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ASSESSMENT OF OXIDE PROPERTIES OF CLAY DEPOSITS FROM ANAMBRA GEOLOGICAL BASIN FOR THEIR SUITABILITY AS CERAMIC RAW MATERIALS

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Abstract
Many ceramic companies that use clay as their chief raw material are springing up across the country. There is need to continuously explore for clay deposits to feed these industries. Atomic Absorption Spectrometry was used to analyse the oxide contents of fifteen clay samples obtained by pitting and trenching methods from Abia, Imo and Anambra States in the Anambra geologic basin of Nigeria. The depth and in situ characteristics of the clay deposits were also evaluated. Four samples taken at Nsukwe in Abia state have deposit thicknesses varying from 0.8 m to 1.5 m with light pink, brown and black colours. Three samples taken from Ikwuano in Abia state have deposit depths from 0.5 m to 1.2 m and are grey to brown in colour. Four samples taken from Okigwe in Imo state have deposit thicknesses of about 0.5 m to 1.0 m along a single stratum. The colour is mostly greyish. Four samples taken from Ozubulu in Anambra State have deposit thickness from 0.7 m in some areas to 2.4 m within a single stratum. An average of ten oxides were identified in the four locations. SiO_2 and Al_2O_3 were the dominant oxides. SiO_2 mean values of 55.9%, 48.3%, 63.5% and 63.9% were recorded for Nsukwe, Ikwuano, Okigwe and Ozubulu respectively. Al_2O_3 mean values of 25.92%, 31.45%, 11.13% and 12.45% were recorded for Nsukwe, Ikwuano, Okigwe and Ozubulu respectively. Our findings show that there is no single deposit in the region that has a suitable set of oxide contents required in the manufacturing of ceramic products. A blend of the material mix would achieve a desirable raw material mix for ceramic raw material.

Keyword: Clay deposit, raw material, mineral reserve, clay mineral characteristics

Introduction

Clay is a fine grain, earthy, and naturally occurring argillaceous material (Grim, 1962) which formed from the weathering of silicate-bearing rocks. Clay mineral grain size is generally less than 2 microns. Clay deposits are important raw materials in the manufacturing of ceramic products where they act as the main binding agents, and may also provide the fluxing medium. Clay are sedimentary rocks which either remain in the region of weathering as a primary clay deposit or are transported and deposited in a low-energy area as a secondary clay deposit. Clay deposits have several uses. It is used in the manufacturing of ceramics, as fillers in paint, as drugs in calamine lotion and Plaster of Paris, as refractory in factories, and as bricks and roofing sheets in buildings. Clay deposits abound in Nigeria and are the major raw materials in ceramic factories (Alfred et al., 2023).

An oxide is a chemical compound containing at least one oxygen atom as well as at least one other element. The oxides result when elements are oxidized by oxygen in air (Halder and Tisljar, 2016). Several chemical analyses of clay deposits in Nigeria show that clay deposits from different geologic origins and formations have different oxide contents (Osemenam *et a,l*, 2019; Jong *et al.*, 2018; Mark, 2018; Ojo *et al.*, 2017; Ochieng, 2016; and Onyeogu *et al.*, 2016). Different oxides in clay bodies provide different functions in ceramic manufacturing. SiO_2 acts as the binding agents, alkali metal oxides act as the fluxing and flexural agents, and little amount of iron could be used as colouring agents (Zhangyang and Gangqin, 2016).

A ceramic is any of the various hard, brittle, heat-resistant and corrosion-resistant materials made by shaping and then firing an inorganic, non-metallic material, such as clay, at a high temperature. Common examples are earthenware, porcelain, and brick (Heimann, 2010).

Clay deposits contain mostly oxides of metals and metalloid. Important metalloid oxides found in clay deposits are silicate, alumina and zinc oxide. Metallic oxides found in clay deposits include oxides of earth metals like sodium oxide and potassium oxide, and oxide of rare earth metals like calcium oxide and magnesium oxide. Other important oxides found in clay deposits are zirconium, manganese oxide, and titanium oxide. "Ceramic oxides represent the most extensive group of ceramic materials produced today", according to Ralph and I-Wei (2010). Because of the importance of oxides to the manufacturing of ceramic, detailed attention must be paid to oxide characteristics of clay deposit raw material selection process. Variations in oxide properties also play important role in the raw material mix and ratios.

Coefficient of Variation (CV) is the measure of the ratio of standard deviation to the absolute mean in a data set (Dharmaraya and Dipoyan, 2018). The knowledge of variations gives the understanding of dispersion of raw material contents. It helps in quality control where materials are sorted and graded. Raw materials of less dispersion could be mixed to improve on their qualities. Spatial variability occurs when a quantity that is measured at different spatial locations exhibits values that differ across the locations (Kandagur, 2015). Spatial variation is the way that properties of physical quantities vary over an area on the earth's surface, in the atmosphere, or the sea.

