

MINERAL SURVEY REPORTS JAMMU & KASHMIR GOVERNMENT.

NON-METALLIC MINERALS

OF

JAMMU AND KASHMIR

BY

C. S. MIDDLEMISS, C.I.E., F.R.S., F.G.S.,

Superintendent, Mineral Survey, His Highness' Government,

JAMMU AND KASHMIR.



JAMMU:

Printed at "The Ranbir Government Press"—25-1-87—300.

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P R E F A C E.

This report on the Non-Metallic Minerals is the eighth of the present series issued by His Highness' Government of Jammu and Kashmir. As explained in the Introduction, it omits certain economic minerals of this class reports on which have already been published separately. A few other minerals, not yet specially investigated, or which for the present are under the control of the Revenue Department, are also omitted. Among the latter are common salt, borax, *phulli* (mainly sodium carbonate) and ordinary clay. If building-stone, road-metal and such like mineral aggregates may be considered to belong here, all that it is necessary to say about them is that they naturally occur almost everywhere in inexhaustible amounts in this mountainous State. The control of their output is vested in the Revenue Department, and they have received as yet no special attention from the Mineral Survey.

Although this report appears under my name and responsibility, the discoveries made, the collection of material in the field, and the examination of it at head-quarters have been fairly equally shared with me by my two present Assistants, Messrs. Labhu Ram Badyal, M. Sc. and Sohani Ram, B. Sc.

Chemical analyses, in some cases, have been done by officers of the Geological Survey of India, through the courtesy of the Director, and by the Government of India Test House, Alipur (Calcutta); others by Prof. B. K. Bose, M. Sc., of the Prince of Wales College, Jammu; and others again by the Industrial Chemist, Srinagar, and by the Mineral Survey. An experiment in Low Temperature Carbonisation of a consignment of Kashmir lignite was made by the Tozer Company of Battersea, London, and the fractionation of the crude oil obtained therefrom was done by Dr. Mollwo Perkin, C. B. E., F. I. C. An experimental sale of lignite for household consumption was undertaken by the Forest Department at the Fuel Depôt, Lal Mandi, Srinagar. A few other extra-departmental tests of minerals are acknowledged in the text.

This account will be followed by another on the Precious and Semi-precious Gemstones of the State, as soon as it can be put through the press.

Subjoined is a list of published reports on Kashmir minerals that have so far appeared since the Mineral Survey started work in 1917,

the first three in the *Records of the Geological Survey of India* :—

- (1) Note on the Aquamarine mines of Daso on the Braldu R., Shigar Valley, Baltistan, (published in *Records, Geological Survey of India*, Vol. XLIX, pt. 3, 1918, with plates 6 to 10).
- (2) Possible occurrence of Petroleum in Jammu Province: Preliminary note on the Nar-Budhan dome of Kotli Tehsil in the Punch Valley, (published in *Records, Geological Survey of India*, Vol. XLIX, pt. 4, 1919, with plates 13 to 16).
- (3) Lignitic Coalfields in the Karewa formation of the Kashmir Valley, (published in *Records, Geological Survey of India*, Vol. LV, pt. 3, 1923, with plates 28—30).
- (4) Abrasives : Note on the Polishing material of Risin Spur Khunamuh near Srinagar, (printed by order of the Kashmir Government, with plates 1 and 2).
- (5) The Graphite deposit of Braripura, Uri Tehsil, Kashmir, (printed by order of the Kashmir Government, with plates 1 to 5).
- (6) Ochre deposits of Nur Khwah, Rata Sar and Jhuggi in the Jhelum Valley, Uri Tehsil, Kashmir, (printed by order of the Kashmir Government, with plates 1 to 6).
- (7) The Gypsum deposit of the Lachhipura, Bagna, Islamabad, Limbar and Katha nalas, Uri Tehsil, Kashmir, (printed by order of the Kashmir Government).
- (8) Bauxite deposits of Jammu Province (printed by order of the Kashmir Government, with plates 1—17).
- (9) A Resurvey of Jammu Coalfields : The Kalakot, Metka and Mohogala fields (with notes on the Chakar, Chinkah and newly discovered Dhansal-Sawalkot fields), (printed by order of the Kashmir Government with plates 1—25).

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- (10) Ore deposits of Lead, Copper, Zinc, Iron and other metals, in Jammu and Kashmir State, (published by order of the Kashmir Government, with plates 1—16).

C. S. MIDDLEMISS.

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The NON-METALLIC MINERALS of
JAMMU and KASHMIR: by C. S.
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Superintendent, Mineral Survey, His Highness'
Government, Jammu and Kashmir.

—o—

INTRODUCTION.

TH**E**SE are defined as such because of the common uses to which they are put, which are independent of the extraction of metals therefrom.

Definition.

Certain minerals belonging to this class, namely graphite, ochre, gypsum and abrasives have already been described, and reports on each have been published separately (See list in Preface). As regards the lignite of the Kashmir valley, it has already been described in *Rec. Geol. Surv. of India*, Vol. LV, pt. 3, 1923, and therefore will only be redescribed here by reference to certain recently resurveyed areas and experiments made with it. The list of non-metallic minerals of economic importance under present description then becomes:—lignite, clays (including kaolin, highly aluminous varieties, fuller's earth and bentonite), slate, talc (steatite), barytes, magnesite, graphite (of Sapphire Mines area) and mispickel. The chromite of Dras and neighbourhood is too heavy and bulky a mineral, and too far distant, to require mention here.

All of these except talc, barytes, magnesite and mispickel are bedded deposits and, with the further exception perhaps of the fuller's earth, occur in very great abundance. The talc (steatite) and barytes occur in veins in the Great Limestone and are of necessity of less calculable abundance. The magnesite is presumed to occur in veins in serpentine.

Mostly bedded deposits.

LIGNITE.

Introduction.

In the outline map (Pl. 1) the lignite areas so far examined are shown. An account of them was published some years ago in the *Records of the Geological Survey of India*, Vol. LV, pt. 3, 1923; but additional details, especially as regards certain practical trials and results of retorting the lignite, and a more complete description of the Handwara neighbourhood, are given here, together with a few explanatory remarks summarising what has already been published.

Long before the organised search for and recognition of the lignite or brown coal of the Kashmir valley by the Mineral Survey, there had been certain vague rumours of the occurrence of coal or bituminous shale in the valley; whilst two reports had briefly mentioned it in two distinct areas, reports which this Department was not aware of at the time it made the independent discovery of the mineral.

The more important of these reports, in the form of a diary by Mr. H. Roy, Mining Engineer, was submitted to Raja Sir Amar Singh in 1904. It gave an account of a number of outcrops of lignite in the Laingyat and Handwara neighbourhoods; but, it made no attempt to connect up these outcrops or combine them into any rational account. Many place-names mentioned by Mr. Roy are not shown on the new one inch to one mile Survey of India Sheets; so that it is not easy to trace them now, in the absence of any map accompanying the diary. The other report is a very brief mention of the discovery of lignitic coal seven miles from Gulmarg on the Rampur road by a herdsman whilst grazing his cattle, as reported by the tehsildar of Gulmarg in 1903. On being found to be of a shaly constitution it was at that time dismissed as worthless. Some further remarks on these and some historical references to the burnt areas at Suyam near Nichahom will

be found in my already referred to published note. It is a curious thing that, notwithstanding these burnt areas and in spite of the fact that even at that time the firewood problem was beginning to be a pressing one, the opinion come to was that the "shale" of Raja Sir Amar Singh's Jagir (as it then was) and of Gulmarg "would not burn" and "was useless as fuel", a belief that is still not uncommon.

In 1922 the Mineral Survey began a systematic investigation of the lignite. It was found to occur in the late Tertiary formation known geologically as the Karewas, and the search was continued during the succeeding summers up to October 1924. It was carried out by detailed surveys, first on the one inch to one mile Survey of India maps, enlarged 4-times, and afterwards, particularly in the Nichahom neighbourhood (Handwara tehsil), on specially constructed plans on a scale of one inch to 100 feet, showing sketched contours of 25 feet intervals. Pits, trenches and borings with the Isler percussion hand-power drill were made to prove the continuation of the seams underground.

Descriptive.

The Outline Map gives a general view of the Karewa Raithan, (Shaliganga R.) formation in relation to the older rocks of the Pir Panjal range. It also shows the areas of the lignite fields, one main group to the N. W. and another to the S. E. The 4 inches to one mile enlarged map of the Raithan (Shaliganga R.) and Lanyalab areas given with the already published account, taken in conjunction with the outline map, expresses the present state of our knowledge concerning the south-east areas. This has not advanced much beyond what has already been reported on, except the S. W. extension of the Lanyalab field in the Raiyar and Guravet forest areas.

The Nichahom (Handwara) area on the other hand, has made a considerable advance on the preliminary description of it as recorded in the

first report. The large-scale maps and sections now shown (see Pl. 2 and 3) are reduced from the 1 inch to 100 feet survey. They illustrate very well the advantages that a detailed large-scale plan possesses (in the matter of exact delineation) over the enlarged Survey of India Sheets. For on it we have been able not only to represent the lignite outcrops more faithfully, but also to record what was previously unknown, namely that two sets of these seams at two horizons, separated by 160 feet of barren clays and loams, really are present, instead of one set as previously supposed. This has made a great deal of difference to the appearance of the maps, as will be seen by contrasting the later with the earlier, and it makes an important difference to the calculated amount of lignite.

Even with all the advantages of the new large-scale plan, the working out of the later details could not have been accomplished without the evidence afforded by the excavations and the borings and much minute study on the ground. It should be remembered that the outcrops are frequently hidden at the surface and that the dip of the beds roughly coincides with the slope of the ground—two features which for the field geologist always present especial difficulties.

Extension and Thickness.

As regards extension, the very numerous natural outcrops in burnt nala (Suyam) and other places in the Nichahom field, together with pits, trenches, three major borings of between 150 and 300 feet depth, and a number of others of 30 feet or so, all afford clear evidence that the lignite occurrences of this area, as one would naturally suppose, are continuous, and of the nature of seams. As such they are shown in unbroken outline on the map and sections. This is the first and most important result of the work of the Mineral Survey—this linking together of the various exposures and showing them to belong to one or other of two sets of seams 160 feet apart which persist underground as beds or continuous sheets of a definite thickness, whose cubic contents, can therefore be calculated exactly.

Of the two sets of seams the upper set is the better known at present. From the natural sections in the escarpments, from more than two dozen excavations as well as from boring No. 1, we can say that, within a vertical thickness of 25 feet, the lignite has a total thickness of at least 10 feet, composed of two beds of 6 and 4 feet respectively.

The lower set of seams are not so well exposed in the natural sections, but they have been laid bare in trenches and cuttings and struck by two deep borings and a number of shallow borings, and the outcrop of the seams has been followed inwards for a distance of about 30 feet. Of these exploratory proceedings boring No. 2 (as shown in the map and sections) at a depth of 153 feet yielded in this lower set of seams a thickness of 12 feet 8 inches of lignite, within a vertical distance of 30 feet, and composed of one bed over 6 feet thick, another $3\frac{1}{4}$ feet thick and others of smaller thickness. Boring No. 3, in the lower set of seams at a depth of 22 feet 8 inches, yielded lignite over 14 feet thick within a vertical distance of 19 feet and composed of two beds over three feet thick, one 2 feet 10 inches thick and others about one foot thick each. Excavations at the outcrop substantiated this. Other beds of 1 and 2 ft. thickness occur at still lower horizons. It will be very safe to conclude that 10 feet of lignite at least are available from these lower seams.

Both the upper and lower sets of seams continue in outcrop northwards to Budhashung after V-ing down the intervening stream bed and northwards. beyond that to Lokut Dardahaj. A number of pits have been sunk at Budhashung showing beds of 6 and 3 feet, but the large-scale mapping and detailed exploration in this direction are not yet completed.

From the map and sections it will be seen that the gentle inclinations of the beds at angles of 8° should enable large areas in the neighbourhood of Nichahom, Budhashung, Satakohaj and Lokut Dardahaj to be worked for their lignite content. The actual size of this area will vary according to the depth at which

it is found practicable to work the seams: but at the very lowest estimate this will be as much as 4 square miles.

Amount available.

