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Characterisation and liberation of graphite schist

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ABSTRACT

This paper deals with the characterisation and liberation studies of graphite schist from Shivaganga, Tamilnadu. The graphite flakes are interbanded with quartz and calcite. Secondary calcite veins often traverses graphite flakes and quartz grains. Based on grain counting, frequency curves, comminution followed by flotation tests, the liberation size of graphite is estimated between 150 to 90 microns. The rougher concentrate achieved at d_{80} passing of 145 micron size product contain 35% FC with 99% recovery. The SEM study reveals the presence of minute inclusions of calcite and quartz within graphite flakes.

INTRODUCTION

Characterisation and liberation studies play a vital role in mineral beneficiation. Characterisation includes textural peculiarities, distribution, pattern of valuable and gangue minerals and their grain size to asses the liberation of minerals. Liberation studies include, grain counting, frequency curves, comminution while laboratory beneficiation studies infers to the selection of suitable process to upgrade the valuable minerals. Many researchers have published articles, on Indian graphite ores[1-3], but work related to calcareous graphite deposits of Shivaganga area is very limited[4-6]. The detail studies on characterisation, liberation and beneficiation of this ore is essential for its optimum utilisation. There are evidences of foliation, schistocity, cataclastic texture, vein fillings of calcite and other associated minerals present in this deposit. Similar graphite deposits are being exploited and processed for recovery of graphite by Rajasthan Government. Normally graphite concentrate with maximum 75% fixed carbon is obtained. The reason for not getting a good grade graphite is probably inclusion of calcite in the graphite. Since the Shivaganga deposit is almost similar to the Rajasthan deposit in its geological setting. The graphite from Shivaganga deposit further needs detail studies on characterisation, liberation and beneficiation, with a view to suggest a common flow sheet for obtaining high purity graphite from Banswar, Rajasthan and Shivaganga, Tamilnadu deposits. This paper highlights the mineralogy, liberation and grain, frequency data followed by some beneficiation results on Shivaganga graphite ore.

MATERIALS AND METHODS

The graphite sample assaying 11.1% fixed carbon was obtained from Shivaganga graphite deposit, Madurai, Tamilnadu. Characterisation and liberation studies of graphite sample were carried out by using ore microscope (Leitz make), scanning electron microscope etc., (Jeol, Jsm 35 CF) and X-ray diffractometer (Phillips 1700). Comminution followed by size classification and flotation were taken up to assess the liberation size of graphite. All the samples including feed, concentrate, tailing etc., were analysed for fixed carbon. In all the cases, the fixed carbon was determined by difference of ash weight from the oven dried feed sample (100 -ash%). The mesh of grind was determined by using the efficiency factor (E), where

$$E = \frac{\%\text{Fixed carbon in the concentrate} - \%\text{Fixed carbon in the feed}}{100 - \%\text{Fixed carbon in the feed}} \times \%\text{Recovery}$$

RESULTS AND DISCUSSION

Characterisation

The X-ray diffraction of graphite sample as shown in Fig. 1, indicates that the sample contain graphite, quartz and calcite as the major minerals. The megascopic observations show that the graphite is flaky and foliated. The flakes are interbanded with quartz and calcite. The presence of coarse size calcite grains [Photo 1] is evident from the vigorous effervesence when treated with dil. HCl. The graphite flakes are also traversed by secondary calcite veins. Calcite in the graphite is probably originated from the adjacent limestone formations. In weathered samples, graphite flakes are easily liberated due to the leaching of calcite and alteration of feldspar leaving behind unaltered graphite flakes and quartz grains.

The graphite is flaky and the schistocity exhibited by graphite flakes is clearly seen under transmitted light [Photo 2]. Quartz, in general, is granulated and show cataclastic texture [Photo 3]. Besides, it also occurs as fine inclusion within calcite. Calcite veinlets occupies the fractures and weak folia planes. Sometimes graphite flakes are found to be enclosed within calcite and quartz [Photo 4]. Occasionally calcite fills the marginal boundaries of graphite and quartz grains. At places, calcite and quartz appear as independent grains. The SEM image snaps illustrated in [Photos 5 and 6] reveal the mutual disposition of different phases in graphite.

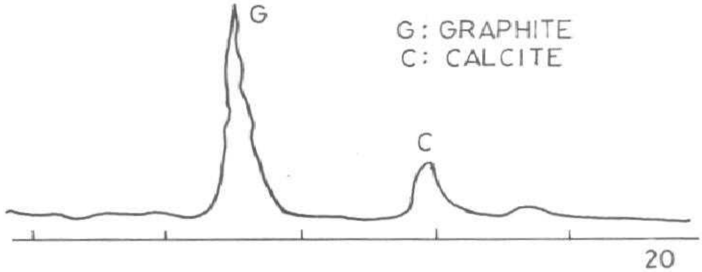

Fig. 1 : XRD pattern of graphite sample.

