Characterization Studies on Graphite From Shivaganga Area, Madurai, Dist., Tamilnadu

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Abstract

A study of the origin and formation of mineral deposits can give, the reason for the development mineral texture and associations. Characterization encompasses, detailed mineralogical association, texture, micro-texture, mineral composition, grain size variation of valuable mineral and gangue mineral and also their interlocking etc. And it gives valuable guidance for carrying-out the various beneficiation studies. In this context the characterization studies on ore is essential in the field of mineral processing. Processing of graphite deposits for industrial grade is not difficult as long as the gangue minerals are silicates and are present in the form of free grains. Graphite is easy to concentrate by flotation due to its natural floatability but difficult to refine in order get high purity concentrates which are of premium value probably due to flotation of graphite coated gangue and sandwiched – artificially impregnated hard gangue in to soft graphite. If the deposit is of calcareous origin, it is very difficult to carryout the beneficiation due to soft nature of calcite and graphite. The calcite mineral is not in the free form. It is intruded even in the flakes of graphite. Banswara graphite of Rajasthan and Shivaganga graphite of Tamilnadu are of this type. In the flotation process some amount of calcite mineral also floats along with graphite. In addition to this, the redeposited calcite mineral in the graphite flake also floats and this results in the low grade concentrate of inferior quality. Though there are several papers on processing of graphite but a few papers are dealing with characterization of graphite vis-à-vis their processing.

1. Introduction

About thirty-seven graphite beneficiation plants in India are under operation with varying capacities ranging from 300 to 8500 tones per day. Only two beneficiation plants at Rajasthan and Tamilnadu are state owned and all other plants are being operating by private agencies. Almost all the plants are located near to the mine site and the beneficiated products are sold to different industries like crucible, refractory etc. due to diverse properties of graphite. Almost all beneficiation plants have adopted more or less similar flow sheet. The common method of beneficiation is size reduction followed by flotation. The flotation is being carried-out in different stages ranging from two to several stages depending upon the characteristics of the ore. But these flotation circuits are not functioning efficiently due to the lack of preliminary studies about the ore and operational problems. Processing of these graphite deposits for obtaining industrial grade graphite is not difficult as long as the gangue minerals are silicates and are present in the form of free grains. Graphite is easy to concentrate by flotation due to its natural floatability but difficult to refine in order get high purity concentrates which are of premium value probably due to flotation of graphite coated gangue and sandwiched – artificially impregnated hard gangue in to soft graphite. If the deposit is of calcareous origin, it is very difficult to carryout the beneficiation due to soft nature of calcite and graphite. The calcite mineral is not in the free form. It is intruded even in the flakes of graphite. Banswara graphite of Rajasthan and Shivaganga graphite of Tamilnadu are of this type. In the flotation process some amount of calcite mineral also floats along with graphite. In addition to this, the redeposited calcite mineral in the graphite flake also floats and this results in the low grade concentrate of inferior quality. Though there are several papers on processing of graphite but a few papers are dealing with characterization of graphite vis-à-vis their processing.

2 Experimental

A number of investigations were carried out for characterization of graphite ore as well as its flake liberation to study under the ore microscope by preparing thin and polished sections. For this purpose, twenty of each thin sections and polished sections were prepared as described below.

2.1 Preparation of sections:

Selected samples were cut by diamond jaw into two different size ranges 25mm to 75 mm for thin section and for polished surface respectively. The specimens are prepared for polished surface respectively. The specimens are prepared for polished section was passed into the hot plastic on the slide. The mounted chip was first ground on a carborundum lap until it about 0.06 mm thick. It was then ground on the lap charged with 600 carborundum,
until it was about 0.035 to 0.04 mm thick. The final stage of grinding was by on a glass plate with 600-alundum abrasive. The technique of preparing thinned polished sections the chip of rock was jawed in to two parts. The chip was polished first, and then mounted in glass with the polished surface against the mounting glass and ground down to a standard thickness of 0.03mm. The thin section was transferred on to cover glass.

2.2 Thin section studies:
The studies were carried out with different thin sections of the graphite samples to know the microstructures, texture, and mineralogy and to some extent paragenesis of the graphite ore, by using ore microscope with reflected and transmitted light at different magnifications such as 1.5µ, 9.5µ, 20µ and 100µ. About 20 sections were studied. A few of them, were selected for colour photographs.

2.3 Polished section studies:
Polished sections were prepared to study the mineralogy of the graphite sample. These polished sections were observed under reflected light in the ore microscope with different magnifications at 7.5µ, 9.5µ, 20µ, 50µ and 100µ. About 20 sections were studied. A few of them were taken for colour photographs.

3 Results and Discussion

3.1 Chemical analysis:
Characterization of the ore is the first step and this study plays a vital role in mineral beneficiation. Characterisation study covers the mineralogical association, texture, microstructure, mineral composition, grain size, variation of valuable and gangue and its interlocking, etc. In this paper the detailed physical and chemical characters, mineralogy, and paragenesis of graphite have been discussed. The presence of trace elements in the ash, are detected by Optical Emission Spectroscopy (OES) are shown in the Table 1. The data indicate that aluminium, chromium, barium, sodium and strontium are major elements, where as cobalt, gallium, lead, beryllium, and vanadium, etc. are present as trace to minute trace elements.

