CHAPTER II.

GEOLOGY AND MINERAL RESOURCES.

The main geological formation.

The greater part of the Hazaribagh district is still geologically unsurveyed though the district has long been famous as the home of the well-known ruby mica and has several large coal-fields including the Giridih coal-field which contains the best metallurgical coal in India though now diminishing in quantity. Consequently the portion of the Bihar mica belt and the coal-fields which lie in this district are not only economically the most important but geologically the most well-explored areas of the district.

The main geological formations of the district are the following :—

(1) Recent deposits of alluvium and laterite.

(2) Post Gondwana	Dykes of basic igneous rocks.	Cretaceo-Eocene.
	Dykes of basic and Ultrabasic igneous rocks.	Jurassic and Triassic.

(3) Gondwana system.	Upper	..	Panchet or Mahadevas.	Lower Jurassic.
	Lower	Damuda	Panchet series.	Lower Triassic.
			Raniganj series.	Upper Permian.
			Ironstone shales.	Middle Permian.
			Barakar series with Karharbari stage.	Lower Permian.
			Talchir series with glacial boulder bed.	Upper Carboniferous.

(4) Basic intrusives, meta dolerite, amphibolite and epidiorites.

(5) Mica pegmatites and granite pegmatites.

(6) Chota Nagpur granite gneiss.

(7) Dharwars-Crushed or fault breccia, garnet-amphibole schist, granulites, schists, phyllites, quartzites, etc.

In his " Geological Notes on parts of North Hazaribagh ", Mallet distinguished the following three stages among the schists : —

(a) Upper stage of quartzites as seen in Mahabar Hill.

(b) Middle stage, thick with predominant mica-schists.

(c) Basal stage with prevalent quartzite as in the Bhiaura ridge.

The massif of Parasnath Hill consists mainly of a pyroxone-bearing garnetiferous quartzite with felspathic gneisses near the base.

The hills apart from those made up of quartzites consist either of huge dome-shaped masses of granite-gneiss or of irregular masses of dark hornblende gneiss. The rock of the former group of hills has been called the " dome-gneiss " owing to its peculiar weathering into dome-like hummocks and ellipsoidal masses due to exfoliation. These domes form a very striking feature of the landscape along the northern fringe of the district. Typical examples of dome-shaped hills made of dome-gneiss are the Nero Hill, 1,737 feet, west of Domchanch (24°28′ : 85°42′) : Banda Hill, 1,883 feet, near Kodarma; Maramoko, 2,052 feet, north-east of Kodarma; and Banresur 1,739 feet, north-east of Gawan (24°40′ : 86°1′).

The dome-gneiss, a variety of the Chota Nagpur granite-gneiss, is a pink-coloured gneissose granite, sometimes porphyritic, composed essentially of microcline, quartz, acid oligoclase and biotite as the main constituents, hornblende in subordinate amount, and accessory sphene, apatite, zircon and fluorite. The rock also occurs as thin sheets intruded into the schist folia giving rise to a composite gneiss or injection gneiss. Near the margin, the gneiss is coarse-grained and slightly banded. Near the granite-mica-schist boundary, as near Jurga, Ambakola Lora, etc., it becomes a porphyroblastic gneiss with large ovoids of porphyroblastic felspars, resembling the Rapakivi type of gneiss described from Finland. In the western part of the mica belt, granitic material has soaked through the country rocks forming hybrid mica-schists and mica-gneisses.

The following types of the dome-gneiss and associated rocks have been recognised by N. L. Sharma : granite-gneiss, foliated granite-gneiss, biotite-rich granite-gneiss, epidote-bearing granitic rocks, schistose and aplitic muscovite-biotite gneiss, granulitic hornblende and biotite gneisses and biotite-hornblende gneiss. Holland gave the first petrographical description of the dome-gneiss and regarded it as a granite (or granitite) intrusive into the schists. The gneissose structure was considered as due to parallel disposition of the constituents. Though the banding may be original due to tectonic forces during the intrusion of the granite magma, there is no doubt that the rock has suffered from later regional metamorphism.

