CHAPTER V

LABORATORY INVESTIGATIONS

Petrography

In this chapter, the various structural, textural and mineralogical characters of the rock types, distinguishing and classifying the sedimentary and metamorphic features are fully described.

The petrographic study brings out the following conclusions:

1. All the graphite deposits are located within the area of Pre-Cambrian metamorphic rocks. The Pre-Cambrian terrain is affected by folding,

regional metamorphism and contact metamorphism due to intrusive granites. Original textures are generally obliterated during regional metamorphism. Though the relict textures are much less common in the rocks, the sedimentary characters are preserved at some places. The lithology, depositional arrangements and textures ideally reveal the successive events and environments of deposition.

2. In most of the areas investigated, intrusions of granite masses are evident. They are responsible in modifying the nature of the rocks in contact zone superimposing contact metamorphism over regional metamorphism.

Graphite Schist (Ankli): The graphitic rocks from Ankli mine consist almost entirely of quartz and graphite with varying percentages of mica. Much of the mined rock is medium grained and dark gray in colour due to the presence of graphite. The workable layers of graphitic rocks show alternate bands of grayish brown and light whitish yellow colour.

Under the microscope, the rock shows tightly foliated structure and consists of muscovite with quartz and graphite.

The grains of quartz and graphite flakes are interlocking.

Graphite, the most abundant mineral occurs as microflakes, oriented subparallely with mica giving the schistose appearance to the rock (plate XXII). The grayish brown bands are seen to consist of earthy black graphite with mica (muscovite) and occasional grains of epidote and sphene (plate XXIII A and B). Light, whitish yellow bands are composed largely of quartz with carbonaceous matter (plate XXIV A and B). Some bands show the presence of both quartz and graphite flakes. Most of the quartz grains are enclosed by graphite flakes but the inclusions of graphite flakes in quartz grains are absent. The interbanded nature of the rock gives an indication of sedimentary character.

Tremolite is abundant and occurs in fibrous form.

Epidote occurs in granular aggregates. The appearance of these minerals indicate low grade regional metamorphism.

Feldspar has altered to muscovite shreds.

Graphitic schist near the contact of granitic intrusion, consists of tremolite, epidote and occasional grains of biotite and apatite. This rock shows incipient

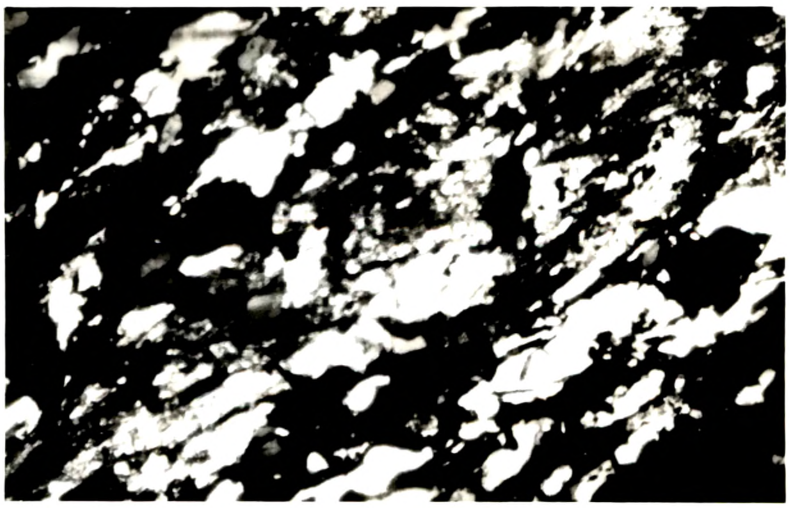

Plate XXII. Graphite schist (Ankli) showing schistose structure (Photomicrograph: Crossed nicols, X60).

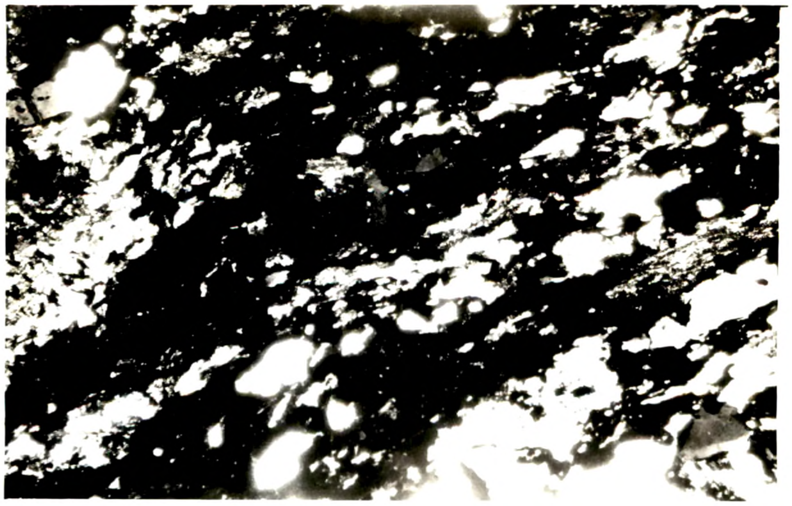

Plate XXIIIA. Graphite schist (Ankli) showing graphite flakes disseminated in grayish-brown band (Photomicrograph: Crossed nicols, X60).

Plate XXIIIB. Graphite schist (Ankli) showing graphite flakes disseminated in grayish-brown band (Photomicrograph: Polarised light, X60).

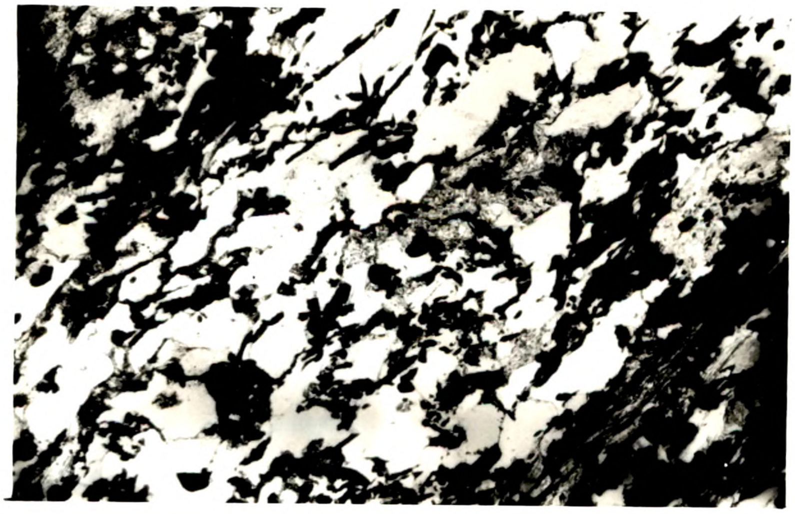

Plate XXIVA. Graphite schist (Ankli) showing graphite flakes disseminated in light whitish yellow band (Photomicrograph: Crossed nicols, X60).

