A review on beneficiation prospect of some of the graphite deposits of Palamu District of Bihar

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INTRODUCTION

Graphite constitutes one of the important minerals for the manufacture of special types of refractory materials. In nature it occurs both in crystalline as well as amorphous forms. It is reported to occur in almost every State of India. In Bihar economic deposits of graphite are confined to the district of Palamu only with some minor occurences in Monghyr and Ranchi districts. G.S.I. has located some important workable deposits whose estimated total reserves amount to about 16 lakhs tonnes upto 20 meters depth. These deposits are poorer in grade but sometimes the fixed carbon content is of the order of 50% F.C. A few customary processing plants have also been put up by some private parties.

Graphite is a mineral consisting essentially of carbon but often impure with clays, iron oxides and other gangue minerals. It crystallises in hexagonal system. It is one of the softest minerals, and its specific gravity varies between 2.09 to 2.23. It is a good conductor of electricity, a property which permits it to be distinguished from amorphus carbon.

Uses of Graphite :

Graphite being versatile mineral and due to its diversified properties, it finds important place in many crucially important industries. It is used in the manufacture of special type of electrodes, special lubricants and also in the atomic reactors in the form of bricks of high purity grahpite. It is also used for foundry when casting iron, copper, aluminium and also steel and magnesium under special condition. Graphite fibres composite absorbs rather than reflects radar waves and so the use of graphite continues to grow rapidly in the use of radar masking stealth technology and also in making other non-aerospace weapons. In the development of plastic engine 90% of the components would be made of graphite fibres reinforced composites to be used in Ford's small car to make them lighter and quiter. Although much of the graphite used in industries is manufactured, natural graphite is indispensable for certain purpose.

Mode of occurence :

Graphite occurs chiefly in those rocks that have undergone intense metamorphism and thus it is found in older gneiss and schists, crystalline limestone, carbonaceous material in original sandstone, shale and limestone, recrystalline in the form of graphite. It may also be product of contact metamorphism where igneous rocks intrude carbonaceous sedimentary rocks. In Palamu district the main rocks associated in the graphite include various types of metamorphosed sediments. Good amout of graphite occurs here as original constituent in schistose rocks. At some places its close association is found with pegmatites, quartz veins and gneissic rocks.

Specifications :

Specifications for graphite for use in various industries differ considerably and sometimes the consumers specify for the grade of graphite they use. The following table is however indicative of the specifications, for its use in some specific industries.

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Specification of graphite for different industries

Sl.No.	Industry	Type of graphite	Assay requirement % F.C.	Size
1.	Crucibles	Flaky graphite	Min. 80%	−15+100 mesh
2.	Dry cells and battery manufacture.	Flaky graphite	Min. 85%	85% −200 mesh
3.	Explosives	All types	Min. 85—97%	−100 mesh
4.	Foundry facing.	Flaky crystalline or amorphous.	40—80%	Dust grade.
5.	Lubricants	All types.	Min. 94—98%	Coarse to fine.
6.	Paints	Silico-graphite.	55%	—
7.	Pencils	Soft amorphous.	95%	—
8.	Stove Polish	Amorphous graphite.	80%	—

Mineralogy and chemical characteristics of the deposits :

A number of graphite samples from various locations of Palamau district were studied at NML for assessing their amenability to beneficiation. The mineralogical studies undertaken on the bore hole samples from the graphite bearing areas of Palamau, namely Betla, Pokhri and Kutmu indicated similar nature of graphite mineralisation and same gangue mineral association and their interlocking nature. The graphite was of crystalline, flaky, fine grained, disseminated and sporadic in distribution in the associated quartz biotite gangue minerals. Presence of pyrite, pyrrhotite and chalcopyrite in the sample was of academic interest only. Fixed carbon content of these samples varied between 2 to 7% only, with an exception of Hathinala sample which assayed about 20% F. C. on an average and was coarse grained in nature.

The samples under investigation were from Manasoti, Sewadih, Bishrampur, Uchari and Hurdag areas of Palamau dist., where workable deposits of good grade of graphite were reported to occur. Mineralogically the sample from Sewadih, Uchari and Hurdag contained micro to cryptocrystalline size of graphite associated with arenaceous and argillaceous gangues. In case of the former the graphite grains were liberated at about 200 mesh size whereas in later two samples they were only liberated below 400 mesh making their processing difficult and uneconomical.

The sample from Bishrampur was of flaky type and the graphite grains were liberated at about 48 mesh, and assayed 8—12% F.C. The samples from Manasoti and Sewadih were of amorphous variety and on average assayed 8—15 % F.C. These were present as lenticular pockets of quartz graphite schist embedded in granite gneiss. The chief gangue minerals associated with the sample were quartz, felspar, micas, iron minerals and traces of tourmaline. Lock liberation studies carried on these samples indicated that the values were liberated at fairly coarse to medium-fine grinds making the process economic for their recovery.

From the study of the mineralogy, grain size, their liberation and fixed carbon content of the samples a few important conclusions could be drawn.

(1) Chemical superiority of the sample alone does not signify the real worth of the sample but external characteristics have an important role in determining the value of any workable deposits. Sometimes the textural characteristics play a dominant role in this regard.

(2) Flaky nature of graphite having flakes above 80 mesh finds many important uses in industries as well as in manufacture of crucibles. It fetches higher price also.

(3) Interlocking of the gangues with graphite (at very fine size) needs very fine grinding which consumes 40-60% of the total processing cost rendering it uneconomical. Moreover grinding of graphite to very fine size is also extremely difficult owing to its greasy nature.

Keeping the above points in view two ways of beneficiation of graphite may be suggested.

(a) If the liberation of graphite is at a coarse size, gravity methods of concentration may be effective.

