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Alumino-Silicate Mineral Material for Ceramic Manufacturing Industries

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Abstract
Intensively, fireclay deposits were found within ijero-Ikoro areas specifically. The mineral resources of Ekiti state have not being fully appraised due to insufficient research works and poor intensive studies. While the localization of these minerals is by geological formation of minerals within the basement and quaternary deposits as found in the state. Scanty researches and little studies have identified very few number of mineral deposits in the state since 1942. For example, fireclay as residentially found contained profile of sand, kaolin and lateritic clays within the top soils of various huge deposits that could be industrially and constructively useful. Other minerals found within the axis include Feldspar at Ikoro. Gold and Quartz were also found at Efon and Itawure respectively. Feldspar and Gemstone were obtained at Okeowu, Ikoro and Ijero intensively. Industrial mineral axis was technically examined under this present study where valuable minerals that were largely unevaluated before were currently evaluated for Ekiti state economic growth and development. More so, the paper reviews and updates the mineral potentials within the basement rocks and quaternary alluvial deposits as found within Ijero-Ikoro-Okemesi-Efon-Alaye-Aramoko geological formation specially for Ekiti State industrialization.
Keywords: Minerals, Evaluation, Usage, Industrialization

INTRODUCTION

Literature survey indicated many researchers and scholars have worked on this axis before. The geological, mineralogical and industrial studies have been made before . Oyinloye, (1991) worked on the geological and mineralogical aspect of the clays. Aderiye, (2005) also used two of the Ekiti clays to develop some industrial refractory bricks. The characteristic properties of some the Ekiti clays have also been examined previously by Oyinloye, and Ojo (1998). Factually, majority of these researchers have submitted that equatorial weathering affected most Ekiti clay deposits as found mainly in the study area (Aniyi,1985; Ahmed,1986). Analytically, all these explanations show that major clay deposits examined were sedimentary clay deposits. These clay deposits should be technically planned for Ekiti state industrialization, if beneficiated (Shittu, 1998).

Within Ekiti-State there were numerous clay deposits. But fireclays were found within the Ijero Local government notably, they could be industrially useful for furnace bricks, sanitary and dinner wares production (Doyle, 1979). Clay deposits in Ekiti were mainly Kaolintic in nature when examined (Aderiye, 2005). These clays could be also processed for chemical industries that required alumina compound. Industrial evaluation of clays within this region was based on the quantity and quality of the clay deposits. Clays have not been fully utilized in Ekiti-State industrialization.

Majority of Ekiti State citizens are highly educated and industrious, therefore they should be encouraged through active industrialization policies. Even though industrial activities of minor exploration and exploitation and utilization are taken place in Ekiti-State. Lack of capital is mainly responsible for the low turnover of these local miners and the economic activities. Machineries and capital should therefore be provided for the Ekiti State registered mining companies. This will increase the state revenue through taxation and commercial activities.

Whitish clay with above 25% alumina is referred to as kaolin or with a trade name China clay. Colored clays could be classified as lateritic and ball clays which are very high in plasticity with less 20% alumina compounds. Above 25% plasticity makes clay workable industrially. Empirically wet clays are workable than dry ones (Heckroodt, 1994).

Economically, viable manufacturing industries such as glass, ceramics, chemical, insulating wares, sand paper, and other building material industries could be located near these found raw material deposits. High revenue is expected to be generated, if the research recommendation is upheld by both the state and national relevant industrial policy makers.

MATERIALS AND METHODS USED.

Geographically and geologically structures within three local government areas of Ekiti State have shown mainly sedimentary deposition of clays with some minerals in various very large quantities. These are found in various colors ranging from white to grey and red, with some brownish color at intervals mainly on the surface areas. Geologically, these explored Ekiti clays were mainly found at the lowland plains of Aramoko and Ijero environs. Between two to twenty meters clay thickness, exploration and exploitation studies of these clays have shown they were buried beneath with some over burden that were made of organic matters. When the sample clays were beneficiated with wet sieving device, most unwanted materials were thereafter removed. Minerals required were technically sampled and examined before they were processed for use.

With the use of probing holes and geological evaluations, Ijero-Ikoro-Okemesi-Efon clays were found at above thirty million metric tons, apart from other associative minerals found in the deposits. When examined with X-ray Diffractometer , X-ray Fluorescence (XRF) and Atomic Absorption Spectrotometer (AAS) experimentally, these deposits have Feldspar, Silica, Zinc and Mica minerals (Table 1 and Figures 1 to 4) in large reserves. In addition, Gravels, Granite and Quartz with associative minerals were also found. Fireclay was found as the largest mineral in the midst of other minerals within the geological area. The raw fireclay found physically was very smooth with fine grain sizes. Thereafter the fireclay was finally beneficiated. Other characteristic properties as shown by the clays were very plastic in nature which could be useful for molding ceramic and other refractory products (Figure 3). Therefore, drying and firing shrinkages would be relatively high during industrial production.