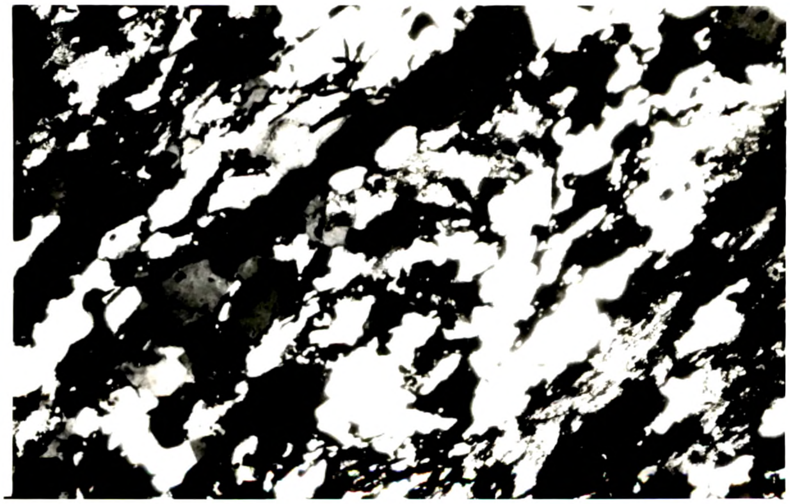

Plate XXIVB. Graphite schist (Ankli) showing graphite flakes disseminated in light whitish yellow band (Photomicrograph: Polarized light, X60).

gneissic structure suggesting early effects of contact metamorphism (plate XXV).

Crystalline limestone (Ankli): Bands of crystalline limestone near Ankli mine are confined to a narrow zone above graphitic schist bordering granite. The colour of the limestone varies from grayishwhite to gray in which light gray bands show coarse plates of calcite and dusty granular carbonates. These crystalline limestone bands are not traceable for any long distance.

Under the microscope, the rock shows fairly crystalline granular matrix of calcite with little quartz. Coarse and granular calcite occurs with amphibole (tremolite) and micaceous minerals. The tremolite is colourless, bladded or acicular in nature (plate XXVI). The bladed form tapers at one end or appears as wedge shaped, clear or crowded with dominant cleavage cracks. The extinction is almost parallel. Tremolite is not very conspicuous in handspecimen but appears as very small irregular faint greenish black grains with brilliant lustre. The occasional grains of forsterite (olivine) are found to be thoroughly altered to serpentine (plate XXVII). This alteration suggests the contact metamorphic effects. The micaceous minerals occur

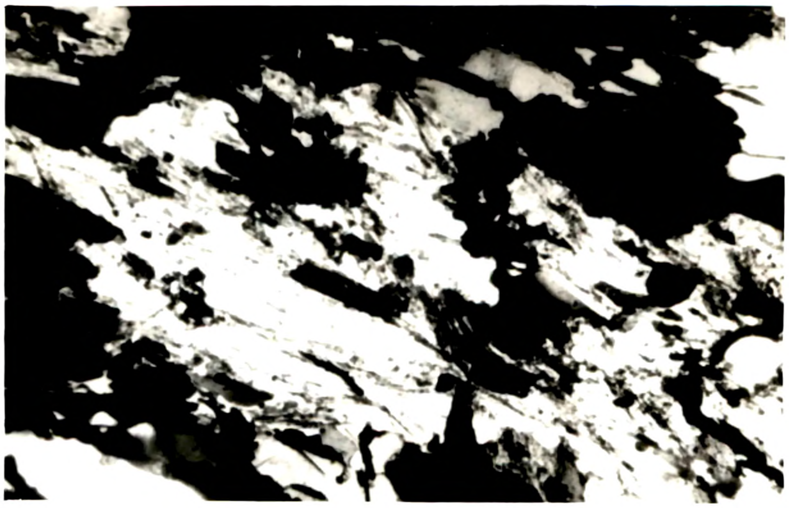

Plate XXV. Graphite gneiss (Ankli) showing presence of tremolite (Photomicrograph: Crossed nicols, X60).

Plate XXVI. Crystalline limestone (Ankli) showing presence of tremolite (Photomicrograph: Crossed nicols, X60).

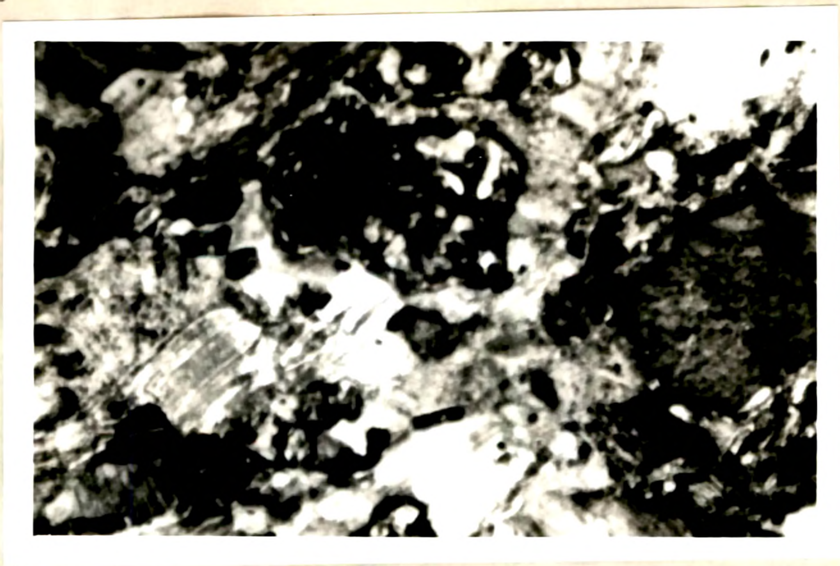

Plate XXVII. Crystalline limestone (Ankli) showing forsterite (Photomicrograph: Crossed nicols, X60).

Plate XXVIII. Gray granite of Ankli (Photomicrograph: Crossed nicols, X60).

as bent flakes and elongate grains of quartz showing wavy extinction, indicate the contact metamorphic effects. Gray amphibole (tremolite) occurs in small patches. Graphite occurs as irregular flakes in the matrix of calcite with little quartz. Few flakes of graphite are also associated with the grains of quartz and the acicular amphibole (remolite).

Granite (Ankli) : Granite outcropping near Ankli cuts across the associated schist and crystalline limestone. This granite is distinctly intrusive. A common type of granite rock exposed few feet away from graphite exposures, is leucocratic, coarse-grained and essentially consists of quartz, feldspar (both potash feldspar and plagioclase) and biotite in varying proportions. The gray granite contains more biotite while pink granite, exposed in mined section contains more potash feldspar. Thin veins of milky quartz cutting across the schist and crystalline limestone are probably offshoots from the larger intrusive granite.

Gray granite: Texturally, this rock is medium to coarse-grained, hypidiomorphic, containing porphyritic plagioclase, quartz, microcline and biotite as the important constituents of the rock (plate XXVIII).

Quartz forms anhedral grains and occupy interstitial spaces.

Plagioclase (An_{10-30}), is the dominant constituent. It occurs, generally as sub-hedral grains and shows alteration to sericite.

Microcline is very subordinate and occurs as few anhedral to subhedral grains often showing myrmekitic texture.

Biotite occurs as stray flakes.

Pink granite : Fine to coarse grained rock consists of quartz, microcline, oligoclase and biotite (plate XXIX).

Quartz is invariably anhedral and also occurs as small rounded, inclusions in the feldspar.

Plagioclase (An_{10-20}), tends to be subhedral while most of the potash feldspar is anhedral to subhedral or with quartz occupy irregular interspaces. Myrmekitic texture is quite common. Plagioclase grains (An_{10-20}) show subhedral to enhedral form and occur as separate individuals.

Plate XXIX. Pink granite of Ankli
(Photomicrograph: Crossed nicols,X60).

