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Characterization of Okpilla Feldspar Deposit for Glass and Ceramic Production

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Abstract: ***In this work, the characterization of Okpilla feldspar deposit in Edo State, Nigeria was carried out with the view of finding its suitability for glass and ceramics production. The Chemical Analysis, Mineralogical Analysis, Differential Thermal Analysis (DTA), and the Loss on Ignition (LOI) were carried out using XRF and Rational Analyses, XRD, and DTA furnace respectively. Glass batch and ceramic body (ornamental ware) were composed with the feldspar to determine its suitability for glass and ceramic production. The chemical analysis shows the feldspar deposit is a potash feldspar with 10.40% K_2O. From the various analyses it is concluded that the Okpilla feldspar is suitable for the production of glass and ceramic bodies.***

Keywords: Feldspar, XRD, XRF, DTA, Rational Analyses

1. Introduction

Feldspars and other feldspathic materials such as nepheline syenite are mostly used in the glass and ceramic industries. In the glass industry, they are used as sources of alkali and alumina while in the ceramic industry; they are used for their fluxing properties [1]. According to [2], feldspar is the most common mineral found on the earth crust and which is an essential raw material for both glass and ceramic industries. Feldspar is utilized as an essential material in batches for the making of fine ceramic products like a hard ware, vitreous china, porcelain and the likes due to its fluxing properties. In the production of glass, feldspar provides alumina, which improves hardness, durability, and ability of glass to resist chemical corrosion. In the ceramic industry, feldspar is mostly utilized in ceramic bodies and glazes. As a flux, feldspar lowers the vitrifying temperature of a ceramic body during firing and forms a glassy phase in the body [3].

The mineral of which the composition is comprised between Albite and Anorthite are known as plagioclase feldspars, while those comprised between Albite and Orthoclase are called the alkali feldspars [4]. The latter category is of particular interest in most industrial use of feldspar.

Feldspar that has high amount of potassium has been discovered to be better for body formulation. While feldspar that has high amount of sodium is more useful in glaze formulation as a result of its relatively low melting point. At about 1250^0C most feldspar melts. It was also reported by [4] and [5] that feldspar is commonly the only source of body flux. Generally, feldspar plays a significant role as a fluxing agent with the formation of liquid during firing but when cooled, the liquid forms a glass and brings the grains of clay and silica together. Feldspar has also been considered a main constituent in most porcelain and other white bodies [6]. In view of this, porcelain manufactures use feldspar to a great extent for body and glaze formulation. [7] also stated that feldspar are commonly recognized by its cleavage, lustre, hardness and colour. However, potash feldspar according to [8] is often pink in colour but that this is not due to iron oxide. These consist of the elements oxygen, silicon and alumina with potash, soda and calcia. Feldspar is abundant and available in commercial quantities in many parts of the Country [9]. [5] however reported that there are large deposits of feldspar in the granite rocks of Nigeria and that feldspar rich in pegmatites are found in different parts of the country. Although, Nigeria possesses appreciable quantity of non-metallic mineral raw materials like feldspar, low sourcing and utilization have been the major problem, hence over dependence on importation of these resources with little or no value additions to the disadvantage of the local industries [10]

This research work however focused on the characterization of okpilla feldspar in Edo State, Nigeria to determine its suitability for glass and ceramic production.

2. Experimental Procedures

2.1 Sourcing of the Feldspar Material

The feldspar used for this research was collected from Okpilla. Okpilla is a border town between Edo State and Kogi State situated in Estako East Local Government of Edo State, Nigeria.

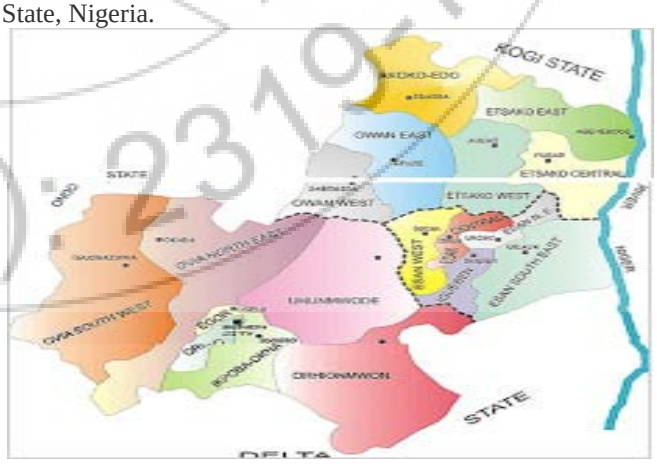

Figure 1: Map Showing Etsako East the location of Okpilla.

2.1. Characterization of the Okpilla Feldspar

The chemical analysis, mineralogical analysis, differential thermal analysis, and the loss on ignition (LOI) of the Okpilla feldspar were examined in the Materials Laboratory of the Obafemi Awolowo University (OAU), Ife. Rational analyses were also carried out at the Research Laboratory of The Federal Polytechnic, Ado Ekiti to determine the percentages of oxides present. The results were then compared with the results published in literature.

2.2 Sample Preparation

The feldspar collected in boulder form from the site was first reduced to smaller particle size and further milled to fine powder using Jaw crusher and Ball mill respectively at the department of Mineral Resources Engineering of The Federal Polytechnic, Ado Ekiti and kept inside a cleaned porcelain crucible. The feldspar sample was then dried at 110^0C for15hrs, in an oven of the department of Glass Technology, Federal Polytechnic, Ado- Ekiti.

2.3 Chemical Analysis

Chemical analysis of the powdered feldspar sample was determined using XRF instrument, where the sample was dried at 110^0C (because moisture might have been added due to storage before analysis) for 8hrs prior to analysis. Rational analyses were then conducted using sulfuric acid to determine the various oxides percentage present.