Beneficiation Methods used for samples.

Wet sieving method was used to know the grain size distribution. Clay was dissolved with water; there was an attraction between the particles of the clay and those of the liquid used. Due to this attraction, particles of the solvent were attracted to the solute particles. The random involvement of the solvent particles made the solute particles separated, the solute dissolved in the solvent that resulting in a solution for clay beneficiation process (Bridges, 1973). Undissolved materials and big clay grains are sieved out with a 45 micron sieve as samples to be used for minimum grain particles. These deposits, as found with the sample taken, were mainly fine and smooth grains with a means of 47% fireclay as beneficiated material. The clays also contained some coarsen materials as unwanted materials at an average of 53% (Figure 2).

Mineralogical Methods and Instruments Used

The clay geology, economy, physical, chemical, mineralogy and some main characteristic properties of the clay deposits have been specifically examined by writers such as Oyinloye, (1991); Ojo, (2009) and Oyinloye, (1988) respectively. In this research various tests were conducted on industrial implications and applications for improving the Ekiti manufacturing economy. Liquid and plastic limits of the clays were determined by plasticity index test for clays workability (Figure 3). For intensive study, differential thermal analysis, (DTA), X-ray-diffraction, (XRD) and X-ray fluorenscence, (XRF) methods and devices were used for the examinations of the minerals present in the sample. While atomic absorption spectrophotomentry (AAS) is used to study other major and minor elements and compounds present therein (Figure 1 and 4).

Solid minerals materials above 300 microns indicated various mineral materials as gravels and other large mineral particles. These mineral materials were largely present at above 53% of the representing sample taking for further examinations and analyses (Figure 3). Many scholars and researchers have used the term “mineral” in more extensive or extended sense to include anything of economic value extracted from the earth (Olarewaju, 1987; Ojo, 2009; Odeyemi, 1981). Alternatively, clay, quartz and granite should not be called minerals. Chiefly for reasons that these materials are not homogeneous both in chemical and physical compositions as found in various minerals. For instance, granite is found at Aramoko is the most abundantly igneous rock in Ekiti-State of Nigeria is composed of three main mineral constituents mica, quartz and feldspar. These three constituents and homogeneous mineral components occur in varying proportions and different parts of the same granitic mass (Rahaman, 1996, and Olarewaju, 1981).

The present study of Aramoko-Efon-Okemesi-Ijero-Ikoro axis reviewed and confirmed the localization of different clays, feldspar, sand, mica materials present that were found in very large quantities. These materials have been technically formed by the geological formations restricted to the basement of quaternary alluvial deposits (Rahaman, 1976). Economically, many industries could be generated from the ridges of Efon and Okemesi with the low lands from Aramoko to Ijero area. The potentiality of the various minerals with their industrial importance and reserve estimation in million tones materially would support Ekiti State industrialization (Faluyi, 2004).

Technically, the beneficiation process used control the oversized solid materials and other materials through wet sieving. Therefore, the above 300 micron and gravels indicated various other major quartzites, sand, cassiterite, columbite, tantalite, granite and charnockitic mineral materials (Oyinloye, 1988 and 1991, Steward, 1984).

Generally, these four deposits are also associated within the mixures of a wide (45 to 300) micron range of rounded particles sizes and as single phase solid solutions or compounds. Two samples of different particles shapes and sizes of less than 300 and 300 micron ranges are further examined with X-ray fluorescence (XRF) as presented in Table 1. Scientific analyses provide the elemental minerals present within the ores for characteristic evaluations (Stone, 2000). Significantly, there is a strong correlation within the fine rounded fine grains and the rough shaped mineral particles of above 300 microns (Chesters, 1973).

RESULTS AND DISCUSSIONS

Physical Examination and Instrumental Analyes.

Above 47% of grain size distribution of these deposits are found below 75 microns for fireclay samples. Therefore, 53% of the tested clays are made up of coarse and medium grain size of unwanted materials. Economically, the 75 micron clay should be advisably used for ceramic and refractory plant efficiently, milling time, energy capital and labour used would be reduced by 47 percent of the milling period for body slip preparation production industrially, the 53% unwanted material could however be economically used for burnt brick industry besides the main plants focused in this research project.

Beneficially, figure 4 shows the fractions of these fireclays within a cut 75 microns sieve size. Bigger grains of 0.0002mm could be avoided as sand grain. Mainly these particle sizes will be found at an average of 0.05mm. Technically they are removed due to the cut at sieve 75 microns. While the fireclay samples are technically used for multiple industries.