The schist belt forms an irregular scarp, with a series of *ghats* leading from the gneissic upland of North Hazaribagh to the Ganga plain. The comparatively rapid erosive action of the swift flowing streams has dissected the country in a way which facilitates the detection of mica-bearing pegmatites and the mining of mica. The schists represent rocks of diverse origin, many of which such as the amphibolites, hornblende schists and granulites differ very little in composition from known igneous rocks. The amphibolite bands are portions of pre-existing masses of basic igneous rocks which were disrupted by the later granite intrusives.

The para-metamorphic rocks in the Kodarma area fall into the following classes, according to Sharma: (*i*) sillimanite-gneisses which pass into (*ii*) muscovite and biotite-gneisses without sillimanite. These pass into (*iii*) mica-schists or muscovite biotite-schists with the complete absence of felspar and an abundance of muscovite. Lastly are the (*iv*) calc-silicate granulites which are very subordinate in quantity and represent bands of impure calcareous sediment.

In the Giridih area Holland had described diorite rocks which generally rise as small hills from the crystalline basement rocks. They also occur as dykes in various places in Chotanagpur parallel to the foliation of the pre-existing rocks. The diorites have formed from original plagioclase-pyroxene rocks. In the Bonkhoonja Hill, a small peak west of the Usri and north of the coal-field, hornblende has developed parallel to the porphyritic augite. In Chepo Hill, hornblende has formed isolated crystals in the augite while the rocks have been crushed and foliated into fissile hornblende-schists. Another rock which is somewhat peculiar is an eurite which forms two large dykes, one of which runs along the northern boundary of the coal-field for some distance, and the other running parallel to the south boundary from a little to the south of the junction of the Komaljore and Suni *nadis*. The eurite is a dark green compact rock, brecciated, and the pieces recemented with granular quartz and with occasional patches of granitic material.

The pegmatites represent the end products of the granite magma which had earlier formed the dome-gneiss. The pegmatites which carry mica are always associated with mica-schists and gneisses, while the pegmatites which traverse the dome-gneiss do not contain workable quantities of mica. There are two types of pegmatites, namely, simple and complex. The simple pegmatite is a microcline-pegmatite, consisting essentially of microcline and quartz with subordinate muscovite which is not usually in workable quantity. Biotite and tourmaline are the common accessory minerals. It traverses both granite-gneiss and the para gneisses and schists. Where the dome-gneiss is contaminated with inclusions of basic rocks, or is itself a hornblende-bearing rock, the pegmatites are rich in hornblende. These are intersected by pegmatite veins of later phase devoid of hornblende.

The complex pegmatites are mica-bearing. They are plagioclase mica-pegmatites. In addition to plagioclase and muscovite, they contain tourmaline, apatite, garnet and beryl. The minerals occur as big crystals. These do not traverse the granite-gneiss but are confined to the country rocks in the manner of lenses, and the schist inclusions in the granite and they follow the strike and foliation direction of the schists. The 'books' of mica are found on both the foot and the hanging walls of a pegmatite vein, or only on one of them. When large books of mica occur quartz forms as a central core with books of mica on its two sides.

Pegmatite veins more than two feet in thickness have been enriched in mica, but veins of greater thickness are not so rich probably because reactions producing mica have been very limited. The reacting solutions may have travelled along the walls and also along the junction between the central core of quartz, if present, and its marginal zone of felspar. The veins may split, or may pinch out and appear again in depth. Some veins consist only of massive felspars containing tourmaline and barren on the surface. In the western portion of the mica belt, the veins become thin, less frequent, and the mica is of small size and of inferior quality such as near Chauparan and Gurpa. Tourmaline and beryl occur to a smaller extent, and the mica is green, or stained, or white.

The mica in the pegmatite is associated with a peculiar grey quartz locally known as '*Kajra*' meaning black. There is another type of colloidal silica known as '*Jogni*'. These are considered as a good indicator of mica. The quartz is followed by a massive zone of felspars locally called '*Harwa*', followed by massive quartz in the core known locally as '*Bhuja*' which, as has been said above, may not be present always.

