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Determination of the Suitable Engineering Applications of Ilekpi Calcium Carbonate Formation for Foundary, Refractories, Paint Glass and Ceramics

Fatai K. Jimoh
Department of Mining Engineering,
Federal University of Technology,
Akure.
Department of Mining Engineering.

Babatunde Adebayo
Department of Mining Engineering
Federal University of Technology,
Akure.
Department of Mining Engineering.

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Abstract: *The engineering applications of carbonate formation depend on its physical, chemical and other properties. The chemical composition of carbonate formation from Ilekpi, Akoko Edo Local Government, Edo State, Nigeriawas determined using X Ray Fluorescence – analysis. The results from the formation shows that the major oxides obtained from the X Ray Fluorescence analysis includes: SiO_2, MgO, and Al_2O_3. The entire samples revealed high SiO_2 content resulting from high value of quartz mineral. The average SiO_2 content is 91.06% with the next oxide being MgO of 5.61%. The formation is predominantly a dolomite quartz formation and having low Al_2O_3 value of 0.92% and high SiO_2 value of 98.6% makes it suitable for refractory industry.*

Keywords: carbonate formation, engineering applications, physical properties, chemical properties, xrf analysis.

INTRODUCTION

Calcium carbonate ($CaCo_3$) is the most widely used filler in polymer formations. As filler, calcium carbonate allows cost reduction and improves mechanical properties. It is found in sedimentary rocks (chalk, limestone), marble and dolomite. Some typical properties are density 2.7-2.9 g/cm^3: oil absorption 13-21 g/100g, depending on their origin, geological formation, and their impurities. (Ref) Calcium carbonate had been identified to have different properties. Three major technological processes are used in the production of calcium carbonate fillers, milling, precipitation and coating. However, most calcium carbonate filers processed by melting using a dry or wet method. Milling provide ultra-fine calcium carbonate grade (particles sizes about 0.6um) (ref). The natural milled calcium carbonate is added to decrease cost in rubber base adhesives.

Properties of the Dolomitic Quartz that makes it Suitable for Foundary and Refactory Purposes.

High Melting Point: Quartz powder boasts the exceptional melting point of the sample, making it ideal for foundry and refactory applications with a melting point of around 170^0C (3092F). It can withstand extreme temperatures without melting or deforming, ensuring excellent performance and durability in high heat environments.

Low Thermal Expansion: This means that even when exposed to drastic fluctuations in temperature, it does not undergo mineral expansion or contraction. This stability prevents cracking, distortion and damage to the materials.

High Heat Resistance: It possess excellent heat resistance without losing its structural integrity or compromising its efficiency. This property is essential in blast fumes kilns.

Chemical inertness: That is does not react with most chemicals, retaining its properties even when exposed to corrosive materials.

Understanding the Deposit

Understanding the composition and structure of this deposit is essential to grasp its significance. It comprise primarily a silicon dioxide (SiO_2), the most arburdant mineral in the earths crust.it is found in form of crystalline quartz, the powder consist of finely grand quartz particles that exhibit excellent thermal and chemical stability.

Different grade of dolomitic quartz powder are made to fulfill specific industrial needs, for example finer grades are commonly used in refractory applications where high purity and controlled particles size are essential .coarse grade are often utilized in foundry applications where a controlled expansion and high refractoriness are required. One of the uses is in lining furnaces where it act as a protective layer against extreme temperature. Whether it is an industrial furnace used in steel production or a glass kilns, it is also indispensable for constructing glass melting tanks and annealing furnace in the glass industry. Additionally in the ceramic industry, it is for lining kilns during the manufacturing process of ceramic products.

Quartz Powder Specifications

- High content of SiO_2, 99.8% and above

- Size 200 mesh, 300 mesh, 325 mesh, 400 mesh and up to 1000 mesh
- FeO_3 content: 0.02 or 0.008
- AlO_3: not or maximum: 0.005%
- Oil absorption value: 20%
- Specific gravity: 2.69
- Refractive index: 1.55
- Loss on ignition: 0.3%

Geological Setting

The study area lies within latitude 006 06 626 N and longitude 07 28 519 E. Ajibade and Flitches (1988) established that the Precambria n basement complex of Nigeria is polycyclic in nature and had been subjected to more than one orogeny episode together with metamorphism. The most conspicuous of these is the Pan African Orogeny, which overprinted and largely destroyed earlier structures of the basement complex (Flitches *et al.*, 1985). Ilekpi formation shares a common boundary with Lampese on the North side, Ogori-Magogo on the south, Ibillo on the East and Bekuma community at north direction (Figure 1). The formation is a ridge spanning over a length of 1 kilometer by 200 met

