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Chemical Characterization and Beneficiation of Barite from Ushongo Local Government Area of Benue State

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Abstract

The chemical compositions of barite (containing $BaSO_4$) obtained from Ushongo Local Government Area of Benue State were determined. The barite had a pre-beneficiation specific gravity of 3.82 and post-beneficiation specific gravity of 3.90 and its loss on ignition (LOI) was 0.10. Chemical characterization was carried out using Pye Unicam Atomic Absorption Spectrophotometer (AAS) for Al^{3+} (396.5 nm) and Ti^{4+} (365.3 nm) in nitrous oxide-acetylene flame, Ca^{2+} (422.7 nm) and Mg^{2+} (285.2 nm) in oxy-acetylene flame while the presence of Ba^{2+} and Si^{4+} were by determined by gravimetry. The analysis gave the percentage composition of Al^{3+} (1.67), Fe^{3+} (0.83), Na^{+} (0.08), K^{+} (0.02), Ca^{2+} (1.10), Ba^{2+} (91.15), Si^{4+} (3.60), while Ti^{4+} and Mg^{2+} were below the limit of detection. The beneficiation of barite was carried out using the Wifley shaking table and the post beneficiation percentage composition of the ore are: Al^{3+} (0.81), Fe^{3+} (0.48), Na^{+} (0.05), K^{+} (0.01), Ca^{2+} (0.87), Ba^{2+} (94.45), Si^{4+} (1.76).

Keywords: Barite, Beneficiation, AAS, Ushongo, Benue State.

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Introduction

The quest for the wealth minerals derived from the earth for the benefit of man's vanity, necessities, comfort have been a powerful incentive to discovery, exploration and trade. The control over them had resulted in both industrial and commercial development. Barite occurs in a large number of depositional environments, and is deposited through a large number of processes including biogenic, hydrothermal, and evaporation, among others (Hanor, 2000). Barite commonly occurs in lead-zinc veins in limestones, in hot spring deposits, and with hematite ore. It is often associated with the minerals anglesite and celestine. It has also been identified in meteorites (Rubin, 1997). It has various colours but mostly yellow, isomorphous orthorhombic crystals in shape associated with galena and of specific gravity 4.3, a Mohr's hardness level of 3.00 – 3.75. The Raw Material Research and Development Council (Raw Materials Research and Development Council, 1989) revealed that extensive deposit of barite occurs in Plateau and Benue states with an estimated reserve of over 500,000 metric tonnes in Nassarawa State. Nigeria is yet to be fully exploited. The ore appear to have had carbonate subjected to chemical weathering which resulted in two distinctive types of barite namely; barite with quartz and limonite as gangue and barite with siderite and ankarite as gangue (Raw Materials Research and Development Council, 2005) vary from normal opaque to transparent crystals. About 75-80% of barite extracted is used to make drilling mud heavier; the rest is used in the chemical and pharmaceutical industry, in the production of colours (as white pigment) in the textile, paper, rubber and glass industries; it is also used as a starting material in the production of barium salts, and heavy concrete.

Barite concrete is obtained by mixing concrete with the mineral; in the production of manufactured goods: cutaway shaped barite concrete bricks in cableways, in the production of ballasts for washing machines. Crystallized barite is destined for the mineral collector's market. Natural barites are chemically stable and highly temperature-resistant. Their high density, low Mohr's hardness and low binder requirement make them suitable for a broad range of applications in the plastics industry, and also in the field of paints and coatings. They are also used as weighting elements for vertical-slat curtains and for noise reduction in piping systems. The principal worldwide uses of barite are estimated as 88% for additive to drilling fluids; 6% for chemicals (Raymond, 1988). The worldwide demand for barite will probably continue to grow as petroleum products continue to be the energy sources of choice. The result of this analysis shows the barite is of high grade that will be suitable in ceramic industries (Keegan, 1997).

Materials and Methods

Barite was collected as rock lumps from deep excavation from a mine. Contaminants were washed off with running water and finally rinsed with water and dried in the atmosphere. The rocks were crushed by hammer and the size reduced in a size reducing machine. The sample was then pulverized and passed through a 120 µm mesh silk sieve. The samples were then packed in polythene bags and stored until they were needed for analysis. Dissolution of silicates carbonates and sulphide ores were carried out using non-oxidizing acids e.g: HCl. At elevated temperature, HNO_3, was used to dissolve samples not dissolved in oxidizing acids. Acid insoluble components were fused with an acid or basic flux namely $KHSO_4$, $K_2S_2O_7$. The LOI was determined by heating 1.0g of the sample to an equilibrium mass at 1000-1100^oC. The lost mass at this temperature is the LOI.

