

	Feet.	Inches.
Yellow clay (surface soil)	1	0
Brown shaly sandstone	10	0
Dark brown shaly sandstone	5	0
Carbonaceous clay	2	0
" shale	9	0
Grey shaly sandstone	2	0
Brown shaly sandstone	5	0
Coal	17	0
Carbonaceous shaly sandstone	1	0
Grey " "	1	0
Coal	3	0
Carbonaceous shaly sandstone	1	0
Grey " "	1	0
Carbonaceous " "	3	0
Coal	8	0
Carbonaceous shaly sandstone	4	0*
Grey " "	2	0
Carbonaceous shale	2	0
Grey shaly sandstone	1	0
Carbonaceous shaly sandstone	1	0
Grey " "	4	0
Coarse sandstone	1	0
Grey "	6	0

No. 3.—*Commenced 13th March 1882, ended 23rd April 1882.*

	Feet.	Inches.
Dark brown surface sandy soil	1	0
Dark shaly sandstone	1	0
Grey " "	1	0
Brown " "	3	0
Coal	17	0
Grey shaly sandstone	1	0
Carbonaceous shale	6	0
Grey shaly sandstone	1	0
Carbonaceous shaly sandstone	9	0
" shale	2	0
Coal	6	0
Carbonaceous shaly sandstone	6	0
Grey " "	4	0

The proving of the Umaria coal-field shows how valuable an adjunct to the labours of the Geological Survey are the facts that can only be discovered by a series of borings. A large area of coal has thus been proved, and our doubts dissipated; and we have now ample knowledge to direct us in our projects and plans for the future. The coal is good, and there is plenty of it. It is within *one hour's* railway journey of Kutni, and from its commanding geographical position, as may be seen by looking at a map, it is one of the most important areas of supply for Central and Upper India. It will be of immense utility to the Great Indian Peninsula railway, and to the feeders of that line; and I have no doubt that a large up-country consumption will be established.

What is now wanted is a line of rail to Umaria, and I trust it will be my fortune to see one started and completed within the next two years. There is a large grain traffic passing through Umaria, but I have no statistics to give. I have no hesitation, however, in saying that a railway would probably pay its way, though perhaps 2 to 3 per cent. of interest would be all that the capital would realise until the road was extended more to the east and served a larger area of country.

The Daranggiri Coal field, *Garo Hills, Assam*—*By* TOM D. LA TOUCHE, B.A., *Geological Survey of India*.

Immediately to the north of the gneissic range running westward from the Khasia plateau and forming the culminating ridge of the Garo hills, the cretaceous rocks in which the coal of this district occurs occupy a series of detached basins in the gneiss, and rest directly upon it. Of these basins the two largest,—marked as coal-fields on the Ordnance map, and known as the Rongrenggiri and Daranggiri fields respectively,—are situated in the valley of the Sumesary or Semsang river. In the Rongrenggiri field, which extends from about 2 miles to the west of the thanna at that place eastward to a short distance to the east of Shemshanggiri, there are, as far as I could discover, no coal seams of any practical value. A seam of good coal, 1 foot thick, occurs in a hill due east of Shemshanggiri, and at the west end of the field are several outcrops of a bed of carbonaceous shale, about 3 feet thick, which, I believe, represents the principal seam of the Daranggiri field described below. A fairly continuous section is exposed in the bed of the river and its tributaries between these beds and the gneiss on the one hand and the nummulitic rocks which occupy the centre of the basin on the other, and in these rocks only a few insignificant strings of coal and thin beds of carbonaceous shale occur.

The Daranggiri field, its position and area.—The Daranggiri field is situated on both sides of the Sumesary river, where it turns south in a long reach before cutting through the main range at Jankaray village. It is about 10 miles in length from west to east, extending from a little to the west of Daranggiri to Rengdim in the Khasia hill district, and about 6 miles in breadth from north to south, from a short distance above the junction of the Rongoli stream with the Sumesary to the Rongkhai stream on the south. On the south side of the latter river are a few outliers, but these are separated from the gorge of the Sumesary, through which the projected railway will probably pass, by some miles of exceedingly rugged ground so that they are not of much importance.

Within these limits the coal-measures occupy an area of about 50 square miles, but, as will be seen from the analyses given below, the seams which occur in the portion of the field lying between the Rengchi, Rongkhai and Lengta streams is almost, if not quite, worthless; besides which the small thickness of the seams in this portion of the field, not more than 2 feet 6 inches, would probably prevent their being worked with profit, even if the coal were of better quality. There remains, then, the western half of the field extending from Daranggiri to the Rengchi, an area of about 20 square miles, in which there is at least one seam of coal of good quality of a thickness sufficient to be worked profitably.