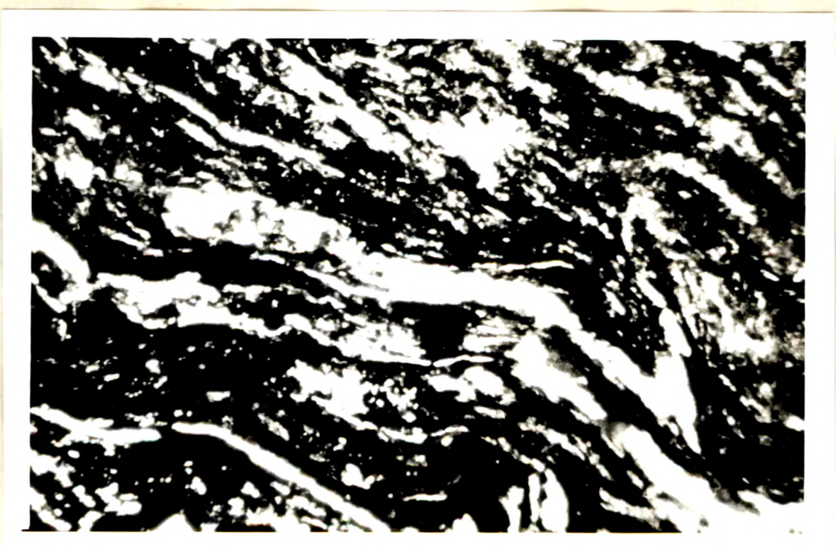

Plate XXX. Graphite schist (Sewania) showing
schistose structure (Photomicrograph:
Polarized light, X60).

Potash feldspar is microcline and is characterized by its typical crosshatching.

Biotite occurs as small flakes.

Accessary minerals are epidote and iron ores.

Graphite is not traceable in any of the above types of granites and quartz veins.

Graphite schist (Sewania): It is light gray to dark grayish black in colour and shows well developed foliations, marked by the flakes of mica along with graphite flakes. In mined sections, the schistose formation shows layering. The rock consists of quartz, graphite, mica and calcite as its essential minerals. Pyrite occurs as thin veins, mainly parallel to the schistosity of the rock.

In thin sections, the schist shows well foliated mass of mica (muscovite, sericite) and graphite along with quartz, calcite and iron ores (plate XXX). When the percentage of calcite is more than that of mica, this rock is without strong foliation. The layering in graphite schist with layers of graphite, mica and calcite indicate that the layers of carbonaceous matter, clay and calcareous sediments on metamorphism have given rise to graphite schist (plate XXXI).

Plate XXXI. Graphite schist (Sewania) showing layers of graphite-mica and calcite (Photomicrograph: Crossed nicols, X60).

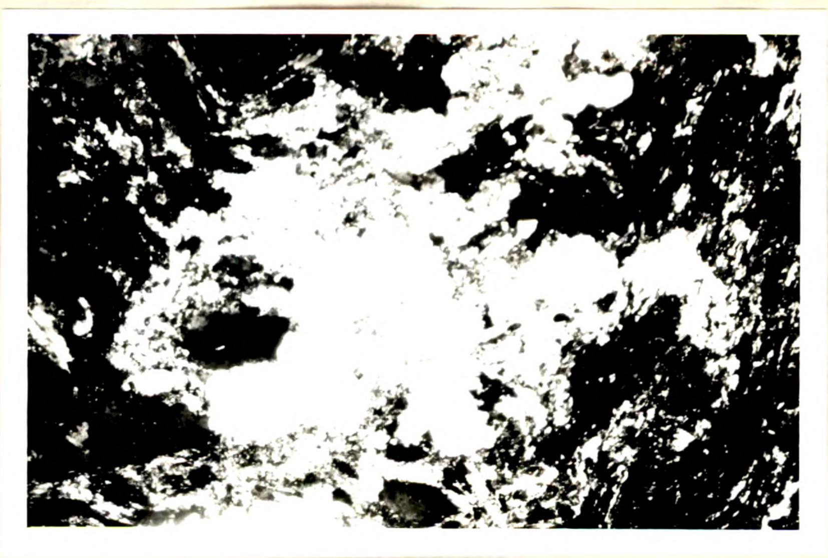

Plate XXXII. Graphite schist (Sewania) showing quartz grains enclosed by calcite and graphite (Photomicrograph: Crossed nicols, X60).

Quartz, occurs as grains of various sizes and often forms small elongated clustures parallel to the schistosity. Most of the quartz grains are enclosed by graphite flakes.

Graphite occurs as microflakes or minute grains of various sizes oriented sub-parallel to the schistosity. It is closely associated with mica in calcareous matrix and also encloses most of the quartz grains (plate XXXII). Few flakes cut across the foliations. This mineral gives the dark colour to the rock. Throughout the rock the concentration of graphite is not uniform. This may be due to the uneven distribution of indigenous carbonaceous matter.

Calcite is always present and forms the matrix. Thin veins of calcite run along and across the schistosity of the rock (plate XXXIII). The grains of calcite are less separated in matrix as compared to thin veins. The rock can be called as calc-graphite schist due to the abundance of calcite and graphite. The isolated quartz grains present in the calcareous matrix represent the siliceous impurities originally present in calcareous sediments.

Mica (muscovite, sericite), is invariably present as flakes, scattered throughout the rock. Sericite is a common alteration product. Biotite, occurs in small proportion and the flakes are oriented along the foliations.

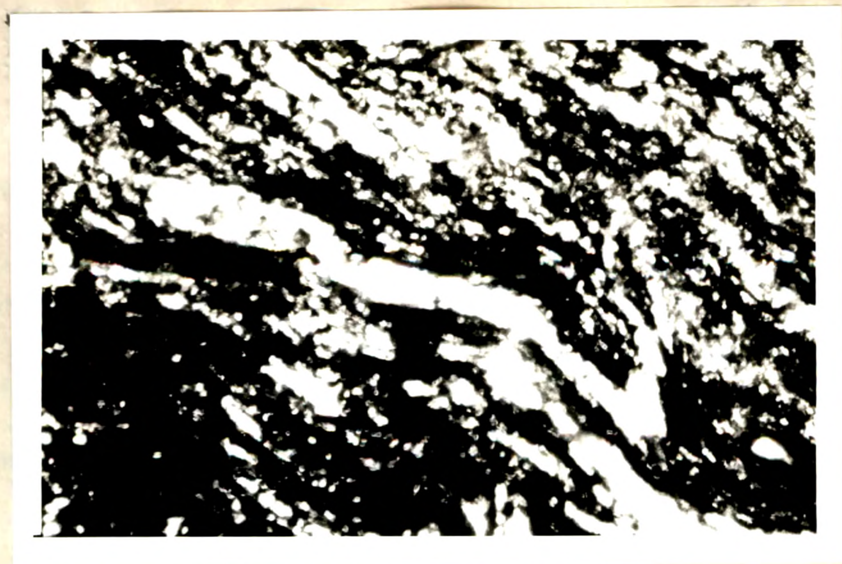

Plate XXXIII. Graphite schist (Sewania) showing calcite veins along the schistosity (Photomicrograph: Crossed nicols, X60).

Plate XXXIV. Pink granite of Sewania (Photomicrograph: Crossed nicols, X60).

Chlorite occurs as minute shreds in the calcareous matrix with quartz. It is characterized by its pale greenish colour.

Hematite, characterized by brownish red colour is found bordering the fractured quartz grains.

Diopside, occurs as an irregular grains in the calcareous matrix which are difficult to identify. The other accessary mineral is magnetite.

Some graphite schist contains wallastonite as fibrous aggregates in calcareous matrix. It shows parallel extinction.

The high lime content of graphitic rock containing silica is regarded as an evidence of its sedimentary origin (Bastin, 1910). Like the other Pre-Cambrian sediments of this region, these rocks were unquestionably subjected to regional metamorphism with recrystallization and development of schistose structure. Later they were intruded by granite. Graphite represents an original carbonaceous constituent of the impure argilliceous sediments containing calcareous material and is the product of regional metamorphism followed by recrystallization in whole or in part through the igneous metamorphic effects of the granite (Huang, 1962). The presence of diopside chlorite, biotite and wallastonite suggest the low to medium grade metamorphic effects and contact metamorphic effects respectively.