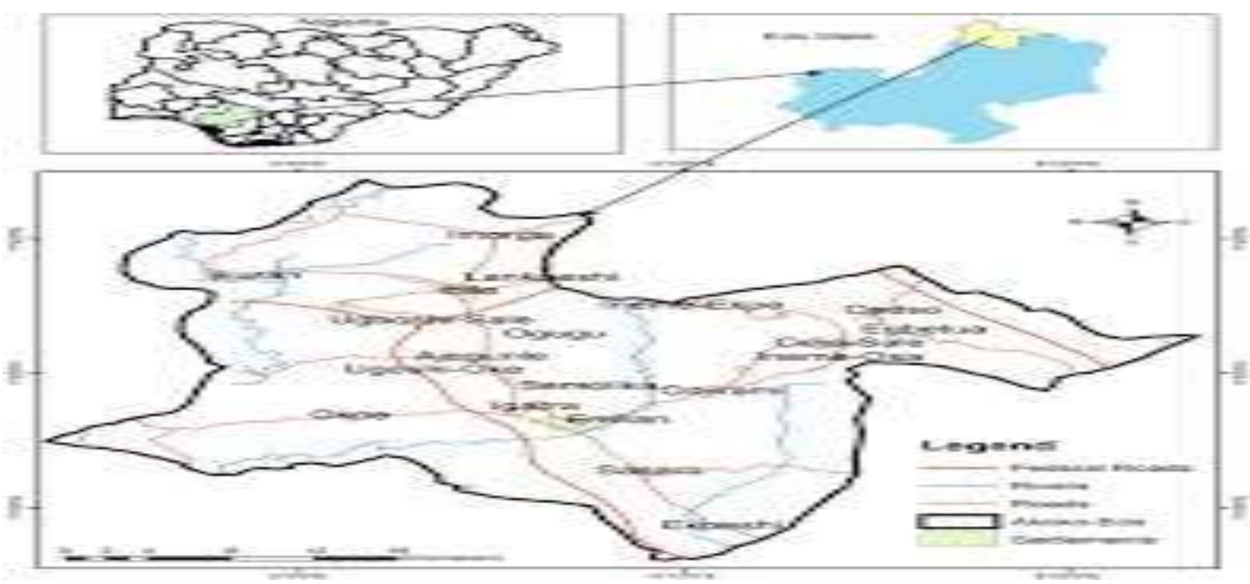

Figure 1. Location Map Showing the Study Area (Modified after Oloto and Anyanwu 2013).

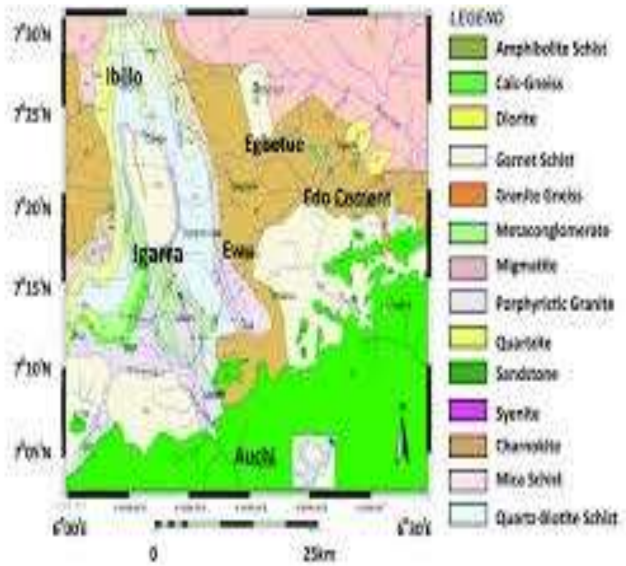

Figure 2. Geological Map of the Igarra Area Showing Study Areas Lithology (Modified After Obiadi *et al.*, 2013)

MATERIALS AND METHODS

Representative samples from the formation were collected according to the method suggested by Margui *et al.*, (2006). It was analyzed with X Ray Fluorescence package by Lithium Borate Fusion /XRF. Purposive sampling according to Etikan and Bala (2017) was used to collect representative samples from two (2) locations from the formation.

Methodology

Bromate Fusion Method of Xray Fluorescence

The bromate fusion method is a sample preparation technique used in x-ray fluorescence (XRF) analysis. XRF is a non-destructive analytical method that provides quantitative information about the elemental composition of materials.

The bromate fusion method involves dissolving a sample in a flux, typically lithium tetraborate (LiB_4O_7) or Lithium Metaborate ($LiBO_2$) in the presence of Potassium Bromate ($KBrO_3$). The sample is mixed with the flux and bromate, and then heated to a high temperature (around 100^0) in a platinum crucible. (Taylor *et al.,* 2013)

Procedure (Taylor *et al.*, 2013)

Here's a step-by-step overview of the bromate fusion method:

1, Sample Preparation: The sample is crushed and ground into a fine powder.

2. Mixing: The powdered sample is mixed with lithium tetraborate or lithium metaborate flux and potassium bromate.

3. Fusion: The mixture is heated to a high temperature (around 100^0) in a platinum crucible, resulting in a molten glass bead.

