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Sedimentary Mineral Depositions for Economic Development

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Abstract
Sedimentary minerals, clays, fireclays, quartz; silica sand; precious stones and granitic rocks are numerous within an axis of Ekiti-state. Intensively, fireclay deposits are found within ijero-Ikoro areas specifically.The mineral resources of Ekiti state have not been fully appraised due to insufficient research works and poor intensive studies. While the localization of these minerals is by geological formation within the basement and quaternary deposits. Scanty researches and little studies have identified very few number of mineral deposits in the state from 1942 till date. For example, fire clay as found contains profile of sand, kaolin and lateritic clays within the top soils of various huge deposits that are industrially and constructively useful. Other resources or minerals as found within the axis include Feldspar at Ikoro, gold and quartz are found at Efon and Itawure respectively. Feldspar and Gemstone are obtainable at Okeowu, Ikoro and Ijero intensively. Factually, the industrial mineral axis is technically examined under the present study. Where valuable minerals that are largely unevaluated before is technically evaluated for the industrial uses of 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 the rock type area along (Ijero-Ikoro-Okemesi-Efon-Alaye-Aramoko) geological formation axis for the economic growth and rapid development of Ekiti State.

INTRODUCTION

Geographically, drainage, relief and physical structures within the three local government areas of Ekiti State have shown mainly sedimentary deposition of various clays and fireclays in various very large quantities. These clays are found in various colours (ranging from white to grey with some brownish colour at intervals) mainly on the surface areas. Geologically, Ekiti-State clays are mainly found in variables inbetween two to eighty meters thickness. Exploration and exploitation studies have shown they are buried beneath with some over burden that are made of organic matters. These mineral materials are mixed with lateral clay materials in a most dispositional way within an area. If evacuated and beneficiated, unwanted materials are less than three metres thickness. Thereafter, minerals are technically sampled and examined before they are processed for use (Aderiye, 2005).

With the use of probing holes and geological evaluations of the Ijero-Ikoro-Okemesi-Efon axis. Commercial viable materials are found at above thirty million metric tones of fireclays with other materials. Specifically, apart from other associative minerals that are present in figure 1, fireclays could not be characteristically evaluated at the initial. When examined with X-ray diffractometer (Figure 2) and X-ray Fluorescence (XRF), Atomic Absorption Spectrotometer (AAS) experimentally, most deposits have fireclay largely with Feldspar, Silica, Zinc and Mica minerals in large reserves (Table 1). In addition, gravels,granite and quartz with some other minor associative minerals are also found with the three probling technological devices. Physically, at Aramoko and Ijero axis, the transported fireclays found is the largest mineral deposit. Due to transportation they are found to be very smooth and fine grains even before the benefication process takes place. However, coarse grains are also found at the top surface of the clays at about five meters upwards due to sedimentation process (Figure 3). Other characteristic properties as shown by the clays are that they are very plastic in nature which could be useful for moulding ceramic and refractories, paints and other industrial products. Therefore, drying and firing shrinkages will be relatively high during industrial production of ceramic wares and refractories bricks (Figure 4).

MATERIALS AND METHODS USED FOR THE SEDIMENTARY AXIS DEPOSITS.

Emperical evidence and literature survey indicate many researchers and scholars have worked on this axis before. Some characteristic and geological studies have been made by Oyinloye, (1991) and Aderiye, (2005) on Ijero deposits. While the characteristic properties of Ikoro and Ijero have also been examined previously by Oyinloye, (1988) and Oyinloye (1998). Infact, majority of these scholars submitted that as a result of equatorial weathering of western region of Nigeria, various secondary fireclay deposits are found in Ijero environs (Olarewju, 1987). However, most Nigerian researchers have technically distinguished their various explanations with the association of equatorial deep weathering within Ijero local government area, (Aniyi,1985; Ahmed,1986).

Analytically, all these explanations have also shown that major deposits to be examined is probably fireclay deposits at Aromoko, Ikoro and Ijero areas. These deposits are specifically planned for benefication and constructive industries for Ekiti-State (Shittu, 1998). Mineralogically, fireclays are mainly natural earthly fine grains that are crystalline particles packed together in a solid, but very energetic thermally. Yet strongly attracted and packed closely with their definite shapes and volume. They do not usually flow like literitic clays (Rhodes, 1968). They are usually used as industrial mineral for ceramic manufacturing majorly.