1. Daranggiri outcrops.—The outcrops of the principal seam in the neighbourhood of Daranggiri have already been described by Mr. Medlicott. (*Records*, *G. S. I., Vol. VII, pt. 2, p. 58*). Besides this seam three are five others exposed in the cliffs about Daranggiri, but of greatly inferior thickness. The following section is exposed in a cliff on the east side of the Rongwi (Nongal) stream, a short distance below its junction with the Rongmadu, and may be taken as a type section of the coal-measures throughout the field :—

		Ft.	Ins.
1. Coarse yellow and brown sandstones	about	240	
2. White sandstones with bands of shaly clay rock .	"	70	
3. *Coal*	"	1	
4. Shaly clay rock	"	3	
5. *Coal*	"	0	10
6. Shaly clay rock	"	4	
7. *Coal*	"	0	6
8. White sandstone with bands of shale	"	20	
9. *Coal*	"	7	6
10. Sandy shale with strings of coal in lower part .	"	5	
11. *Coal*	"	1	
12. Carbonaceous sandy shale	"	5	
13. *Coal*	"	1	
14. Carbonaceous shale, base hidden under water .	"	?	
	TOTAL .	358	10

The section is given in natural order; dip about 5° to south-east.

In this section the beds immediately below the coal are not exposed, but on following down the stream the rise of the strata gradually brings them up until, at a short distance above the junction of the Rongwi with the Sumesary, they are seen resting directly upon the gneiss, and consist of about 200 feet of coarse purple and yellow grits and conglomerates. Similarly to the west of Daranggiri the seam may be traced rising steadily along the cliffs bordering the Rongmadu, the lower grits and conglomerates appearing beneath it, until it is overlapped by the higher strata which rest against the gneiss of Naramkhol and Tobeng hills. To the south of Daranggiri the principal seam disappears beneath the bed of the Rongwi, a short distance above its junction with the Rongmadu, but it appears again in the same stream, about 1½ miles further to the south, being bent up sharply against the gneiss of the main range, with a dip to north-east increasing in this section from 35° to 65° within a distance of 100 feet. On the same strike the seam appears to the west in the Nongalbicha stream and to the east in the Rongju below the village of Baduri, where it is nearly vertical.

2. *Sumesary outcrops.*—Descending the Sumesary from its junction with the Rongwi, the south-east dip of the strata brings the coal seams down to the river level about quarter mile above its confluence with the Garigithem stream. The same series is seen here as in the section at Daranggiri, except that the lowest one foot seam is absent. The dip of the beds is 2° to 3° to south-east, but slightly undulating, and becoming horizontal a little further down the river. The outcrop of the principal seam here, and in the Garigithem stream, about a quarter mile to the east, has been described by Mr. Medlicott (*loc. cit.*); it is about 6 feet thick. Further to the east the coal is overlapped towards the north by higher beds, which rest directly upon the gneiss, and occur in patches on the tops of the hills as far north as Sadungiri

3. Goreng hill outcrop.—In the north-south reach of the Sumesary gneiss is exposed for a considerable distance above the junction of the Rengchi. This rock extends beneath Goreng hill to the Renchi, forming an almost horizontal but uneven floor, upon which the coal-measures rest horizontally. The lower part of these, about 200 feet, consists of coarse grits and conglomerates, which form a perpendicular cliff extending almost continuously round the south end of the hill. At the top of this precipice the coal occurs, but generally its outcrop is much obscured by talus. Large fragments of it, however, occur in all the streams which flow from the hill to the Sumesary and Rengchi. A good section is exposed in the Nengja stream, a small tributary of the Rengchi, about 1 mile from the latter, as follows:—

	Feet.	In.
1. Coarse sandstone, about	12	0
2. Coal, about	3	6
3. Clay rock with carbonaceous markings, about . .	4	0
4. Fine yellowish brown sandstone, about	4	0
Total	23	6

The beds are horizontal.

A short distance down the stream a band of carbonaceous shale, about 18 inches thick, is exposed, but in this part of the field I could not find any of the smaller seams which occur at Daranggiri.

Total amount of coal.—In this area of 20 square miles the average thickness of the seam is 5 feet 6 inches (7 feet 6 inches at Daranggiri and 3 feet 6 inches on the Rengchi); the total amount of coal calculated from these data is about 76,000,000 tons.

Quality of the coal.—The coal of the principal seam is bright black in colour, becoming brown when crushed; it contains numerous specks and nests of a brown resinous substance; it lights readily and burns freely. The seam is very free from shaly partings. The coal from the seams to the east of the Rengchi is brownish-black in colour, and much more shaly. Specimens taken from four localities have been assayed by Mr. Hira Lal, Sub-assistant Geological Survey, with the following results. To these I have added an assay of the coal from the outcrop at Daranggiri, taken from Mr. Medlicott's report, *loc. cit.*:—

Assays of Daranggiri coal.