The next younger geological formation in the district belongs to the Gondwana System, the lower division of which comprises the most important coal measures of India. The coal-fields of the Hazaribagh district lying in the Damodar valley are the westerly continuation of the great belt of coal-fields beginning with the Raniganj coal-field in West Bengal and followed by the Jharia and the small Chandrapura coal-fields in the Manbhum district. In the Hazaribagh district they begin with the Bokaro followed by the South and North Karanpura coal-fields. All these were once part of a great spread of Gondwana strata along a rift valley formed by trough faulting along the Damodar valley—the rift being a branch of the main belt of trough faulting following the line of the Narbada-Son.

All the coal-fields have been intruded by dykes and sils of dolerite and basalt, which have usually been considered as the hypabyssal representatives of the Rajmahal flows. According to Fox they may belong to the younger Deccan period of volcanicity. The coal measures are also intruded by dykes and sills of an ultra basic rock known as lamprophyre and related rocks. These are older than the basaltic intrusives. While the basaltic rocks have not damaged the coal much, excepting making mining more expensive necessitating drilling through hard rock, the ultra basic rocks have spoilt large quantities of good coal. They were very fluid at the time of injection and have traversed bedding planes of strata specially in contact with or within the coal seams and have turned the coal into natural coke and otherwise rendered it useless for mining.

The oldest Gondwana rocks belong to the Talchir Series. They consist of greenish splintery needle shales and greenish buff-coloured earthy sandstones and trappoid shales. These have been found in almost every area of coal-bearing Damuda rocks. The basal boulder-bed is rather uncommon. The Talchirs rest over the older rocks with a great unconformity but are overlain by the Damudas with a slight unconformity. The discovery of striated boulders, and occasional facetted pebbles and glaciated pavements led to the conception of an Ice Age before the end of the Carboniferous period in Gondwanaland. The Talchir boulder-bed has the appearance of a re-deposited water-sorted moraine formation.

Plant fossils have been found in the shales overlying the boulder-bed with a slight unconformity. The best occurrence is that near Rikba (23° 45′ : 85° 22′) in the Karanpura coal-field. The plant-bearing rocks are lithologically similar to the Talchirs but pass conformably to the Barakar strata.

Karharbari Stage.

In the Giridih coal-field coal occurs associated with strata of both the Barakar Series and the upper division of the Talchir Series which is known as the Karharbari Stage. The former is known as Upper and the latter as the Lower Coal Measures. The flora of the Rikba plant bed is almost identical with that obtained from the Karharbari Stage, and this led to the view that the Karharbari Stage belonged to the Talchir series. There is, however, an unconformity between the Lower Coal Measures and the underlying Talchir Series in the Giridih area. Moreover the Karharbari coal measures could not be separated by mapping from the overlying Barakar coal measures, and many of the plant fossils are common to both the Karharbari beds and the Barakar beds. In view of all the above facts the Karharbari stage is now included with the basal Barakars.

Barakar Series.

The strata are best developed as a coal-bearing formation in the Jharia coal-field where they are roughly 2,000 feet thick. In the other Damodar Valley coal-fields, the number and total thickness of the beds, including the coal seams, are less than in the Jharia field. The strata consist of yellowish sandstones with occasional carbonaceous layers. Pebbly sandstones are also common, some of which are immediately above seams of coal.

The Barakars pass upwards into a series of strata which are devoid of workable seams of coal and are somewhat less arenaceous. These are known as the Barren Measures.

Raniganj Series.

The type area of the Raniganj Series is the Raniganj coal-field. It is a coal-bearing formation in both the Raniganj and Jharia coal-fields. The series consist of sandstones, shale and coal seams. The sandstones are, in general, finer textured than those of the Barakars and coarse grits are wanting.

Panchet Series.

Upper Gondwana strata are found in the Bokaro coal-field and the North Karanpura coal-field. In the Bokaro field, all the sub-divisions of the Damudas are found. The deepest part of the coal-field is under the Lugu Hill where Talchir rocks show up at the east and west ends of the field below the Barakars. The plinth of the Lugu Hill is formed by the Panchet Series of rocks which are unconformable to and overlap the Raniganj Series westwards under Lugu Hill. The top of the Lugu Hill is made of sandstones which are correlated with the Mahadevas of the Satpura region and the Dubrajpur beds of the Rajmahal Hills. There is, therefore, a great break between the Panchets and these top beds.