Liberation

The size and elemental analysis of mill feed shown in Table 1 indicate that there exists liberation of graphite around 150 micron size. The fixed carbon at 250 micron size fraction is around 13%, while at below 150 micron size it is above 15%. The degree of liberation measured according to Falustu[7] shown in Fig. 2, indicates that maximum 95% of free liberated graphite flakes could only be noticed from the ore at size fractions between 150-45 microns. These observations are also in agreement with the earlier findings that the liberation of graphite flakes may be achieved at d_{80} passing size of 150 microns. It is important to mention that most of the gangue particles are smeared with graphite at size fractions below 90 microns. Hence these particles are washed thoroughly and seen in binocular microscope. It is observed that most of the graphite flakes are embedded in the quartz grains or vice versa. The free liberated graphite flakes are accounted to a limit of 95%. Thus these observations reveal that second stage of liberation of graphite could be achieved only after regrinding the rougher concentrate.

The effect of grinding time on flotation as shown in Fig. 3 indicate that data on the 35% FC could be achieved at d_{80} passing of 145 micron size with 99% recovery. The separation efficiency data also clearly indicate that sample ground to d_{80} passing of 145 micron size is sufficient for first stage of liberation of graphite. These observations confirm earlier findings at grain counting method that the graphite flakes need further grinding for obtaining higher grade of graphite.

Table 1 : Analysis of ball mill feed

Moisture	:	15%
Volatile Matter	:	21.7%
Ash	:	65.7%
Fixed Carbon	:	11.1%

Size micron	Weight (%)	Moisture (%)	Volatile (%)	Ash (%)	FC (%)
2800	4.8	0.4	20.0	68.1	11.5
2057	14.1	0.3	21.1	68.7	9.9
1400	16.2	0.3	20.3	69.7	9.7
1003	7.1	0.2	19.1	71.2	9.5
700	8.6	0.2	17.5	71.0	11.3
500	9.9	0.3	15.3	70.9	13.5
350	8.2	0.5	14.3	71.3	13.9
250	7.1	0.5	12.7	73.0	13.8
150	8.4	0.5	13.9	71.3	14.3
90	7.1	0.3	17.8	68.3	13.6
45	3.7	0.7	17.3	66.3	15.7
–45	4.8	0.2	28.5	62.7	8.6
Total	100.0	0.68	18.14	69.7	11.47

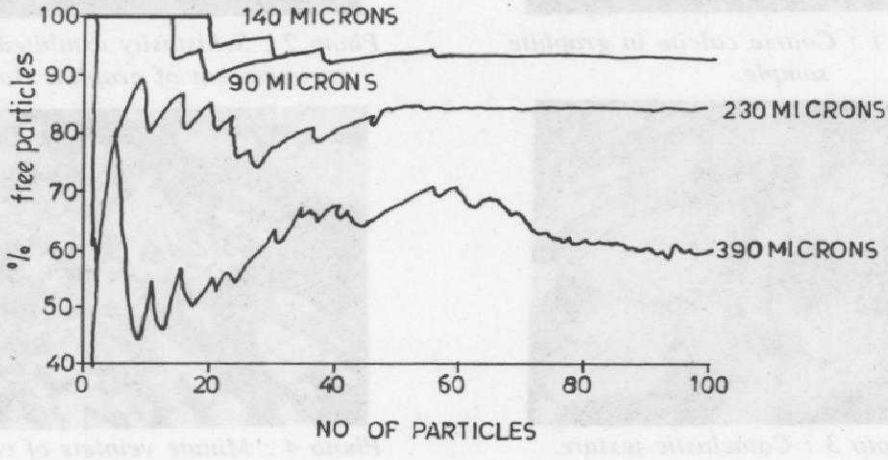

Fig. 2 : Liberation of graphite by grain counting using Faltsu method.