The purpose of this research is to assess the oxide characteristic of clay deposit in the Anambra geologic environment for the use of ceramic industries. Oxide characteristic plays an important role in the clay properties used in ceramic manufacturing. Mineral exploration is key to the continuous supply of raw material to manufacturing industries, (Fend and Cheng, 2020). A good knowledge of the raw material characteristic will allow for adequate planning for future exploitation of these clay deposits.

Geology of the Study Area

Anambra geological Basin is the post-deformational sedimentation in the Lower Benue Trough. Deposition of sediments in this basin started with the Campanian-Maastrichtian marine and paralic shales of the Enugu and Nkporo formations, which is overlain by the coal measure of the Mamu formation (Obaje, 2010). The strongly folded Albian-Coniacian succession is overlain by nearly flat-lying Campania-Eocene succession with Nkporo Group as the oldest sediment (Nwajide, 1990). This Kporo Group is overlain by Mamu Formation which comprises of siltstone, shale, coal and sand stone in succession, (Kogbe, 1989). Clayed shale with intercalated ironstone, thin sandstone, and carbonaceous plants make up the Nsuka formation, overlaid by Ajala Sandstone, Kogbe, (1989) and Nwajide (1990). Figure 1 shows the geological map of the study area.

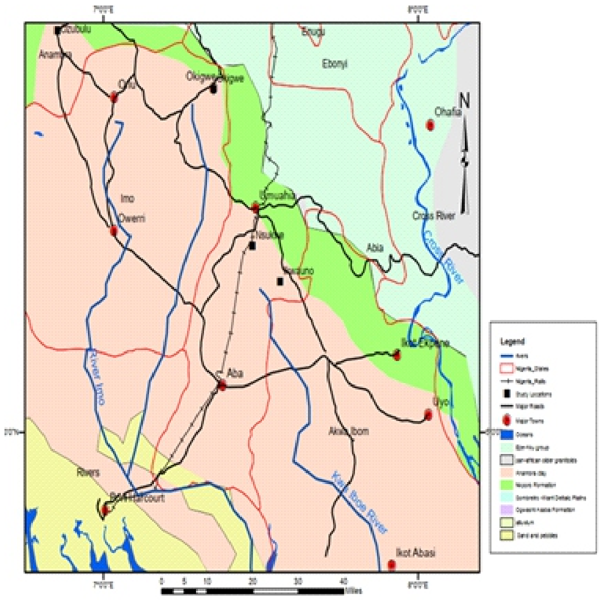

Figure 1: Geology Map of the Study Area, (After Obaje, 2009)

Materials and Method

Fifteen representative samples from clay deposits from four locations in three states of Abia, Imo and Anambra, in the Anambra Geological Basin were selected using pitting and trenching methods. Samples were taken from Nsukwe in Umuahia South Local government and Ikwuano in Ikwuano local government of Abia State on coordinates N5°30´24´´ E7°26´28´´ and N5°21´20´´ E7°27´04´´ respectively. Other samples were taken from Ozubulu in Ekwusigo Local government area of Anambra State on coordinates N5°58´50´´ E6°48´34´´ and the last sample location was at Okigwe in Okigwe local government area of Imo state on coordinate N5°51´04´´ E7°20´09´´. Samples were prepared and analysed at Rolab Research and Diagnostic Laboratory, Ibadan, Oyo State, Nigeria, for oxide analyses using PerkinElmer AAnalyst 400 AA Spectrometer. The samples were first pulverized using mortar and pestle. About 1 g of each sample was weighed into the dry digesting tube. About 5 ml of concentrated perchloric acid was added in the ratio and stirred. The tube was placed on a water bath set at 100 °C to boil for 2 hours. To avoid caking, the sample was shaken vigorously, and the resulting solution was referred to as a stock solution. The stock solution was filtered and made up to 50 ml with distilled water. The stock solution was loaded into PerkinElmer AAnalyst 400 AA spectrometer to read the oxide contents. The results were analysed with the WinLab32 software of the spectrometer. The oxides detected were compared with oxide standards required in the ceramic industries.