In the North Karanpura field the Panchet beds are well-developed along the base of several hills, those of Mahudih, Satpahari, Malhan (Gerwa), and Tarhi, where they are capped unconformably by the Supra-Panchets or Mahadevas.

Apart from the coal-fields lying in the Damodar valley, there are three other small coal-fields in the district. These are the Giridih, Chope and Itkhori coal-fields.

Bokaro Coal-field.

The Bokaro field forms a narrow strip along the valley of the Bokaro river, roughly forty miles from east to west and less than seven miles from north to south, between longitudes 85° 25′ and 86° 05′. The field is usually considered as divided into East Bokaro, east of 85° 42′ and West Bokaro to the west of this longitude. Mining has been concentrated in East Bokaro, east of Gumia (23° 48′ : 85° 50′) and practically restricted to the Kargali seam which in one section in the Bokaro quarry was found to be 125 feet thick including thin carbonaceous shales. There are 19 seams over 4 feet in thickness. The more important seams are the following :—

12 feet A seam.

Kargali 100 feet seam.

Bermo 40 feet seam.

Karo 80 feet seam.

The reserves in the East Bokaro field in the Kargali seam alone are more than 500 million tons of good coal, most of which is of good caking character, and if cleaned, is suitable for metallurgical coke. According to Fox, if the inferior coal in the Bermo, Karo and other seams is included, the quantity is above 1,000 million tons. The coal is mainly used by the railways. A sample taken by Dr. Fermor from 24 railway wagons with coal from the joint railway quarry at Bokaro gave the following results on analysis :—

Moisture—1.6 per cent.

Volatile matter—23.57 per cent.

Fixed carbon—58.96 per cent.

Ash—16.31 per cent.

Sulphur—0.465 per cent.

Calorific value—7,149 calories.

The West Bokaro field has not been surveyed in great detail but the seams appear to be more disturbed and less attractive than those of the East. One of the best sections is in the Bhagatala nala under the south-west slopes of the Jilunga Hill (23° 50′ : 85° 40′). Here 11 seams have been found. Coal occurs in many other places.

In the East Bokaro field a few seams occur in the Raniganj Series but they are thin and unattractive.

Ramgarh Coal-field.

Five miles south of the Bokaro field is the Ramgarh coal-field which extends along the valley of the Damodar between 85° 31′ and 85° 4′, covering an area of about 40 square miles out of which 30 square miles are occupied by the Barakar coal measures. Three seams, 36 feet, 26 feet and 30 feet have been proved, of which only the middle 6 feet of the 26 feet seam is workable. At least five million tons of workable coal is available over an area of at least one square mile, whereas the coal measures occupy 30 square miles so that the reserves may be 150 million tons.

Karanpura Coal-fields.

The Karanpura coal-fields form two areas of Gondwana rocks in the upper part of the basin of the Damodar between 23° 38′ : 23° 56′; and 84° 46′ : 85° 28′. Their extreme length from east to west is about 44 miles and their extreme breadth from north to south is about 22 miles. Their total area is roughly about 550 square miles and they occupy portions of the districts of Hazaribagh, Palamau and Ranchi, about two-thirds of the total area being in the Hazaribagh district. The South Karanpura field lies entirely in the Hazaribagh district.

The Karanpura coal-fields were discovered by Mr. D. H. Williams who died there in 1848 while carrying on the survey. They were originally mapped by T. W. H. Hughes in 1867-68 after Dr. V. Ball had discovered the South Karanpura field near Tungi (23° 40′ : 85° 26′). They were re-surveyed by Dr. A Jowett on behalf of Messrs. Bird and Co., during 1915—18. Dr. Fermor reported to the Railway Board on selecting portions of the Karanpura coal-fields and the areas recommended by him have received considerable attention with a view to immediate development. The areas named by Dr. Fermor are Khapia, north of Rikba, Arhara (23° 53′ : 85° 14′) and Devalagara, a mile east of Ara (23° 50′ : 84° 57′).

There are strong east-west boundary faults along the south side of both these coal-fields.

South Karanpura Coal-field.

