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Upgradation of barite waste to marketable grade concentrate

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ABSTRACT: The paper presents the results of the characterisation and beneficiation studies carried out on a low grade barite sample with a view to developing technology for upgrading it to a marketable product. Considering the properties of the barite and the associated gangues, basically two beneficiation routes i.e. gravity separation and froth flotation were attempted. Gravity concentration of the sample in the coarse as well as fine size ranges gave concentrate with acceptable grade but barite recovery was low. Adoption of flotation process resulted in recovery over 88% with specific gravity of 4.25. The results of the bench scale studies were validated through large scale trials. Based on the studies a process flow-sheet was developed for the processing of barite waste dump sample.

1. INTRODUCTION

Barite is an important industrial mineral and main source of barium. It finds major application as heavy muds in oil well drilling. For this purpose the barite should contain 90% $BaSO_4$ with a specific gravity of 4.1-4.2. It is also used in the manufacture of barium chemicals, paints, paper, asbestos products, rubber, abrasive and ceramics. World reserves of barite are estimated to be 480 million tonne (Anonymous, 2001). Depending upon purity of the ore, the low grade barite is beneficiated to meet the commercial specifications of the product. As per the mineralogy of the ore, the simple gravity based methods are not often suitable and concentration by froth flotation is required (Brobst, 1983). Barite is also recovered as a by-product from sulphides by flotation route (Davis, 1985)

In India Mangampet deposit in Cuddapah district of Andra Pradesh is the single largest deposit in the world containing 61 million tonne barite (Anonymous, 2001). Presently at Mangampet, barite is extracted through mechanised open cast mining. Subsequently, depending upon the specific gravity, barite is manually sorted into four grade namely, A,B,C. and D. Barite of A and B grade are directly saleable to oil industry while majority of the low grade material along with the waste is accumulated in huge dumps (Singh & Srivastava, 2002). Detailed characterisation and beneficiation studies were undertaken to develop technology for upgrading different varieties of low grade barite samples from Mangampet deposit. The present paper presents the results of beneficiation studies carried out on a typical barite waste sample from this deposit.

2 EXPERIMENTAL

2.1 *Materials*

2.1.1 *Ore sample*

Low grade barite sample from Mangampet, Andhra Pradesh (India) was used for the studies. The sample assayed 71.75 % $BaSO_4$ with 19.12% SiO_2 and 3.95% Al_2O_3. The physico-chemical and mineralogical characteristics of the sample are discussed under the subsequent section.

2.1.2 *Reagents*

For flotation studies oleic acid emulsion (prepared with LR grade oleic acid and sodium hydroxide) was used as collector for barite whileLR grade sodium silicate was used as depressant/dispersant for siliceous gangues.

2.2 *Methods*

Gravity separation and flotation studies were carried out under varying process conditions. For this purpose the as received sample was crushed in stages in jaw and roll crushers to –1.7 mm and wet ground to the required fineness in rod mill. The products from the beneficiation studies were analysed for BaSO4 and the specific gravity values of the products were also determined using Le-chatlier's flask. The results of the bench scale studies were validated through large scale trials.

3 RESULTS & DISCUSSION

3.1 *Chemical and mineralogical characteristics*

As it can be seen from Table 1 the sample assayed 71.75% $BaSO_4$ with 19.12% SiO_2 and 3.95% Al_2O_3. The specific gravity of the sample was found to be 3.76.

Table 1. Chemical analysis of barite sample

Constituents	Weight %
$BaSO_4$	71.75
SiO_2	19.12
Al_2O_3	3.95
CaO	0.20
MgO	0.09
LOI	1.56

Microscopic study of the representative head sample revealed that barite was the predominant mineral and quartz was the major gangue. The other mineral impurities associated were small amount of devitrified glass and carbonates, very little amount of pyrite, carbonaceous impurities and argillaceous matter. It was further noticed that a considerable amount of barite was present in both coarse and fine sizes. The coarser barite had scales and stains of tuff and other impurities, while the fines had very little impurities. The X-ray diffraction study also corroborated the findings of optical microscopic study. Locking and liberation study on the sample was carried out by grain count method. As it can be seen from Figure 1 that a fair liberation of barite from the associated gangues is expected below 150 mesh.