Table 1: Trace elements by Optical Emission Spectroscopy

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Trace Elements</th>
<th>PPM</th>
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<tbody>
<tr>
<td>1</td>
<td>Ni</td>
<td>1625</td>
</tr>
<tr>
<td>2</td>
<td>Co</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>Zn</td>
<td>350</td>
</tr>
<tr>
<td>4</td>
<td>Pb</td>
<td>220</td>
</tr>
<tr>
<td>5</td>
<td>Cr</td>
<td>370</td>
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<tr>
<td>6</td>
<td>Na</td>
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<tr>
<td>7</td>
<td>K</td>
<td>370</td>
</tr>
<tr>
<td>8</td>
<td>Sb</td>
<td>22</td>
</tr>
<tr>
<td>9</td>
<td>Be</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>Cu</td>
<td>75</td>
</tr>
<tr>
<td>11</td>
<td>Ba</td>
<td>5000</td>
</tr>
<tr>
<td>12</td>
<td>Sr</td>
<td>20</td>
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</tbody>
</table>

3.2 Mineralogical analysis:
Different graphite samples were studied under transmitted and reflected light microscope to decipher the texture, structures and macrostructures of graphite, associated silicate, calcite gangue minerals as well as opaque minerals and ore paragenesis. These observations are shown in microphotographs 1 to 6 and 7 to 19.

3.2.1 Micro structural and Textural Characters:
Different graphite samples were studied under transmitted and reflected light microscope to decipher the texture, structures and macrostructures of graphite, associated silicate, calcite gangue minerals as well as opaque minerals and ore paragenesis. These observations are shown in microphotographs 1 to 6 and 7 to 19.
3.2.2 Mineralogy: Further both thin and polished sections reveals that graphite is dominantly associated with quartz and calcite. The graphite mineralization is present as crystallized flaky, plates, scales, and specks, as can be seen earlier in graphite schist in Fig 1. It can also be seen that in the schistosity the coarse grained quartz and calcite minerals are present. Some of the quartz minerals exhibits the angular, bladed, and fragmented grains as shown in Fig 7. A few of these fragments are filled with graphite flakes. Graphite flakes are often associated with the fresh and weathered coarse grained garnets, which can be seen in Fig 8. It is interesting to note from Fig 8, that coarse grained quartz also contain ferruginous matter. The ferruginous matter may be due to weathered garnet or some primary iron oxide minerals. It is also observed that the major minerals quartz and calcite are present as inclusions in either of the minerals with graphite. Typical micro-inclusions of quartz grains within the graphite flakes are seen in Fig 9. The inclusion of calcite in graphite can also be seen in Fig 10. In some samples, the calcite is channeled into graphite as in Fig 11. The wall filling of calcite along the silica grains can be seen in Fig 12. It is interesting to note from Fig 13, that small amount feldspar mineral is replaced in brecciated quartz grain.
The graphite ore also contains disseminations, small veins of sulphide minerals and few other oxide minerals. These minerals occur along the grain boundaries and open spaces of silicate minerals, and replace the silicate minerals as well as graphite and enclose their un-replaced islands. Microphotographs shows the presence of pyrrhotite (Fig 16) in quartz rich samples, microinclusions of scheelite and wolframite (Fig 17) in quartz grain, are typical sections. Cassiterite mineral along the pegmatite zone is common as seen in Fig 18. Traces of silver also present in between quartz and graphite flakes, which are seen in typical Fig 19. Any attempt to recover this valuable minerals specially the silver as byproduct are also essential.

3.2.3 Paragenesis: From pre megascopic & microscopic studies, the para genesis of the graphite deposit of Shivaganga is reported, as the mineralization of graphite and quartz are the earliest formations. During original metamorphism, the incompetent graphite has developed schistosity and competent quartz has developed schistosity as well as cataclastic texture. Evident to later formation of calcite is that the veins and minute veins less at some places with quartz have intruded along the weaker foliation and along the fractures in quartz grains. The appearance of large and coarse size veins of crystalline limestone’s and calcite in graphite deposit indicate the latest formation. Earlier quartz and graphite schist is thoroughly impregnated with later calcite veins or veinlets.

4 Conclusions
From the study of mineralogical characters of the Shivaganga graphite ore, the following conclusions are drawn. An attempt also made to suggest beneficiation method and recovery of byproducts along with graphite. The study of thin and polished sections of the sample indicates the existence of schistosity, ‘S’ type
folds, cataclastic and orbicular texture and structures. The mineralogy reveals that graphite is a major mineral followed by quartz, calcite and other minerals. The graphite is well crystallized and flaky. All these three minerals are coarse to fine grained and mostly associated together. The gangue minerals such as clay, garnet and ferruginous matters, goethite or limonite, magnetite or hematite, feldspar and clay are present occasionally along with quartz or along the boundaries of graphite flakes or as fillings. In some cases, the micro inclusions of calcite or quartz in graphite or vice-versa are present in graphite. Thus, it is difficult to separate calcite for obtaining high purity graphite. The presence of pyrrhotite, wolframite or scheelite, cassiterite are in traces and in mostly associated with quartz. Traces of silver also present in between quartz and graphite flakes. From the above conclusions, it may be suggested that since quartz mineral is mostly available as very coarse to medium grained, an attempted can be made to pre concentrate the ore by the classification followed by gravity separation. Calcite mineral is medium to fine grained and mostly occurs as secondary fillings and minute veinlets along the foliation. Hence, fine grinding of ore is required prior to flotation. However, for the selective separation of calcite, either leaching or calcinations prior to grinding or vice versa, followed by flotation may be attempted. Any attempts to recover the economic minerals such as pyrrhotite, cassiterite, wolframite, especially silver as byproduct from the tailing are essential.

References:

10. IBM (1977) Monograph on Graphite IBM, Nagpur