The South Karanpura coal-field forms an elongated strip of Barakers along the Chaingara fault and has an outlier of Barren Measures with basal Raniganj Measures westward from south of Sanda (23° 40′ : 85° 20′) to Binja (23° 40′ : 85° 13′). It is connected with the North

Karanpura field by a small strip of Talchirs about Hosir one and a half miles north-west of Patal Hill. It has an area of 75 square miles between 85° 9′ and 85° 30′. The South Karanpura field has been developed greatly and several railways and private firms have their quarries. The railway station of Barkakana is situated at the south-east edge of the field. From Barkakana the Eastern Railway continues up the Damodar valley over the south-west end of the North Karanpura field and over the Auranga and Hutar fields of the Palamau district to Daltonganj, whence it follows the Son valley to Son East Bank.

Most of the coal mined is from large open quarries. The Argada area is being worked, on behalf of the former Bengal Nagpur Railway. There are two coal beds, the upper 50 feet and the lower 38 feet thick, separated by sandstone, shales and shaly coal, mixed coal and shale. The coal, according to analysis made by the Coal Grading Board, is of first grade and of low volatile content. In the adjoining Sirka area worked by Bird & Co., the two seams are separated by 17 feet of shale, sand stone and shaly coal. The two Sirka seams are 20 feet thick. The Argada seams are about the middle of the Barakars and may represent the Karo and Bermo seams of Bokaro. The Sirka seams might represent the Kargali seam of Bokaro. The Sirka seams come together and form one single seam 40 feet thick in the Gidi area. The lower Sirka seam and the Upper Argada seams are thought to be the same. The number and thickness of the seams as well as the thickness of the Barakars are quite as well developed as in the best areas of the Jharia coal-field.

North Karanpura Coal-field.

Little work has been done in the North Karanpura field due to lack of communications north of the Damodar river and owing to lack of first class coal according to Dr. Fermor, though according to Dr. Jowett first class coal occurs and the reserves are about 5,000 million tons, of first class and 10,000 million tons of second class coal down to 2,000 feet. The field extends between 84° 49′ and 85° 27′ and has an area of 550 square miles. Besides Talchirs, Barakars, Raniganj, Panchets and Mahadevas also occur. Coal seams occur in both the Barakars and Raniganj. There is a large number of seams some over 72 feet.

Structurally the North Karanpura field consists of three separate basins: the main area under the Mahudi Hills, Satpahari, and on to beyond Ganeshpur forming a single large elongated basin; the Mahlan (Gerwa) basin in the south-west corner along the axis of the South Karanpura field; the Chano or Rikba half basin, which is largely due to faulting, from north of Ango eastwards into the western end of the

Bokaro coal-field. There is an inlier of gneisses between Chano and Larunga in the valley of the Tordeg nala (23° 46′ : 85° 20′), north-west of the Chano basin. The main basin is sliced in three by faults trending east-south-east.

Giridih Coal-field.

The Giridih coal-field is situated 11 miles south-west of the town of Giridih. There are three main seams, namely, the Lower Karharbari, the Upper Karharbari and the Bhaddoah seams. The Lower Karharbari seam varies from 10 feet to 24 feet in thickness and provides the finest metallurgical coal. The Upper Karharbari seam is 4 feet to 10 feet in thickness but is now exhausted. The Bhaddoah averages 6 feet in thickness. The other seams aggregate 66 feet but are of poorer quality. In 1934 Fox estimated the reserves at 49 million tons and a life of 25 years allowing for losses.

Chope Coal-field.

About ten miles west of Hazaribagh and about six miles north of the northern edge of the Karanpura coal-field, there is a small area of Talchir and Barakar coal measures in the bed of the Mohani river, a mile and a quarter south of Chope village (24° 2′ : 85° 14′). The area covered by the coal measures is less than one square mile. Only one seam of coal 4 feet thick has been found, but the amount is limited and the quality is poor.

Itkhori Coal-field.

About 25 miles down the Mohani river from the Chope coal-field and extending westward for 3½ miles from the village of Itkhori (24° 18′ : 85° 9′), there is a narrow strip of Talchirs with a small area of Barakars (coal measures). There are three coal seams, the lowest or Mohani seam is 8 feet thick, and the second 4 feet and the top is not clearly exposed. Hughes considered the middle 4 feet seam as the best in quality. He estimated the quantity of coal in the field at about 1,500,000 tons. The coal has a high ash content but is suitable for local use.