Result and Discussion

Deposit Thickness of Nsukwe, Ikwuano, Okigwe and Ozubulu Samples

From Table 1, the clay deposits at this location occur in four different strata with intercalation of beds of sandstones and ironstones. NSW-1 is a pink-coloured clay sample, with a deposit thickness of 0.9 m and taken at a depth of 2.0m from the surface. NSW-2 is brown in colour, taken at a depth of 3.7 m from a deposit stratum that is 1.5 m thick. NSW-3 is a black clay material taken from a depth of 4.5 m from a clay stratum that is 0.8 m in thickness. NSW-4 is grey taken from a stratum of 1.1 m thickness and at a depth of 5.6 m from the surface. Three samples were taken from a single pit, but at different depths from Ikwuano. The deposit occurred in three different strata. IKW-1 is grey, with a thickness of 0.5 m, taken from a depth of 1.5 m from the surface. IKW-2 is also grey in colour with a thickness of 1.2 m, taken from the second stratum at a depth of 2.7 m from the surface. IKW-3 is brown colour taken from the third stratum at a depth of 3.2 m, and of 0.5 m thickness. Four samples were taken from different pits about 30 m apart on a single clay stratum occurring at an average depth of about 0.8 m from the surface at Okigwe. All samples collected are greyish in colour. All the four samples collected from Ozubulu were taken at different pit at about 20 m apart but on a single clay stratum that has an average thickness of 1.3 m, at an average depth of 2.45 m.

Table 1: Data Collection at In Situ (Alfred, 2023)

S/No	Sample code	Location	Coordinates	Deposit Thickness(m)	Depth from Surface(m)	Colour of Sample at Collection point	Remark
1	NSW-1	Nsukwe	N5°30'24" E7°26'28"	0.9	2.0	light pink	Same pit
2	NSW-2	Nsukwe		1.5	3.7	brown	
3	NSW-3	Nsukwe		0.8	4.5	black	
4	NSW-4	Nsukwe		1.1	5.6	grey	
5	IKW-1	Ikwuano	N5°21'20" E7°27'04"	0.5	1.5	grey	Same pit
6	IKW-2	Ikwuano		1.2	2.7	grey	
7	IKW-3	Ikwuano		0.5	3.2	brown	
8	OKW-1	Okigwe	N5°51'04" E7°20'09"	1.0	4.2	grey	Different pit with average of 30m from each other
9	OKW-2	Okigwe		0.5	2.7	grey	
10	OKW-3	Okigwe		0.6	3.2	grey	
11	OKW-4	Okigwe		1.0	3.8	brown	
12	OZB-1	Ozubulu	N5°58'50" E6°48'34"	2.4	2.4	white	Different pit with average of 20m from each other
13	OZB-2	Ozubulu		1.0	2.5	white	
14	OZB-3	Ozubulu		1.2	2.1	red	
15	OZB-4	Ozubulu		0.7	2.8	deep red	

Oxide Composition of Nsukwe Samples

Ten oxides were identified in all four samples collected at Nsukwe, Table 2. Most of the oxides identified are correlated with increasing depth. SiO_2, Fe_2O_3, CaO, P_2O_5, MnO, MgO and LOI contents increase down the strata. While Al_2O_3, TiO_2, K_2O and Na_2O contents decrease down the depth. The difference in the oxide contents of the strata could be due to differences in their diagenesis. Different strata are formed by sediments from different geologic times and origins, (Halder and Tisljar, 2016) and (Tucker, 2001). The SiO_2 contents of all the samples are higher than the minimum 45.90% specification (Despan *et al*, 2009) for ceramic raw material. Because the higher the concentration of SiO_2 content in clay deposits the better the quality, the samples have SiO_2 contents suitable for ceramic manufacturing. Whereas, none of the samples has the range of 33.50-36.10% of Al_2O_3 contents required in ceramic industries, (Despan *et al*, 2009). Iron oxide is a natural colouring agent in ceramic raw materials. However, the higher concentration of Fe_2O_3 in the clay deposit could result in coloured-fired ceramic products. This particular characteristic of clay material could prevent the raw material from being used for unglazed products that require white to off-white or creamy colour surfaces. The higher concentration of Fe_2O_3, i.e. greater than 0.6%, in all four samples makes the clay deposit suitable only for the glazed types of ceramics products. Nevertheless, a higher concentration of iron oxide could produce ceramics with much higher strength (Teow *et al*, 2020).

Table 2: Percentage of Oxide Composition in Clay Samples from Nsukwe Abia State (Alfred, 2023)

Location Name	Sample ID	Percentage of Oxide Content (%)											
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	P_2O_5	K_2O	MnO	MgO	Na_2O	LOI	Total
Nsukwe	NSW-1	55.97	25.89	1.63	0.01	2.47	0.22	0.13	0.04	0.51	1.88	11.24	99.99
	NSW-2	55.58	26.75	2.57	0.03	3.1	0.06	0.15	0.15	0.39	1.97	9.24	99.99
	NSW-3	55.7	25.2	2.5	0.3	2.21	0.33	2.1	0.07	0.5	2.85	8.14	99.9
	NSW-4	56.36	25.83	2.4	0.58	2.02	0.21	0.09	0.06	0.32	1.88	10.15	99.9
	Average	55.9	25.92	2.28	0.23	2.45	0.21	0.62	0.08	0.43	2.15	9.69	