Taking 20 feet, the total thickness of the two sets of seams, over an area of 4 square miles, we obtain an amount of lignite equal to 80,000,000 tons.

Tonnage easily available from Nichahom area.

In the Shaliganga area (Raithan and Lanyalab), as yet only partly explored without the aid of the boring apparatus, we can at present only reckon on one workable seam of 3 feet thickness, but, the area being much larger and of about 16 square miles, we get a yield of 48,000,000 tons. The two areas together then will yield 128,000,000 tons.

Tonnage easily available from Shaliganga area.

The large extent of country between Nichahom and the Shaliganga is also known to contain lignite at a number of places, but the co-ordination of these outcrops has only been begun as yet at one or two places; so that for the present no estimate will be framed for them. Similarly both north-west and south-east of the total region shown on the outline map lignite probably extends uniformly with the Karewa formation.

Intermediate areas not estimated.

The evidence of extent, thickness and tonnage given above is enough to prove that the resources of this lignitic coal are very large indeed and more than sufficient to warrant exploitation, if the quality can be shown to be good enough.

Enough to warrant exploitation.

Quality.

A reference to, and a careful consideration of, the proximate chemical analyses which are given separately at the end (See sub-section *Chemical Analyses*) will show that, chiefly owing to its high percentage of ash, the quality of the lignite as a whole is only moderate. This showing is however mainly from the point of view of the

Moderate with high ash.

direct use of the lignite as a fuel for household purposes, for furnaces and other similar kinds of consumption. For still other purposes to be discussed later on the high ash is not so great an objection. When it is used directly as a fuel, this rather large amount of incombustible ash in the first place limits the distance to which it can profitably be carried. Secondly, after the lignite has been burning for a while, it retards combustion by clogging the fire unless special means are provided in the grates used for periodically getting rid of the ash. This ash is generally a white or grey powder which becomes a soft clinker when forced draught is employed.

It will be seen that on the whole an average taken of the ash works out at about 30 per cent. on the simple air-dried lignite. Similarly the moisture is about 15 per cent. As regards the other two components of proximate analysis, there is some considerable doubt as to the relative percentages of volatile matter and fixed carbon. This is due to the fact that different methods of conducting the analysis give different results.

Practical Trials.

We will now consider the lignite from the point of view of a fuel for heating purposes in its crude state after only drying in air. In the first place the bulk of the lignite after extraction from the mine remains as a tough somewhat splintery material which travels perfectly well without any serious disintegration. (All the lignite packed in gunny bags received at the Tozer Works in London for experimental treatment appeared to be in exactly the same state as it left Kashmir after travelling on ponies, boats, carts, railway and on shipboard).

In an ordinary house fire-place, provided with a grid with bars set one inch apart and an ash pit underneath, I have successfully burnt Kashmir lignite for many months together in the cold weather and found the use of it beneficial and economical. The resulting fire is more uniformly heat-giving and does not need the constant attention that a wood fire does. It never sparks or ex-

plodes and so is a very safe fuel. Like all low-grade fuels however it needs a certain attention to a few points in order to get the best results. Some of these points for a room fire are:— (1) The fire must be well started with 2 or 3 layers of sticks laid flat on the bars one above the other, the lignite in pieces not larger than the fist being added after the burning wood has got a good hold ; (2) the draught must be good and if the fire-place is provided with a movable shutter or a damper, all the better ; (3, after an hour or so, during which time the fire requires no further attention, the ash must be raked out and dropped through the grid into the ash pit ; (4) the fire must not be allowed to get too low ; (5) a very small fire will not be successful, as is the case with all coal ; (6) the lignite should be dried in the open air or in godowns before use, but not exposed directly to the sun. Precautions under (1) above are necessary because, owing to the high volatiles in the lignite, a good start with plenty of wood is necessary to get the gases burning instead of driving them away unconsumed up the chimney and thus wasting the better portion of the combustibles present in the fuel.

It is impossible to say whether its use in furnaces, stoves and central heating arrangements will ever become popular or not. The only experiments in this direction were made at the Silk Factory, Srinagar, by Mr. Mackenzie and by the Director of Electricity Hyderabad, and were complete failures. I attribute the first of these chiefly to the attempt having been made in boilers adapted for wood fuel and to the fact that the lignite had not been air-dried before use. It appears certain that the fuel was not burnt to an advantage in this experiment at the Silk Factory. The testimony of all the analysts who have examined the lignite is clear as regards the calories and B T. U's. obtained by burning it. All these show it to be slightly better than ordinary wood fuel and certainly not only equal to $\frac{1}{3}$ the quantity of wood as deduced by Mr. Mackenzie from his experiments. My own experience, burning it for months in my own house is equally conclusive that its heat giving qualities are at least somewhat better than those of ordinary wood when burnt in a proper way and in sufficient quantity. As before remarked very small quantities cannot be burnt with success any more than with good coal itself.

In consequence of a suggestion made that our lignite would probably be successful if tried in a pulveriser and sprayed as fine dust into the furnace, a method now in use at Hyderabad, a large consignment of one waggon load was sent to the Director of Electricity, Hyderabad (Deccan). A brief statement to the effect that it was found useless for this purpose, without any exact statistics of amounts used in the test being given, is all that has been received with reference to this experiment.

On the whole, considering first, that lignite is only a low-grade fuel at the best and secondly that its use is unfamiliar and a novelty as well as opposed to custom and tradition, I have little hope that, in anything short of a wood famine, it will supplant wood in common use in the bazars and villages of the Kashmir valley. Whether it will eventually attain some sort of vogue in specially constructed grates and stoves among the better-class inhabitants is an open question.

Retorting the Lignite.

The above uses however do not exhaust all those to which lignite in common with all coal can be put. One and a half tons of Kashmir lignite were retorted at the Tozer Low Temperature Carbonisation Works, Battersea, London, and the fractionation of the condensed volatiles was done by Dr. Mollwo Perkin, C. B. E., F. I. C., M. inst. P. Tech. The Engineering firm of Messrs. Wardle and Co. of Manchester and London also put up a preliminary scheme for supplying a retorting plant which, so far as the data then available to them were able to be considered, appeared to be a very profitable undertaking. I do not wish to lay too much stress on the partial and confessedly imperfect figures given in this scheme of Wardle's, nor do I propose to go into them in any way here. I confine my remarks to the general features of the problem. It will be fairly obvious that the valley of Kashmir, separated as it is by 200 miles of mountain road from the railway systems of India, must be able advantageously to sell the products of distillation of the lignite, namely motor spirit, kerosene, Diesel

Carbonisation : Wardle's scheme for retorting the lignite.

engine oil, lubricating oil, pitch, phenols and sulphate of ammonia. all made on the spot, at a reasonably good profit in competition with imported articles that have had to travel all this distance by road in addition to the previous distances by rail.

We have also Dr. Mollwo Perkin's statement to the effect that in the retorting there was a loss of 10 per cent. in the oils probably due to the oil sticking to the sides of the condenser tubes, which loss with a continuous throughput of large quantities would correct itself: also his statement that the fraction, 170° to 230° C (kerosene fraction) is a good illuminating oil and that the fraction 270° to 360° C also contains a considerable quantity of paraffin scale. Furthermore that the very large yield of gas, 4,000 to 4,500 cubic feet with a calorific value of about 550 B. T. U's. must also be considered, since, in addition to using it for carrying on the retorting process, it might be mixed with producer gas and used for gas burners whilst it could also be employed mixed with producer gas as motive power for gas engines. Lastly the phenols when emulsified will produce a powerful disinfectant. The final residue in the form of soft pitch could be used for roads or for briquetting lignite (after conversion into hard pitch) into a form of patent fuel (see Dr. Perkin's report, p. 18).

A good kerosene fraction and paraffin scale.

Very large yield of highly calorific gas.

Phenols and pitch.

A few words may be said about the calorific values of Kashmir lignite and its contained gas in comparison with others. Whilst ordinary lignite is quoted as having a calorific value of ... 7,200 B.T.U's.

Earthy lignite of	...	5,400	„
and Saxony lignite of	...	4,720	„
we find Burma lignites of	...	5,460 to	
		7,800	„
and Kashmir lignite of	...	5,614 to 7,261	
		B. T. U's.	

(See Tables of Analyses.)

Thus in spite of the large amount of ash present in the Kashmir fuel, its calorific value is well to the fore. I suspect that this is mainly due to the high calorific value of the large quantity of gas and other volatiles present in it. For, comparing it in this respect with other lignites, we have:—

Burma,	{	Namma lignite yields 5,590 cubic feet per ton.
		Lashio " " 6,460 " " " "
		Pauk (average of 3 fields) lignite yields 4,837 " " " "
		and Kashmir lignite yields 4,000 to 4,500 cubic feet per ton.

Also, as regards the calorific value of the gas compared with that of other coal and lignite gases, we have:—

High calorific value of the gas.

		Calorific Power.
From Molesworth pocket book.	{	London coal gas 630 B. T. U's.
		Manchester coal gas 650 "
		Birmingham " " 640 "
		Liverpool " " 750 "
		Glasgow " " 830 "
		Kashmir gas 550 "
Burma.	{	Namma gas 350 "
		Lashio " 310 "
		Pauk (average of 3 fields) gas 391 "

from which we see that the gas from Kashmir lignite is considerably higher in calorific value than that of the Burma lignite and about the same amount below that of British coals.

There may be some other industrial products still to be derived from lignite and all coming within the scope of organic chemistry to initiate. According to a test made privately by Mr. H. J. Wilson of Newton Abbot, who is working the Bovey Tracy lignite in Devonshire, there is scarcely any montan wax present in our Kashmir material ⁽¹⁾. The same was found to be true for the Burma lignites.—(N. B.—Montan wax is used for polishing and for gramophone records and is very valuable).

Communications.

The Karewa formation, in which the lignite occurs, is all in fairly easy country descending gently towards the Jhelum river. The various mines could be connected up with the navigable waters of the Jhelum river by roads, tramways or wire ropeways. Once in boats on the river, the lignite or its distillation products could easily and very cheaply be carried to any part of the valley where there would be a good local market. In time it might be possible for these products to penetrate further afield into the Punjab, but this would probably depend on many matters that lie outside the sphere of action of the Mineral Survey.

Chemical Analysis.

From a number of proximate analyses of the lignite, made by the Mineral Survey in Kashmir, and in the Geological Survey of India laboratory by the kindness of the Director, the contained

⁽¹⁾ 1.63% crude montan wax; melting point 81.5, which is quite good: It could easily be refined. In Germany lignites are being mined for montan wax extraction with a content below 4%—Wilson Syndicate Ltd., Heathfield, Devon. The Burma lignites contain approximately 2%.

moisture was found to vary between the wide limits of 8.6 per cent. and 33.43 per cent. It appears that ordinary exposure in the air, such as is incident to its extraction and manipulation during testing, causes this wide difference according to climatic changes. An average of about 15 per cent. in the climate of Kashmir may be taken as approximately correct. This percentage, on transmission of the material in bags to Jammu in the dry air of the Punjab, became reduced to 10 per cent. whilst, on transmission to Calcutta, it became increased to nearly 30 per cent. This is well shown in the table of analyses given below, which were made in Calcutta.

The ash content in ordinary bulk samples, in Kashmir, free from surface dust and impurities, comes out fairly uniformly in all the assays as about 30 per cent. This leaves 55 per cent. combustible matter, but the distribution of this under the heads of fixed carbon and volatile matter is not quite simple.

The following analyses were done by the Mineral Survey, the Geological Survey of India, Prof. Bose of the Prince of Wales College, Jammu, and the Government Test House, Alipur:—

Analyses by the Mineral Survey.

Lignite from	Moisture.	Volatile compounds.	Fixed Carbon.	Ash.
Raithan (outcrop)	11.70	21.30	37.00	30.00
Raithan, Pit No. 1 (18 ft. from outcrop)	17.60	34.05	28.35	20.00
Raithan, Pit No. 2 (6 in. bed)	15.33	29.23	26.11	29.13
Lanyalab	12.36	23.20	34.01	30.43
Budhashung	6.00	20.00	46.40	27.60
Average	12.60	25.56	34.37	27.43

Analyses by the Geological Survey of India.