COPPER.

The occurrence of copper at Baragunda (24° 05′ : 86° 04′) in the Giridih subdivision was first noted by Mc. Clelland and Smith. According to Mallet the ore is of copper pyrites which occur in lenticular stringers usually up to ½ inch thick but sometimes up to 3 or 4 inches, and parallels with the foliation of the schists. The country rocks are garnetiferous mica schists with some quartzites, talc-schists and hornblende-schists. The ancients mined to a depth of 120 feet along two sections up to 120 feet in width on the surface. The Bengal Baragunda Copper Co., formed in 1882, opened up five shafts, the most westerly shaft reached a depth of 330 feet. The average production was 25 tons of copper per year but the maximum was 40 tons per month over a period of 10 years. The ore averaged an assay of 1—15 per cent copper.

In the Patru stream near Golgo (24° 24′ ; 86° 22′) minute particles of chalcopyrite and galena have been noted in a rock consisting of garnet and diopside.

Iron-ore.

Lenticles and nodules of iron-ore are found in the Bokaro, Ramgarh and Karanpura coal-fields. These were at one time used by indigenous smelters. They may have a small demand from time to time owing to their special properties, e.g., a certain amount of soft limonite ore is used as a desulphuriser in coking and gas plants.

Limestone.

Isolated patches of limestone occur along a belt extending east and west parallel with the coal-fields between Ramgarh and Palamau. These are associated with schists and dip at a steep angle and appear to persist to some depth. In consequence of the steep angle of dip, the overhead cost increases with quarrying. They are generally low in magnesia but many are high in silica. The cement works at Khalari uses this limestone. The limestone areas now being worked in the Damodar valley are as given below :—

Bundu-Basaria (23° 40′ ; 85° 23′—85° 26′).—The belt of limestone has a width varying from 500 to 1,200 feet. The limestone is inter-bedded with the schists but thick sub-zones of good limestone are available for development. Large reserves are available for the manufacture of lime and cement. At present the limestone is used for local lime manufactured by the Karanpura Development Co., Ltd.

Kurkuta Religara (23° 43′ ; 85° 21′—85° 22′).—The strike of the zone varies from east-west to north-east—south-west and the dips are high to the north and north-west. There is inter-banding between thick sub-zones of good limestone and schists, and the main limestone sub-zone is succeeded by a thick group of calcareous schists. The average quality of the limestone is superior to that at Bundu, and there are large reserves for the manufacture of cement and lime and for use as flux. The area has not yet been developed.

Lapanga-Bharkunda-Kursa (23° 38′, 85° 21′—85° 23′).—The direction of strike is variable but the main trend is north-west—south-east with high dips to the north-east. Exposures of limestone are fairly widespread but they represent only local bands and lenticles within thick masses of schists. Some are of good quality but most are poor.

Hosir-Bachra-Dundu-Ray (23° 40′ : 85° 03′—85° 07′).—Part of this is in Ranchi district. Strike of the zone is east-west, and the width varies from 800 to 1,200 feet. Dips are steeply to the north. The limestone is interbedded with calcareous schists, but the main mass, which forms hills in some places (in the Hosir-Bachra section) is of good quality suitable for cement manufacture. In the western or Dundu-Ray section of the zone, beds of calcareous schists become much more numerous. Here it is being developed by the National Cement Mines and Industries, Ltd., for the manufacture of lime at Ray.

MICA.

The mica industry of Bihar is of great importance not only to Bihar, but to India and the World. Seventy per cent of the world's sheet mica comes from India and eighty per cent of India's total production of mica comes from the Bihar mica belt, the greater part of which is situated in the Hazaribagh district. The ruby mica of Bihar is regarded as the best mica for electrical purposes.

