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COMPOSITIONIAL AND INDUSTRIAL ASSESSMENT OF ISUA-AKOKO, AKURE, AYADI AND LAFE (ODE AYE) CLAY DEPOSITS OF ONDO STATE, NIGERIA

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ABSTRACT

The physical and chemical properties of clay deposits around Isua-Akoko, Akure, Lafe and Ayadi in Ondo State southwestern Nigeria have been examined. The results have shown that Isua-Akoko, Akure and Lafe Clays are plastic fire clays while Ayadi clay is kaolinite. Grain size analysis reveals that Isua Akoko Clay contains 45% of clay, 18% silt, 12% fine sand,14% medium sand and 11% coarse sand and no gravel; Akure clay contains 42% clay, 14% silt, 13% fine sand, 20% medium sand and 8% coarse sand with 1% gravel. Lafe Clay contains 21% clay, 8% silt, 25% fine sand, 37% medium sand and 8% coarse sand with 1% gravel while Ayadi clay contains 83% clay and 17% silt. The liquid limits of these clay samples range from 41% to 73%% and plastic limits range from 18% to 26% respectively. The chemical analysis reveals that the most abundant mineral is silica (60.97%) and aluminum was next in abundance (23.69%) while other oxides are low. The results show that Isua-Akoko and Akure are residual while Lafe and Ayadi are sedimentary and transported Clays. The firing test, $_{P}$H, and bleaching tests of the clays are also discussed. The chemical and physical characteristics of the clay deposits are strongly indicative of their industrial importance in the production of ceramics, refractories, paving bricks, paint and pharmaceutical products.

KEYWORDS: Kaolinite, fire clay, gravel, ceramics and alumina.

INTRODUCTION

Clays are very useful raw materials from which many domestic and commercial wares can be manufactured. In Nigeria, clay deposits have not been utilized adequately considering the qualities of this type of industrial mineral that occurs in the country. This may be due to lack of geological information on the assessment of the clay deposits and what they can be used to manufacture. It is very pertinent that the physical and chemical properties of any clay deposit should be ascertained for industrial uses.

The geology of Akure and Isua Akoko (Fig.1) areas is part of the basement complex of Nigeria which have been well studied by Oyawoye (1964), McCurry 1976), Turner (1983), and Rahaman (1984) while geology of Ayadi and Lafe which is part of eastern Dahomey basin have been studied by Burke and Dewey (1974), Omotsola and Adegoke (1981). The major rock units found in both Akure and Isua include porphyritic charnokite, migmatite gneiss, granite gneiss (Fig.2), while the major rock found in both Lafe and Ayadi include Sandstone, shale, limestone and some Clay intercalations. Mineralogically, the gneisses in both Akure and Isua have been found to be composed of quartz, biotite, plagioclase feldspar and traces of accessory minerals such as Zircon, tourmaline and staurolite while the sandstones in both Lafe and Ayadi have also been found composing of accessory minerals like rutile, iron oxides and opaque minerals (Elueze and Bolarinwa (1995).