Pink Granite occurs as an intrusive in metasediments. It is medium to fine grained, massive and compact. Joints are distinct and the rock is fractured. The rock consists of quartz, microcline and biotite.

Under the microscope, quartz, potash feldspar, muscovite and biotite are the chief minerals (plate XXXIV).

Quartz grains are anhedral and are comparable in size to feldspar grains.

Potash feldspar is microcline and is characterized by crosshatching. It also occurs as big phenocrysts enclosing quartz and plagioclase. Plagioclase (An_{10-20}) occurs as as separate individuals and as inclusions within microcline.

Muscovite occurs as shreds. Biotite occurs as small flakes and shows pleochrosim.

Accessary minerals are apatite, zircon, epidote and iron ores. Absence of graphite is noticed.

Graphite schist (Muthai) : It is grayish black to black, medium grained and well foliated. The thin veins of calcite run across and along the foliations.

Granite occurs as wall like intrusive.

Under the microscope the rock shows foliated structure. The chief constituents are quartz, graphite and mica (plate XXXV). The foliated mass is interspersed with elongated aggregates of quartz grains which represent crushing followed by recrystallization of bigger quartz grains during deformation.

Quartz is an abundant mineral characterized by its undulatory extinction. Quartz grains along with muscovite and graphite show schistose structure and form mosaic pattern.

Graphite is present in equal proportion as quartz. The dark colour of the rock is due to the presence of graphite. The subparallel orientation of flakes of graphite gives the schistose appearance to the rock. While few flakes and earthy mass of graphite occur irregularly in the matrix of quartz.

Chlorite occurs as irregular scaly masses or as minute shreds in the matrix of quartz and graphite. It is characterized by its greenish colour, weak pleochroism and parallel extinction. Muscovite and Sericite are always present as tiny flakes and small shreds in the ground mass.

Hematite occurs irregularly in the matrix of quartz.

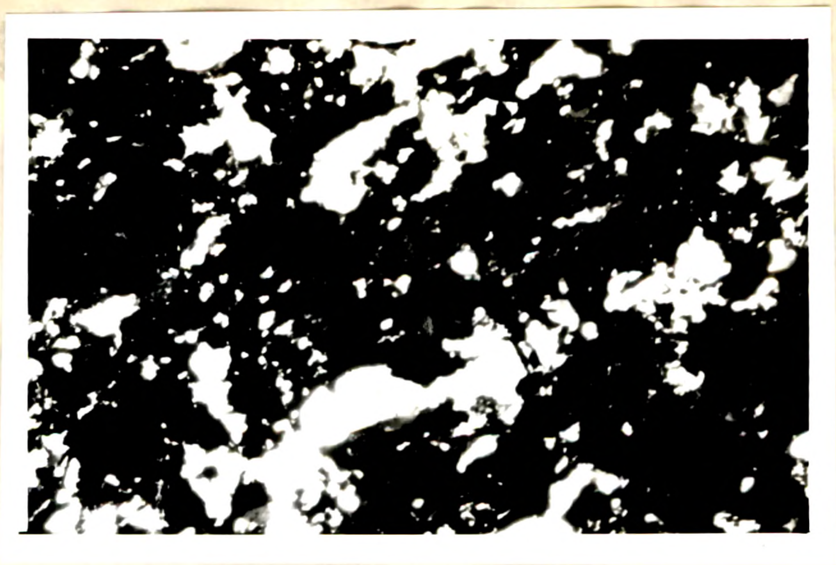

Plate XXXV. Graphite schist (Muthai) showing dissemination of graphite flakes (Photomicrograph: Crossed nicols, X60).

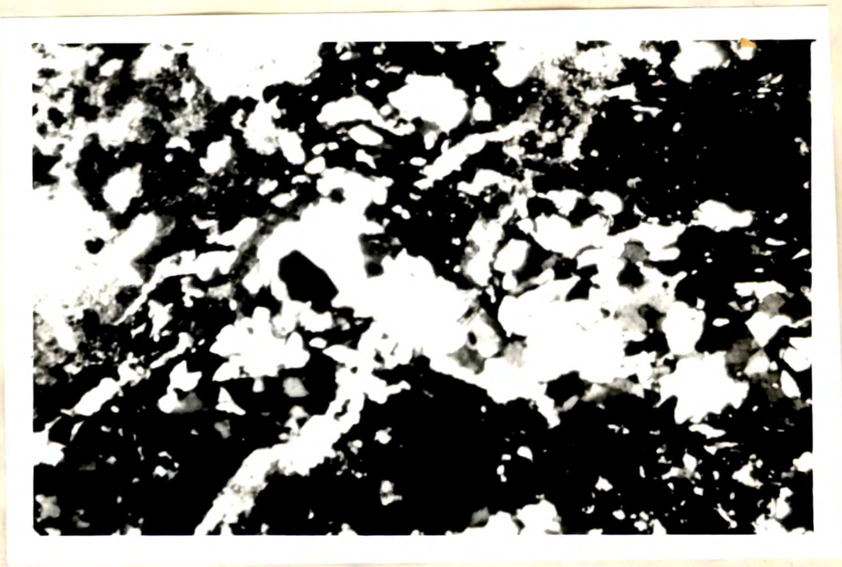

Plate XXXVI. Graphite schist (Muthai) showing calcite veinlet across the foliations (Photomicrograph: Crossed nicols, X60).

Calcite mainly occurs in vein form, cutting across the foliations of the rock. The small anhedral grains of calcite which are characterized by their twinkling nature, do not show distinct cleavage. Chlorite is present in the middle portion of the vein and graphite is completely absent. The vein fillings are later than the foliations. Near the contact, graphite flakes are perpendicular to the vein (plate XXXVI).

Scanning under Electron Microscope of graphite schist indicate that the amorphous graphite, clearly shows flaky nature (plate XXXVII).

From the mineral assemblages present, the rock can be called quartz-chlorite-graphite schist which represents regionally metamorphosed pelitic sediments. In this pelitic schist, interlocking, elongate quartz grains occur as layers alternating with layers of interleaved parallel graphite and muscovite flakes. Quartz, graphite, chlorite and muscovite represent the derivatives of low-grade regional metamorphism of originally pelitic rock.

Granite (Muthai) : It is leucocratic and medium grained showing equigranular to nearly porphyritic texture often grading into gneissic texture. The gneissic foliation is

Plate XXXVII. Graphite schist (Muthai) showing micro-flakes of graphite (SEM, X5000).

due to the alignment of mica flakes, chiefly biotite. The amount of mica varies (plate XXXVIII A and B).

In thin sections, the texture is hypidiomorphic equigranular to often porphyritic with phenocrysts of K-feldspar measuring about 1/2 cm. The average grain size is about one mm. Mineralogically, quartz, plagioclase and K-feldspars are almost in equal proportion. Biotite the only mafic mineral, varies from less than 5 per cent to about 10 per cent. Muscovite is also present. All minerals particularly quartz show effect of strain.

Quartz shows effect of deformation as strain shadows and deformation lamellae.

Plagioclase (An_{15-28}) is slightly altered to dusty, white, opaque Kaolinite and colourless mica. Most of the grains show multiple twinning. K-feldspar is usually unaltered and often occurs as phenocrysts of about 1/2 cm. It shows cross-hatched twinning (superimposed on carlsbad twinning) and often shows hair like perthitic intergrowth, indicating a high temperature origin. Frequently it is surrounded by myrmekitic plagioclase at the border.