Material Compositional Analyses

X-ray diffraction (XRD); and differential thermal analysis (DTA) are used to study the mineral composition of these clays thermal. While the major minerals present are known with the (XRD) method by simple calculative analysis through standard charts. These majors minerals in the beneficiated clays are: Kaolinite with an average of 36%. Quartz of 8%; Feldspar of 3%, Montmorillite of 2% and illite of 1% only (Figure 2).

Furthermore confirmation is made with the use of (DTA) method with the standard or knows mineral sample charts. Mineral analyses (Figure 5) graphically explains the mineral relationship to the clay usage and industrial significance. Analytically, these clays could be advisably used for ceramic production industrially due to the beneficial minerals present with about 66% Kaolinite in the fireclays. More so, they could be used be used as refractory materials to withstand above 1550^0c temperature resultantly (Rhodes, 1968).

With the use of Atomic Absorption Spectrophotometry (A.A.S) method, major elements presented in the fireclays are presented in Figure 5. However, high percentage of 50% aluminum, 29% silicon, 6% calcium, 6% potassium, 20% sodium, 2% Iron, 11% loss on ignition show that these deposits are not residual fireclay (Aderiye, 2005 and Aniyi, 1985). Where aluminum and silica are remained after the leaching of other compounds such as alkaline, and alkalis residual fireclay is formed (Ahmed, 1986). Chemically, this removal could be due to high humidity or by water erosion within the tropical equatorial weathering. 3. 2% Iron content present could be removed by a magnetic device (Chesters, 1973). While aluminum and silica contents could be further tested by classical methods once the loss on ignition is known (Stone, 2000 and Doyle, 1979).

Characteristic Properties Analyses.

There are high shrinkage capacities with an average of 5% in all the deposits tested for dryness; and 6.5% for vitrification respectively at lower region of the geological axis of Aramoko, Ijero and Ikoro deposits. This is due to high organic material content present in such clay that weathered down by agents of erosion. At Efon and Okemesi there are sharp increase of shrinkage capacities with an average of 5% dryness and 2% for firing respectively.

While deposits below six meters downward fired white colour at 1450^0c temperature. Resultantly, reasonable colours from the deposits shown are excellent for silicate industries.

CONCLUSION

Huge resources identified within Aramoko, Efon, Okemesi, Ikoro and Ijero have been shown (Table 1 and Figures 1to3) in the study with their locations and economical evaluations. These large reserves of minerals deposits have significant benefits to Ekiti State within Nigeria in terms of industrial mining, processing and industrialization. Exploration, exploitation and utilization of these materials should be developed urgently through reasonable governmental policies. This study will definitely bring qualitative rural integration the three local government areas under studies. All the mineral depositional towns are planned to be provided with various processing plant to feed the manufacturing industries to be localized with the Ekiti State soonest.

RECOMMENDATION

Identified industries should be encouraged to be built in Ekiti State based on major raw materials found within the sedimentary geological formation. The old local ceramic plant found with the people of Ara Ijero should be upgraded. Researches should further be encouraged through various schemes such as graduate's empowerment and Self employment. Viable industries, employment and revenue will rapidly be achieved.

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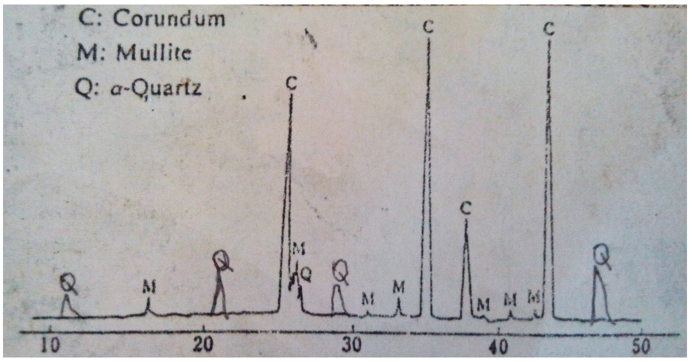
TABLE 1: SEDIMENTARY MINERAL DEPOSITS AT ARAMOKO, EFON, OKEMESI, IJERO, IKORO USING X-RAY FLUORESCENCE (XRF) LABORATORY TESTS.

