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Geotechnical Characterization of Barytes from Ihugh Area, Lower Benue Trough, Nigeria

NGUKPOSU A. LABE[1], MUYIBAT M. IBRAHIM[2], CALEB K. NYAJON[3], AMBROSE A. RUFI[4], ADAMU IBRAHIM [5]
[1,2,5] *Department of Geology, Kano University of Science and Technology, Wudil, Nigeria*
[3, 4] *Department of Geology, Ahmadu Bello University, Zaria, Nigeria.*

Abstract: The Ihugh area lies within the Lower Benue Trough, southeastern Nigeria. Baryte mineralization in this area occurs generally as vein and cavity-type deposits in Turonian Lessel Sandstone. Baryte samples from Ihugh were subjected to density and moisture content tests to establish their physical attributes and quality. The result reveals that baryte from this locality exhibits low moisture content (1.18-1.28%), moderately high specific gravities (4.01 – 4.02), $BaSO_4$, SiO_2, SrO and low Fe_2O_3, CaO, Pb, Zn, Cu, Cd, Hg contents. Barytes from the Ihugh area fall below the international standard specification of American Petroleum Institute and therefore are of moderate quality or Grade II barytes, but can be beneficiated to improve their quality.

Keywords: Ihugh, Lower Benue Trough, baryte, specific gravity, international standard specifications

I. INTRODUCTION

The mechanical properties of earth materials are important in geotechnical investigations. These properties are used to ascertain the economic viability of rocks and minerals. Economic minerals whose value has been established are presently mined at commercial scale (Akpeke *et al.* 2006; Moon *et al.* 2006; Akpan *et al.* 2014). Baryte is a relatively dense mineral with high specific gravity ranging from 3.0 - 4.4. The suitability of baryte for industrial purposes, such as source of barium chemical, weighting agent, radiation shield, etc, depends largely on its physical properties such as high specific gravity, chemical inertness, brightness and whiteness.

In Nigeria, occurrences of baryte deposits usually associated with galena-sphalerite-fluorite (PbS-ZnS-CaF_2) have been reported in several locations within the NE-SW trending Cretaceous Benue Trough (Akande *et al*., 1989; Omada, 1996; MMSD, 2008; Oden, 2012; El-Nafaty, 2015). The distribution and structural control of galena-sphalerite-baryte (PbS-ZnS-$BaSO_4$) mineralization has been attributed to the opening/rifting of the trough (Maurin and Benkhelil, 1990; Ofoegbu and Odigi, 1990).

The southeastern part of the present Benue State comprises two major baryte fields - Lessel and Ihugh fields, as proposed by Oden (2012). Studies in these fields reveal that baryte mineralization is structurally controlled by major NE-SW and marginal NW-SE trending fractures (Labe *et al.,* 2018). Baryte veins run through the basement gneiss into the overlying Turonian Lessel Sandstone via these fractures (Labe *et al.,* 2018). Baryte lenses of limited sizes ranging from 0.5 – 7 cm thick are also common within the ferrugenised Lessel Sandstone at Mbaakase, Ihugh.

In this study, geotechnical techniques are applied to establish the characteristic attributes of baryte that make it suitable for industrial use.

II. METHODOLOGY

In order to ascertain the quality of baryte samples from Ihugh area, the samples were subjected to geotechnical tests in addition to geochemical analyses.

Geotechnical Tests

The geotechnical tests include: moisture content, density and uniaxial compressive strength. These tests were carried out at the Concrete Laboratory and Soil Mechanics Research Laboratory, Department of Civil Engineering, Ahmadu Bello University, Zaria.

Moisture Content Test

Three representative baryte samples were weighed and oven dried at a temperature of 110° C. These samples were removed after 48 hours, cooled at room temperature and weighed using a D and G JJ3000 Electronic Scale. The process was repeated until a constant weight was attained. The moisture content of each sample was calculated using the following equation:

$$\%W = \frac{(A - B)\,100}{B} = \frac{\text{Weight of water}}{\text{Weight of dry sample}} \times 100$$

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Where:
%W - Percentage of moisture in the sample
A - Initial weight of sample (wet sample in kg)
B - Final weight of sample (dry sample in kg)

Density and Specific Gravity

Baryte samples were cut into rectangular blocks (cuboid), and the length, breadth and height of each baryte block were measured with a vernier calliper. The volume of each block was calculated. Each block was then weighed on the D and G electronic scale to determine its mass. The density of each sample was calculated as the mass of a material per unit volume. The specific gravity is therefore derived by substituting the density values into the specific gravity formula. The specific gravity is a dimensionless unit defined as the ratio of the density of a substance to the density of water at a specified temperature.