Within Ekiti-State there are numerous clay deposits aside fireclays. But residual clay and fireclays are found within the Ijero Local government areas mainly. Noteably, they could be industrially used for furnance bricks, sanitary and dinner wares production specificially (Doyle, 1979). Since the clay deposits are mainly Kaolinitic in nature when examined. They could be also processed for refractory industries that required above 25% alumina content for the Nigerian heating industries. This is based on the clay quantity , and quality of these deposits. (Chesters, 1973). Refractory clays have not been fully utilized adequately in Ekiti-State industrialisation. However, at Ikoro and Oke Owu the whitish variety clay may be refered to as kaolin, otherwise called China clay. While the coloured ones (brownish types) found at Efon and Okemesi could be classified as lateralistic clays, because they are high in plasticity. This makes it workable industrially. Wet clay is somehow workable than dry ones industrially (Heckroodt, 1994).

Characteristically, quartz is found in Ijero and Efon local government areas largely (Figure 5). The quartz mineral is economically viable for manufacturing industries such as glass wares,sand paper, and building industries. The colour quartz could be used for building and refractory bricks industries. While metals like iron and Chromium oxides are useable in refractory and electrical insulators as minor minerals. These are associative industries planned to be established within Efon and Okemesi areas that have no clay. But the two towns have minerals such as Sand, Quartz and Feldspar. These mineral mterials could be used to improve Ekiti-State economically. Apart from these industries, processing plants for Zinc, Colobite, Mica and other precious stones like gemstones would be established at Ikoro and Oke Owu. Processing plants could also be established for the Nigerian economy. While high revenue is expected yearly for Ijero and other local government areas,if the research recommendations are implimented or upheld by the Ekiti state policy makers on industrialization.

BENEFICIATION METHODS USED FOR SAMPLES.

Wet sieving method is used to know the grain size distribution, when clay dissolve in liqid water, there is attraction between the particles of the clay (solute). And those of the liquid used (solvent). Due to this attraction, particle of solvent attract themselves to the solute. The random involvement of the solvent particles makes the solute particles separate and spread out as a result, the solute dissolves in the solvent that resulting in a solution (Bridges, 1973). Undissolved clay grains are sieved out with a 45 microns sieve as samples to be used for minimum grain particles. These deposits, as found with the sample taken, are mainly fine and smooth grains with 47% fireclay as beneficiated material. While they also contains coarse materials as unwanted materials at 53% (Figure 3).

GEOLOGICAL METHODS AND INSTRUMENTATION USED

Geological economy, Physical, chemical and mineralogical compositions with some main characteristic properties of these deposits have also been specificially examined by some writers in journals (Oyinloye, 1991 and Ojo, 2009). In this research however various tests are therefore conducted on industrial implications and applications for improving the Nigerian manufacturing economy. While liquid and plastic limits of these clay are determined using the plasticity index test for clays workability (Figure 2). For intensive study, differential thermal analysis, (DTA), X-ray- diffraction, (XRD) and X-ray fluorenscence, (XRF) methods with some other devices are used for the examination 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 (Figures 2 and 5).

The geological controls of solid minerals above 300 microns indicates various major minerals are in gravel or in large particles forms. These minerals are largely present at above 53 percent of the representing sample taken for further examinations and analyses. Many scholars and researchers have use the term “mineral” in more extensive or extended sense to include anything of economic value extracted from the earth (Olarewaju, 1981; Ojo, 2009; Odeyemi, 1981). Alternatively, clay, quartz and granite should not be called minerals. Simply because 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 aboundantly igneous rock in Ekiti-State of Nigeria. It is composed of three main mineral constituents (Mica, Quartz and Feldspar) (Olarewaju, 1981). These are three constituents and homogeneous mineral components that occur in varying proportions, which is found in different parts of the same granitic mass (Rahaman, 1996, Oyinloye, 1988).

The present study of Aramoko-Efon-Okemesi-Ijero-Ikoro axis reviewed and confirmed the localization of different clays, feldspar, sand and mica materials are present in very large quantites. 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 within the plain lands of Aramoko to Ijero area. The potentiality of the various minerals with their industrial importance and reserve estimation are in million of tones. This could eventually and materially support the Ekiti State industrialization (Faluyi, 2004).