Lignite from	Moisture.	Volatile compounds.	Fixed Carbon.	Ash.
Raithan, Pit No. 1 (A bed)	26·27	27·71	19·00	27·02
Raithan, Pit No. 1 (D bed)	26·86	29·98	19·70	23·46
Raithan, Pit No. 2	29·52	31·88	21·62	16·98
Lanyalab	28·41	25·98	15·09	30·52
Nichahom, Upper bed	32·85	29·69	16·22	21·24
Nichahom, Lower bed	33·43	30·61	18·34	17·62
Average	29·56	29·31	18·35	22·81

Calorific power tests done by the Geological Survey of India.

Lignite from	Calorific power in heat units C°.	Evaporative power.
Raithan, Pit No. 1 (A bed)	2,714	5·05
Raithan, Pit No. 1 (D bed)	3,154	5·87
Raithan, Pit No. 2	2,274	4·23
Lanyalab	3,822	—
Nichahom, Upper bed	2,714	5·05
Nichahom, Lower bed	4,034	7·51

The above calories done by L. Thompson's calorimeter. (Very difficultly combustible.)

Analyses by B. K. Bose of Prince of Wales College.

Lignite from	Moisture.	Volatile components.	Fixed Carbon.	Ash.
Raithan, Pit No. 1, A. 2	10·1	23·3	26·1	40·5
„ „ „ A. 3	12·1	24·5	21·3	42·1
„ „ „ A. 4	12·5	27·1	27·3	33·1
„ „ „ D. 1	10·1	36·3	28·4	25·2
„ „ „ D. 2	11·8	29·4	24·9	33·7
Raithan, Pit, 2	8·6	23·7	26·9	40·8
Lanyalab, A. 1	17·3	26·6	26·0	30·1
„ A. 3	15·4	25·4	23·0	36·2
Average	12·2	27·0	25·5	35·2

N. B.—The unusually high ash is due to admixture of dirt in the joints and crevices of the rock.

Owing to the discrepancies between the ratio of fixed carbon to volatiles as shown by the Mineral Survey and Geological Survey of India analyses, the latter repeated certain of them, assaying the volatiles in an atmosphere of nitrogen (which of course is inert as regards the carbon) with the result that the new method gave 5 per cent. less volatile matter than the old.

Subsequently, through the Director, Geological Survey of India, four samples were forwarded to the Government Test House, Alipore. These samples were taken from the Raithan main bed A, Lanyalab and Nichahom Upper and Lower beds, but the results are stated in terms of samples(1), (2), (3) and (4) only.

The following is a copy of the Test Certificate No. 434-Coal, dated 22nd June 1923 :—

Four samples of lignite.

	(1)	(2)	(3)	(4)
Moisture	14.55	14.77	14.78	13.71

Proximate analyses (on *dried* samples).

Volatiles	28.68	29.65	39.60	32.03
Fixed carbon	28.96	28.33	33.48	31.64
Ash	42.36	42.02	26.92	36.33

Total	100.00	100.00	100.00	100.00
-------	--------	--------	--------	--------

Colour of ash Brown. Brown. Grey. Brown.

Coking properties Non-coking. Non-coking. Non-coking. Non-coking.

Calories per gram 3,243 3,184 4,378 3,722

B. T. U. per lb 5,837 5,731 7,880 6,699

The Superintendent, Government Test House remarks:—

“I agree that the ashes are high. I suggest that the difficulty in such cases is that fuel of this sort cannot stand high freight charges. Taking into consideration the high moisture content and low calorific values the actual heating power of the lignite must on a practical scale be small. Even if the ash could be reduced this difficulty would still to some extent remain with any ordinary lignite”.

The above analyses agree better with those done by Mr. Bose for the Mineral Survey than with any others. The

average of these 4 analyses calculated on the whole sample comes out approximately as follows :—

Moisture	14·45
Volatiles	27·79
Fixed carbon	26·18
Ash	31·58

Total	100·00
-------	--------

Even more does this average agree with the average given by me as reasonable and forwarded with my paper for publication in the *Records Geological Survey of India* and before the Government Test House had been consulted. The average composition I there gave was :—

Moisture	15·00
Volatiles	28·00
Fixed carbon	27·00
Ash	30·00

Total	100·00
-------	--------

which nowhere differs by more than 1·5 % from the average of the Government Test House results.

In view of this agreement I think we may finally take that composition as being correct.

The average calories per gram = 3,632

„ „ B. T. U. per lb = 5,837

One other analysis I may quote, done privately by Mr. Randall of Messrs. Villiers Ltd., (a coal expert who was conducting experiments on Indian coals in the Geological Survey office, Calcutta).

His assay yielded :—

Moisture	15.6
Volatiles	33.8
Fixed carbon	22.9
Ash	27.7

Dr. Mollwo Perkin's Report on Retorting the Lignite.

I quote below the report made by Dr. F. Mollwo Perkin, C. B. E., F. I. C., M. Inst. P. Tech:—

In the first place I must mention that the amount of material supplied was not sufficient for a thorough and reliable test to be obtained. A large portion of the material was employed to clear the retorts and condensing plant from other oils which had previously been retorted. This did not leave sufficient lignite to give a good average sample of what might have been obtained.

From a long experience of the Tozer plant which I have frequently worked, I find that both the water scrubber and oil scrubber plant are at present very inefficient, and I am confident that better results will be obtained on a large working scale with more efficient plant. The retorts are old and have been worked intermittently. In the newer retorts which have been improved in many details better results would most certainly be obtained.

The following results were obtained :—

Lignite passed through the Retorts. 1 ton 10 cwts.
1 qr. 17 lbs.

Analysis of Lignite before Retorting.

Total volatile matter	51.30 %
Moisture	18.05 „

Results on dried Material.

Volatile matter	40.57 %
Ash	45.17 „
Fixed carbon	14.26 „
Nitrogen	0.92 „
Sulphur	1.49 „
B. T. U.	5,657

It will be noticed that although the volatile matter is good the ash is very high and the fixed carbon low.

Spent from Retorts ... 18 cwts. 2 qrs. 25 lbs.

The residual coke contains 7.8 % moisture.

This is equal to 17 cwts. 1 quart. 12 lbs. of dry coke.

Equal to 11 cwts. 1 quart. 12 lbs. per ton of lignite retorted
= 56.79 %.

The water, of course, was added for quenching the heated residue.

Analysis of Coke.

Volatile matter	16.05 %
Ash	59.43 „
Fixed carbon	24.52 „
Nitrogen	1.01 „
Sulphur	1.19 „

This analysis shows that either the shale was passed through the retorts too rapidly or that the temperature of the retorts was too low. Owing to the small amount put through I should expect the latter to be the case.

Scrubber Liquor 90 gallons of water used.

This is equal to 59·20 gallons of water used per ton of lignite retorted.

This give a yield of 0·54 lbs. sulphate of ammonia per ton lignite retorted.

Stripping Oil 95 gallons of oil.

This is equal to 62·49 gallons per ton of lignite retorted.

This gives a yield of 1·25 gallons spirit per ton of lignite retorted.

Condenser Liquor 67 gallons.

This is equal to 44·07 gallons per ton of lignite retorted.

This gives a yield of 8·43 lbs. sulphate of ammonia per ton of lignite retorted.

Crude Oil 25 gallons.

Equal to 16·44 gallons per ton of lignite retorted.

Fractionation of Crude Oil.

Water.....	6·49 %.
Up to 170° C.....	1·80 motor spirit.
170—230° C.....	5·29 illuminating oil.
230—270° C.....	6·34 light fuel oil.
270—360° C.....	4·08 heavy fuel.
Residue	14·00 soft pitch.

This is equal to 5·18 gallons water-free oil per ton of lig nite retorted.

Analysis of water from Oil distillation.

11.26 gallons per ton of lignite retorted.

This gives a yield of 1.88 lbs. Sulphate of Ammonia per ton of lignite retorted.

Fraction up to 170° C.

0.30 gallons per ton of lignite retorted.

Sp. Gr. at 15° C.....0.8647 flashes below 60° F.

This oil contains 8.33 % phenols=0.025 gallons per ton lignite retorted.

Oil after removal of phenols (motor spirit)=0.275 gallons per ton of lignite retorted.

Sp. Gr. at 15° C..... 0.8496 flashes below 60° F.

Fraction 170—230° C (Kerosene Fraction).

0.87 gallons per ton of lignite retorted.

Sp. Gr. at 15° C.....0.9056 flash point 120° F.

This oil contains 9.17 % phenols=0.08 gallons per ton of lignite retorted.

Oil after removal of phenols=0.79 gallons per ton of lignite retorted.

Sp. Gr. at 15° C.....0.8839 flash point 118° F.

This is a good illuminating oil.

Fraction 230—270° C (Diesel Engine Oil).

1.04 gallons per ton of lignite retorted.

Sp. Gr. at 15° C.....0.9627 flash point 178° F.

This oil contains 9.66 % phenols=0.10 gallons per ton of lignite retorted.

Oil after removal of phenols=0.94 gallons per ton of lignite retorted.

Sp. Gr. 15° C.....0.9164 flash point 221° F.

Fraction 270—360° C.

0.68 gallons per ton of lignite retorted.

Sp. Gr. at 15° C.....0.9719 flash point 190° F.

This oil contains 10.83% phenols=0.074 gallons per ton of lignite retorted.

Oil after removal of phenols=0.606 gallons per ton of lignite retorted.

Sp. Gr. at 15° C.....0.9612 flash point 230° F.

This fraction also contains a considerable amount of paraffin scale.

Results per ton of lignite retorted.

Spent.....	11 cwts. 1 qrt. 12 lbs.
Liquor.....	55.83 gallons.
<i>Sulphate of Ammonia</i> ...	10.85 lbs.
Oil	5.43 gallons.
Spirit from Gas Scrubber	1.0 gallons.

Results per 100 tons of lignite retorted.

				Tons.	Cwts.	Qrts.	Lbs.
<i>Spent</i>	...	...	...	56	15	2	24
<i>Liquor</i>	...	...	...	24	14	...	2
<i>Spirit</i>	...	...	...	...	2	2	2½
Fraction up to 170° C (including spirit scrubbed from gas)	...	...	...	...	2	...	17
Fraction 170—230° C	...	...	...	...	7	...	4
Fraction 230—270° C	...	...	...	...	8	3	20
Fraction 270—360° C	...	...	...	...	5	3	17
Residue above 360° C	...	...	...	1	...	2	6
Gas and Loss	...	...	...	16	3	...	1½

Briquettes made from spent of Kashmir lignite.

Total volatile matter..... 29.40 %
 Moisture 9.80

Results on Dried Material.

Volatile matter.....21.73
 Ash.....46.89
 Fixed carbon.....31.38
 Sulphur..... 0.57
 B. T. U.....6,503
 Evaporative Value..... 5.71 lbs.

These briquettes are of little value owing to the large amount of ash content and consequent low calorific value. They are difficult to burn: they might be used satisfactorily in a gas producer.

There is a loss of about 10 % in the oils, probably the heavy oil. This is very likely to be accounted for by some of the oil sticking on to the sides of the condenser tubes. In dealing with a large throughput this would correct itself. The yield of gas is about 4,000 to 4,500 cubic feet, having a calorific value of about 550 B. T. U.—that is to say it is a very rich gas; it may be returned under the retorts and would probably be sufficient to carry on the carbonisation after the retorts had once been started, or it might be mixed with producer gas and used for gas burners. It could also be employed when mixed with producer gas as motive power for gas engines for production of electricity.

The amount of disinfectant is not very great—about a half gallon per ton of lignite retorted—but when emulsified the volume will be considerably increased and a powerful disinfectant produced.

September 17th, 1924. (Sd.) F. MOLLWO PERKIN.

The following report on the pitch obtained from the lignite is by the same analyst:—

This pitch is rather soft owing to the fact that it contains a certain quantity of paraffin wax. I consider however, that if mixed with sand or particularly with small granite, it should make a very useful road binder and should not readily deteriorate. Very hard pitches are apt to do so. A rather harder pitch would be obtained if the material were carbonized at a higher temperature.

13th February 1925. (Sd.) F. MOLLWO PERKIN.