Towns within the geological axis	ARAMOKO	EFON	OKEMESI	IJERO	IKORO	TOWNS AVERAGE	ARAMOKO	EFON	OKEMESI	IJERO	IKORO	TOWNS AVERAGE	Part per million
Elements	Conc. Value						Conc. Error						Unit
K	120	130	132	132	128	102	±7	±8	±8	± 7	± 7	±7	ppm
Ca	250	258	265	347	340	292	±12	±10	±10	± 12	±10	±11	ppm
Si	300	600	500	491	480	474	±12	±10	±10	± 14	±12	±12	ppm
Cr	6	7	8	8	10	8	±2	±2	±2	± 2	±2	±2	ppm
Mn	10	18	25	15	20	18	±5	±4	±5	± 4	±4	±4	ppm
Fe	18	32	30	21	25	25	±6	±5	±6	± 6	±5	±6	ppm
Al	350	288	200	365	400	321	±20	±18	±18	± 18	±20	±19	ppm
Na	15	12	15	13	10	13	±2	±2	±2	± 2	±2	±2	ppm
Zn	10	9	8	7	5	8	±3	±4	±3	± 4	±3	±3	ppm

Source: Aderiye and Akinwamide, (2013). Fieldwork of the project.



X-ray diffraction pattern of calcined kaolin

Figure 1: Presence of high alumina and silica contents are shown in the X-ray diffraction picture of calcined kaolin

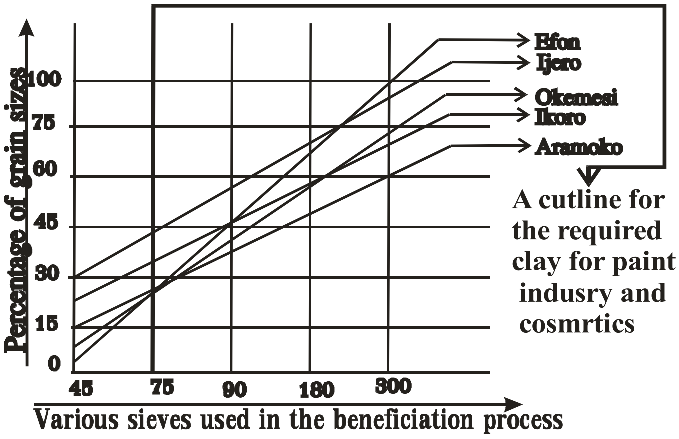


Figure 2: Beneficiation process graph of the sedimentary deposit for particle size distribution for the towns within the axis
Source: Aderiye, (2013). Fieldwork of the project.

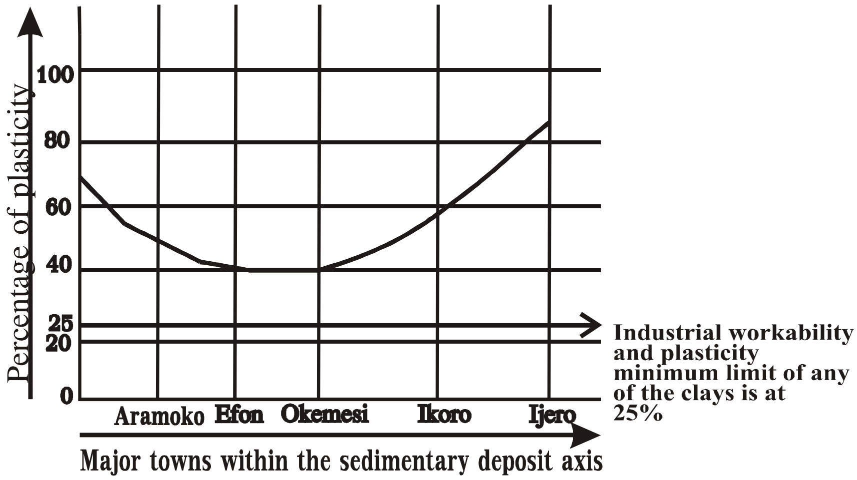


Figure 3: Plasticity indices of various mineral clays found at the various towns.Source: Aderiye, (2013). Fieldwork of the project

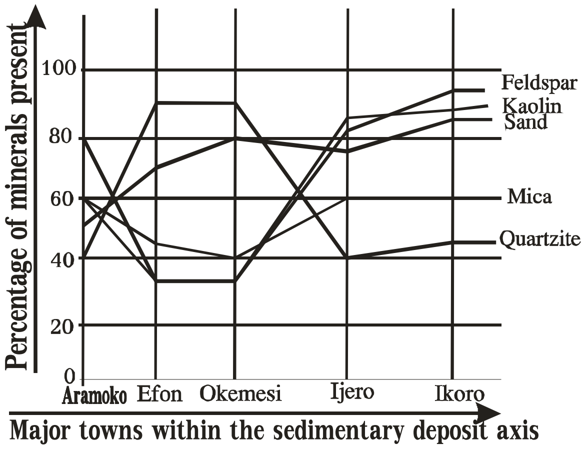


Figure 4: Mineral compositions as found at the town within the sedimentary zone.
Source: Aderiye, (2013). Fieldwork of the project.