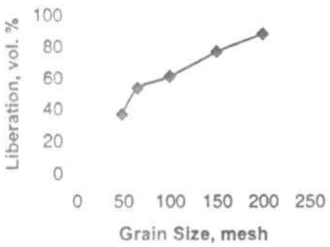

Figure 1. Liberation of barite from associated gangues.

3.2 *Gravity separation at coarse size*

The specific gravity of barite is 4.5 as against 2.65 for quartz, the major gangue associated with the sample. So there exists possibility of concentrating the low grade barite sample by gravity separation technique. The results of liberation studies shows that a fair liberation of barite from the associated gangues is expected below 150 mesh but it was observed that considerable amount of barite was present in both coarse and fine size ranges. So the possibility of concentration of the sample at a coarser size was examined. For this purpose experiments were carried out at particle sizes ranging from - 0.6 mm to -1.7 mm using mineral jig, spiral and shaking table. The results are summarised in Table 2. As it can be seen from this table, the results obtained by spiralling at –1 mm, by single or even by re-processing the middling i.e. two stage spiralling, are not satisfactory. Concentration by tabling and a combination of jigging and tabling produced acceptable product (specific gravity > 4.1) but recovery is relatively low i.e. 63.7 – 66.9%. Microscopic examination of the products indicated that low recovery was mainly due to rejection of a part of barite as locked particles.

Table 2. Results of gravity separation at coarse size

Unit operation	Weight %	Assay $\%BaSO_4$	Recovery $\% BaSO_4$	Sp. gr.
Jigging+ Tabling	54.2	89.60	66.9	4.21
Spiralling (1 stage)	35.4	87.85	44.2	4.15
Spiralling (2 stages)	44.3	86.68	53.5	4.12
Tabling	50.7	90.96	63.7	4.24

3.3 *Gravity concentration at fine size*

In view of the liberation characteristics and the high loss of barite due to locking during processing in the coarse size ranges, further gravity separation was carried out at finer sizes. Considering the beneficiation results obtained by tabling at -0.6 mm, initially concentration was studied at varying sizes using Carpco shaking table. For this purpose the ground feed was deslimed and the sand and slimes fractions were processed separately on 'sand' and 'slime' decks respectively. The combined results are shown in Figure 2. As it is evident from the data shown in Figure 2 that due to better liberation of barite, with a decrease in particle size from 48 mesh to 60 mesh, there is a sharp improvement in improvement in specific gravity of the product (4.27 to 4.31), yield and grade of the concentrate also. But a further decrease in particle size to 100 mesh, there is deterioration in the results. This was due to the limitation of shaking table in treating particles in very size ranges and hence the increased loss of barite as fines.

In the next series of experiments, concentration was attempted using some of the modern fine gravity separators like duplex concentrator, combination of Bartles mineral separator and cross-belt concentrator (BMS-CBC) and multi-gravity separator (MGS). The results obtained at 100 mesh feed size including those for tabling are shown in Figure 3. It can be observed from Figure 3 that a combination of BMS-CBC gave the highest recovery i.e. 65% but specific gravity is only 4.12 while MGS produced concentrate with sp. gr. 4.30 with a recovery of 60.6%.

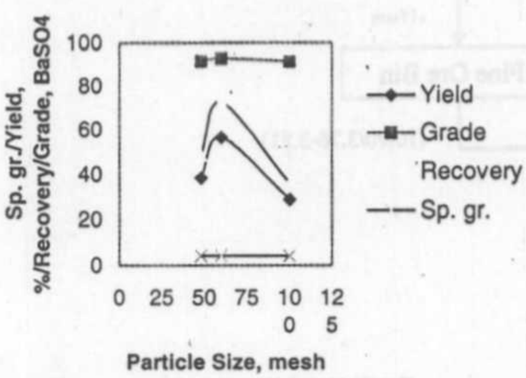

Figure 2. Results of gravity separation by tabling at varying feed sizes.

