

ARTICULOS CORTOS

Characterization and upgrading of a Nigerian barite sand

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ABSTRACT.—Chemical and thermal treatments of a barite from Nigeria.

An investigation was made of the mineralurgical composition and thermal behaviour of a barite sample from Nigeria. Chemical analysis, X-ray diffraction and DTA/TG analyses were employed in the investigation. Using Na-cetylsulphate as collector at a pH of 10.8, a concentrate with 96.8wt% BaSO₄ was realized.

RESUMEN.—Tratamientos químicos y térmicos de una barita de Nigeria.

Se ha llevado a cabo una investigación mineralógica y del comportamiento térmico de una muestra de barita de Nigeria. Se han realizado análisis químico, difracción de rayos X y DTA/TG en dicha investigación. Se ha conseguido obtener un concentrado del 96,8% peso de SO₄Ba usando cetilsulfato de sodio a pH=10,8.

1. INTRODUCTION

Barite, the barium sulphate mineral is an abundant and well distributed mineral. It occurs as lens-like crystals in compound granular mass-like soil or in stalactites. It is often associated with the sulphates of lead, silver, strontium and antimony with limestone as the most favourable host rock. Barite is a transparent to opaque mineral, usually white or light in colour but sometimes yellow, red, grey or nearly black. As heavy mineral, it has a density of 4.3 to 4.6 and a hardness that varies from 2.5 to 3.5 (1,2).

Barite is the main source of barium that occurs in sufficiently large and economically viable quantity. It is the raw material basic to the manufacture of barium carbonate from which other barium chemical and industrial applications are derived. The used areas of barium chemicals are dictated by their special properties and characteristics. The use of barium sulphate in the form of drilling mud in oil exploration is dictated by its density and hardness. Natural barites for their low solubility in water and most acids; high whiteness and chemical stability are used as paper fillers, pigments extenders and cement additives. Barium carbonate is an im-

portant additive in the *glass industry* in the production of colour picture tubes especially television tubes. This is due to its good capability of absorbing X-ray radiation. It also finds use in *silicate glasses* where high refraction indices and improved glass hardness are required. Besides the use of barites in the production of barium chemicals, the chemical industry uses barium compounds for the removal of inconvenient impurities, in the extraction of citric acid from citrus fruits; in the purifications of wet phosphoric acid and of bauxite-lixiviation lye in the Bayer process. The *ceramic industry* uses barium carbonate in the production of roof tiles, clinkers and floor slabs and in the so-called *electroceramics* where barium ferrites and titanates are produced for their special magnetic and dielectric properties (3,4).

The mineral ones containing economically recoverable barite are usually composed of barite, fluorspar, calcite, iron oxide and celestite. The separation of barite from these inconvenient impurities is effected by physical processes—setting treatment, wet milling, flotation and dry or wet magnetic separation. Finished barite products are marketed in three grades: The drilling mud grade is specified for a density of 4.2 to 4.25 with a content of 91 to 92% BaSO₄. This can be achieved from a high grade ore after the rough froth flotation stage. The actual specifications of the commercial grade ceramics—depend upon the individual requirements of the consumer. The average grade runs at 95 to 96% BaSO₄ content with less than 2% SiO₂ and 0.5% CaF₂ and Fe₂O₃ respectively. This grade may be achieved after one or two froth flotation cleaning stages. Spars for chemical and filler industries are specified at up to 98% BaSO₄ against the MgO content, a maximum of 2.0% SrSO₄ and 0.5% CaF₂. Here again, specifications are varied; different fillers requiring different stipulations. More stringent limits may also be imposed on the iron oxide content and particle size distribution (3,4).

The collectors used for direct flotation of barites on commercial scale are reagents of the classes of alkylsulphates (lauryl- and cetylsulphates) or of alkylsulphonates (sulphonate alcohols and crude oil sulphonates) and oleins of the carboxylates (5,6). Carboxylate flotation of barites suffers a serious drawback in that carboxylic acids are difficult to desorb from barite grains. But both alkylsulphonate classes of collectors have effectively promoted the selective flotation of barites from the commonly associated minerals (7,8). The most effective of these reagents is Na-cetylsulphate (9, 10, 11); its most favourable conditions being an alkaline environment

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(pH higher than 10) with Na-silicate to depress the calcite, fluorspar, and silica. Desorption is achieved by conditioning the flotation froths with an alkaline phosphate (sodium hexameta- or pyrophosphate) before filtering (9).