Mr. D. N. Wadia of the Geological Survey of India also kindly made a distillation test his description of which I reproduce here :—

“I took a 100 grams of coarsely powdered oil-shale-looking stuff and submitted it to a low-temperature distillation, taking care not to “crack” any oils. At the end of two hours, with a heat of dull redness of the retort, I obtained about 30 grams of distillates—water, oils, paraffins and a tarry anthracine-like heavy oil. All the fixed carbon remained with the residue in the retort (it had not changed appreciably in appearance at all) which weighed 51 grams at the end of the experiment. A large quantity of yellow-brown coloured gas (inflammable) of strong odour continued to be evolved all through, ceasing only just before the end of the experiment. It is probable some light oils escaped with it, which could have been obtained by more careful condensation.

(2) Of the 30 grams of distillates obtained, at least 8—10 grams are heavy brown oils, the rest being water and water-emulsion. I believe the substance is poor in light petrol oils, benzine, etc. and rich in waxy and tarry products.”

CLAYS.

Kaolin.

Jammu Province possesses large deposits of kaolin (china-clay). In the main these constitute the lower portion of the Bauxite Series, a bedded deposit of uncertain age between Neocomian and Eocene. It overlies the Great Limestone and Breccia and underlies the

Extensive deposits.

Coal Measures and Nummulitics, forming extensive dip-slopes in the Chakar, Sangarmarg, Salal and other areas. It has been described in detail, with fully illustrative maps, sections and photographs in the already published report belonging to this series, under the title of "Bauxite Deposits of Jammu Province". A reference to this report should be made in order to identify the places and particular spots indicated by letters and numbers as referred to in the present article ; because the bauxite deposits and the kaolin deposits are one and the same geological formation and have therefore been mapped together. The bauxite, in fact, has been shown with great probability to be a surface modification of what was originally entirely kaolin by desilicification, due to the action of alkaline meteoric waters.

One other variety of kaolin, occurring in small pockets on the exposed surface of the Great Limestone formation of Jangal Gali area, and locally known as "makol", may have had a residual origin. Limited occurrences of this variety are shown marked on the map, Plate 16, of the Bauxite report.

The Mineral Survey, in addition to noting the presence of kaolin during the bauxite investigations, subsequently made a special examination and collection of one-maund samples, with the object of providing data concerning these and other clays for the purposes of a pottery industry. Local varieties of the white plastic clay, "makol" had long been known and used in the State for white-washing purposes, and it was presumed that these might be utilized as kaolin for the production of better-class pottery. These and the kaolins of the Bauxite Series were investigated in some detail, to the exclusion of all the common terra-cotta clays, which are widely distributed elsewhere among the alluvium and younger Tertiary system of the State, but have not yet been systematically examined.

The kaolins of the Bauxite Series are sometimes white and powdery, but more generally dove-coloured or of various tints of pale grey, cream-colour, and occasionally of darker neutral

Lithology: a soft white clay.

tints. They are more generally compacted into a soft rock, which breaks up into splinters or little rounded cakes. In their passage upwards into more aluminous clays and bauxitic clays they increase in hardness and assume a glossy surface, which resists erosion and takes a high polish.

As already remarked, the kaolin underlies the crust of hard, dense bauxite in most of the areas. Thinning away locally. Occasionally, however, in a few places which are noted in the Bauxite report, and especially in the northern part of C area and all D area Chakar the kaolin layers thin away or disappear almost altogether, their place being taken by a greenish ferruginous rock, of varying degrees of richness in iron and titanium, probably a ferrous silicate of aluminium allied to greenalite, which becomes further enriched to limonite and hematite at and near the surface of the ground. These places would naturally be avoided by those working the kaolin.

From certain selected areas in the different bauxite fields the kaolin was collected, ground up and washed, with results as stated below:—
Impurities very few.

Nine large samples were collected by Assistant Superintendent Labhu Ram from Chakar and six from Sangarmarg areas, which were found to be generally fairly free from iron and other foreign fluxing ingredients, the residue of sand, grit, etc. being very small, seldom reaching 6 or 8 per cent. (mostly kaolin grains and a little sand) and frequently being as low as 1 or 2 per cent.

Similarly, from seven samples collected by Assistant Superintendent Sohani Ram from the Salal field, the siliceous residue only averaged 1.4 per cent.
Salal area.

Part analyses done of some of these by Prof. B. K. Bose of the Prince of Wales College and by Mr. D. N. Wadia (then Professor of Geology at the same College) are given below in tabular form :—
Chemical analysis of kaolins underlying the bauxite.

Kaolins of the Bauxite Series.

Locality.	Depth below surface.	S. G.	Al ₂ O ₃ percentage.	SiO ₂ percentage.
Chakar C. 7.	7th foot	2.69	51.30	41.60
„ B. a.	11th foot	2.58	..	..
„ C. c.	11th foot	2.57	48.00	42.60
„ C. e.	6th foot	2.57	..	..
„ B.	14th foot	2.56	53.40	41.50
„ B. a.	13th foot	2.55	55.30	42.00
„ B.	12th foot	2.54	..	44.15
„ B. a.	14th foot	2.54	..	45.00
„ B.	15th foot	2.53	..	..
Sangarmarg IX-8	5th & 6th foot	2.58	34.60	55.70
„ XII-7 N. E...	„	2.53	49.30	36.60
„ X-8	7th foot	2.54	43.10	48.40
„ IV-V-4	4th and 5th foot	2.46	..	..
„ XI-(10-9)	Washed-out and re-deposited.	2.35	42.30	46.80
„ XII-7	„ „	2.33	42.30	46.00
Salal VIII-6 S. E.	3rd foot	..	38.60	47.60
„ „ N. N. E.	Below 6th foot	..	46.90	46.60
„ „ N. W.	3rd foot	..	45.20	46.10
„ X-5. S.	5th foot	..	43.90	44.80
„ „ N.	6th foot	..	48.80	47.60
„ XI-5	6th foot	..	44.90	43.30
„ XI-6	1st foot	..	30.10	59.40

From these analyses it will be seen that the average percentage of alumina and silica are about equal. The total (about 90 per cent.), when allowance is made for the contained water, leaves very little room for other impurities. The analyses also show that these kaolins differ from typical China clay and some other kaolins in having an excess of alumina. Kaolins from China and Cornwall have about 73 per cent. silica; but many others from France and other places have silica about 46 and alumina about 36 per cent. These latter varieties also generally contain more water and a number of other impurities, and are more in agreement with the mineral kaolinite (which is regarded as the pure basis of kaolin and all clay) than are the typical China clay and Clay from Cornwall. Dana in his System of Mineralogy gives silica 46.5, alumina 39.5 and water 14 as the composition of kaolinite. Judged by this standard these Jammu clays come nearer to kaolinite than to the China clays of China and Cornwall.

Analyses made by Mr. Bose of a few of the makol clays collected by Sohani Ram from Jangalgali area, where they lie in pockets and limited patches on the Great Limestone slope, show some differences. These analyses are as follows :—

Locality.	Al ₂ O ₃ percentage.	SiO ₂ per centage.	Fe ₂ O ₃	CaO.
W. of Jangalgali village N. locality.	44.31	51.90	Trace	..
W. of Jangalgali village S. locality.	38.60	61.80	3.2	1.6
1 mile N. by W. of Cherayeh.	23.00	68.70	Trace	..

Not only do these makol clays differ in composition from that of the washed-out and re-deposited clays of Sangarmarg

XI-(10-9) and XII-7 given in the preceding list (which are also locally called makol), but the increase in silica relative to the alumina is so marked as to bring them much nearer in composition to the typical Chinese and Cornwall clays.

It will be observed that the specific gravity of the kaolins is uniformly low, being a little over 2.5. This is in strong contrast with the best bauxite of the area, with a specific gravity well over 3 and sometimes as much as 3.25. The intermediate aluminous and highly aluminous clays also have intermediate densities corresponding to their alumina percentages. This, together with the marked difference in hardness, makes a rapid and convenient means of distinguishing them in the field so long as undue quantities of iron and titanium are not present, when however the latter betray themselves by the colour imparted to the rock.

The source of this fundamentally kaolinic deposit is not clear, except that it does not seem to have originated from any granitic or dominantly felspathic rock in the neighbourhood. It may possibly have been formed from the green rock allied to greenalite, or the two may have had a common origin in some colloid substance, which, after or during deposition, split up—the iron migrating to or settling in a few places and the purer kaolin in others.

The amount of kaolin available, in beds of from 4 to about 12 feet thickness, reaches many million tons at each of the larger localities as exposed close to the surface beneath the 3 or 4 feet of bauxite; so that there is no lack of material, easily accessible, and still much more if followed underground.

The presence of coal of good quality in normal sequence 60 feet above the kaolin and bauxite is naturally advantageous. (See Coal report p. 65).

All the kaolins were found to 'slake' or fall to powder, when soaked in water. This sometimes

took several days, but frequently only a few hours or minutes. The "makol", or washed-out and re-deposited kaolin slaked at once.

Attempts to test the plasticity and other effects, when the material was made into rude pots and roughly fired in camp were apparently quite successful. It would seem from these experiments made by Messrs. Labhu Ram and Sohani Ram that makol clays possess the requisite qualities of plasticity before, and hardness and rigidity after, firing, and that the kaolins obtained from under the bauxite only require proper exposure to weathering, with grinding and sufficiently long slaking, to fit them equally for pottery purposes.

Later, large samples were dealt with at the Sir Amar Singh Technical Institute, Srinagar, and in every way excellent crockery articles, insulators and tiles were made from these Jammu kaolins. Unfortunately, owing to changes in the staff at the Technical Institute, these practical experiments were discontinued, and the scheme for starting a pottery was allowed to lapse for the time being.

Good porcelain, of which the author has seen samples, was also once made from Jammu makol.

Nearly all the other accessories required in pottery and porcelain manufacture can be obtained locally with the exception of felspar, which would have to be imported from other parts of the State, such as Uri Tehsil in Kashmir, where coarse very felspathic granite and aplite can be obtained in abundance.

Should it ever be found practicable to develop these very large and easily won, deposits of kaolin, there are many other uses to which they may be put, such as a filler for paper and cotton fabrics, for white-wash, wall-papers and as an adulterant and substitute in many manufactured products.

Highly Aluminous Varieties.

These are found in all the bauxite localities, coming between the kaolin and the bauxite, and Found everywhere with bauxite: Uses. may be of varying alumina content. All those that are low in ferric oxide can be utilized in chemical works, for the manufacture of abrasives, of furnace refractories, high alumina cements and for oil purification. Dr. C. Fox in his work on Bauxite, p. 90 has suggested that, in conjunction with the establishment of a ceramic industry in Jammu Province, there might be attempted the manufacture of mullite, or artificial sillimanite, for use in the preparation of Indian made sparking plugs.

At the time of writing, experiments are being made by a private syndicate in mixing sillimanite from Assam with our high grade white bauxite from D area Chakar, in order to produce a particularly effective refractory. Should this result in a large demand for Chakar bauxite, it will in the first place be necessary to open up the country by good roads at least; and I would suggest that experiments be tried with 2nd and 3rd grade bauxite and highly aluminous kaolin having a silica percentage of from 15 to 25; so as to reserve as far as possible the purer forms of bauxite for aluminium making.

FULLER'S EARTH.

Bentonite.

A peculiar clay was found in Bhimber bazar by Mr. Labhu Ram, whilst carrying a route traverse from Naoshera to Gujrat in Jammu Province in 1922 and later again in 1923. It was known locally as "Serati matti" and was excavated in the hills near by and used for cleaning grease spots and washing silk and other clothes. Discovered in Bhimber bazar.

The mineral was first thought to be fuller's earth, but later was determined in the Geological Survey of India laboratory as probably Determination and analysis.

bentonite. The present writer visited the locality in 1925 and saw the deposit in two or three places, besides having had an opportunity of comparing the mineral with typical bentonite from Alberta in the Empire Exhibition at Wembley in 1924. In appearance and certain physical characteristics the resemblance was certainly very strong. Chemically analysed in the Geological Survey laboratory, the clay gave :—

SiO ₂	48.64
Fe ₂ O ₃ }	11.15
Al ₂ O ₃ }	
CaO	1.83
MgO	8.67
Loss on ignition.	29.91
	100.20

This is sufficiently like the composition of bentonite from Alberta ; but is also not unlike analyses of many fuller's earths ; from which the belief seems to be generally held that the ultimate chemical constituents have less to do with the properties of the clays than the physical condition in which they exist.