Technically, the benefication controled the oversized solid material and other materials through wet sieving. Therefore, the above 300 micron and gravels indicate various other major (quartzites, sand, cassiterite, columbite, tantalite, granite and charnockitic) mineral materials. These gauges constitute above 53 percent of the representative sample taken at the random sampling. Most mineral ores from the axis are mixtures of extractable minerals and other extraneous rocky or peblic materials. Instrumental examinations screened the gangue materials as oxides, silicates and other complex ores (Wills, 1992). Largely, complex ores are traceable to Ijero local government area of the axis. Within 23 towns and other land areas specifically examined; Ijero, Ikoro, Ipoti and Ayetoro are rich in various minerals (Table 1 and Figure 1).

Generally, these axis deposits are also associated with mixures of a wide (45 to 300 micron) range of rounded particle sizes and as single phase solid solutions or compounds. Two samples of different particle shapes and sizes of less than 300 and above 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 grains and the rough shaped mineral particles of above 300 microns (Chesters, 1973).

Summarily, the present study of the axis reviewed and confirmed the localization of various clays, feldspar, sand and mica materials to have formed by geological formation. However, sedimentation of minerals at Ijero local government areas makes the region aboundant in clay and feldspar at Ikoro, Ijero and Oke-owu. These (clays and feldspar) deposits are enough for exploitation as identified during the research experimentations and surveys. The deposits are all mainly kaolinitic in composition. But they vary in physicochemical properties. Through experimentations, examinations and physical tests these are clay found with feldspar (Steward, 1984 and Stone, 2000).

RESULTS AND DISCUSSIONS

INSTRUMENTATION ANALYSES FOR PHYSICAL EXAMINATIONS AND GRAIN SIX DISTRIBUTION ANALYSES

At above 47 percent grain size distribution of these deposits are found below 75 microns for other clays and fireclay samples. Therefore, 53 percent of the tested clays are made up of coarse and medium grain sizes of unwanted materials. Economically, the 75 micron clay should be advisably used for ceramic and refractory plant efficiently (Rhodes, 1968). Milling time, energy, capital and labour used could technically be reduced by 47 percent of the milling period for body slip preparation and wares production. The 53 percent of the unwanted materials could however be economically used for burnt brick industry besides other plants locally established for this axis in this research project.

Beneficially, figure3 shows the fractions of these clays and fireclays within a cut 75 microns sieve size. Bigger grains of 0.0002mm could be avoided as sand grain. Mainly sand particle sizes will be found at an average of 0.05mm. (Wills, 1992). Technically they are removed due to the cut at sieve 75 microns. While other clays and fireclay samples are technically used for multiple glass wares, paint and cosmetic industries.

INSTRUMENTATION ANALYSES FOR MINERALOGICAL AND CHEMICAL COMPOSITIONS

X-ray diffraction (XRD); and differential thermal analysis (DTA) are used to study the mineral composition of these clays thermally. 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 that calcined to corundum and mullite with an average of 56%, Quartz of 28%, Feldspar of 10%, Montmorillite of 4% and illite of 2% (Figure 2). Furthermore, confirmation is made with the use of (DTA) method with the standard of known mineral sample charts. Minerals are analysed graphically which explains these minerals relationship to the other usage with other industrial significance (Figure 5). Analytically, beneficiated clays could be advisably used for ceramic production industrially due to the beneficial minerals present with about 56% Kaolinite found in the clays. They could be used also as refractory materials to withstand heat at above 1550^0c temperature resultantly (Rhodes, 1968).

With the use of Atomic Absorption Spectrophotometry (A.A.S) method, major compounds presented in the fireclays are (Table 1) high percentage of 45% aluminum, 39% silicon, 6% calcium, 4% potassium, 6% sodium, 2% Iron, 8% loss on ignition. This explains that these deposits are not residual, but secondary fireclay (Aderiye, 2005 and Aniyi, 1985). Where aluminum and silica are remained after the leaching out of other compounds such as alkaline, and alkalis residual fireclay is formed (Aderiye, 2005 and Ahmed, 1986). Chemically, this removal could be due to high humidity or by water erosion within a tropical equatorial weathering. For purification method, 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). Theoretical analyses of Figure 2,3,4,5 have shown that through modification methods characteristic materials could be added to produced other composites or technical products (Doyle, 1979).

CHARACTERISTIC PROPERTIES AND QUALITY CONTROL ANALYSES.

There are high shrinkage capacities with an average of 6.5% in all clay and fireclays deposits tested for dryness; and 5% for vitrification respectively at the 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 clay deposits below six meters downward fired white colour at 1450^0c temperature. Resultantly, reasonable colours from these clay deposits have shown they are reasonable raw materials for most silicate industries.