Plate XXXVIIIA. Granite of Muthai (Photomicrograph: Crossed nicols, X60).

Plate XXXVIIIB. Gray granite of Muthai (Photomicrograph: Crossed nicols, X60).

Mica is mainly of biotite variety and shows typical light yellow to dark brown pleochroism. Colourless muscovite in smaller amount also occurs with biotite.

There are no traces of graphite in this rock.

Graphite schist (Virpur): Silvery gray rock shows schistose structure due to the sub-parallel orientation of elongate quartz grains along with flakes of mica and graphite. This rock differs from other graphite bearing rocks in that it is more quartzo-feldsphathic, more biotitic and less calcitic.

Under the microscope, the rock is composed of interlocking grains of quartz and feldspar (orthoclase, microcline) with much biotite and graphite (plate XXXIX).

Quartz is dominant and forms schistose structure along with flakes of mica and graphite. Interlocking grains of quartz and feldspar give gneissic appearance (plate XL). Some of the elongate quartz grains show strain effects.

Microcline occurs as irregular grains characterized by its hazy cross-hatching. Orthoclase is altered to microcline. Plagioclase (An_{10-20}) is occasionally present and shows myrmekitic texture.

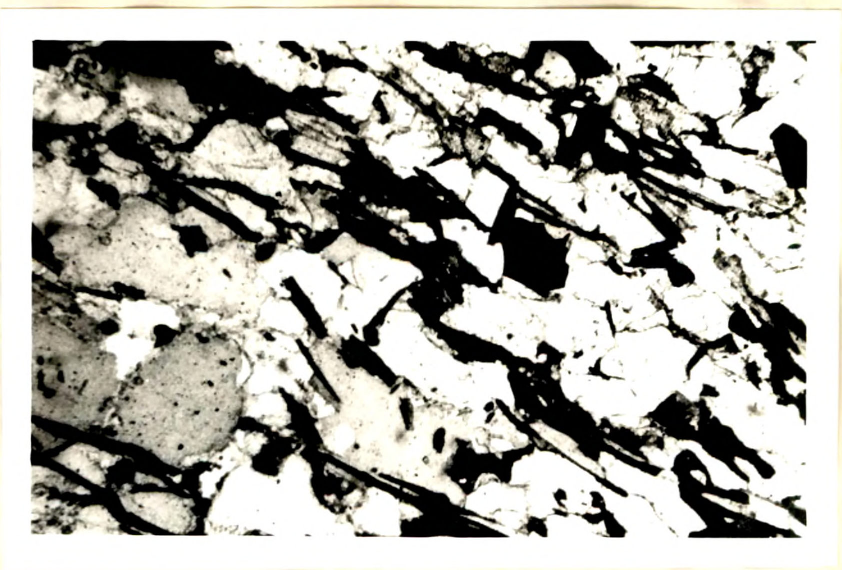

Plate XXXIX. Graphite schist (Virpur) showing schistose structure (Photomicrograph: Polarized light, X60).

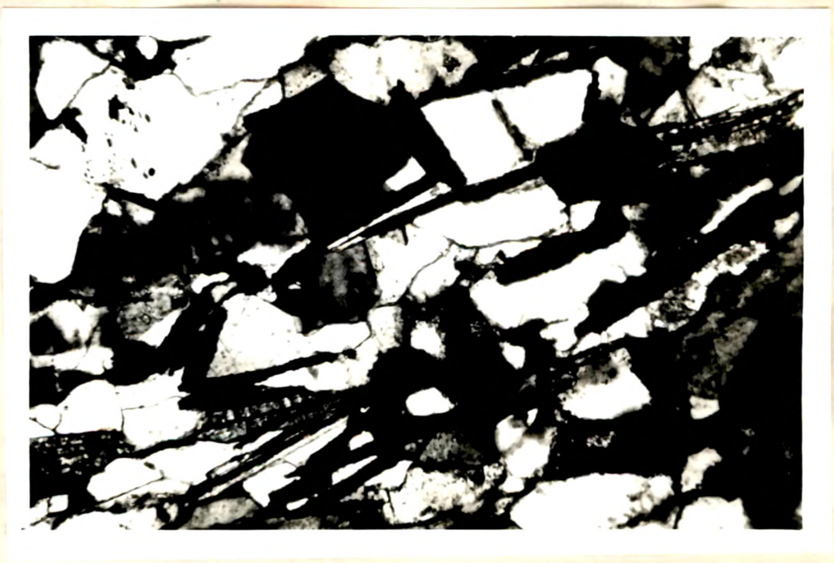

Plate XL. Graphite gneiss (Virpur) showing gneissic structure (Photomicrograph: Crossed nicols, X60).

Graphite is either intergrown or closely associated with biotite. Most of the quartz and feldspar grains are enclosed by graphite flakes.

A typical fibrous nature of muscovite is observed. The alteration of muscovite to sericite is common and may be due to the hydration of muscovite and alteration of feldspar grains.

Biotite is abundant and occurs as sub-hedral flakes along with quartz-feldspar matrix. It also forms big porphyroblastic flakes. The parallelism of biotite flakes produces a sort of schistosity in the rock. It is pleochroic from light yellow to brown or rarely to green.

Sillimanite occurs as small irregular needles or in fibrous form associated with mica in quartzose-matrix of the schist (plate XLI).

The other accessary minerals are dravite, brown in colour occurring as anhedral to euhedral grains. Zircon and apatite are occasional minerals.

The presence of feldspar with quartz, strained quartz grains and biotite as an abundant mineral and occasional presence of sillimanite suggest that this rock has undergone modrate to high grade regional

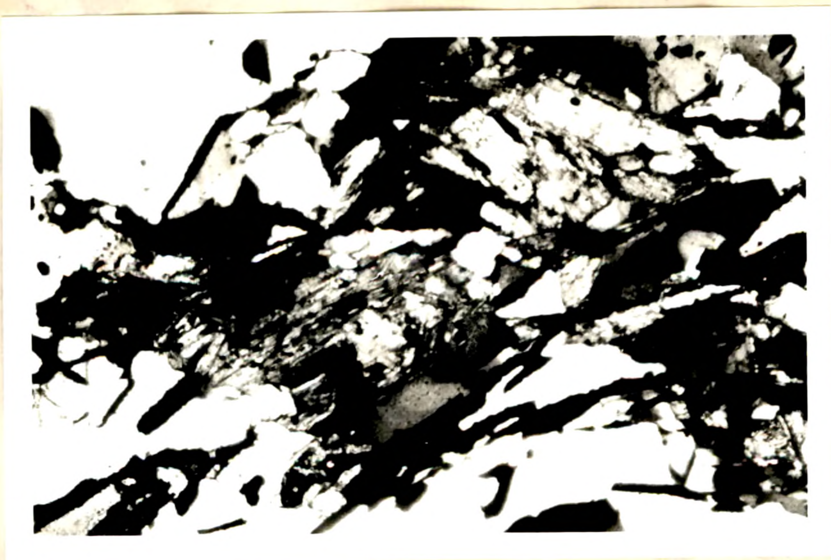

Plate XLI. Graphite schist (Virpur) showing presence of sillimanite (Photomicrograph: Crossed nicols, X60).