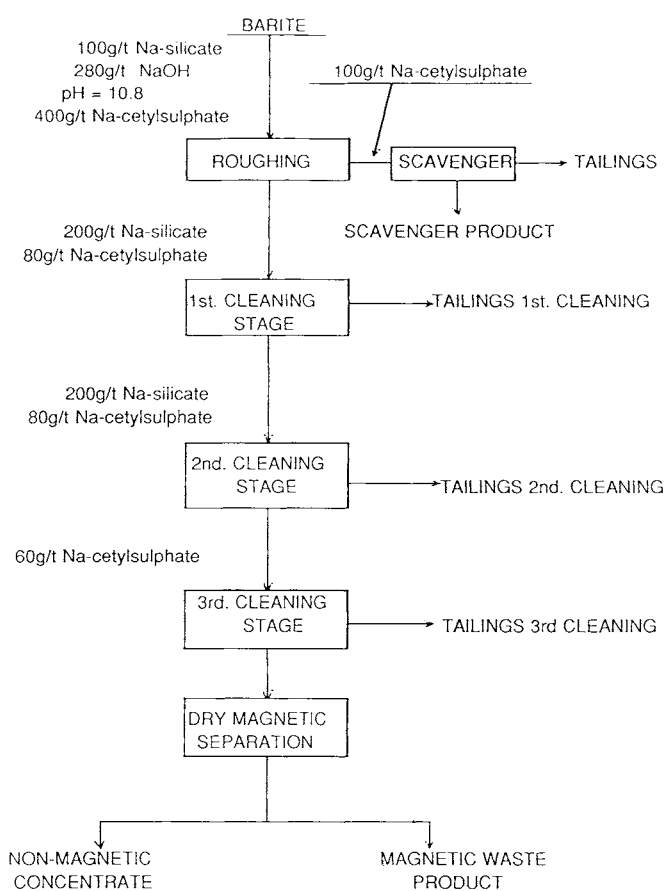


Fig. 1.—Mineral processing circuit applied to barite sand sample.

2. EXPERIMENTAL

The barite sample investigated in this paper was supplied by the Nigerian Mining Corporation, Jos, Nigeria. It was supplied as a light grey sand with particle size less than 850 μm . The exact location of the deposits, the environment, the host rock and any previous studies of the ore were not made available to the author.

Chemical analysis of the barite sand sample was conducted according to ASTM standard methods while the data on the differential thermal and thermogravimetric behaviour were collected on a Netzsch Simultaneous Thermal Analyzer STR 409 using alumina crucibles in air. A Philips diffractometer with $\text{CuK}\alpha$ radiation was used for the X-ray diffraction analysis of the sample both before and after magnetic separation.

Direct froth flotation of barite in alkaline pulp at a pH of 10.8 using Na-silicate as a depressant and Na-cetylsulphate as a collector was effected on the sand sample after milling to $-200\mu\text{m}$. NaOH was used to modify the pH of the pulp and a 5 minutes conditioning time was allowed before the addition of the collector. The combination of reagents employed with the consumption referred to one ton. of solid feed were:

Roughing	Na-Silicate	1,000 g/t
pH = 10.8	NaOH	280 g/t
	5 minutes conditioning	
Scavenger	Na-cetylsulphate	400 g/t
	Na-cetylsulphate	100 g/t
1st Cleaning Stage	Na-silicate	200 g/t
	Na-cetylsulphate	80 g/t
2nd Cleaning Stage	Na-silicate	200 g/t
	Na-cetylsulphate	80 g/t
3rd Cleaning Stage	Na-cetylsulphate	80 g/t
	Na-cetylsulphate	60 g/t

The barite concentrate of froth flotation was subjected to dry magnetic separation in a Ring-Sneider Dry Magnetic Separator at a flux density of 0.7T (Figure 1).

3. RESULTS

A gradual exothermic hump over the first 300°C and a shallow endothermic valley centered at 324.4°C characterize the low temperature end of the DTA curve. The corresponding TG curve shows weight losses of about 0.3% in each case. These phenomena are not characteristic of barites and they are attributed to dehydration and the presence of some organic matter. The high temperature end of the DTA curve has a sharp and pronounced endothermic peak at 1,171.4°C corresponding to the rhombic-to-monoclinic transformation of barite (10, 11).

Table I gives the results of the chemical analyses of the original barite sand sample and the concentrate of the dry magnetic separation. With 89.3wt% BaSO_4 , 1.8wt% SrSO_4 and 0.25wt% CaF_2 ; the original sand sample is a high grade ore. The concentrate with corresponding figures of 96.8wt%; 1.9wt%, 0.05wt% respectively and an Fe_2O_3 and MgCO_3 contents of 0.14wt% and 0.006wt% respectively is adequate for use in the glass, chemical, ceramic and filler industries. It compares favourably with most European flotation grade barites (3).

The X-ray diffraction graph for the original barite sand sample gave peaks of both BaSO_4 and BaS_2O_7 with the highest intensity shifted towards the 100% intensity for SiO_2 (at $2\theta = 26.8^\circ$). In the X-ray curve for the non-magnetic concentrate, the latter peak occurred at $2\theta = 26.2^\circ$, closer to the 100% and 90% intensities for BaSO_4 and BaS_2O_7 respectively. The other BaSO_4 and BaS_2O_7 peaks had better definitions.

TABLE I

CHEMICAL COMPOSITIONS OF BARITE SAND SAMPLE

	Original sample (wt%)	Non-magnetic concentrate
BaSO_4	89.3	96.8
SrSO_4	1.8	1.9
CaF_2	0.25	0.05
SiO_2	5.0	0.25
Al_2O_3	0.2	0.015
Fe_2O_3	3.1	0.14
CaCO_3	0.30	0.10
MgCO_3	0.007	0.006
PbO	0.0015	<0.001

Barite froth flotation concentrates assaying 96.8wt% BaSO₄ with an average recovery of about 66.88% (Ba,Sr)SO₄ were obtained after three cleaning stages. The recovery can be improved on by recycling the baritocelastite contained in the cleaning middlings (20.85%).