The deposit runs for 27 miles as a continuous bed 1 to 2 feet thick, occupying a definite horizon in the Upper Siwalik formation and having a dip of 15°—20° S. W. and S. S. W. The position of the bed is near the edge of the hills. Starting in the north-west at Para (lat. 33°-2½', long. 74°) the outcrop runs south-east *via* Chitta Pail, and Chitti Dheri to Dharyah (1 mile north of Bhimber). Thence, after the Bhimber river is crossed, east-by-south to Chhatta, Mulot, Panjpir, Purani Gakhri and Kheri to Battal and Dhakhar (lat. 32°-56', long. 74°-25'). All the above places are marked on the Survey of India 1 inch to 1 mile sheets, Nos. 43K/4, L/1 and L/5. The line of outcrop is very nearly a straight

one, save for the V-ing down all the stream beds, which gives the line a jagged appearance in detail.

As the bed itself is not very prominent at the surface, it may be found near Bhimber by reference to a shelly limestone bed, 2 feet thick, capping the ridge at Chuna Dhera $1\frac{1}{2}$ miles E. by S. of Bhimber. The bentonite layer is about 3,400 feet below this limestone bed. The latter is burnt for lime at Bhimber.

The bentonite is coloured white and also green and can be cut with a knife into very thin shavings, both varieties being of a waxy appearance and with a conchoidal fracture. Both are slightly plastic and sticky to the feel. The most characteristic property of the clay is that, when placed in water, it absorbs several times its weight of water and swells up and disintegrates. This action is particularly energetic, a small conical piece in water presenting the appearance of a miniature volcano in eruption. In the mouth it has a peculiar taste and becomes curd-like. Its specific gravity, taken with the bottle, gave 2.01.

The thickness of the bed varies somewhat. West of Chhatta it is 2 feet thick. East of Chhatta 1 foot thick increasing to 4 feet. A typical section north-east of Mai Mangla near Bhimber being:—

Top foot—light or apple-green compact splintery bentonite with no biotite mica.

Middle 9 inches – dark-green bentonite with much biotite

Bottom 3 inches —white bentonite.

Bentonite has been used in a variety of ways: in soap, as a diluent for certain powerful drugs, in the manufacture of antiphlogistine, as a retarder for cement plasters and for weighting and filling paper⁽¹⁾. It is also used in ceramics; and this use for it, in connec-

⁽¹⁾Clays by Ries (Wiley and Sons) 2nd edition, 1908, p. 514.

tion with the kaolin of the Bauxite Series of Jammu, may be locally important. Being close to the foot of the hills, there would be no difficulty in bringing it to the present N. W. Railway at or near Gujrat Station.

Mr. Sohani Ram in 1925 discovered another peculiar clay Fuller's earth of Budil. in Budil area of Rampur-Rajouri Tehsil, which appears to have the properties of fuller's earth. He has noted its occurrence at three places near Budil town (lat. $33^{\circ}-22\frac{1}{2}'$, long. $74^{\circ}-39'$). These places are (1) 2 miles N. W. of Budil town, (2) $1\frac{1}{2}$ miles N. by E. of Budil town, and (3) at Kandra Hil, $2\frac{3}{4}$ miles W. N. W. of Budil.

The earth is found as a bed 6—7 feet thick (so far as seen at the surface) in a slate formation of the older rocks of the area, and to the north of the "main-boundary" dividing the latter from the Murree Series (Upper Tertiary). It is immediately underlain by a bed of trap of an intrusive nature; but it is uncertain whether the three localities represent one or more beds.

The clay is white to bluish-white in colour, and soft and soapy to the feel. Its specific gravity is 2.5. When freshly dug it comes out in hard clay-like lumps; but, soon after drying on exposure, these lumps disintegrate into a fine powder. In water the stuff "slakes" to powder. It is easily fusible, becoming a dark-blue enamel-like mass in a few minutes.

It was analysed in the Industrial Laboratory, Srinagar, with the following results:—

SiO ₂	58.58
Al ₂ O ₃	17.20
Fe ₂ O ₃	8.20
CaO.....	7.10
MgO	0.29
Loss on ignition.....	7.20
Total	<hr/> 98.57

(Na₂O, K₂O, etc. not determined).

These results agree very well with other typical analyses of fuller's earth as compiled by Dr. Ries and published in Merrill's "Non-metallic Minerals"; but they do not seem to be of much value compared with the other physical properties concerned.

In 1927 some ten maunds were collected and tested by Mr. Sohani Ram for their absorptive and de-colourising qualities, which are the most important for testing the efficiency of such earths in clarifying mineral and vegetable oils, fats and greases.

Applied wet to grease stains, it proved quite effective in removing them. Oils, both vegetable and mineral, of a deep brown colour were selected, and, after treatment, they became of a pale yellowish shade.

Large samples, at the request of the then Member for Commerce and Industries, were sent to the Attock Oil Company, Rawalpindi and to the Industrial Chemist, Srinagar, for further experiment. The report of the former was not favourable. The earth, raw, burned and well-roasted was found to have a small decolourising action on untreated, and on acid and soda treated, kerosene; but not to anything like the extent of "Floridin". "Floridin" is described as a normal fuller's earth mine in Florida; its effectiveness in oil refining being attributed to minute crevices and canals in the granules of the earth, which afford a larger surface of contact for absorption of tar and coloured impurities in the oil.

The Industrial Chemist has made no report and the result of his and some other experiments are still awaited.

It is quite possible that by special treatment of the earth as at present known, or by careful selection of other more suitable varieties, a material could be obtained in time that might better meet requirements. It should not be forgotten that, in America, these and similar experimental processes for the adaptation of the non-metallic minerals to various

uses are threshed out very carefully under the impulse of strong competition.

Furthermore, a local substitute for some well-established commercial product of this kind that has made a reputation for itself under some special trade name, has always a very up-hill fight to make for recognition; largely because it is new and unknown, but also because it has not been standardised and graded and uniformity assured in the quality of the supply offered to the public.

However Budil is unfavourably situated, far away from the plains, among the lower hills at the foot of the main Pir Panjal range; and so the earth from that place is not likely to be made use of in the near future, even if further experiments and special treatment show better results.

SLATE.

Slate of good quality is available in Jammu and Kashmir State. As is the case with all Himalayan slate, the cleaving forces appear to have been not very intense, but only sufficient to produce fissility in the older argillaceous complex when the direction of cleavage (or weak cohesion so produced) coincided with the original bedding. Incipient mineralisation has been also added along the cleavage planes, so that nearly all the slate so far known and partly exploited in the State is slightly phyllitic.

In the sense, then, that slate (such as that of North Wales) is a rock in which pressure has induced a fissility at any angle with, and entirely independent of, the original sedimentary laminae—in that sense, there is probably no true slate known in the Himalaya; but in the sense that thin, strong, plane-surfaced sheets of argillaceous material, capable of being split to $\frac{3}{16}$ inch or even less, and of being trimmed to any suitable size, constitute slate, the State may be said to possess abundance of it in certain localities.

Banihal Quarries.

The first of these localities to be mentioned here is on the Banihal cart road between the Banihal group of villages and Ramsu, in lat. $33^{\circ}-22\frac{3}{4}'$ —long. $75^{\circ}-12'$, and consists of three neighbouring quarries or irregular excavations lying 4 miles due south of Banihal rest-house.

The presence of good commercial slate at this place was first brought to the notice of this Department in the autumn of 1921 by the State Engineer. The slate had been successfully used for roofing certain State buildings on the Banihal cart road for some time. The rest-house at Ramsu, said to have been roofed with it 24 years ago, showed no deterioration, though the slates selected were not the best available, and a report had already been written about the slate by the Assistant Engineer, Public Works Department.

In this report the Engineer showed that the three quarries opened up in the slate were extensive and that good roofing slate and slabs for flooring, etc., could be obtained. He described the best quality as being of a good uniform colour, smooth texture and with a glistening semi-metallic appearance. It was available in thicknesses of from $\frac{1}{8}$ to $\frac{1}{4}$ ($\frac{3}{8}$ to $\frac{1}{2}$) inch, $\frac{3}{8}$ being a reliable average.

He made some calculations showing the quantities and weights necessary for covering a given surface of roof and that the slate might be quarried and despatched certain distances along the Banihal road and compete with G. C. iron. The area was in Forest land and the Forest Department were charging royalty at the rate of Rs. 1/4/0 per hundred slates.

An investigation made by the writer in the spring of 1922 showed the age of the series of rocks in which the slate occurs to be

Age of the rocks.

Engineer's report: quality and thickness.

Calculations : covering power.

certainly older than Carboniferous and probably Cambro-Silurian or older.

As a consequence of the principles governing the formation of slate in the Himalaya as outlined in the first two paragraphs of this Section, the so-called quarries were found to present a number of layers, highly inclined with the horizontal, yielding thin slate suitable for roofing, which alternate with other layers yielding only slabs, or a quantity of useless rock. Hence the term slate quarry has not quite the same significance as the Welsh mining term, but refers to a cliff-edge of mixed rock, whence, from the more suitable layers, a payable percentage of good roofing or slab slates may be obtained. In other words, the present quarries that have been opened up must not be regarded as so many discoveries of slate in a region of no slate, but rather as chance places by the roadside where working happens to have been begun in a formation that presents similar facilities over large areas.

In what is known as quarry No. 3, the only one in operation when the writer was there, the planes of cleavage, of incipient mineralisation (foliation) and of original sedimentation (which all coincide, or nearly coincide, as already stated) dip at 50° N. N. E., and these are crossed by single regular and sharp joint planes at intervals of from 6 inches to 2 feet, dipping at 30° E. N. E. These naturally limit the size of the slate that can be extracted, but at the same time are a help to the quarryman in the labour of extraction. Other secondary joints, less distinct, occur at right-angles to the bedding.

No machinery or explosive was being used in getting the slate, the local people using only hand labour, crowbars, splitters and a knife and trimming edge. Fifteen to twenty coolies, every batch of five working under one 'mistri', were employed intermittently, which were sufficient for occasional demand such as roofing for bungalows and offices on the road. Twenty coolies were said to turn out in this way about 350 slates a day, of size 18 by 10 inches, and the wages paid were Rs. 3 per hundred slates.

A total of 28,000 slates made in two years up to the date of the author's visit were utilized as follows :—
 Outturn and use.

Ramban rest-house and Hindu kitchen	...	4,000
Digdaul rest-house	... ..	6,000
Ramsu rest-house, additions	... ..	8,000
Banihal rest house, motor shed, telegraph office, etc.	... ..	10,000
		Total
		... 28,000

The quality appeared to the writer to be fairly good. In
 Quality: composition. composition the material is extremely fine, showing under the microscope as chiefly quartz, chlorite and a micaceous mineral and some opaque grains of iron ores. The colour ranged through various shades of blue-grey, from pale tints with a silvery sheen to darker tints with a graphitic sheen. Many were seen to be mottled with rusty blotches and some were spotted. These blotches and spots which are due to the development of iron ores or other iron-containing minerals, must be regarded as defects.

The strength and sonorousness of the slates I should put
 Strength: sonorousness. down as medium. The slates were said to have stood the absorption test well, according to experiments made by the Engineers.

Cleavability is frequently good, but is very variable. The
 Cleavability. best samples from this point of view give slates $\frac{1}{8}$ inch in thickness, but these are rare. The average as turned out are $\frac{3}{16}$ inch thick and not infrequently this rises to $\frac{1}{4}$ inch. The planes of cleavage are good and straight, though frequently rather rough and uneven and minutely wavy.

Extra large sizes of slates of from 20 by 10 inches to 24 by
 Sizes obtainable. 14 inches, such as are quoted in slate bargains in Wales are unknown from these

quarries where a good working size is 18 by 10 inches. Many however are smaller than this being 15 or 16 by 8 inches.

The slates look well on the roofs of rest-houses, the varying shades of bluish and greenish grey giving a pleasing effect.

Appearance.

It should be possible gradually to extend the use of these slates for roofing purposes along the cart road as soon as the people realize their lasting qualities as compared with the ordinary wooden shingles, and at the same time their fire-proof qualities.