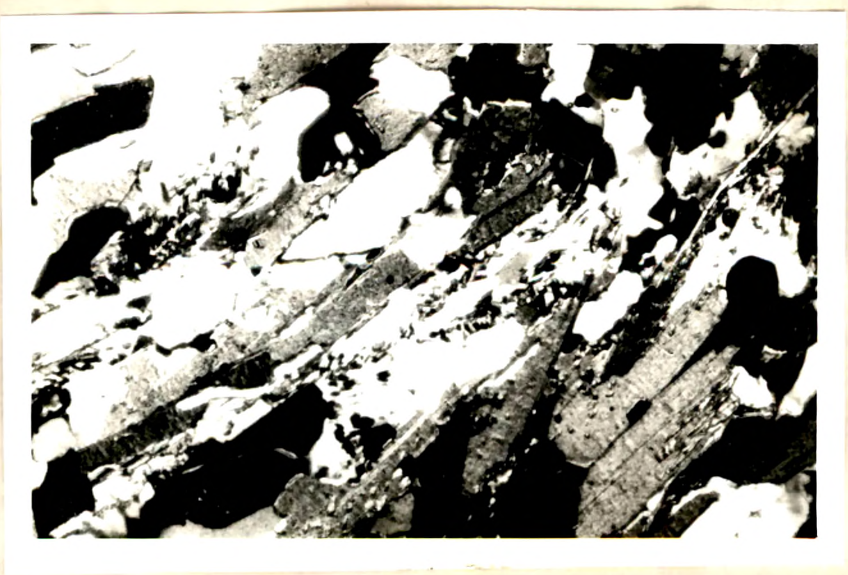

Plate XLII. Biotite schist of Virpur (Photomicrograph: Crossed nicols, X60).

metamorphism together with contact or thermal metamorphism due to granitic intrusion.

Biotite schist (Virpur): It is exposed between the schistose rocks and intrusive granite near the Virpur graphite mine. The rock is melanocratic and well-foliated, the schistosity being marked by sub-parallel orientation of biotite flakes. The rock is made up of biotite, muscovite, quartz and feldspar. The feldspar is mostly orthoclase with small amount of microcline and occasional plagioclase (An_{15-28}) (plate XLII).

Under the microscope, this rock shows coarser grains than mica-schist. The foliation is characterized by parallel flakes of mica, the intervening space filled with aggregates of quartz and feldspar.

Quartz is the dominant constituent. It forms the groundmass as well as aggregates of elongate grains. Most of the quartz occurs as the original constituent of the rock.

Orthoclase occurs as small grains which are scattered in the foliated mass. Big crystals contain inclusion of mica and show alteration to sericite. Myrmekitic texture is common.

Microcline is also present but less in proportion. It is recognized by its cross-hatched twinning. Plagioclase (An_{15-28}) is occasionally present and is characterized by lamellar twinning.

Muscovite occurs as slender tiny flakes in sub-parallel layers or irregularly scattered in the matrix.

Biotite occurs in aggregates of flakes forming lenses which are parallel to the schistosity. Individual flakes within each lenses may show sub-parallel arrangement. Smaller biotite flakes are also scattered in the matrix. It is strongly pleochroic. Pleochroism is marked by pale green to green colour. One set of cleavage is distinct and shows parallel extinction.

Sillimanite is present in good proportion. It occurs as small irregular needles in the quartzo-feldsphathic matrix and shows parallel extinction.

Magnetite is the main accessary mineral.

The presence of biotite and sillimanite in biotite schist suggests high temperature effects on originally pelitic rock later subjected to regional and contact metamorphism.

Quartz-mica-graphite schist (Chaena) : It is grayish black, fine grained and foliated. It is more micaceous and represents medium metamorphic grade.

Under the microscope, it shows usual foliated structure and consists of muscovite, graphite, quartz and at times biotite (plate XLIII). The whole mass shows clear evidence of shearing and crushing. Muscovite form irregular or at places elongated streaks and the intervening spaces are filled with elongate aggregates of quartz which obviously represent higger quartz grains crushed and recrystallized during the deformation.

Quartz occurs as tiny granular aggregates characterized by undulating extinction and is oriented parallel to the schistosity.

Muscovite occurs as tiny flakes as well as shreds in matrix of quartz.

Biotite occurs as sub-hedral flakes which are oriented along as well as across the foliations. The presence of it indicates the effects of low to medium grade metamorphism.

Graphite The micro-flakes of graphite are closely associated with muscovite and quartz grains giving rise to schistose structure.

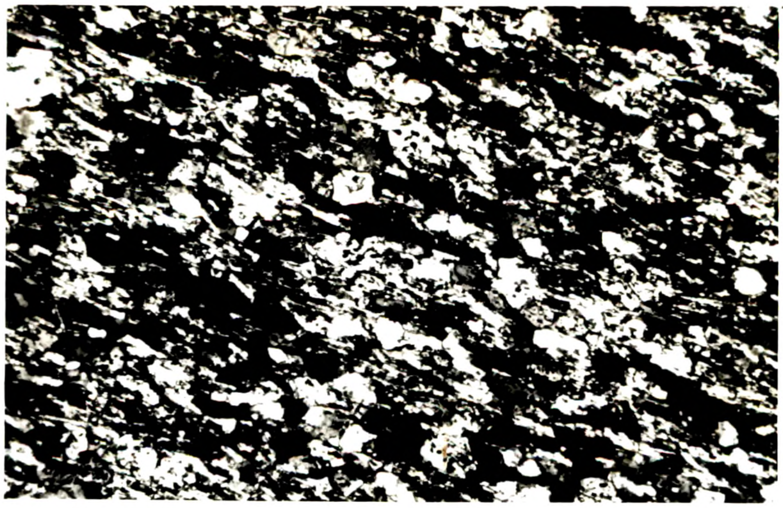

Plate XLIII. Quartz-mica-graphite schist (Chaena) showing fine grained, schistose structure (Photomicrograph: Crossed nicols, X60).

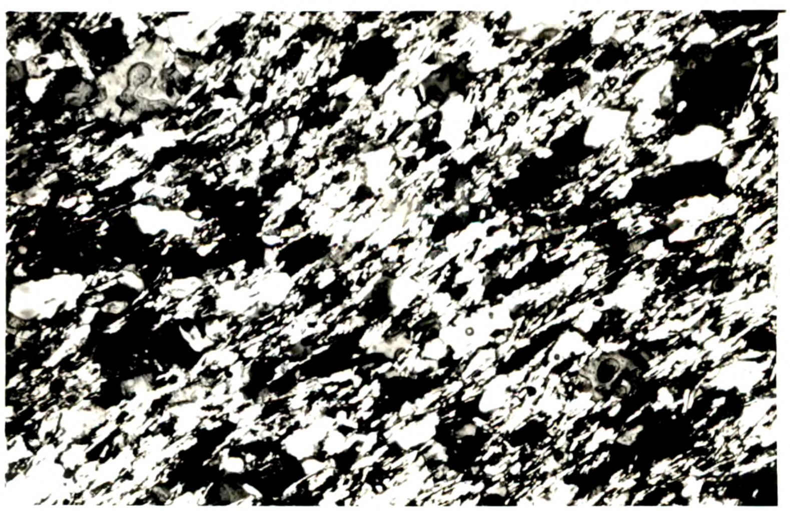

Plate XLIV. Quartz-mica-graphite schist (Jaloda) showing schistose structure (Photomicrograph: Crossed nicols, X60).

Magnetite occurs as accessory mineral.

Quartz-mica-graphite schist of Chaena is more fine-grained and micaceous than the other graphite bearing rocks. The tiny graphite flakes, closely associated with muscovite and quartz are difficult to identify in hand specimen.

Quartz-mica-graphite schist (Jaloda): It is light gray to grayish black and shows well developed schistosity. In thin sections, the schist shows a finely foliated mass of quartz, sericite, muscovite, graphite, chlorite and iron ores (plate XLIV).

Quartz occurs as tiny granules which often form small elongated clusters and lie parallel to the schistosity.