The average barite concentrate recovered from the dry magnetic separation was 99.63wt% with an extraction of 95.5wt% of the iron oxide content of the original sand sample. Further studies are still in progress to verify the possibility of attaining a high grade barite concentrate by gravity processes.

4. CONCLUSION

The chemical compositions of the original sand sample and the processing concentrate, and, the result of the preliminary froth flotation and magnetic separation indicate the possibilities of developing a barite deposit from Nigeria for its barium sulphate content. However, only further studies of the deposit (extent, location, etc.), mineralogical composition of the host rock and close areas together with exploration methods, can reveal the actual commercial value of the deposit. Its low content of celestine (1.8wt%) and the fact that it is amenable to both alkylsulphate froth flotation and dry magnetic separation suggests that it could easily gain a place in the international market.

5. ACKNOWLEDGEMENTS

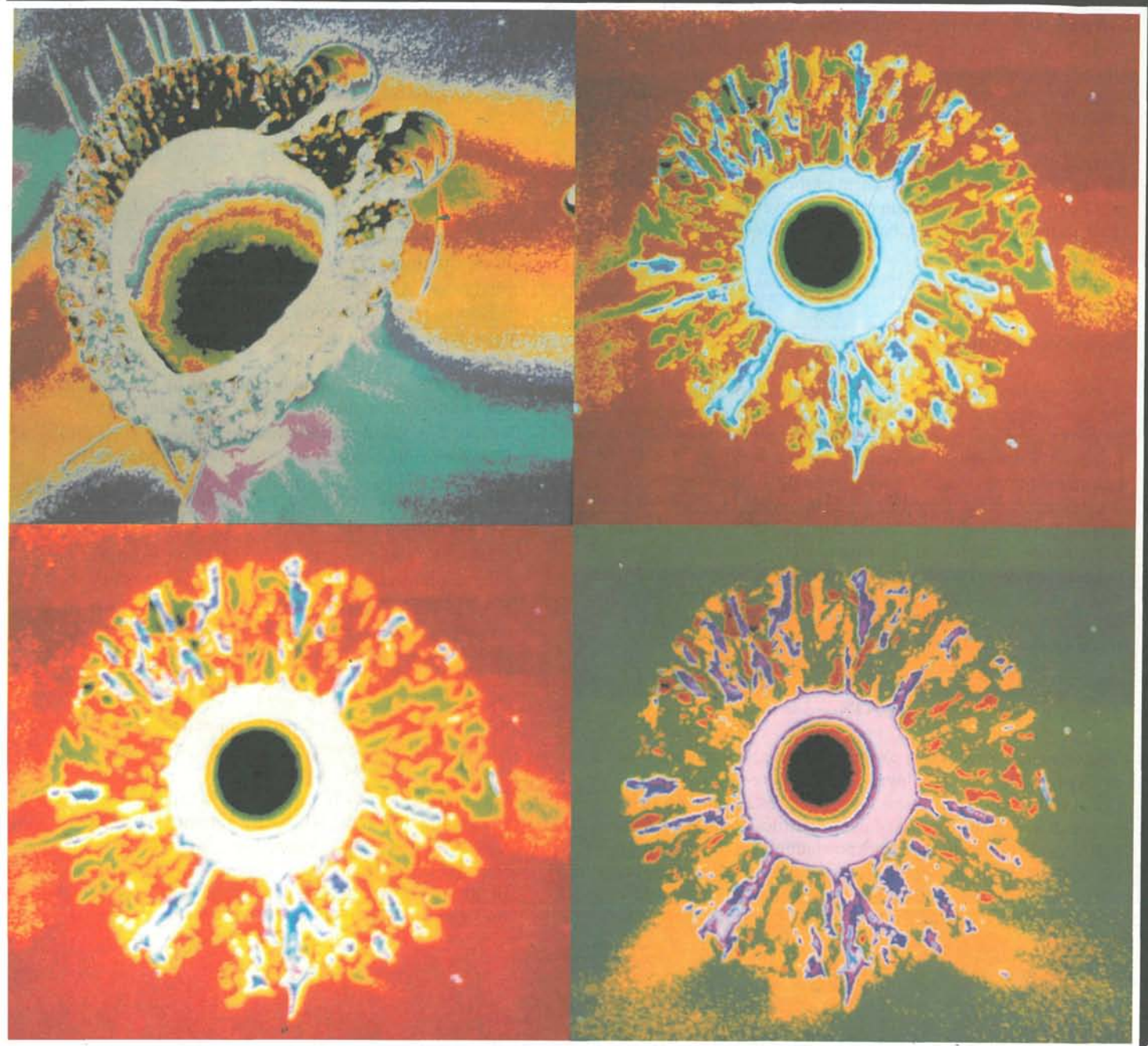
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