Extended use advocated.

It is probable that blasting with explosive will greatly help the miner, but in the present state of the trade it is doubtful if the importing of cutting and slate-splitting machinery would be found advisable.

Machinery not necessary.

Mar. Pathri near Gulmarg.

The occurrence of very good to excellent slate at this locality was brought to the notice of this department in 1923 by the firm of Munshi Wali Mohammed and Sons, Engineers and Contractors, Rawalpindi, through the then Director of Industries, Mr. D. N. Nagarkatti. The firm was for some time anxious to work the deposit for school slates, slabs for roofing and other purposes; but for certain reasons they did not carry their wishes into effect.

Discovery.

The locality was examined by the writer in 1925. It lies in lat. $34^{\circ}-4'$, long. $74^{\circ}-16'$, at altitudes round about 11,000 feet, on a good pony track connecting Linyan (Lian Marg) with the gap or small pass overlooking the Hapatkhai (Buniyar) Nala at Mohr Dor; all these places being in the hills 8 miles west of Gulmarg. The several places, both above and below the road where good slate appears, are situated between the points on the road bearing $E. 5^{\circ} S.$ and $E. 45^{\circ} S.$ from the prominent hill marked Mar Pathri, 11,600 feet, on the Survey of India sheet 43 J/8.

Locality.

The position is just above the upper limit of forest, only a few straggling representatives of fir and birch remaining here and there. There is no cultivation at that height, only pasture for sheep and cattle. The geological formation is probably the same as that of the Banihal slates, namely Cambro-Silurian or older.

Position: Geological age.

Structurally the slate is also similar to that of other Himalayan slates, but is less phyllitic than the Banihal variety.

Structure.

The texture is fine-grained and uniform, without serious spotting or flaky patches. The colour is a slate grey inclined to a bluish or purplish tinge. The inclination of the cleavage planes and coinciding bedding planes is uniformly between 40° and 50° W. S. W. Thus the slate exposures in all the side streams and hill spurs present a succession of scarps and dip-slopes, which, with the absence of moraines, soil and forest just here, offer convenient surfaces for opening quarries. Slabs of all kinds, already weathered out and exposed in the road cuttings, litter the ground.

Texture, colour and cleavage.

The known area is a slice of open country, $\frac{1}{3}$ mile wide, cutting through Mar Pathri and Khan Pathri hills. Reckoning only $\frac{1}{10}$ of this to be useful slate, the above would yield 100,000,000 tons of roofing slates, sufficient to cover about 100 square miles. These figures are given to avoid generalities; but it is clear that such quarries as could be opened here would be practically inexhaustible.

Area and quantity.

The slates obtained are always remarkably straight and truly plane, without any tendency to waviness or distinct schistosity. They are always hard and strong and sonorous. Lengths up to 50 inches and widths up to 14 inches with thickness of $\frac{3}{16}$ inch may be expected, judging by numerous experiments made by the writer. Still thicker slabs, $\frac{1}{2}$ inch and upwards with true parallel surfaces, can be obtained.

Quality.

The surface of the slate varies in smoothness, but is generally a dull "matte" surface, without any stripiness, but with a pronounced "grain" parallel to the length of the slabs.

Surface: "grain".

The combined cleavage and bedding planes are crossed by two, and sometimes three, systems of clean-cut joints, one of which is parallel to the "grain" and the others make various angles with the first, which usually result in rhomb-shaped slabs, and these after splitting, require trimming down into rectangular slates.

Joints.

Mr. H. E. Moon, with the help of cutters, splitters and borers from Banihal, arranged by the Chief Engineer, Roads and Buildings, extracted over 8,000 slates in 1926 as an experiment for roofing his stables and godowns. The sizes taken were 18 inches by 6 to 10 inches. The writer saw these later in position on the finished buildings, and, so far as at present known, they have given entire satisfaction; but time only can answer the question as to their lasting powers.

Experiment in roofing.

The chief difficulty in the way of encouraging their use in dwelling houses and other large buildings is that stronger supporting timbers and rafters are necessary than for wooden shingles or corrugated iron. This means an immediate outlay in excess of ordinary requirements, which is not immediately balanced by their lasting powers—to appreciate which time is necessary.

Stronger roof timbers required.

Slabs of a size 8 inches square and $\frac{1}{2}$ inch thick, perfectly plane and true, were sent by the Mineral Survey Department to the Chief Engineer, Electrical Department, in November 1926 for testing as bases for switches and a reply was received that the slate was found to be very good for the bases of switches for 220 volt supplies, and that its insulating qualities were good and stood the pressure well. Sizes up to 20 × 14 × 1 inches and over of the same quality should be available for auto-transformers and other purposes.

Switch-boards and fuse-bases.

TALC (STEATITE).

This mineral, in the compact form of steatite, has been met with at different times by members of the Mineral Survey as veins in the Great Limestone in the neighbourhood of Riasi. The material has been used locally in a small way for making small cups and bowls.

Like all the other minerals, both metallic and non-metallic occurring in the Great Limestone, it is found as veins and pockets, up to a few feet across, filling what were probably fissures or zones of shattering in the limestone; and (in this case) especially well-marked along the southern faulted boundary. In addition to being found *in situ* at the few places detailed below, it is also present in the stream beds as pebbles and in the contents of the long slopes of talus and disintegrated limestone scree that cover the lower ends of the ridge-spurs. Hence there must be many more places where veins occur, only they have not so far been detected.

As veins and along shatter zones.

The localities so far recorded are :—

- (1) One mile N. N. E. of Kunian (lat. $32^{\circ}59\frac{1}{2}'$, long. $74^{\circ}59\frac{1}{2}'$), at a point where the Recent and Sub-recent gravel, scree-material and fault-breccia lie as great and thick terraces and ledges at the foot of the Trika Great Limestone mass. (See Survey of India 1 inch to 1 mile maps, sheet 43 L/13). The path from Kunian to Kaur passes a few yards south below the outcrop.

Localities where known: Kunian.

The vein of white, soft, translucent and very pure steatite (rather like that from the Marble Rocks, Jubbulpore), as here exposed, is only 20 feet long and from 2 to 6 inches thick. It is compact and without any noticeable cleavage, and when ground to an impalpable powder, this material makes a very white preparation, entirely suitable for toilet and other purposes. Dark grey and mottled

Quality: size of vein.

varieties in irregular veins occur near by. On account of their colour, they are not readily distinguished from the limestone. These darker variegated kinds carve into figures very well. The powder is also white but with a slight greyish tinge. On the whole it is clearly not so pure as the white variety.

- (2) One mile E. of Adkanwari temple, up the side nala, N. E. of Purana Daruhr (lat. $33^{\circ}-\frac{1}{2}'$, long. $75^{\circ}-57\frac{3}{4}'$) in very steep, difficultly accessible country. The locality is marked on the Survey of India sheet 43 K/16.

The material here is soft, but firm and compact and can be got in good large lumps. It occurs scattered in veins and patches, some white and some grey, over an area 200 feet by 40 feet. It is from here that there is a small trade in fashioning cups and bowls. Considering the large number of pilgrims who visit the Adkanwari temple and other sacred places in the vicinity, this little trade might well be expanded in the direction of making carved figures. Artistic examples of this material were carved by Delhi craftsmen and exhibited at the Wembley Empire Exhibition in 1924.

- (3) Kotli Maniotrian, just above the highest houses (lat. $33^{\circ}-2'$, long. $74^{\circ}-54'$) on the hill spur north of the Pei Khad.
- Kotli: as pebbles.

The steatite here is not *in situ*, but is found in some profusion as angular and sub-angular pieces (the size of nuts) in the talus and scree, which, as is usual along this faulted edge of the Great Limestone, is consolidated into a rather thick superficial covering over the much crushed and brecciated limestone.

Both the white and grey varieties were found in some profusion, but being in the condition of water-worn pebbles, they could not be recognised except by trying them as marking chalk on any handy stone. It is clear from this that the parent veins are not far away.

(4) One mile N. N. E. of Nangal village, on the northern side of the Anji nala and some 800 to 900 feet above it (lat. $33^{\circ}-5'$, long. $74^{\circ}-54'$). Nangal in Anji valley. Both the white and grey varieties were found here also, in a few thin veins 20 to 60 feet long and about 6 inches thick, arranged parallel to the bedding of the Great Limestone, which here dips 70° E. N. E. in a steep cliff.

(5) $1\frac{1}{2}$ miles N. W. of Kashi Khaira (lat. $33^{\circ}-7\frac{1}{2}'$, long. $74^{\circ}-47\frac{1}{3}'$) on the left bank of a stream bed called the Parian Wala Khad, Kashi Khaira. $\frac{1}{4}$ mile from its confluence with the Chenab R.

The material from this place entirely resembles that from Purana Daruhr described above. It occurs in a group of small veins of from a few feet up to 10 feet long, and a few inches to a foot thick. They lie with their length parallel to the strike of the enclosing limestone, that is, about east and west.

Large samples were collected from all these localities and have been distributed from time to time to enquirers. The Curator of the Geological Survey of India, to whom specimens of the white varieties from Kunian, Purana Daruhr, and Kashi Khaira were referred for an opinion, wrote that they were of good quality, though harder and somewhat less pure than similar material from Jubbulpore.

Pieces were also sent to Mr. Andrews, then Principal of the Sir Amar Singh Technical Institute, Srinagar, who turned out some gas-burners from a model supplied him, which were quite successful, though showing a slight tendency to flake off along the lamination.

The origin of these veins of steatite seems to be connected with the disturbance and fracturing which this southern zone of the Great Limestone has suffered—for all the localities are within a mile or so of the faulted boundary to the south. This will furnish a guide to the discovery of more veins and lenticles, but an ultimate explanation of their origin is as difficult to find as in the case of the metaliferous veins that traverse this same Great Limestone mass.

It is quite possible that, somewhere along the southern edge of the Great Limestone mass, larger bodies of steatite may any day be found, or a collection of small veins sufficiently near one another to be worked together. Although there are few industries in which talc is an essential, the percentage of users who are finding it replacing other inerts is increasing. This is particularly so in the paper and paint trade. Recent research has shown that it can be used with advantage in concrete to make it waterproof, to facilitate moulding and to increase the tensile strength (Mineral Industry 1927).

From this and other points of view the position of the deposits, at the edge of the hills round the Riasi plain, would be much more favourable for development if Riasi were linked with the North-Western Railway system.

BARYTES.

Passing under the local name of "chitta surma", barytes furnishes another instance of a non-metallic mineral penetrating the Great Limestone of Riasi district in the familiar form of narrow veins. Mr. Labhu Ram has recorded it from two main localities, Jangalgali and Kherikot, which places will be seen indicated on the Outline map (Pl. 6).

At Jangalgali the veins begin to appear $\frac{1}{4}$ mile south of Jangalgali pass, and then continue further to a distance of $\frac{1}{4}$ mile, within which distance 6 or 7 veins are noticeable. They are irregular and have many ramifications, as for instance the vein $\frac{1}{4}$ mile south of Jangalgali pass. This has an average length of 10 to 12 feet, is about 1 foot thick and runs N. W.—S. E. The barytes contains chalcopyrite and malachite stains.

Further south are some five or six more veins, also running N. W.—S. E. in the strike direction of the enclosing limestone. These range from 6 to 28 feet in length and 1 to 3 feet in width. In the first 4 of the above, the barytes is white, and it contains

malachite stains and chalcopyrite crystals with some kaolin. The last vein to be mentioned in this group is 13 feet long and 1 foot broad, and it does not contain any trace of copper minerals. Its position is $\frac{1}{2}$ mile S. S. E. of Jangalgali pass, and about $\frac{1}{3}$ mile S. S. W. of Drive E in the coal of the area, as shown in R. R. Simpson's map¹. This vein is also somewhat irregular though on the whole it follows the bedding of the limestone, which latter is much fractured.

Below the vein is a small thickness of "makol" (see Clays—p. 26), the dip being 50° N. E. White as well as red varieties are found here.

At Kheri Kot, barytes, both red and white, occurs in association with galena and kaolin in the mine west of the stream junction below Samat Khad, which is S. S. E. of the old galena mine (see published report on Ore Deposits of Lead, Copper, etc., pp. 7, 11). The vein lies between jasperoid layers and is 6 to 8 feet long, 4 to 5 feet wide and 6 inches thick.