While those with brownish colours could be used for burnt brick industry. Therefore, no mineral material is wasted with the model characteristic and analytical techniques used to examine the samples produced in this study. Industrial production could be made using these identified minerals and fireclays from the three local government areas.

CONCLUSION

Huge viable resourses are identified within Aramoko, Efon, Okemesi, Ikoro and Ijero shown in the study with their specific locations and economical evaluations. However, very large reserves of five main minerals deposits have very significant benefits to Ekiti State in terms of industrial mining, processing and industrialization. Mining methods for the minerals have also been technically identified. Exploration, exploitation and utilization of the five mineral materials should therefore be developed urgently through reasonable governmental policies. Majority of Ekiti State citizens are highly educated and industrious, hence they should be encouraged through active industrialization policies. Although industrial activities of minor exploration and exploitation are taking place, lack of fund is responsible for the low turnover of these local miners. Machineries and fund should therefore be provided for the Ekiti State registered mining companies. This will increase the state revenue through taxation and other commercial activities. This will also bring qualitative rural integration within the three local government areas. All the mineral depositional towns are planned to be provided with various processing plant to feed the manufacturing industries.

RECOMMENDATION

Identified industries in the research should be encouraged to be built in Ekiti State based on the major five mineral raw materials found within the sedimentary geological formation. The old local ceramic plant found with the people of Ara Ijero should also be upgraded for the town economic upliftment. Researches should further be encouraged on the local miners and their activities for improvement.

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TABLE 1: SEDIMENTARY MINERAL DEPOSITIONS FOR ECONOMIC DEVELOPMENT OF ARAMOKO, EFON, OKEMESI, IJERO, IKORO, AND THE GEOLOGICAL AXIS AVERAGE, USING X-RAY FLUORESCENCE (XRF) LABORATORY TESTS.

Towns within the geological axis	ARsAMOKO	EFON	OKEMESI	IJERO	IKORO	TOWNS AVERAGE	ARAMOKO	EFON	OKEMESI	IJERO	IKORO	TOWNS AVERAGE	
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.

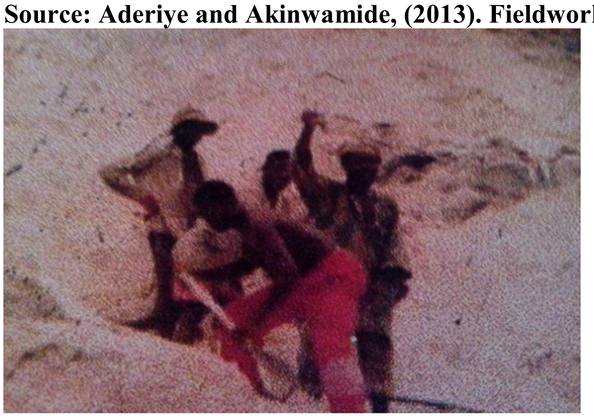
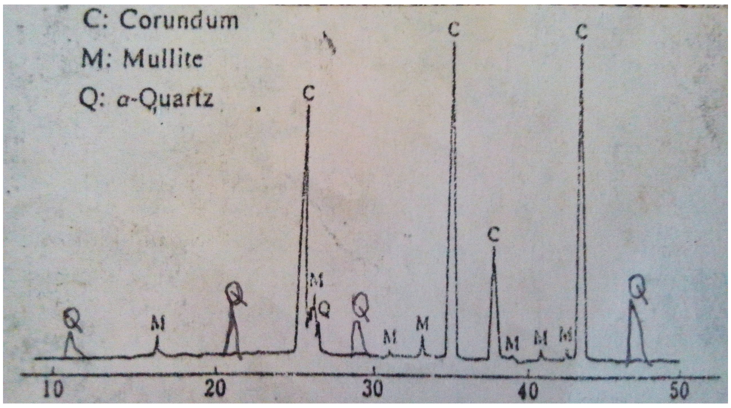


Figure 1: Supporting staff and researchers are using manual (open cast mining) method with the probing holes to calculate the area of the mineral axis between Ijero and Oke Owu township.
Source: Aderiye and Akinwamide, (2013). Fieldwork of the project.



X-ray diffraction pattern of calcined kaolin at 1600c temperature.