Geochemical Test

The major oxides and trace elements were analysed using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS), respectively at Acme Laboratory, Vancouver, Canada.

III. RESULTS

The results from the geotechnical tests show that barytes from the Ihugh area have moisture content values ranging from 1.18 to 1.28% and specific gravity from 4.01 to 4.02 (Table 1). The geochemical data for barytes from Ihugh area are presented against American Petroleum Institute standard (Table 2). Barytes in this study have average values of moisture content, specific gravity, and $BaSO_4$ content of 1.23 %, 4.01, and 83.7 wt.% respectively (Tables 1, 2).

Table 1: Moisture content and specific gravity of barytes from Ihugh area

Location/ Sample Name	Moisture Content (MC)								Specific Gravity			
	IR (kg)	SR (kg)	TR (kg)	FOR (kg)	FIF (kg)	FR (kg)	MC (%)	Mass (g)	Vol. (cm^3)	Density (g/cm^3)	Density of water (g/cm^3)	Specific Gravity
Ihugh-Sample 1	0.86	0.86	0.85	0.85	0.85	0.85	1.18	132	32.99	4.01	1	4.01
Ihugh-Sample 2	0.82	0.81	0.81	0.81	0.81	0.81	1.23	140	34.80	4.02	1	4.02
Ihugh-Sample 3	0.79	0.79	0.78	0.78	0.78	0.78	1.28	129	32.20	4.01	1	4.01
Average							*1.23*			*4.01*		*4.01*

IR – Initial Reading SR, TR, FOR, FIF and FR – Second, Third, Fourth, Fifth and Final readings respectively Vol. – Volume

Table 2: Geochemistry of some selected major oxides and trace elements in barytes from Ihugh areas compared with American Petroleum Institute (API) standard (Modified from Lorenz and Gwosdz (2003).

Sample Location	$BaSO_4$ (wt.%)	SiO_2 (wt.%)	SrO (wt.%)	Fe_2O_3 (wt.%)	CaO (wt.%)	Pb (ppm)	Zn (ppm)	Cu (ppm)	Cd (ppm)	Hg (ppm)	Specific gravity	Moisture Content (%)
Ihugh	83.70	13.30	0.60	1.20	0.10	25.60	54	7.00	0.10	0.01	4.01	1.23
API	>92								<3	<3	>4.2	
Uses												
Extender	>80											
Chemical industry	>94	<2	<1-2	<2		<5000						
Heavy concrete	>90		<2	<2								

Ene *et al.* (2012) reveals that the strength and grade of baryte depends on its depth of occurrence, moisture content/porosity, specific gravity and presence or absence of associated minerals (gangue). The average specific gravity value of 4.01 for barytes Ihugh areas is lower than that of the API standard (Table 2). This moderate specific gravity of 4.01 is attributed to its fairly high $BaSO_4$ content (83.7%).

The percentage composition of $BaSO_4$ and specific gravity of baryte is critical in determining its end use. The geochemical and geotechnical data generated from this research has shown that the barytes from

Ihugh have an average SG = 4.01 which fall below the specification standards for use in petroleum, chemical/pharmaceutical industries in addition to paper, paints, lithopone, glass and heavy concrete industries as outlined by Lorenz and Gwosdz (2003). However, their range is suitable for the manufacture of filler and extender (Table 2).

IV. CONCLUSION

Field evidences show that the Ihugh barytes hosted Turonian Lessel Sandstone are epigenetic deposits and are structurally controlled by NE-SW and marginal NW-SE trending fractures. The geotechnical tests show that barytes from Lessel and Ihugh areas have moisture content values ranging from 1.18 – 1.28%, specific gravity from 4.01 to 4.02. Barytes from Ihugh areas exhibit moderately high specific gravities, low moisture content in addition to high $BaSO_4$, SiO_2, SrO contents but low Fe_2O_3, CaO, Pb, Zn, Cu, Cd, Hg contents. The geotechnical attributes have shown that barytes Ihugh area falls below the American Petroleum Institute (API) specification standard and are therefore of grade II. Beneficiation is therefore required to improve its quality.

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