Barytes pieces were also found on the slope $\frac{3}{4}$ mile west of Balada; but the parent vein was not located.

There are very probably many more occurrences of this mineral in the Riasi area that have not been yet recorded. Its generally white colour, and its crystal form pseudomorphous after calcite, in a limestone country, do not readily draw attention to it until its great weight (specific gravity over 4) is perceived.

Except as "chitta surma" for the eyes, barytes has no uses for the local inhabitants. Its modern industrial uses for paint, lithopone, and in the ceramic and glass industries, (just as in the case of kaolin, other special clays and steatite) must await the general industrial revival of the country and the provision of easy communications.

¹Report on Jammu Coalfields. *Mem. Geol. Surv. of India*, Vol. XXII, pt. 4, 1904.

MAGNESITE.

The only known occurrence of magnesite in Jammu and Kashmir State is at a point on the Kargil-Leh road $\frac{1}{2}$ mile S. S. E. of Shargol, where, in 1921, Mr. Sohani Ram found a number of lumps (some about a cubic foot in size) of this material. They had evidently rolled down from the slope above, where a band of serpentine rock is known to run in a E.—W. direction. Owing to other work in hand, the fragments could not at that time be traced to their *in situ* position.

The magnesite is an amorphous, compact variety, and unusually hard between 6 and 7 of Moh's scale). It has a conchoidal fracture and specific gravity of 2.93. There is some foreign admixture of iron, lime and silica along with the carbonate.

In this out-of-the-way place, in far off Ladakh, its uses for economic purposes are only problematical.

GRAPHITE.

Natural graphite occurs either in a lamellar, scaly, flaky or crystalline condition or it is compact, amorphous and earthy.

In His Highness' dominions both the scaly and amorphous forms are found. The former (the scaly variety) has so far been recently noticed only in the Sapphire Mines area of Sumjam, Padar, and its neighbourhood ; whereas abundant quantities of the amorphous kind have long been known at various places in the phyllitic rocks of the Cambro-Silurian formation. Deposits of this latter variety, present at Braripura and neighbourhood in Uri Tahsil, Kashmir Province, have been described and a report on them published separately (see list in Preface). Another, of less immediate interest, constitutes several parallel bands (also in the Cambro-Silurian formation) in the Bhut Na valley between the villages Mosh and Atholi.

Only the Sapphire Mines occurrence of flaky or scaly graphite will be briefly referred to here. This locality, which has long been famous for the sapphires found there, is in lat. $33^{\circ}27'$, long. $76^{\circ}23'$. The bands of graphite-bearing rock lie at different altitudes between 10,000 and 15,000 feet above sea level, on what constitutes the south side of the lofty hill range dividing Zanskar from the Chenab drainage area. The outcrops of these bands and the village of Sumjam (Sumsam of the 1 inch to 1 mile Survey of India maps) are shown roughly delineated in the map (Pl. 7) which is enlarged from the old Atlas of India sheet No. 45. Similar bands of scaly graphite are also found lower down the Bhut Na river between Palel and Mosh, villages some 16 and 21 miles from Sumjam in a westerly direction.

The discovery of these occurrences of scaly graphite was made by Assistant Superintendent Labhu Ram, who traced them in some detail on the map whilst exploring the sapphire area in 1927.

The rocks of the area, which appear to be a metamorphosed assemblage of originally sedimentary strata, consist mainly of alternations of biotite gneiss, marble, and some hornblende gneiss. Within the marble bands are found occasional large lenticular or ovoid masses of actinolite-tremolite rock, with veins and lenticles of pegmatite, wherein the corundum and sapphire appear. (These latter will be described in detail in another publication of this series to be issued presently).

The graphite, as small flakes or scales (hardly distinguishable by the eye from the biotite flakes), occurs disseminated and aggregated into streaks and thin layers in the biotite gneiss bands, which latter vary in thickness from 6 to 40 feet. Rough tests have determined the percentage of graphite in the biotite gneiss to be between 7 and 35.

Owing to their remoteness among the mountains and the inaccessibility of the area, there is no im-

mediate prospect of any economic use being made of these graphite deposits.

MISPICKEL (ARSENOPYRITE).

This mineral is the chief ore of arsenic. In addition to specimens in the Mineral Survey collection obtained many years ago by Mr. Joti Parshad (late Assistant Superintendent, Mineral Survey) from Padar area, Kishtwar, four occurrences of the mineral have been recently recorded by Mr. Labhu Ram from the same area. These localities are :—

Specimens collected and localities.

- (1) In a pegmatite vein 1 mile S. E. of Chishote (lat. $33^{\circ}-22'-7''$, long. $76^{\circ}-17'-48''$).
- (2) In a calcite vein 2 miles N. W. of Palel (lat. $33^{\circ}-22'-30''$, long. $76^{\circ}-11'-30''$).
- (3) In a quartz vein $1\frac{1}{2}$ miles W. N. W. of Palel (lat. $33^{\circ}-21'-48''$, long. $76^{\circ}-11'-36''$).
- (4) In a quartz vein $\frac{1}{4}$ mile W. of Gagot, (lat. $33^{\circ}-22'-32''$, long. $76^{\circ}-13'-10''$).

Not much has been done to investigate these ore deposits, because of their sparse distribution and the remoteness of the localities which are difficult of access. It is unlikely that they could be worked profitably for arsenic alone, unless some other of the precious metals are discovered in combination with them, which has not so far been done.

Not investigated completely.

In (1) above the pegmatite vein is 200—250 feet long and 3—5 feet wide and the mispickel occurs in lenticles some 6 inches long which at the surface are few and far between. They are associated with the minerals fluorite, green microcline (amazonstone), biotite and smoky quartz crystals.

Vein 1 mile S. E. of Chishote.

In (2) the mispickel occurs in good concentrations, as
 Two miles N. W. of Patel. grains, crystals and small veinlets, in a
 calcite vein 150—200 feet long and 2 feet
 wide. The countryrock strikes W. N. W.—E. S. E. and dips
 N. N. E. at 72° , whilst the calcite vein dips 20° N. E.

In (3) the mispickel is similarly disseminated in a
 quartz vein running E. N. E.—W. S. W.
 1½ miles W. N. W. of Patel. and which is 2 feet thick and about
 40—50 feet long.

In (4) the quartz vein is 50 feet long and 4 feet thick,
 ¼ mile W. of Gagot. coursing N. W.—S. E., and the mispickel
 is found throughout it in disseminations
 1 inch across and sometimes more.

The mineral from all the localities is steel grey, but a
 Appearance. few crystals have a brassy colour. On
 weathering it everywhere produces red or
 yellow stains on the vein rock.

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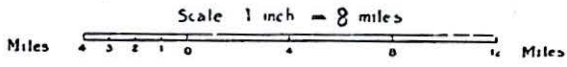
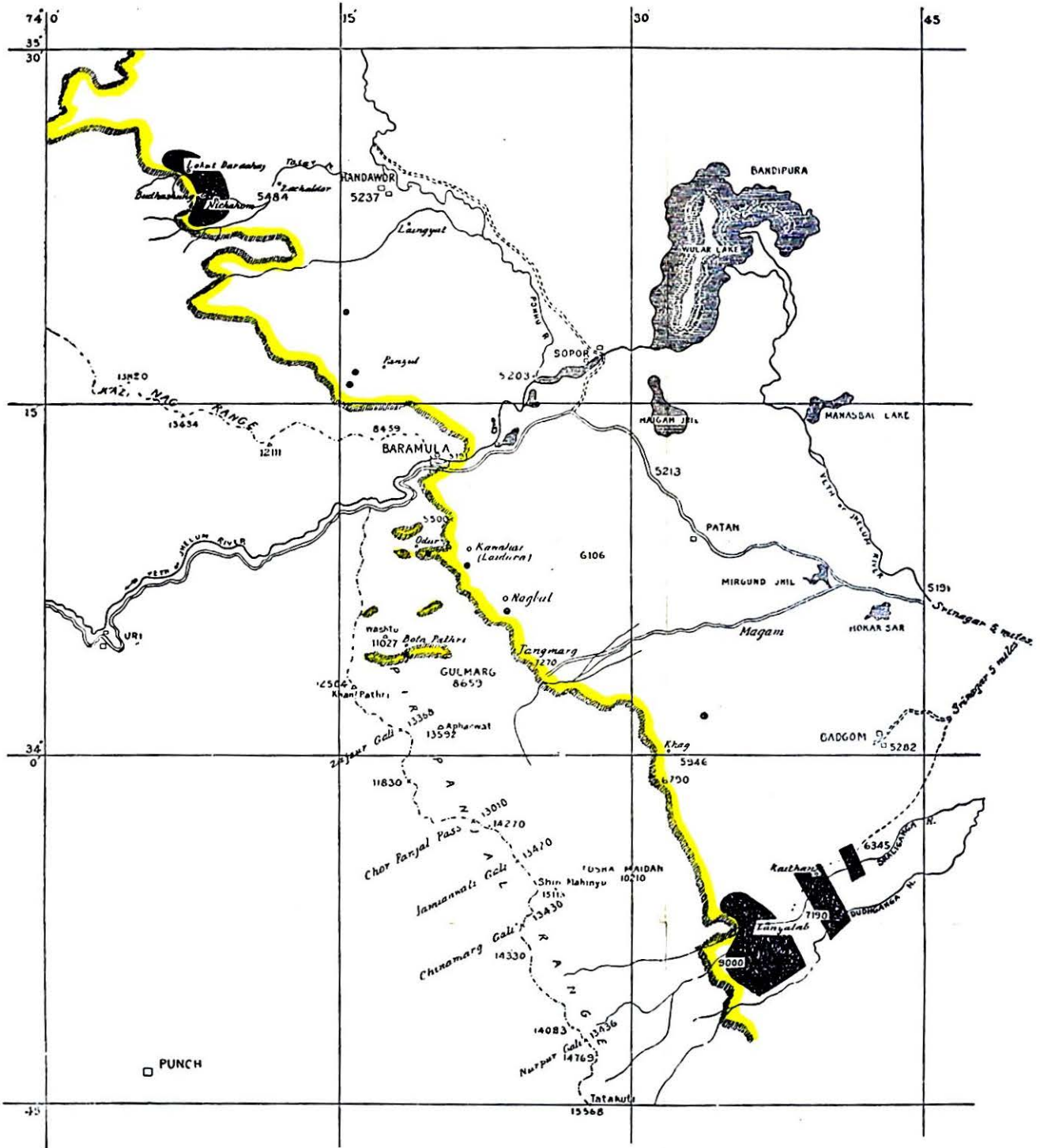
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


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OUTLINE MAP
SHOWING KAREWA FORMATION
AND LIGNITE OCCURRENCES
IN PART OF KASHMIR VALLEY