Feldspar occasionally occurs as tiny granules of orthoclase along with quartz.

Graphite is the most abundant mineral which gives dark colour to the rock. It occurs as micro-flakes oriented subparallely to the schistosity in close association with other flaky minerals.

Muscovite is an abundant mineral occurring as flakes in close association with graphite flakes giving schistosity to the rock. Sericite is a common alteration product scattered throughout the rock.

Chlorite is one of the important minerals in these rocks. It occurs in close association with micas. Sometimes, chlorite segregates into small streaks.

Biotite occurs as small sub-hedral flakes along and across the schistosity. At places biotite is altered to muscovite.

Magnetite occurs sporadically as an accessory mineral in the foliated mass.

The rock is fine grained and micaceous. The graphite flakes are very tiny and closely associated with muscovite. The presence of biotite in addition to chlorite indicates low to medium grade metamorphism.

Quartzite On freshly exposed surface the rock is gray or grayish white in appearance. It is hard and compact.

Texturally, the rock shows mosaic of medium to fine grains of quartz (plate XLV). Other minerals present are muscovite, biotite, sillimanite, and magnetite.

Quartz is the dominant mineral and generally occurs as equant grains.

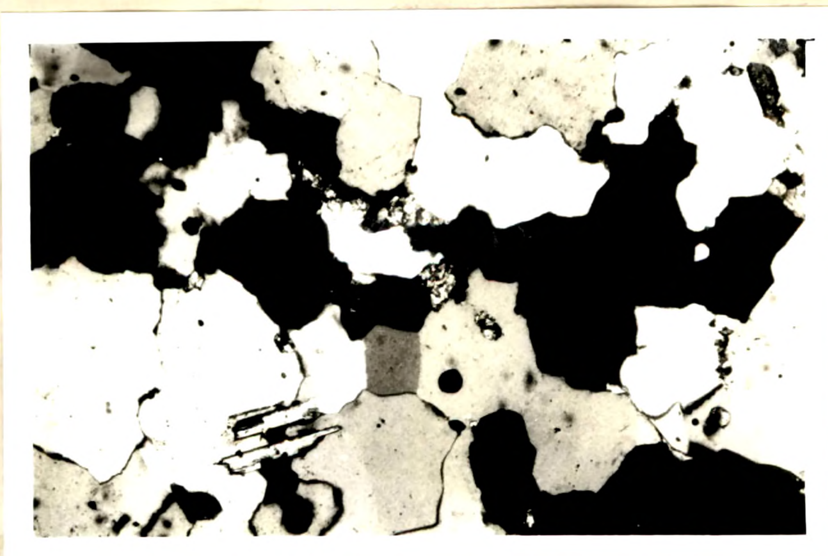

Plate XLV. Quartzite (Jaloda) showing mozaic texture (Photomicrograph: Crossed nicols, X60).

Muscovite is always present and occurs as slender flakes interspersed between quartz grains. Sometimes, small clusters of tiny muscovite flakes are also present.

Biotite is much less than muscovite and is seen only in a few samples. Sillimanite is also less common and occurs in fibrous form in quartzose matrix. Magnetite though always present is in a very small quantity.

The accessary minerals present are zircon and epidote.

Proximate Analysis

The proximate and chemical analysis of a few representative samples of graphite ore, were carried out as per the specification of the Indian Standards Institute.

Graphite bearing samples were ground to minus 72 mesh (B.S.) size. 1.0 gm of each ground samples was used to find out volatile matter content, Moisture content and Ash content (Table I).

The percentages of organic matter and non-graphitic carbon were determined by taking 10.00 gms and 2.00 gms of the ground samples respectively. The percentages of fixed carbon was determined by subtracting the volatile matter, moisture and ash percentages from hundred (Table II).

Volatile Matter (V.M.)

1.0 gm of minus 72 mesh (B.S.) size ground graphitic sample was taken in V.M. bottle and heated at temp. 900°C in a furnace (without air-circulation) for about 7 minutes.

A = Wt. of V.M. bottle

B = Wt. of V.M. bottle + 1.0 gm of graphitic sample (before heating)

C = Wt. of V.M. bottle + 1.0 gm of sample (after heating)

B - C = V.M.

$$X = \frac{(B - C) \times 100}{\text{Wt. of sample taken}} = \% \text{ V.M.}$$

Moisture: 1.0 gm of minus 72 mesh (B.S.) size ground graphite bearing sample was taken in moisture dish and heated in oven at 105°C for about one hour.

A = Wt. of moisture dish

B = Wt. of moisture dish + 1.0 gm sample (before heating)

C = Wt. of moisture dish + 1.0 gm of sample (after heating)

$$Y = \frac{(B - C) \times 100}{\text{Wt. of sample taken}} = \% \text{ moisture}$$

Now X - Y = actual % of volatile matter.

Ash: 1.0 gm of minus 72 mesh (B.S.) size sample was taken in Ash dish and heated in a furnace (with air-circulation) at a temp. 800° or 815° ±10°C for an hour.

A = Wt. of diesh

B = Wt. of dish + material (before heating)

C = Wt. of dish + material after ignition

(C-A) = Wt. of ash

$$Z = \frac{(C - A) \times 100}{\text{Wt. of sample taken}} = \%\ \text{Ash}$$

All the above processes for finding out Volatile matter, Moisture and Ash were repeated until the constant weight was obtained.

Fixed Carbon

% of fixed carbon = 100 - (VM + M + Ash)
(by difference)

Organic matter

10.00 gm of graphite powder was taken on blotting paper and folded. This sample was put in the middle condenser of Soxhlet apparatus which was filled with Petroleum ether till it started flowing in the flask. The flask was heated till all the petroleum ether evaporated.

After cooling petroleum ether flowed back into the flask. This process was repeated four to five times. The petroleum ether remaining in the flask was transferred to a weighed beaker and dried in an oven at 105°C and weighed again.

Petroleum either soluble matter i.e. organic matter

$$\% \text{ by wt} = 100 \frac{w}{W}$$

where, w = increase in wt. (in gms) of the beaker

W = wt. (in gms) of the material taken.

Non-graphitic carbon

2.0 gms of graphite samples was taken in a dish with a lid and heated in the furnace (without air-circulation) at 440°C for about 8 hours.

Non-graphitic carbon

$$\% \text{ by wt.} = 100 \frac{(w_1 - w_2)}{W} - (A + B)$$

Where, w_1 = wt. of dish + lid + powder (before heating).

w_2 = wt. of dish + lid + powder (after heating)

W = wt. of powder taken

A = moisture

B = organic matter.

Graphitic carbon

Fixed carbon - Non graphitic carbon = Graphitic carbon.

Table I : Proximate analysis of graphite samples

Sample No.	Moisture 'M' (% by wt.)	Volatile 'VM' (% by wt.)	Ash 'A' (% by wt.)	Fixed carbon 'FC' (% by wt.) (by diff.)
1	2	3	4	5
A_1	0.60	2.58	80.07	16.8
A_2	1.77	3.33	72.07	22.8
A_3	0.62	3.71	77.18	18.9
A_4	2.08	6.83	73.88	17.2
S_1	2.14	4.25	75.38	18.2
S_2	2.9	5.98	77.4	14.4
S_3	2.15	4.48	70.12	23.0
B_1	1.69	2.49	89.99	5.8
B_2	1.24	2.82	87.93	8.0
B_3	1.15	2.26	82.68	13.9
M_1	0.99	2.89	76.61	19.5
M_2	0.83	1.69	86.97	10.5
M_3	0.25	1.34	76.68	21.7

contd...

Table I (contd.)