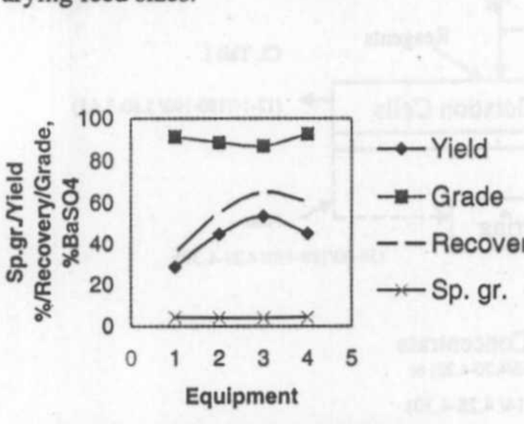

Figure 3. Results of gravity separation using different fine gravity separators.

3.4 *Concentration by froth flotation*

As discussed above, although gravity based processes gave acceptable concentrate but barite loss in the tailings was observed to be high. Froth flotation was considered an alternate route for processing low grade barite. Detailed studies were conducted to determine the flotation characteristics of the sample and the effects of different process parameters were examined. The salient results showing the effects of granulometry on flotation performance are shown in Figure 4. As mentioned earlier, for these experiments sodium silicate and oleic acid emulsion were used as gangue depressant/dispersant and collector for barite respectively. It can be seen from Figure 4 that as the fineness of the feed increases from 44.9% to 66.8%, there is an improvement in recovery from 70.2% to 85.4%. A further decrease in particle size also shows an improvement in recovery by ~3%. A feed consisting of 96.4% particles passing below 200 mesh micron was considered suitable for flotation concentration of the sample. This will suit to the requirement of a fine grained concentrate for use in oil well drilling. The product at this size assayed 91.13% $BaSO_4$ (specific gravity 4.25) with 88.3% recovery. Flotation experiments were also conducted to study the effects of dosage of sodium silicate and oleic acid emulsion on flotation of barite. It was found that 1 kg/t each of the sodium silicate and oleic acid emulsion was sufficient to give optimum results. Attempts were also made to improve the concentrate grade by cleaning flotation. Cleaning of the rougher flotation product resulted in concentrate assaying 93.65% $BaSO_4$ with specific gravity of 4.34 (Singh et al. 2005).

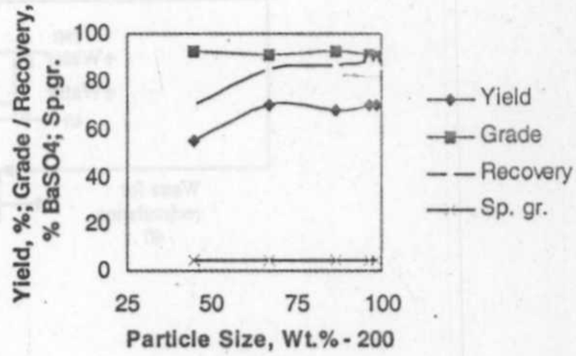

Figure 4. Effects of particle size of the feed on barite flotation performance.

3.5 *Large scale flotation and development of process flow-sheet*

Large scale flotation studies were conducted to validate the results obtained in bench scale. The results of the large scale flotation confirmed the results obtained at bench scale (Singh et. al., 2005). On the basis of these studies a flotation based process flow-sheet was developed and is schematically shown in Figure 5. Based on the large scale runs undertaken the material balance is also shown along the process flow-sheet. As it can be seen from Figure 5 the flow-sheet basically consists of two stage crushing in closed circuit with vibrating screen, wet grinding in ball mill in closed circuit with classifier followed by flotation and dewatering to give barite concentrate. As shown in Figure 5, depending upon the grade requirement of the concentrate either barite rougher float can be taken as the final product or it can be processed further to get cleaner concentrate resulting in product with reasonably high recovery of barite. Based on these studies a process flow-sheet for recovery of marketable grade product from a low grade has been recommended.