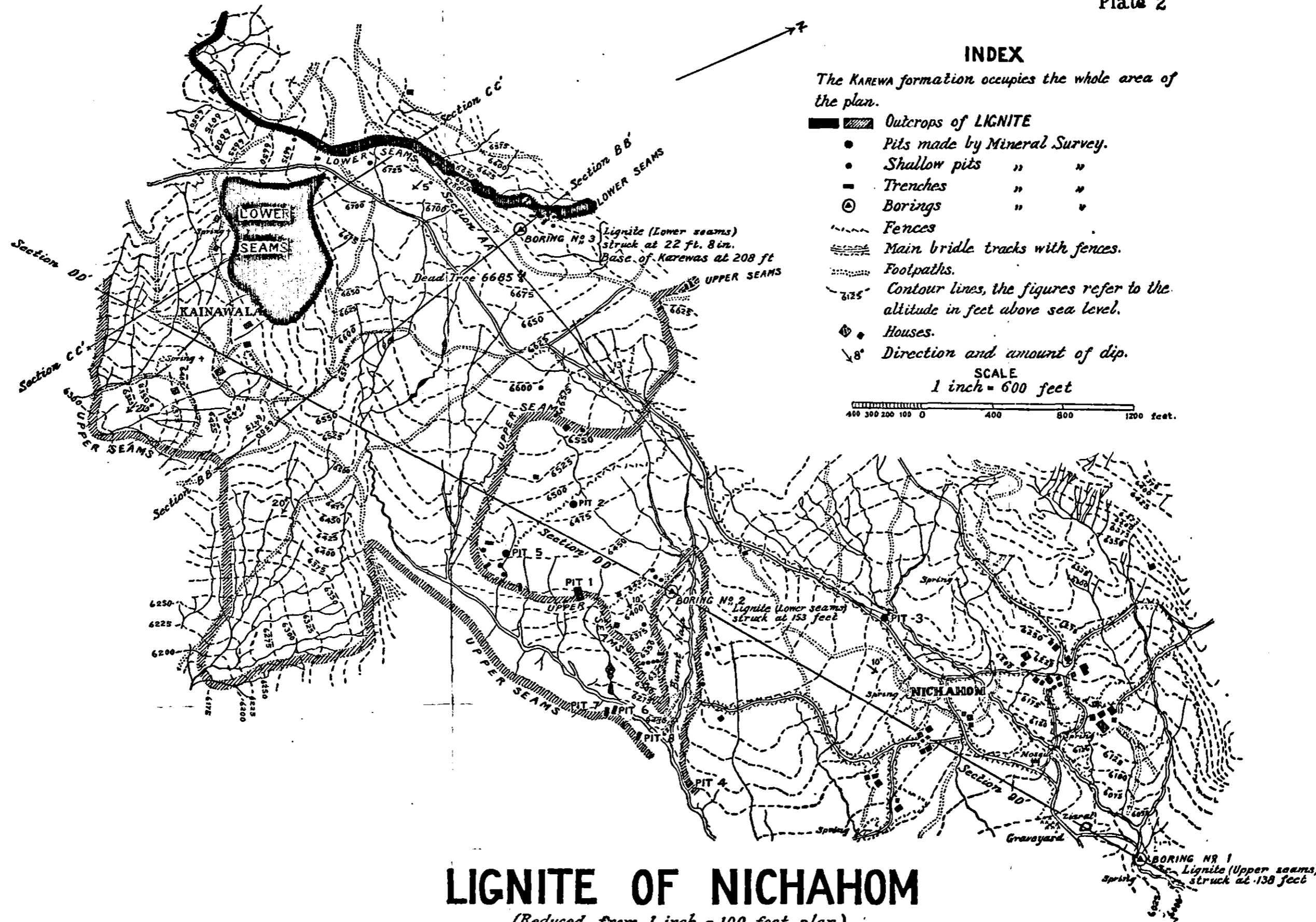
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-  S.W border of Karewa formation
-  Lignite fields (surveyed).
-  Exposures of lignite (not yet surveyed)
-  Line of watershed
-  Metalled roads
-  Unmetalled cart. tracks

(Altitudes in feet above sea level are shown by numbers)

MINERAL SURVEY OF KASHMIR

Plate 2



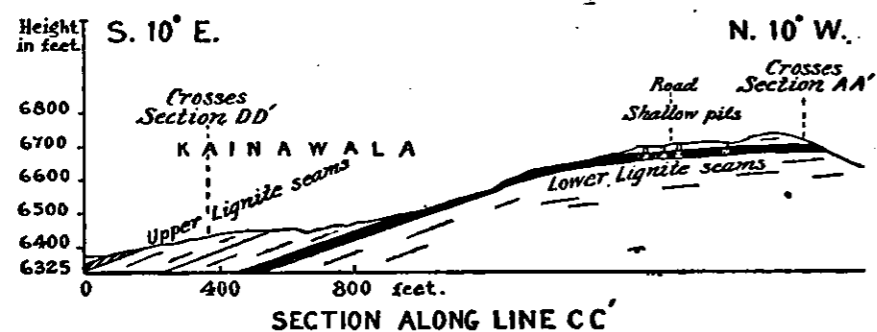
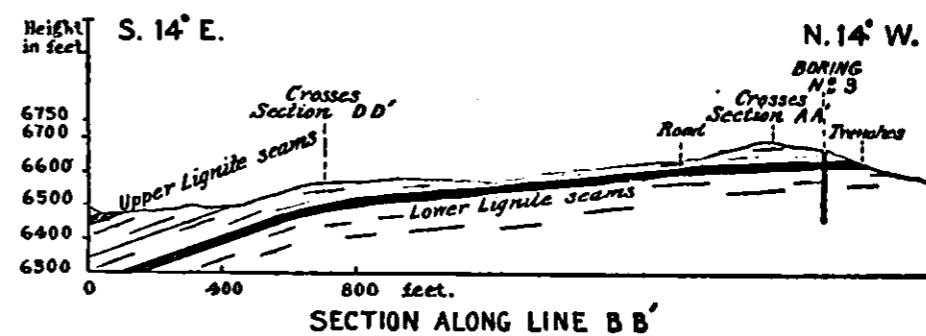
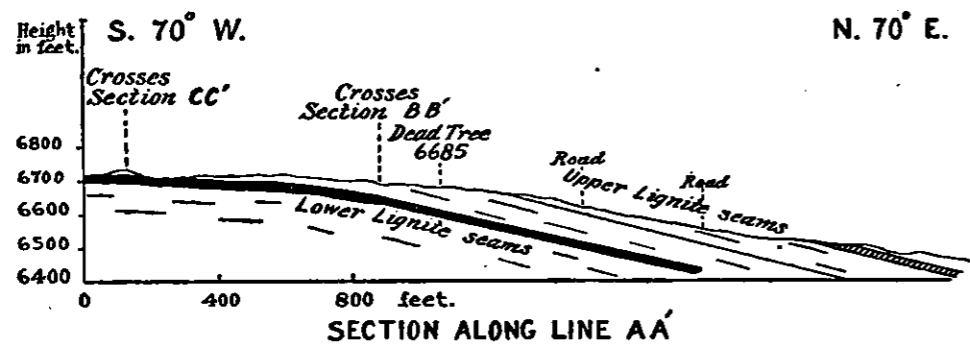
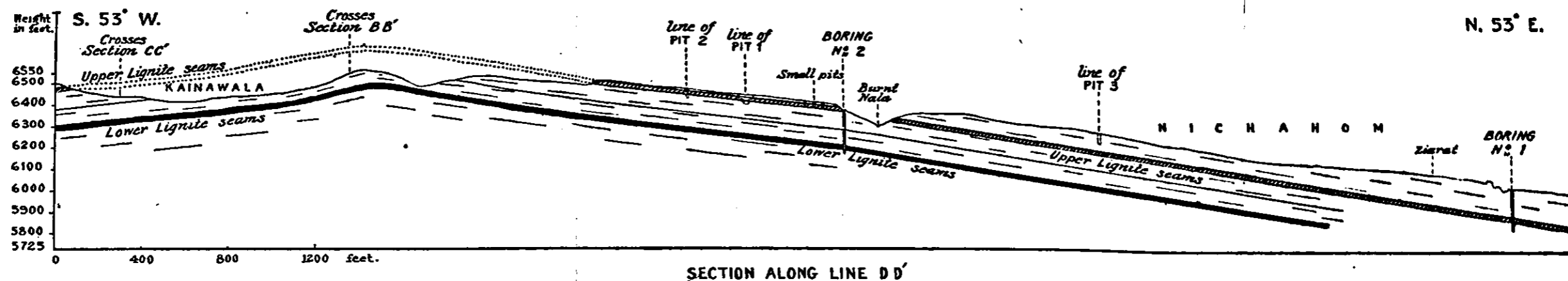
LIGNITE OF NICHAHOM

(Reduced from 1 inch = 100 feet plan).

MINERAL SURVEY OF KASHMIR

Plate 3

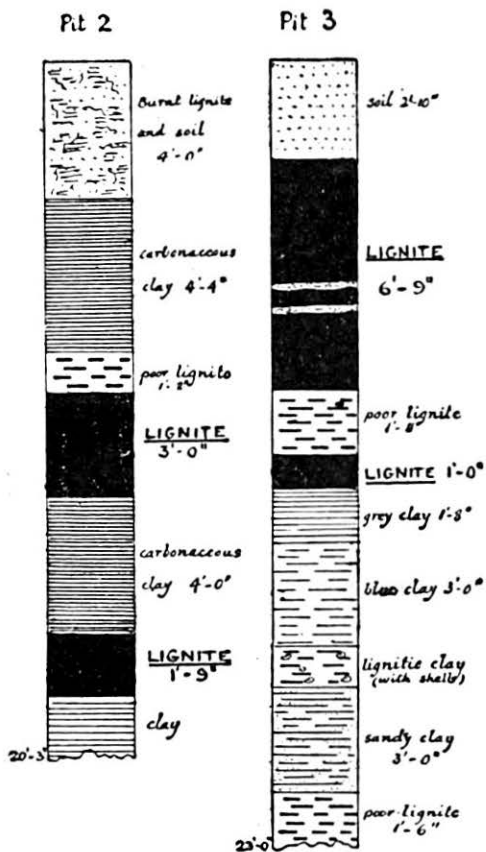
N. 53° E.



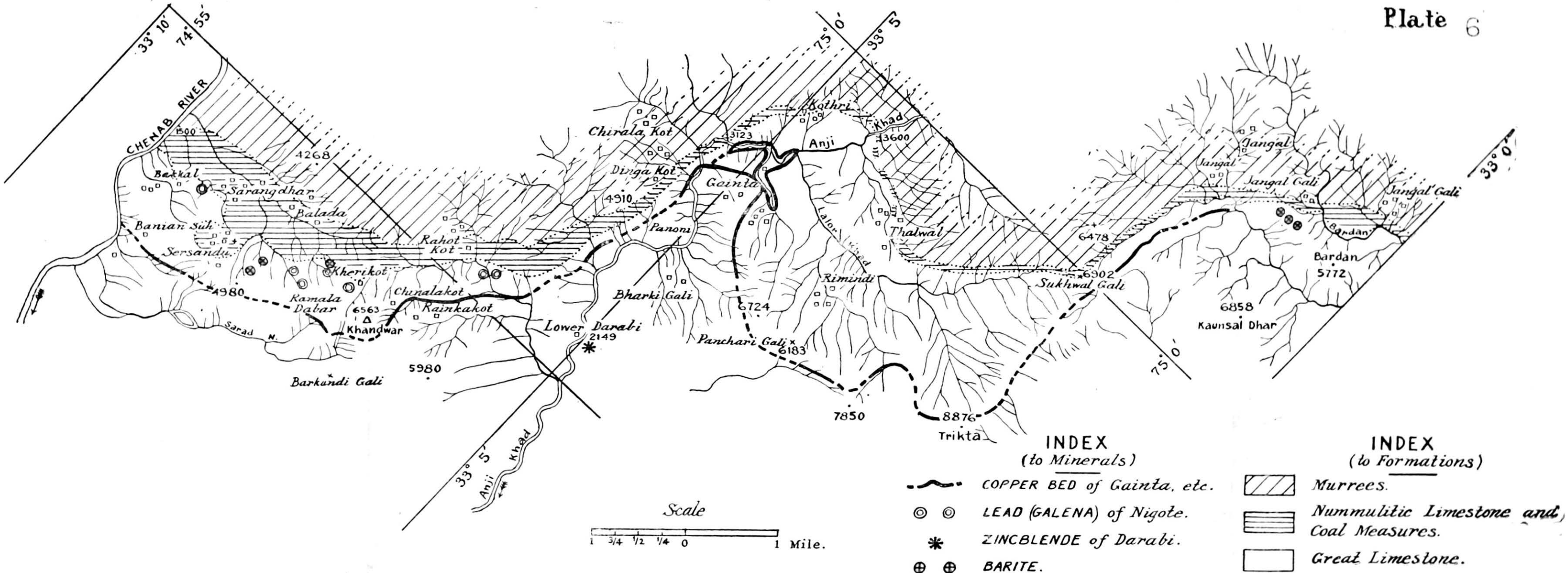
LIGNITE OF NICHAHOM SECTIONS

Scale: 1 inch = 600 feet, (horizontal and vertical).

MINERAL SURVEY OF KASHMIR
 BUDHASHUNG Plate 5



LIGNITE: VERTICAL SECTIONS



COPPER LEAD ZINC AND BARITE RIASI DISTRICT