Determination of silica was carried out gravimetrically from the loss in mass of the impure silica precipitate which was obtained by filtration of the precipitate and subsequent volatilization of silicon as the tetra-fluoride from HF-H_2SO_3 medium. Decomposition of the sample was carried out using Na_2CO_3 and subsequent dissolution of the melt in HCl. 1.0 g of the sample is measured into a platinum crucible and digested with 2 mL HCl. Alumina was determined in a dilute HCl solution of the sample by AAS at 396.5 nm in nitrous oxide-acetylene flame calcium, magnesium and potassium on the other hand were determined by AAS at 422.7 nm, 285 nm and 392 nm respectively in air-acetylene flame while iron was determined in a similar fashion at 248.3 nm in air-acetylene flame. Decomposition of the sample was by HCl. The solution was evaporated to near dryness and dissolved in dilute HCl. This solution was then analyzed for Al, Ca, Mg and Fe.

The percentage oxides of the metals could be derived from the following conversion factors:

% Al_2O_3= 1.890 x % Al
% CaO= 1.399 x % Ca
% MgO= 1.658 x % Mg
% Fe_2O_3=1.430 % Fe

Titanium was determined in a dilute HCl solution of the the sample by AAS at 365.3 nm in nitrous oxide acetylene flame. Fusion of the sample was achieved by dissolving the melt in dilute HCl and Na_2O_2. Barium was determined gravimetrically by precipitating in dilute H_2SO_4 and weighing as $BaSO_4$. Separation from interference by calcium and strontium is achieved by precipitation, as yellow precipitate of $BaCrO_4$ with K_2CrO_4 from dilute acetic acid solution (Reitmer, 1971). The solubility of $BaSO_4$ helps to separate it from interfering substances such as silica, lead calcium and strontium. Ba^{2+} calculated from $BaSO_4$ using the conversion factor $BaSO_4$ x 0.5885= Ba^{2+}.

The wifely shaking table was used for the beneficiation of barite. This technique works on the differential specific gravity of sample components. 1000 g of barite prepared for beneficiation was weighed and mixed with distilled water. This sample mixture was shaken in a #13 Wifley shaking table at the speed of 250 rph. Water was run on the sample to wash it down the table. The riffles were arranged at 45^o and graduated down to zero. As water was run on the sample a trough collects the tailings while succeeding trough collects tailings and middling while a third trough collects the concentrate (Wills, 1987).

Results and Discussion

Table 1 shows the percentage composition of the components of the pre-beneficiation analysis as: Al^{3+} (1.67), Fe^{3+} (0.83), Na^{+} (0.08), K^{+} (0.02), Ca^{2+} (1.10), Ba^{2+} (91.15), Si^{4+} (3.60), while Ti^{4+} and Mg^{2+} were below the limit of detection. Fig. 1 is a column chart of analysed raw ore. Table 1 shows the percentage composition of the concentrate as: Al^{3+} (0.81), Fe^{3+} (0.48), Na^{+} (0.05), K^{+} (0.01), Ca^{2+} (0.87), Ba^{2+} (94.45), Si^{4+} (1.76). Fig. 2 on the other hand shows the column chart of the elemental distribution in the concentrate. Barite was also found to have a pre-beneficiation specific gravity of 3.82 and a post beneficiation gravity of 3.90.

Barite is most commonly coarse grained; it also occurs as platy crystals or fine-grained compact masses that may be white, light yellow, light grey, brown, pink or blue. When pure, barite contains up to 58.8% barium or 67.7% barium oxide, this show that the barium content of Ushongo, (91.15 and 94.45 for raw barite and the concentrate respectively with a percentage increase on beneficiation of 3.62), indicates the high level of purity of this important mineral deposit. Barite is used for both its physical attributes, such as relatively high specific gravity and/or chemical inertness (drilling mud additive, construction, functional filler), and for its chemical properties (source of BaO and chemical feedstock).

Conclusion and Recommendations

The availability of the raw material, its purity especially the high barium content can serve as a source of barium metal and for the production of high quality drilling mud.

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Tables

Table 1: % Composition of barite ore

Parameter	**% Composition**
Ba^{2+}	91.15
Si^{4+}	3.60
Al^{3+}	1.67
Fe^{3+}	0.83
Ti^{4+}	<LOD
Na^{+}	0.08
K^{+}	0.02
Ca^{2+}	1.10
Mg^{2+}	<LOD
LOI	0.10

S.G: 3.82
LOD= Limit of detection

Table 2: % Composition of raw ore and concentrate

Parameter	**% Composition of raw ore**	**% Composition of concentrate**	**% Improvement**
Ba^{2+}	91.15	94.45	3.62
Si^{4+}	3.60	1.76	
Al^{3+}	1.67	0.81	
Fe^{3+}	0.83	0.48	
Ti^{4+}	<LOD	<LOD	
Na^{+}	0.08	0.05	
K^{+}	0.02	0.01	
Ca^{2+}	1.10	0.87	
Mg^{2+}	<LOD	<LOD	
LOI	0.10	0.05	

S.G= 3.90