Figure 2: Presence of high alumina and silica contents are shown in the X-ray diffraction picture of calcined kaolin

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

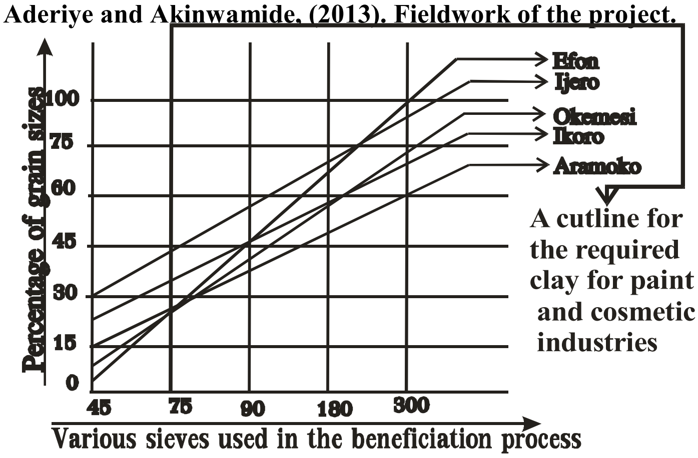


Figure 3: Beneficiation process graph of the sedimentary deposit for particle size distribution for five towns within the axis

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

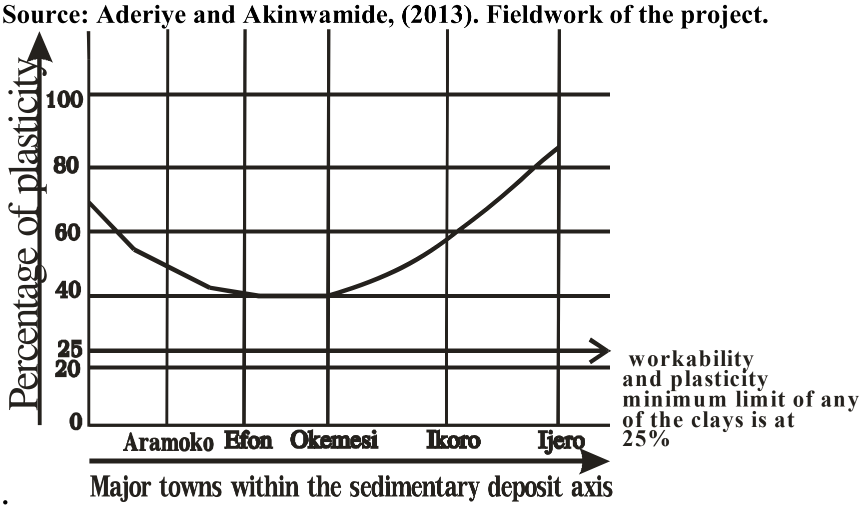


Figure 4: Plasticity indices of various mineral clays found at the various towns within the axis.

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

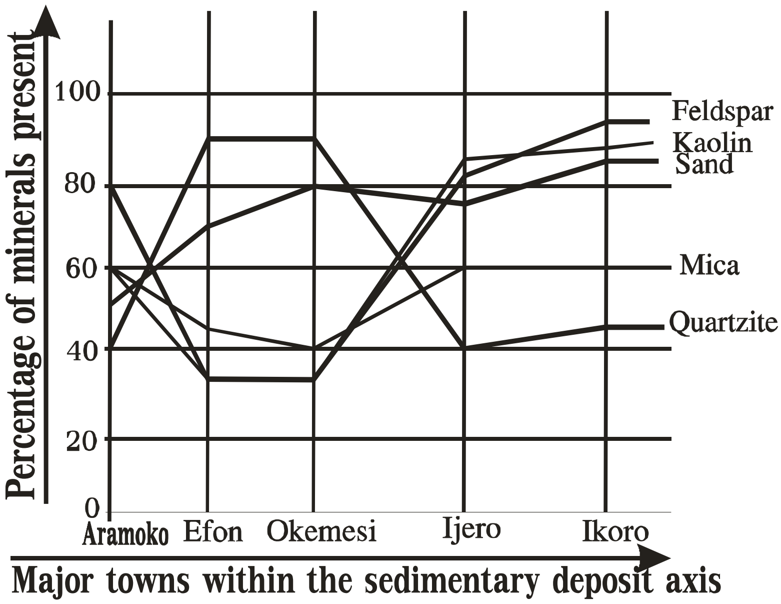


Figure 5: Mineral compositions as found at the town within the sedimentary axis.
Source: Aderiye and Akinwamide, (2013). Fieldwork of the project.