1	2	3	4	5
M_4	0.82	3.14	81.36	14.7
M_5	0.29	1.16	86.53	12.0
M_6	1.63	3.73	77.88	16.76
K_1	0.77	2.38	84.48	12.4
K_2	2.28	5.50	89.08	3.14
C_1	0.15	1.40	93.16	5.29
J	1.5	5.0	84.2	9.3

Ankli graphite samples - A_1, A_2, A_3, A_4.

Sewania graphite samples - S_1, S_2, S_3

Virpur graphite samples - B_1, B_2, B_3

Muthai graphite samples - M_1, M_2, M_3, M_4, M_5, M_6

Kundal graphite samples - K_1, K_2

Chaena graphite samples - C_1

Jaloda graphite samples - J

Table II : Organic matter/non-graphitic carbon and graphitic carbon contents of graphite samples

Sample No.	Organic matter % by wt.	Non-graphitic carbon % by wt.	Graphitic carbon % by wt.
A_1	0.10	0.78	16.02
A_2	0.09	2.40	20.40
A_3	0.07	1.03	17.87
S_1	0.09	4.91	13.33
S_3	0.08	1.82	21.18
B_2	0.02	1.33	6.67
B_3	0.06	0.65	13.25
M_1	0.07	2.00	17.5
M_3	0.08	0.74	20.96
M_4	0.10	1.1	13.6
M_5	0.02	0.38	11.62
K_1	0.07	1.62	10.78
C_1	0.09	0.59	4.7

Chemical Analysis

The chemical analysis of selected graphite schist samples were carried out. The percentages of SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO and loss on ignition are given in Table III.

X-ray analysis

The x-ray diffraction photographs of minus 200 mesh powder of graphite ores from Sewania and Muthai were taken using Debye-Scherrer Camera of 11.42 cms diameter (plate XLVI and plate XLVII). The 'd' values were calculated and compared with ASTM standard 'd' values for different minerals. Data based on x-ray diffraction photographs of both the samples is presented in Table IV and Table V. The 'd' values and the visual intensities of all the minerals fairly coincide with the standard 'd' values and the intensities reported by ASTM.

It is observed that the Sewania graphite ore is mainly composed of graphite, calcite, mica and quartz while Muthai graphite ore is mainly composed of graphite, mica and quartz.

Table III : Chemical Analysis

%	Ankli graphite schist	Sewania graphite schist		Virpur graphite schist	Muthai graphite schist	Chaena graphite schist
		(1)	(2)			
Loss on ignition						
(L O I)	22.0	2.0	3.5	17.0	25.0	16.0
SiO_2	59.0	69.0	57.4	63.0	58.0	70.0
Fe_2O_3	3.4	3.2	3.0	3.0	2.0	1.6
Al_2O_3	11.9	21.3	19.2	14.8	8.5	12.0
CaO	2.3	2.8	13.4	0.8	5.3	0.8
MgO	Traces	1.2	2.1	0.5	0.3	Traces
Insol.	0.4	0.4	0.6	0.3	0.4	0.3
Total	99.0	99.9	99.2	99.4	99.5	100.7

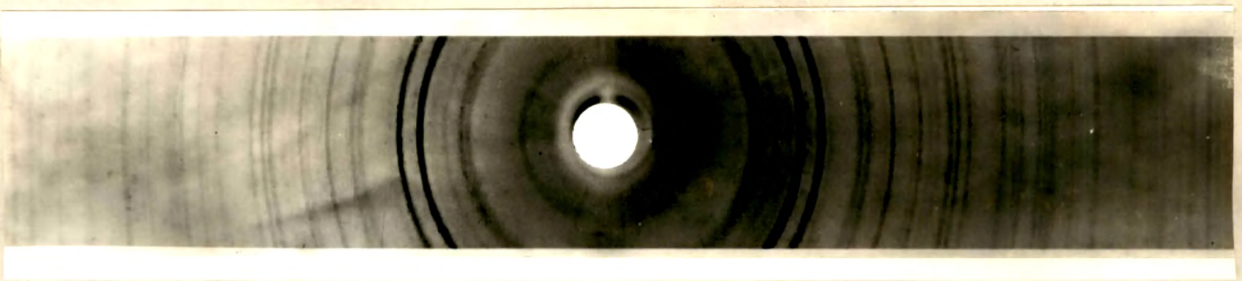

Plate XLVI. X-ray diffraction photograph of Sewania graphite.

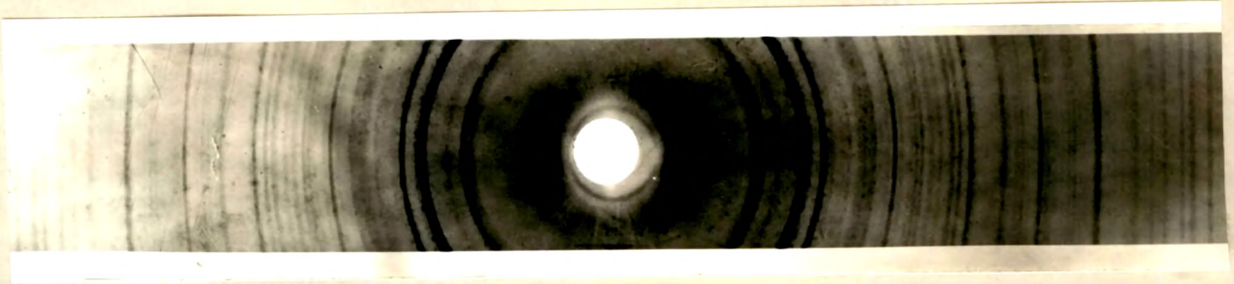

Plate XLVII. X-ray diffraction photograph of Muthai graphite.

Table IV : Data based on X-ray diffraction photograph of graphite ore sample from Sewania

No. of lines	Intensity in visual estimation	dA°	Mineral
1	VW	-	
2	W	-	
3	W	8.1915	
4	W	4.4928	
5	W	4.2502	
6	VW	3.8436	
7	VS	3.3485	Graphite
8	S	3.0339	Calcite
9	W	2.5664	
10	W	2.4813	Mica
11	M	2.2835	Quartz
12	VW	2.1222	Graphite
13	W	2.0867	
14	WV	2.0316	Mica
15	VW	1.9827	Mica
16	M	1.9095	
17	M	1.8733	Mica
18	W	1.8166	Graphite (?)

contd...

Table IV (contd.)

No. of lines	Intensity in visual estimation	dA°	Mineral
19	W	1.6695	
20	VW	1.6104	Mica
21	VW	1.5603	Mica
22	VW	1.4403	Mica (?)

VS = Very strong

S = Strong

M = Medium

W = Weak

VW = Very weak

B = Broad

Table V : Data based on X-ray diffraction photograph of graphite ore sample from Muthai

No. of lines	Intensity in visual estimation	dA°	Mineral
1	VW	4.4394	
2	VW	4.2382	
3	S	3.8338	
4	VW	3.3337	Graphite
5	VS	3.2549	Mica
6	VW	3.0238	Mica
7	S	2.6905	
8	VW	2.6040	Calcite
9	VW	-	
10	VW	2.4422	
11	VW	2.3324	
12	VW	2.2791	Mica
13	M	2.2304	
14	VW	2.1609	
15	VW	2.1212	Graphite
16	VW	2.0867	
17	VW	2.0298	Graphite (?)
18	VW	1.9811	Mica

contd...

Table V (contd.)

No. of lines	Intensity in visual estimation	dA°	Mineral
19	VW	1.9103	
20	W	1.8690	
21	W	1.8173	Quartz
22	M	1.6734	

VS = Very strong

S = Strong

M = Medium

W = Weak

VW = Very weak

B = Broad