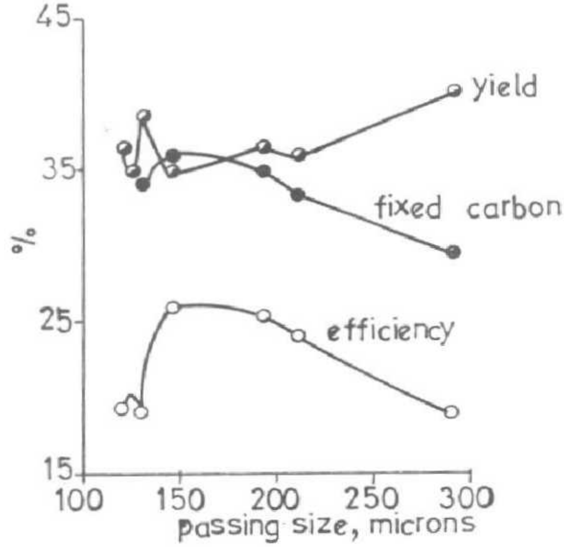

Fig. 3 : Effect of grinding time on flotation.

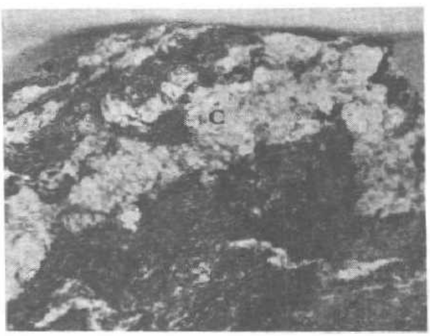

Photo 1 : Coarse calcite in graphite sample.

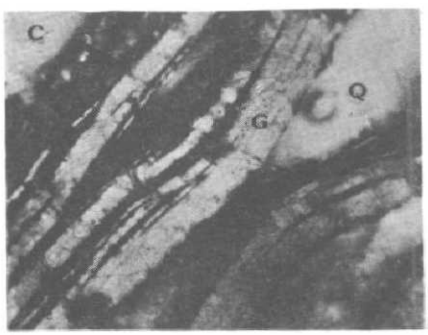

Photo 2 : Schistosity exhibited by llr arrangement of graphite flake.

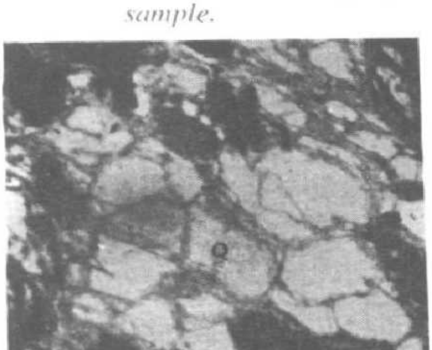

Photo 3 : Cataclastic texture.

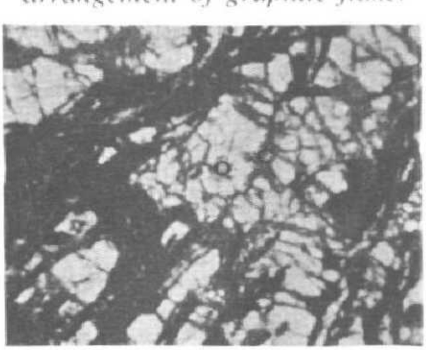

Photo 4 : Minute veinlets of calcite occupy the fractures.

G = Graphite, C = Calcite, Q = Quartz

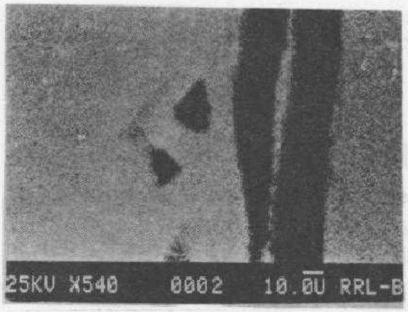

Photo 5 : SEM view of calcite in graphite graphite flake.

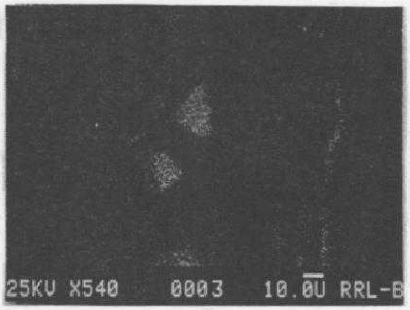

Photo 6 : SEM view of quartz in graphite flake.

CONCLUSIONS

The characterisation studies on graphite schist of Shivaganga, reveal that graphite flakes are interbanded with quartz and calcite. Secondary calcite veins often traverse graphite flaskes and fractured quartz grains and also in folia planes. Based on grain counting and frequency curves, the liberation size of graphite is estimated between 150 to 90 micron size. Comminution followed by flotation tests reveal that, d_{80} passing 150 microns grind is sufficient for first stage of liberation of graphite. The rougher concentrate obtained by flotation contains 35% FC with 99% recovery. However it needs further studies.

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