	% 1	% 2	% 3	% 4	% 5
Moisture (at 230° F.)	11·5	6·2	2·6	3·0	2·8
Volatile, excluding moisture	33 1	39·4	21 6	31·2	40 2
Fixed carbon	47·7	51·8	4·0	14·0	27·4
Ash	7·7	2·6	71·8	51·8	29·6

No. 1.—Daranggiri, 7′-6″ seam (assay made in 1874).
No. 2.—Nengja stream, 3′-6″ seam: caking; ash, white.
No. 3.—Hill side above Rongtok stream: non-caking; ash, white.
No. 4.—Fragment from talus at outcrop in bank of Lengta stream: non-caking; ash, pinkish.
No. 5.—One foot seam in Rongwi stream above Daranggiri: non-caking; ash, greyish white.

Position of the principal seam as regards working.—Except in the south-west corner of the field, where the strata are bent up sharply against the gneiss of the main range, they are either horizontal or dip at very low angles, and there seems to be an absolute freedom from faults over the whole area. The greater part of the seam is above the level of the principal streams so that the coal might be economically extracted, and the mines drained by adits. Moreover, as the rock immediately above the coal is generally a fine clay rock, tolerably impervious to water, the mines would to a certain extent be kept dry by it.

That part of the seam which dips below the surface of the rivers would have to be got at by shafts, but the strata above the coal, consisting of about 300 feet of sandstone and shales would present no difficulty to the sinking of these. Finally, the line of the proposed railway, up the gorge of the Sumesary, passes through the centre of the field so that if this scheme is ever carried out there appears to be no reason why the coal of this field should not be worked with facility and profit.

Nummulitic limestone.—On the high ground to the east of Daranggiri, there are two patches of nummulitic limestone, indicated by surface fragments, but as they are entirely covered by jungle I was unable to determine their thickness and extent. However it is quite possible that quarries opened in them would supply lime sufficient for small buildings and other works in the field itself. At Siju on the Sumesary, to the south of the main range, is a large deposit of limestone of good quality.

In concluding I must express my thanks to Captain Maxwell, the Deputy Commissioner of the district, for the great interest he took in my work, and for the assistance he gave me, so that although I was totally unacquainted with the country when I arrived in it, I had no difficulty in obtaining either carriage or supplies.

On the outcrops of coal *in the* Myanoung *division of the* Henzada *district.*—*By R. Romanis, D. Sc., Chemical Examiner, British Burma (with a plan).*

HAVING ascertained from Major Spearman that the coal reported in the Henzada district was found at Mokhoung, near Hleemouk, on the Nangathoo river, I proceeded thither, leaving Henzada on the morning of April 27th and arriving at Hleemouk on the following morning. The way lies along the Henzada embankment for 25 miles as far as Kyoukywa, where the Bassein river is crossed; thence by cart-roads through rice-fields to Kwingouk, where the Nangathoo river is passed. From this place to Hleemouk is about 8 or 9 miles. The road several times enters the bed of the Nangathoo stream. The last 2 or 3 miles of the road pass through forest, but it is almost level the whole 15 miles from Kyoukywa.

I found the outcrop at Mokhoung, the site of a deserted village about 4 miles from Hleemouk. It is at the foot of a steep bank composed of clay and loose stones lying upon shales which dip to the north at an angle of 45°. The river flows along the foot of the slope, crossing the strata at right angles to the strike. At a point where there is a fold or bend in the strata, and the dip changes to the south, the coal appears as a bed 22 inches thick below 24 inches of carbon-

aceous shales. I was not able to follow the strike of the beds across the river, as there is a wide alluvial tract on the other side beneath which it is concealed, if it exists at all, nor could it be found to the south of the fault, where the beds dip to the south. As it appears at a fault, the coal is much broken by the bending of the rocks, and patches of shale occur throughout the bed, which induced me to think it a mere pocket in the shale. A watercourse, which seems to mark the line of dislocation, enters the stream at the place where the coal appears. About 100 yards further up the stream some coal was found amongst the debris at the foot of the bank; and in a watercourse which enters the stream to the north is a thin bed of carbonaceous shale under a bed of quartz.

While at Hleemouk a piece of coal was brought in, said to be from Kywaising in the Okepo district. On examining it I found that it melted and formed a coke, which the Mokhoung coal does not do. I at once proceeded to the place, which is about 12 or 14 miles from Hleemouk, near the junction of the stream, called in Fitzroy's map the Shwayneing with the Okepo river. It is not marked in that map, which appears to be incorrect in the representation it gives of this district.

On arriving at Kywaising we were conducted to the coal. It is found at a place about 1½ hour's walk from Kywaising over low hills covered with bamboo forest.