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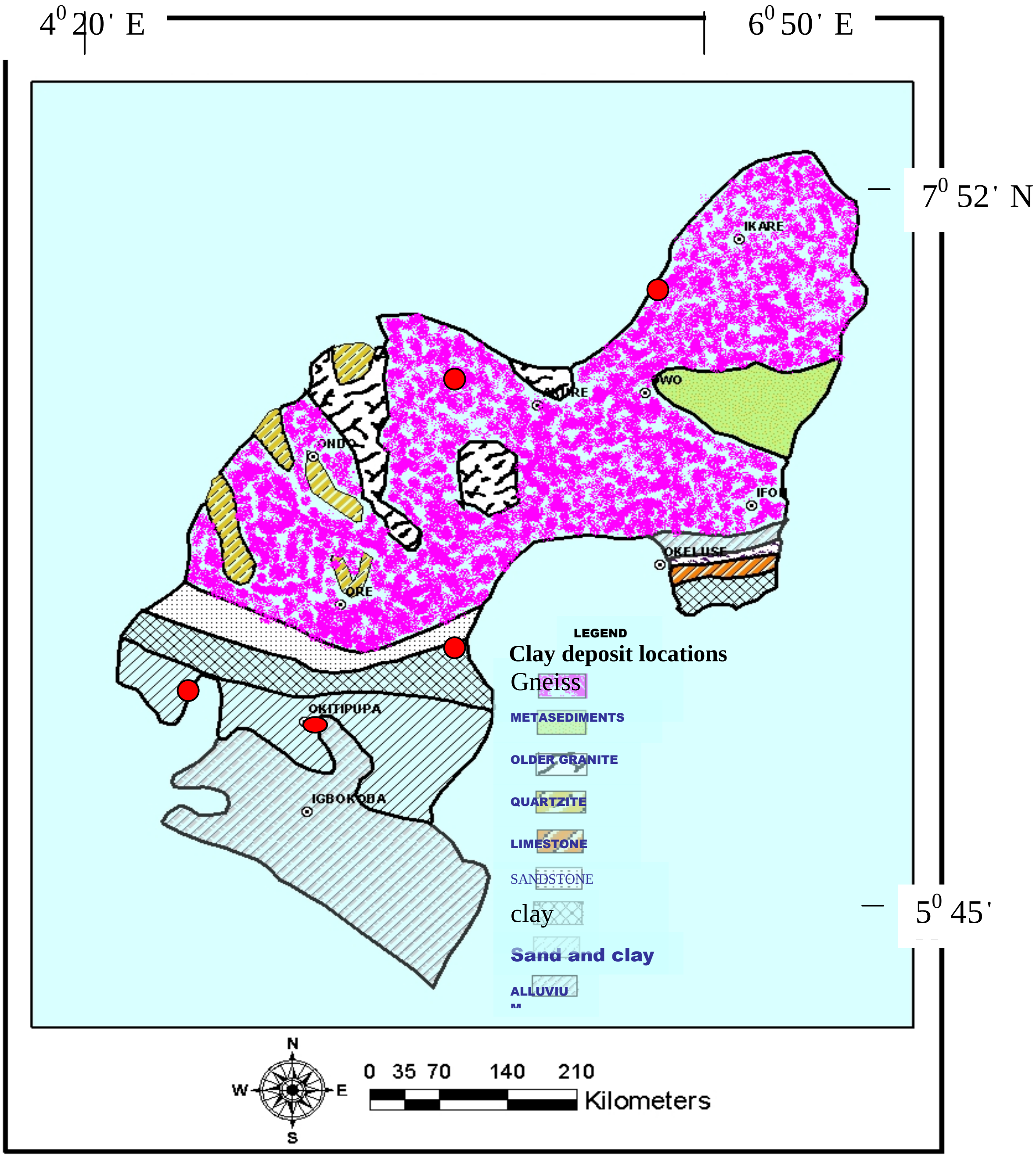
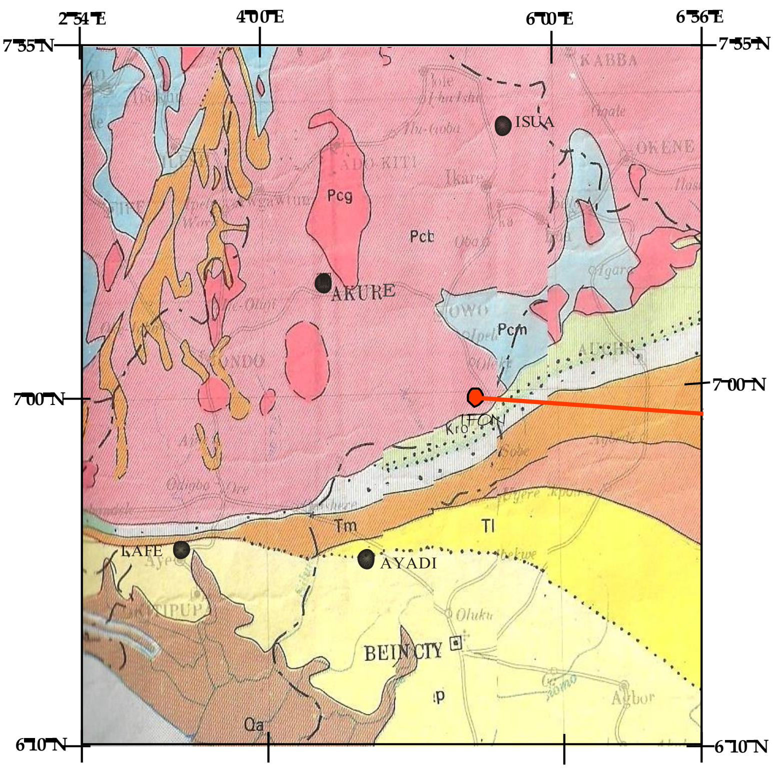


Figure 1: Geological map of Ondo State showing the location of the clay deposits. (Nigeria Geological Survey Agency, 2004).