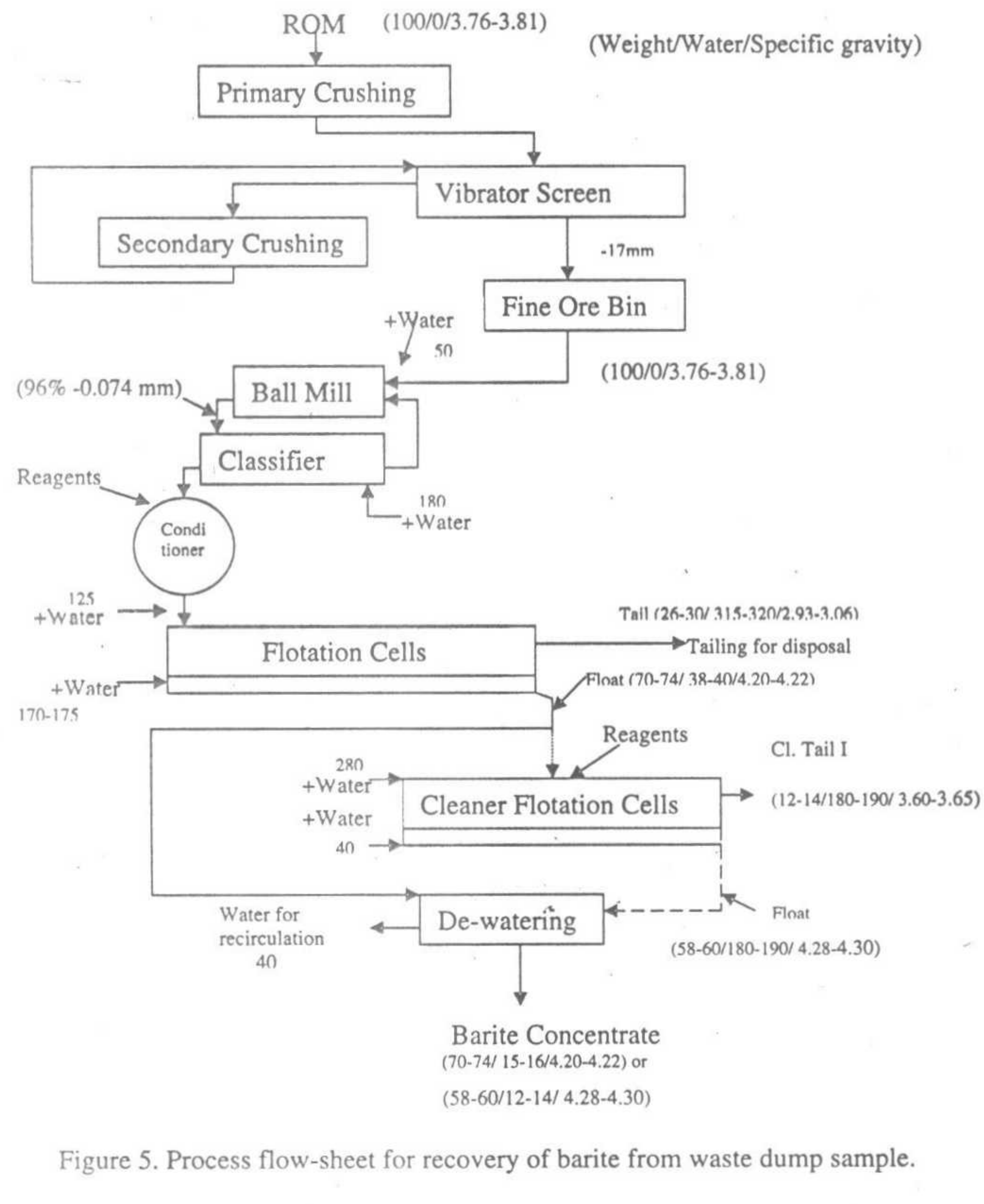

Figure 5. Process flow-sheet for recovery of barite from waste dump sample.

4 CONCLUSIONS

Characterisation and beneficiation studies were undertaken to develop technology for processing of low grade barite sample. The sample contained barite as the predominant mineral along with quartz as the major gangue. Gravity based methods produced acceptable concentrate grade but led to high loss of barite. Adoption of flotation route resulted in product with reasonably high recovery of barite. The studies have clearly established that the waste dump sample from Mangampet Barite Deposit can be upgraded to a product suitable for use in oil well industry.

5 ACKNOWLEDGEMENTS

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