The coal appears at a sharp bend of a watercourse which flows from north to south into the Shwayneing river. At the point where the coal is exposed the stream makes a sharp turn and flows from west to east for about 120 yards. The south bank is about 50 feet high and steep. The coal is exposed along the whole of the bank in a bed about 12 feet thick. A cutting was made into the coal when the following section was found:—

	Feet.	Inches.
Soil and decomposed yellow shale	5 or 6	0
Carbonaceous shale	0	4
Coal	1	6
Carbonaceous shale	0	2
Coal	1	6
Carbonaceous shale	0	4
Coal	1	6
Carbonaceous shale	0	2
Coal	1	6
Carbonaceous shale	1	6
Coal, good quality	2	0
Coal, inferior	2	0
Total	11	6

The lower portion was concealed by debris, and the exact thickness could not be estimated. Since my return I have been informed by Mr. Lewis, who continued the work after I left, that the layers of shale become mere partings in the coal, and that there are 6 feet of coal, then 2 feet of shale, and then 4 feet of coal, the upper 2 feet of good quality.

The dip of the bed of coal is 30°, to E.

I examined the rocks in the neighbourhood and found that they dipped like the coal at 30°, to E. The strike is north and south. I observed layers of carbonaceous shale at three places in the watercourse, and found that they crossed it and passed under the opposite bank, showing that there is no fault but the strata dip under the hill to the east. Over one of these beds there lies a thick bed of quartz-breccia. From the dip of the strata and the position of the quartz-breccia and shale I conclude that they lie under the coal.

Having finished my observations at this place I visited the outcrop at Poosoogyee, in the Myanoung district. On my way through Hleemouk I revisited the outcrop there. It was too dark to see what had been done, but I was told that the coal had come to an end after four bags had been got out, and that the rest was all shale. Mr. Lewis, who saw the place by daylight, says this is not the case; there is a layer of coal 18 inches thick.

Poosoogyee is about 30 miles from Myanoung, on the Padaw river. On my way I halted at a Chin village, Yaynantoung, so named from a petroleum spring about 4 miles away in the hills. I did not visit it as the quantity of petroleum is very small, but it is evidence of the presence of bituminous strata. The spring is marked on the map as east of the village.

The outcrop of coal is about 4 miles from Poosoogyee on the left bank of the Padaw stream. It is a band varying from 18 to 6 inches in a bed of carbonaceous shale dipping 60°, to E. It is very friable, crumbling into powder between the fingers. The stratum in which it occurs is much contorted, and in one or two places the coal thins out altogether. On examining the neighbourhood I found a bed of quartz conglomerate overlying a bed of bituminous shale in two places, one further up the stream than the coal, the other lower down, dip 60° to N.E. at the latter, 60° to E. at the former, evidently passing below the coal, and thus bearing the same relation to the coal that similar beds do at Kywaising and Mokhoung, from which I infer that the same strata of coal, shale and conglomerate appear at each place. The coal is at its maximum thickness at Kywaising and thins out to 22 inches at Mokhoung, 12 miles south, and to less than 12 inches at Poosoogyee, 18 miles north. The following diagram shows the order of the strata, as it appears to me :—

Yellow shales and sandstone several hundred feet.
Coal 10 feet.
Carbonaceous shale (?)
Yellow shale and sandstone, 300 feet.
Quartz breccia, 5 feet.
Carbonaceous shale, 2 feet. (?)

I do not think that it is worth while at present to bore at either Poosoogyee or Mokhoung. At Poosoogyee the rocks are much contorted; they have been indurated by infiltration of silica; the dip is great and the seam irregular. It is possible that the irregularity is due to the twisting of the strata at the point where they crop out, and that a boring put down to the eastward may find the coal more regular and less friable, but it seems to me that the Kywaising outcrop is the one most likely to repay exploration.

I should recommend that two borings be made, one to trace the coal under the opposite bank of the stream, that is, to the eastward, the other to the southward to follow the coal towards the river. The shale and soil covering the coal on the west side of the watercourse cannot be many feet thick, and several borings may be made without trouble.

As to the question of transport, the Okepo river is navigable during the rains for boats of 10 tons as far as Kywaising. The coal is about 5 or 6 miles distant from the village. Four miles of the road are level, but the bed of the Shwayneing river is crossed several times. For the last 2 miles the road is the bed of a watercourse covered with loose stones, but if the coal is in quantity there will be no difficulty in making a path by clearing the bamboo forest and cutting a road in the hillside. Good timber may be obtained from the pyinkado trees *(Xylia dolabriformis)*, which grow plentifully on the spot. In the dry weather there is only enough water in the Okepo to float bamboo rafts, but it is only 16 miles by cart-roads to the Bassein river, and I suppose a light tramway might be laid down at small cost, if the coal is in sufficient quantity.

Analyses of coal:	*Kywaising.*	*Poosoogyee.*
Moisture	1·48	
Volatile matter	26·58	
Fixed carbon	65·12	
Ash	6·82	
	100 00	100·00

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