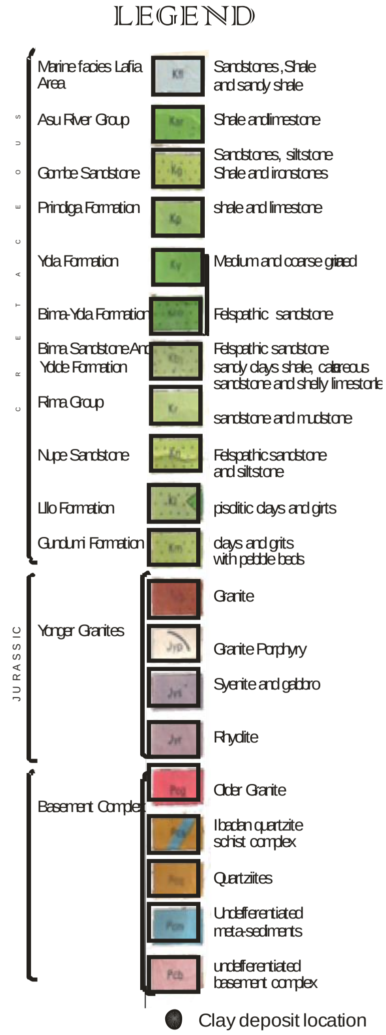


Fig.2: Geological map of the study area showing the clay locations
Source: Extracted from Geological Map of Nigeria, 1974 Compiled by the Geological Survey of Nigeria, (GSN)

These clay deposits lie on equatorial region where weathering is deep and erosional surfaces can be seen on the outcrops. As a result of tropical weathering, there are vast deposits of residual clay at Akure and Isua and vast deposits of sedimentary clays at Lafe and Ayadi in Ondo State. This present work therefore reports the physical and chemical properties of clay deposits from Isua Akoko, Akure, Ayadi and Lafe in Ondo State, southwestern Nigeria in order to assess the industrial applications of the Clays.

MATERIALS AND METHODS

Thirty two fresh representative samples were collected from the four locations. However, eight samples from each of the locations were prepared for physical and chemical analyses. Hydrometer method and wet sieving analyses were used to determine the grain size distribution of Isua-Akoko, Akure and Lafe while hydrometer test was used to determine the grain size distribution of Ayadi Clay because it is predominantly made up of Clay. Liquid and Plastic limits were determined using Cassangrade (1948) apparatus. Representative samples were made into pellets using a pressure gauge. These pellets were fired at about 950ºC for about 24 hours to determine the shrinkage capacity and colour change of the clay deposits. Samples were also selected for the physical tests (firing, shrinkage. $_{P}$H and bleaching). Elemental analysis of the clay samples were carried out using bulk scientific Atomic Absorption spectrophotometer (AAS) model 210VGP for the concentration of Si, Al, Fe, Mn while Na, K and Ca were determined by flame photometer. The suitability of the clay for the production of paints were also examined.

Table 1: Grain size distribution (%) of the Ishua, Akure, Lafe and Ayadi clays.

Location	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand(%)	Coarse Sand(%)	Gravel (%)
Isua	45	18	12	14	11	0
Akure	42	14	13	20	10	1
Lafe	21	8	25	37	8	1
Ayadi	83	17	-	-	-	-

Table 2: Physical and firing properties of the Ishua, Akure, Lafe and Ayadi clays.

Location	**pH**	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage(%)	Bleaching Test	Colour after Firing
Isua-Akoko	5.24	46	28	10,0	No change	Bright Brown
Akure	4.56	49	28	8.6	in colour for	Redish Bluff
Lafe	4.71	41	19	9.3	all the clays	Pinkish Brown
Ayadi	4.76	72	46	14.3		

RESULTS AND DISCUSSION

Grain size distribution

The determination of grain size distribution in a clay deposit is very important in the evaluation of clays for industrial uses. This is because the grain size of clay particles affects the quality of finished clay products (Oyinloye, 1991). The results of the grain size distribution of the clay deposits as presented in the Table (1) show that Akure, Isua and Lafe Clays to be coarsely grained while Ayadi Clay is fine grained. By plotting percentage finer against particle size (mm) for each of the clay samples, it can be inferred that the Isua-Akoko Clay contains 36% of Clay, 16% silt and 47.5% sand with no gravel; Akure Clay contains 42.5% Clay, 13.5% silt, 44.5% sand with 1% gravel; Lafe Clay contains 16% clay, 7.5% silt, 71.5% sand with 11% gravel while Ayadi Clay contains 83% Clay and 17% silt with no gravel. The results of the grain size distribution of Isua, Akure and Lafe show relatively high sand fraction which is the characteristic of residual clay deposit while Ayadi clay deposit is predominantly made up of clay fraction typifying a sedimentary type. This result suggests that milling operations will be required during the industrial use of Isua, Akure and Lafe Clays.