4. Casting: The molten glass bead is cast into a disk or pellet shape.

5. Cooling: The glass disk or pellet is cooled and prepared for XRF analysis.

RESULTS

In order to have an industrial assessment of the Ilekpi formation, we have compared the acquired data with the International Standards to indicate the usage of the formation for industrial uses such as foundry, refractories, ceramics, glass and paint. The compared results (Table 1) indicate the following:

Table 1: Chemical Composition of the Formation (Analyzed Sample)

Element	**Oxide**	**Content (%) Location I**	**Content (%) Location II**
Si	SiO_2	97.1	98.6
Ca	CaO	0.01	0.04
Mg	MgO	0.04	0.05
Al	Al_2O_3	0.92	0.92
Fe	Fe_2O_3	1.33	0.97
Na	Na_2O	< 0.01	< 0.01
K	K_2O	0.3	0.3
L	LOI	0.29	0.32

Other oxides such as BaO, Cr_2O_3, CuO, HfO_2, NiO, PbO, SiO, V_2O_5, ZnO contents are less than 0.005, Mn_3O4 content is 0.01, P_2O_5 0.007, TiO_2 content is than 0.02.

Table 2: Specification for Foundry Industry

Element	Oxide	Content (%)
Si	SiO_2	95-98
Ca	CaO	0.5-2.0
Mg	MgO	0.1-0.5
Al	Al_2O_3	0.5-1.5
Fe	Fe_2O_3	0.1-0.5
Na	Na_2O	0.1-0.3
K	K_2O	0.1-0.3
L	LOI	1.0-2.5

ASTM C129
Foundry Industry specific certifications (ISO/TS 1

Foundry Industry

Going by the chemical composition of the Ilekpi formation, the low Al_2O_3 value of 0.92% and high SiO_2 value of 95.1% is in line with the International Standard requirement for foundry as shown in Table 2 above. Hence the formation is suitable for the foundry industry.

Refractory Industry

Comparing the chemical composition of Ilekpi formation with the International Standard requirement as shown in Table 3 below; the low Al_2O_3 value of 0.92% and high SiO_2 value of 98.6% indicates it is suitable for refractory industry.

Table 3: Specification for Refractory Industry

Element	Oxide	Content (%)
Si	SiO_2	98-99.5
Ca	CaO	0.5-2.0
Mg	MgO	0.1-0.5
Al	Al_2O_3	0.5-1.5
Fe	Fe_2O_3	0.1-0.5
Na	Na_2O	0.1-0.3
K	K_2O	0.1-0.3
L	LOI	1.0-2.5

ASTM C16-17: Standard Test Method for Load Testing Refractory Shapes at High Temperatures.
ISO 10081-1: Refractory materials- Determination of thermal conductivit

Table 4: Specification for Paint Industry

Element	Oxide	Content (%)
Si	SiO_2	95-98
Ca	CaO	0.5-2.0
Mg	MgO	0.1-0.5
Al	Al_2O_3	0.5-1.5
Fe	Fe_2O_3	0.1-0.5
Na	Na_2O	0.1-0.3
K	K_2O	0.1-0.3
L	LOI	1.0-2.5

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Paint Industry

The low Al_2O_3 (0.92%) coupled with the high SiO_2 (95.1%) of the Ilekpi formation, makes it suitable for paint coating when compared with the International Standard requirement as shown in Table 4 .

Glass Industry

Table 5 shows the International Standard requirement for the glass industry. Comparing this with the low Al_2O_3 value of 0.92% and high SiO_2 value of 98.6% as obtained in the obtained in the Ilekpi formation, is indicative that it is suitable for the glass industry

Table 5: Specification for Glass Industry

Element	**Oxide**	**Content (%)**
Si	SiO_2	99-99.9
Ca	CaO	0.1-1.0
Mg	MgO	0.1-0.5
Al	Al_2O_3	0.1-0.5
Fe	Fe_2O_3	0.01-0.1
Na	Na_2O	0.1-0.5
K	K_2O	0.1-0.3
L	LOI	0.5-1.5

ASTM C169-17: Standard Test Method for Chemical Resistance of Glass

Table 6: Specification for Ceramic Industry

Element	Oxide	Content (%)
Si	SiO_2	98-99.5
Ca	CaO	0.5-2.0
Mg	MgO	0.1-0.5
Al	Al_2O_3	0.5-1.5
Fe	Fe_2O_3	0.1-0.5
Na	Na_2O	0.1-0.3
K	K_2O	0.1-0.3
L	LOI	1.0-2.5

ASTM C373- Standard Test Method for Thermal Shock Resistance of Ceramic Materials

Ceramics

The chemical composition of the Ilekpi formation shows a low Al_2O_3 value of 0.92% and high SiO_2 value of 98.6%. This makes it suitable for the ceramics industry in comparison with the International Standard requirement as shown

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