About 25 per cent of the mica raised in the Bihar mica belt was produced from '*Uparchala*' or surface workings, about 20 feet in depth. Up till 1918, most of the mica was obtained from those surface workings or shallow mines, many of which were abandoned due to trouble arising from ground water. The problem of getting rid of the ground water was solved later on by the introduction of machinery. The Kodarma Reserve Forest area was thoroughly prospected by '*Uparchala*' mining. '*Uparchala*' mining had given rise to some controversy since many small mica miners abandon the mines filled with debris after scraping off whatever mica is available near the surface. Other authorities are of opinion that '*Uparchala*' mining is an important method of prospecting for mica deposits. When deep pegmatite is proved, systematic mining is undertaken. Stoping commences after the pegmatite has been thoroughly explored by deep mining methods and yields rich quantities of mica.

The veins of mica pegmatite often pinch out along strike and dip, or a barren part of the pegmatite in the middle may divide the mine into two sections. Most of the mines are not more than 300 feet deep but some have reached a depth of 400 to 500 feet. The enriched portions generally occur between 150—300 feet in depth. Below 300 feet the books of mica become progressively smaller and below 400 feet the pegmatites pass into stringers. The veins may also branch in depth.

The pegmatites carry many accessory minerals in certain places which are of great interest. Felspars occur througout the mica belt and, where large quantities are available, are suitable for the porcelain industry. Pale green apatite occurs abundantly in some pegmatite veins (Lakamandwa) where the surrounding schists are also impregnated with it. Leucopyrite and lollingite are found in lumps in some places in the pegmatites, for example, leucopyrite has been found near Dabur, south of Gawan, in the Sakri river, and at a place one mile south-west of Dhab. Crystals of beryl, both large and small, have been found in the pegmatites but most of them were thrown into the dump heaps. It may be possible to make good collections if the miners learn to recognize the minerals. Specimens of columbite were found in 1897 in the Kodarma Reserve Forest. Garnets are common throughout the district. Transparent tourmaline associated with blue indicolite and lepidolite has been found near Manimundar (24° 37′ : 85° 52′).

Fire Clay.

Fire clay occurs at Emlo (23° 48′ : 86° 00′) associated with the Gondwana coal beds.

Steatite or Soapstone.

Deposits of steatite are worked at a place west of Parasnath. Bricks cut from this material have been used in the alkali furnaces in paper mills.

Mineral Occurrences of Little Economic Value.

Antimony.—Deposits of lead ore were worked for antimony towards the close of the 18th century at Hisatu (24° 00′ : 85° 01′).

Lead ore was discovered by Motte and Farquhar in 1777. The mine was re-discovered by Ouseley in 1842, and specimens assayed 47.02 per cent lead and 4.7 per cent antimony with no trace of silver.

A lead mine is indicated at Nyatand 224° 30′ : 85° 43′) on Sherwills map of Bengal but no particulars are available.

Galena was found associated with copper ore at Baragunda and Mallet noted its occurrence with copper in the Patru stream near Golgo.

Molybdenite.—Rare flakes up to an inch across have been found associated with the zinc lead-copper ores of Mahabank in the Patro river near Golgo in a matrix of cocolite and garnet. Some rare scales have been seen in the Baraganda copper mine with copper and iron pyrites and sphalerite in chlorite and mica-schists.

Tin ore (Cassiterite).—Cassiterite has been found in several places. Within the mica belt, cassiterite has been found near Pihra (24° 39′ : 85° 49′) as small grains in a dyke of lepidolite granite; at Simratanri (24° 39′ : 85° 47′) in a lens of granite intruded into mica-schist; and at Chappatand (24° 40′ : 86° 57′) in a cassiterite-granulite described by Fermor.

Another occurrence at Purgo (24° 10′ : 86° 08′) in Palganj near Parasnath was noted by Mc. Clelland in 1849. It was smelted in village iron furnaces. According to Fermor, a thin layer of cassiterite-granulite up to six inches thick and containing 30 to 50 per cent of cassiterite occurs in a microcline granite which also contains scattered grains of cassiterite specially close to the cassiterite-granulite. Several attempts were made by Europeans to work the deposit but without success. In 1909-10 the surface was worked with the production of 3 cwts. of tin during each of the years 1909-10, a further 0.1 cwt. in 1914, and 0.7 ton in 1915 from village iron furnaces.