2.4 Mineralogical Analysis

The powdered feldspar sample was dried in an oven, and the mineralogical data was obtained on powdered sample using XRD instrument

2.5 Differential Thermal Analysis:

DTA was performed on the powdered feldspar in a thermal analyzer. The sample was heated from room temperature to 1000^0C at heating rate of 10^0C min^{-1}. The DTA scan was conducted in flowing air using platinum crucible with calcined Al_2O_3 as reference material.

2.6 Loss on Ignition

Determination of the loss on ignition was carried out in the furnace and calculated using the following equation:

$LOI = [(DW_i - DW_f) / DW_i] \times 100$ (1)

2.7 Glass Forming

Two batches of 250g were composed with the feldspar along with Borax and Potassium Nitrate respectively:

Sample A	Sample B
Feldspar- 200g	Feldspar- 200g
Borax - 50g	KNO_3 – 50g

The batches were placed in the furnace and heated to a temperature of 1250^0C. After the temperature was attained, the furnace was put off and allowed to cool before the samples were brought out for examination.

2.8 Ceramic Body Preparation

A self glaze ceramic body was composed with the feldspar along with Sand, Soda Ash, Ball Clay, and Borax with little addition of water to a paste form. The body was fired to a temperature of 700^0C inside an electric kiln at the department of Glass Technology, Federal Polytechnic, Ado Ekiti.

3. Results and Discussion

3.1 Chemical Analysis:

Table I gives the results of the chemical analysis by rational analyses method to show the presence and proportion of potassium, sodium, and calcium oxides indicating the existence of orthoclase, anorthite, and combinations of orthoclase/albite and albite/anorthite feldspar with orthoclase as the major component which is in agreement with the XRF analysis.

3.2 Differential Thermal Analysis

Fig. 1 gives the DTA curve of the feldspar sample with the usual endothermic peak at 569.6^0C associated with the change from α- to β- quartz.

3.3 Mineralogical Analysis

Fig. 2 gives the X-ray diffractometer analysis for the feldspar sample which indicates peaks of orthoclase, quartz etc.

3.4 Glass forming

The two batches A and B that were composed with the feldspar were analyzed after melting operation in the furnace by physical examination (fluxing, viscosity, and color) which shows proper melting of the feldspar to form a glassy phase.

3.5 Ceramic Body Preparation

The self glaze ornamental body that was prepared with the feldspar in combination with sand, soda ash, ball clay, and borax was examined by physical examination after firing in an electric furnace which shows a good glossy appearance.

4. Conclusion

It may be concluded from X-ray, chemical and rational analyses of the feldspar sample from Okpilla, Edo state that it is a compound of orthoclase and plagioclase feldspar with a predominance of orthoclase. The results from the glass forming and ceramic body composition show the suitability of the feldspar deposit for glass and ceramic production.

Table 1: Chemical analysis of Okpilla Feldspar by Rational analysis in wt%

SiO_2	Al_2O_3	K_2O	Na_2O	CaO	Fe_2O_3	LOI
41	34	10.40	2.63	2.87	0.74	0.14

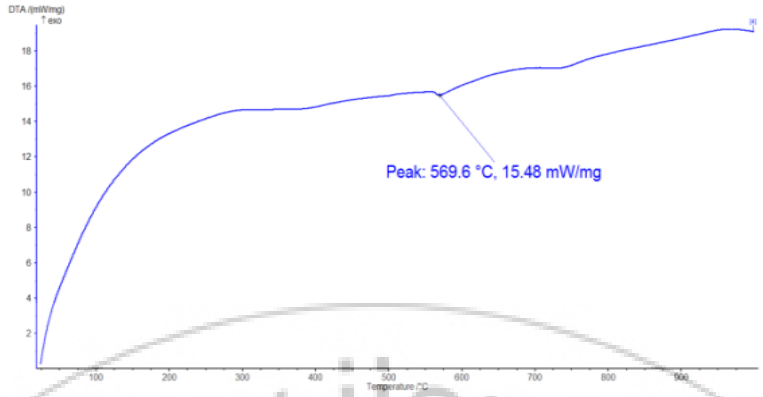

Figure 1: DTA curve of the Okpilla Feldspar

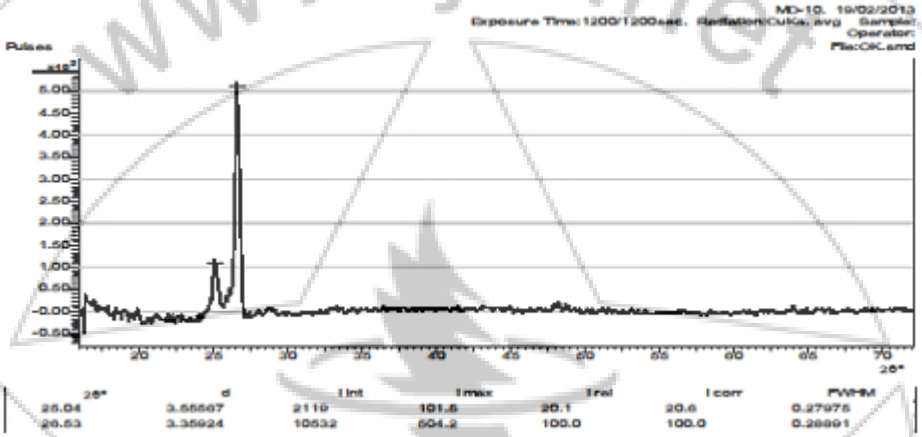

Figure 2: XRD analysis of Okpilla Feldspar

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