Liquid and Plastic Limits

The results of the liquid and plastic limits analyses reveal that these clay deposits have liquid limit values ranged from 41% to 73% and plastic limit values ranged from 18% to 26% (Table 3). The result of the liquid limit shows that Isua, Akure and Lafe Clays are less than 50% while Ayadi Clay is greater than 50% indicating that Ayadi Clay retained more water than the other clays. Also, the result of the plastic limit of the clay samples reveal that they are moderately plastic. The plasticity indices of all the clay samples range from 19% to 47% (Table 3). Using plasticity chart for the classification of clays by Cassagrande (1948), it can therefore be inferred that Ayadi Clays are very poor in sub-grade because of their high compressibility, whereas, Akure and Isua Clay samples are fair in sub-grade because they are clay of intermediate compressibility. Lafe Clay samples are fair to poor in sub-grade due to the high percentage of sand in the Clay samples (Fig 3). Using Bain (1971) method of classification of soil, Ayadi clay deposit plotted in the kaolinite field while Isua, Akure and Lafe Clays plotted in the plastic kaolin, (Fig 4). By comparing the viscosity of these clays with the work of Ajayi, 2009 (Table 3) it can be inferred that Ayadi is light and can be easily moulded and would retain its moulded shape when dried. The viscosity of Akure, Isua and Lafe Clays are greater than the standard 6 poise being used in the paint industry and this can be thinned down to 6 poise by adding water. This shows that these clays can be used as pigment in paints industries.

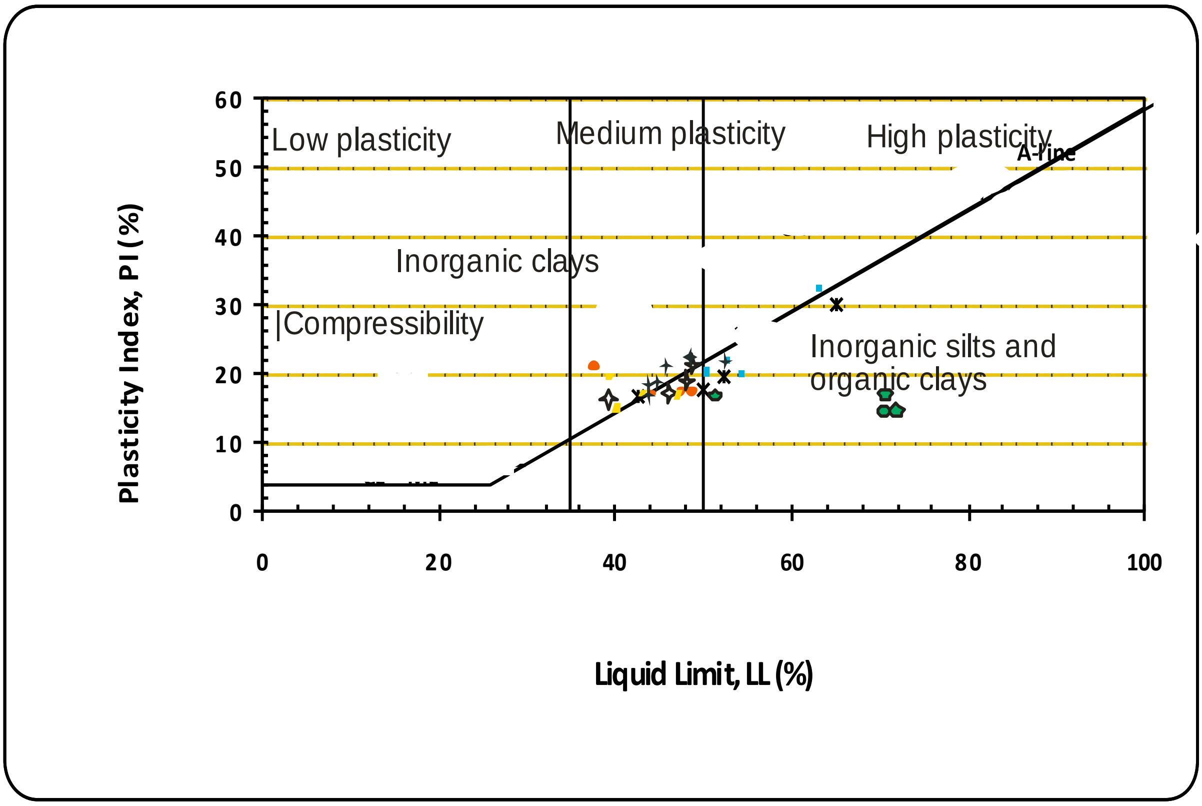


Fig.3: Plasticity chart for the classification of the lateritic clay bodies. (after Cassangrande, 1948)