(b) If the graphite grains are liberated at a finer size, perhaps flotation techniques might work.

(c) If the graphite minerals are associated with gangue at exceptionally very fine stage, the processing may not be economical for obvious reasons (grinding cost will be very high).

Beneficiation studies :

Most of the mineral resources in our country (excepting iron ores etc.) are low to medium in grade which need beneficiation in some form or other to make them suitable for use in mineral based industries. As such, these have to be upgraded to the desired specification (within specified tolerance limits). Beneficiation of graphite includes gravity concentration methods and also flotation. Sometimes chemical treatment like acid leaching and chloridisation are also applied for production of high purity graphite over 99% F.C.

Comprehensive beneficiation studies have been carried out on Palamau graphite samples at NML and a brief account is being presented here. A composite sample from Sewadih, Uchari and Hurdag and three individual samples from Sewadih, Bishrampur and Manasoti areas, where good deposits are reported and where Govt. of Bihar is expected to install a processing plant for the exploitation of these reserves have been investigated on a bench scale. Some of the results of the beneficiation studies on these samples are given below :

A) Composite sample from Sewadih, Uchari and Hurdag area :

A composite sample consisting of equal proportion of each individual sample analysed 11.64% F.C., 82.62% Ash, 5.17% V.M., 1.57 % Moisture, 59.4% SiO_2, 13.59% Al_2O_3 and 9.94% CaO etc., Since the mineralogical characteristics of the sample indicated liberation of graphite only at a very fine size, only flotaion studies were conducted after grinding the sample to suitable fineness. Flotation tests were carried out using different combinations of collector and frother, sodium silicate for dispersion as well as depressant for siliceous gangues, varying pH etc. The effects of feed fineness on flotation was also studied and a few test results are given below :

TEST—1 :

Representative sample was ground to 66% −200 mesh in batch rod mill and floated using suitable combination of reagents at pH 7—7.5. The rougher float, when subjected to a number of cleanings, produced a cleaner concentrate assaying 30.5% ash with a yield of 7.5% only with maximum rejection in tailing, assaying 91.8% ash.

Products	Wt %	% Ash
Ref. Conc.	7.5	30.5
Ref. tails 6	1.6	32.2
" " 5	2.4	—
" " 4	3.7	—
" " 3	3.2	—
" " 2	3.2	—
" " 1	20.0	86.4
Primary tails	58.4	91.8
—	100.0	—

TEST — 2 :

Another test conducted after regrinding the rougher float to about 90% −200 mesh followed by six re-flotations yielded a cleaner concentrate assaying 22.4% ash with an yield of 2.6% only.

Results :

Products	Wt %	% Ash
Cl. conc.	2.6	22.4
Cl. Tail 1—6	39.2	—
P. Tails	58.2	91.8

This concentrate when examined under microscope still contained appreciable amount of interlocked graphite necessitating further grinding for their liberation.

TEST — 3 :

Further flotation test, after cleaning the rougher float as obtained in previous Test No. 2 and grinding it to extremely fine size (below 270 mesh) and cleaning it five times, a concentrate assaying 75.8 % F.C. and 18.38% ash and weighing 2.2% only could be obtained with an overall, fixed carbon recovery of 14.3% only thereby making the process uneconomical.

B) Sample from Manasoti area :

The sample assayed as follows :

F. C.	......	10.85 %
Ash	......	86.72 %
V. M.	......	2.08 %
Moisture	.. ...	0.35 %

Rougher flotation test under optimum conditions with a feed ground to 54.6% − 200 mesh followed by three re-flotations yielded graphite concentrate assaying 84.26 % F.C. and 11.69 % ash with an overall recovery of over 85 % F.C.

Flotation with a slightly finer grind (58 % −200 mesh only) followed by three cleanings of the rougher float the grade of the graphite concentrate improved to 90.33% F.C. and with 7.59% ash. This may perhaps meet the requirements for lubricants and pencil industries.

C) Bishrampur graphite sample :

The sample assayed as follows :

F.C.		9.26 %
V.M.		1.50 %
Moisture	......	0.60 %
Ash	......	88.64 %

The sample was crystalline and flaky in nature. Tabling at 48 mesh size yielded a graphite concentrate 7.6% by weight and assaying 24.2% ash. When table concentrate was subjected to flotation the ash content could be lowered to about 12.92%. The overall F. C. recovery was above 80%. This concentrate could be used in the manufacture of crucibles and battery cells.

Straight flotation after grinding the sample to about 54.6% −200 mesh produced a cleaner graphite concentrate analysing 4.2% ash and 92.6% F.C. with an yield of 10.6%.

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DISCUSSION :

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Question 1 : Whether the mineralogical analysis of the samples has been done ?

Author : Yes, complete mineralogical analysis of the sample has been done. Graphite, the only mineral of interest, is associated with Quartz, felspar, micas and Iron minerals and traces of tourmaline as gangue mineral in order of abundance.

Question 2 : At what pH the flotation has been done ?

Author : All flotation tests were conducted at natural pH.

Question 3 : What are the depressants used ?

Author : Sodium silicate was used as depressant.

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*Question 4 : If the graphite sample containing **mica**, which has got natural flotability like graphite and that too using frother like pine oil, how are you going to separate it from graphite? Secondly why mica is undesirable in case of crucible making? Finally, at what extent this mica content in the graphite concentrate can be tolerated?*

Author : The sample under study contained very little of mica. It did not pose any problem. If mica had been present, it could be easily depressed by using suitable depressant.

Mica's presence lowers the melting point of the refractories. Moreover mica has a tendency to exfoliate at higher temperature. Also, presence of alkali elements has an injurious effect on refractories. The maximum tolerance of micas including Iron oxide is 2.5%.