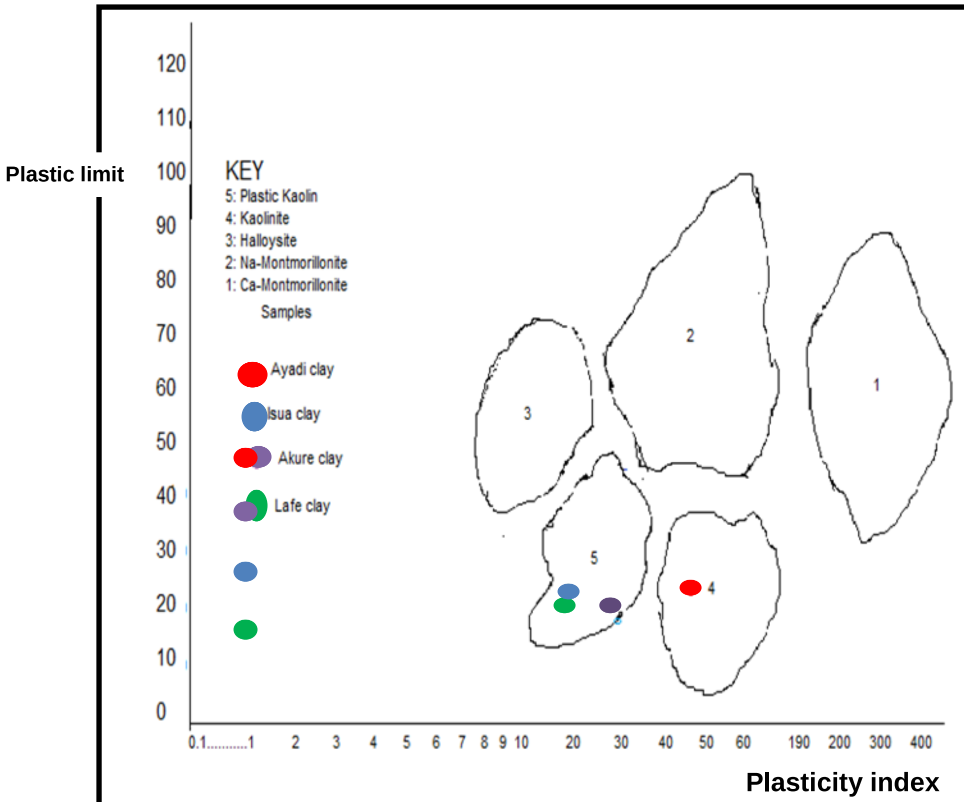


Fig.4: Clay identification chart using plastic limit and plasticity index as a parameter (after J.A Bain, 1971)

Firing characteristics

The results from the firing and colour test (Table 2) show that Akure and Lafe Clays contain a lot of iron impurities as observed from their reddish firing colour. Isua and Ayadi clay samples show colours that can be improved upon, that is, if they are to be used to produce table ceramic wares. The result has shown that, Ayadi and Isua are kaolinite clays while Akure and Lafe are plastic fire clay. Invariably, it is observed that these clay samples also will serve as raw materials in the production of burnt bricks and tiles due to the exhibited vitrification and stability properties they.

$_P$H Test and Bleaching Test Result

The result of the $_P$H values for the clay samples shows that they are acidic, which implies that the clay are not good for agricultural purposes. The bleaching test for all the samples give no colour change, which implies that the colour of the samples need not to be improved through bleaching with HCL (Table 2)

Table 3: Comparison of Viscosity of the Paints Produced from 25% of Clay and 75%Titanium dioxide and 100% Clay (Ajayi, 2009)

This study		Viscosity of paint produced clays from part of Ekiti,Nigeria (Ajayi, 2009)	
Location	Viscosity (poise)	Location	Viscosity
Ishua	9.57	MT 1 - Ido-Ile	11.40
Akure	11.34	MT 3 - Ipole	11.40
Lafe	13.32	MT 4 -Ikere	16.40
Ayadi	17.10	MT 5 -Ketu	16.40
		MT 6 – Adieowe	14.40

Table 4: Average chemical compositions of Ishua, Akure, Ayadi and Lafe clays with some industrial chemical specifications

Oxides	* Ishua (Gray) %	*Akure (Brown) %	*Ayadi (White) %	* Lafe (Yellowish) %	Reference samples A(%)	B(%)	C (%)
SiO_2	56.87	60.70	58.47	67.85	52.92	57.67	46.88
Al_2O_3	24.36	21.53	29.19	19.66	37.00	9.42	24.65
Fe_2O_3	2.98	11.37	1.45	3.35	2.65	3.23	0.88
CaO	2.97	2.97	1.42	1.83	1.91	0.70	0.03
MgO	1.61	1.61	0.09	0.56	0.08	0.30	0.13
Na_2O	0.21	0.21	1.05	0.27	0.03	0.20	0.21
K_2O	1.47	1.47	0.88	0.83	0.98	0.50	1.60

Average values for 8 samples
A - Florida active Kaolinite (Huber,1985)
B - Plastic Fire clay, St. Louis (Huber,1985)
C - (China Clay (Huber,1985)

Table 5: Comparison of the Ishua, Akure, Ayadi and Lafe clays with some industrial chemical specifications

Oxides	* Ishua (Gray) %	*Akure (Brown) %	*Ayadi (White) %	* Lafe (Yellowish) %	Some industrial specifications A(%)	B(%)	C (%)
SiO_2	56.87	60.70	58.47	67.85	45.30-47.90	67.50	51.0-70.0
Al_2O_3	24.36	21.53	29.19	19.66	37.90-38.40	26.50	25.0-44.0
Fe_2O_3	2.98	11.37	1.45	3.35	13.40-13.80	0.50-1.20	0.2-0.7
CaO	2.97	2.97	1.42	1.83	0.03-0.25	0.18-0.30	0.1-0.2
MgO	1.61	1.61	0.09	0.56	0.20-0.30	0.10-0.19	0.2-0.7
Na_2O	0.21	0.21	1.05	0.27	0.20-0.35	0.20-1.50	0.8-3.5
K_2O	1.47	1.47	0.88	0.83	0.10-0.40	1.10-3.10	-

Average values for 8 samples
A-Paints (Payne, 1961)
B-Ceramics (Singer and Sonja, 1971)
C-Refractory Bricks (Parker, 1967)

Chemical composition

It is pertinent to have the knowledge of the chemical composition before using it in the industries. Some elements if concentrated in the clay beyond certain amounts can be very deleterious quality of clay to the finished products (Oyinloye, 1991 and 1997). If quartz for instance is too high in a clay deposit, the plasticity of the clay may be reduced which will make molding difficult (Ajayi and Agagu, 1981, Bolarinwa and Elueze 1995, Elueze et al. 2004). The result of the chemical composition of the deposits as shown in (Table 4) reveal average value of the silica content of the clay samples to be 60.97%, the average value of alumina content is 23.69%, while the average value of iron is 2.66%. average concentrations of calcium and sodium are 1.55% and 0.19% respectively.

A comparison of the chemical composition of these Clays with the work of Huber, (1985) (Table 5) shows the Clay types compared favourably with the Florida active kaolinite and plastic fire clay.in terms of industrial applications (Table 5). These chemical compositions are within the limit of industrial specification for ceramic (Singer and Sonja, 1971), refractory bricks (Parker, 1967) and building bricks (Murry,1960).

Also, from the result of the chemical test, it was observed that all the clay samples contain more than 50% SiO_2. This therefore makes clays from these areas suitable for heavy ceramic product. The ultimate goal of any geological investigation on clay deposits is to be able to recommend it for industrial use and this depends on the physical and chemical characteristics of the clay. The present results of the physical and chemical properties of these clays reveal that the clay are kaolinitic and plastic kaolin. These types of clays can be used for ceramic product such as floor tiles, wash hand basins, jugs, plate, tea cups kettle and water closets e.t.c

CONCLUSION

The study reveals that clay deposits in Isua-Akoko, Akure, Lafe and Ayadi are kaolinitic clay and plastic kaolin. These kaolinitic clays are found to be very good raw materials for the industrial production of ceramics, paints and refractory, low alumina chemical pharmaceutical products and as addictive in cement industries.

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