Oxide Composition of Ikwuano Samples

Two dominating oxides in Okigwe samples are SiO_2 and Al_2O_3, Table 3. The SiO_2 contents of the three samples average 48.32%, suggesting that they have good SiO_2 content suitable for varying categories of ceramic products. Al_2O_3 contents average 31.45% is within the range for ceramic products, between 35.50 and 36.10%. All three samples show a rather too higher iron oxide content averaging 5.12%. This makes the samples undesirable for ceramic manufacturing, (Singer and Sonja, 1971), unless the clay material is de-colourised. This increases the cost of the raw material, and therefore may not be cost-effective to beat the market competition of the final ceramic products. Alkali and Alkali-earth metal oxides are useful in the manufacturing of ceramic products because they act as fusing agents to lower the melting temperature and also increase the flexural strength of the ceramics, (Zhangyang and Gangqin, 2016). Two alkali metal oxides, K_2O and Na_2O were identified in the three samples with average contents of 0.48 and 0.79%, respectively. This is lower than the recommended specification of more than 1.60% for both oxides for ceramic products. CaO and MgO are the only two alkali-earth metal oxides detected in the three samples with average concentrations of 0.23 and 0.79%, respectively. This concentration is also lower than the 1.60% recommended by Daspan *et al*, (2016) for ceramic. Therefore, Ikwuano samples have lower fluxing and flexural agents compared to those needed in ceramic raw materials.

Table 3: Percentage of Oxide Composition in Clay Samples from Ikwuano, Abia State, (Alfred, 2023)

Location Name	Sample ID	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	P_2O_5	K_2O	MnO	MgO	Na_2O	LOI	Total
Ikwuano	IKW-1	46.35	32.01	5.36	0.78	0.20	0.27	0.44	0.02	0.88	3.19	10.50	100.00
	IKW-2	49.28	30.17	5.00	0.69	0.24	0.23	0.48	0.02	0.87	2.96	10.05	99.99
	IKW-3	49.33	32.18	5.01	0.66	0.25	0.31	0.53	0.04	0.62	2.50	8.55	99.98
	Average	48.32	31.45	5.12	0.71	0.23	0.27	0.48	0.03	0.79	2.88	9.70	

Oxide Composition of Okigwe Samples

Samples from Okigwe have very high SiO_2 contents with an average of 63.45% compared to other locations, see Table 4. Al_2O_3 content average 11.13%, and is the second dominant oxide. The samples have a considerably high Fe_2O_3 content, which would undermine its application in unglazed ceramic production because the higher presence of iron oxide in clay deposits gives brownish-fired colour which could prevent the material from being used for unglazed ceramics, (Singer and Sonja, 1971). Titanium oxide content average 2.45%, with phosphorus (IV) oxide having an average content of 4.27%. Almost all the oxide identified at Okigwe have higher content values than in other places. Two alkali metal oxides, Na_2O and K_2O were also identified like in other locations, with average contents of 0.17% and 2.79%, respectively. CaO and MgO contents from Okigwe samples have average values of 0.04% and 1.13%, respectively. The CaO content is rather low at 0.04%. Other impurities detected in the samples include P_2O_5 and MnO with mean contents averaging 4.27% and 0.36%, respectively. Loss on Ignition rages from 8.05% and 10.03%, with a mean value of 9.05%. The low loss on ignition compared to other location suggest that Okigwe samples have lower carbonaceous materials than other location.

Table 4: Percentage of Oxide Composition in Clay Samples from Okigwe, Imo State (Alfred, 2023)

Location Name	Sample ID	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	P_2O_5	K_2O	MnO	MgO	Na_2O	LOI	Total
Okigwe	OKW-1	64.90	10.61	4.97	3.24	0.02	3.36	2.00	0.01	0.70	0.15	10.03	99.99
	OKW-2	64.70	11.00	5.01	2.03	0.04	3.50	3.30	0.30	1.30	0.17	8.45	99.80
	OKW-3	62.59	11.54	6.30	3.41	0.05	4.50	1.52	0.36	1.49	0.18	8.05	99.99
	OKW-4	61.22	11.35	4.57	1.09	0.05	5.72	4.33	0.75	1.04	0.19	9.67	99.98
	Average	63.35	11.13	5.21	2.44	0.04	4.27	2.79	0.36	1.13	0.17	9.05	

Oxide Composition of Ozubulu Samples

Table 5: Percentage of Oxide Composition in Clay Samples from Ozubulu, Anambra State (Alfred, 2023)

Location Name	Sample ID	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	P_2O_5	K_2O	MnO	MgO	Na_2O	LOI	Total
Ozubulu	OZB-1	60.22	16.00	7.48	-	2.00	0.66	0.99	0.04	1.70	4.20	6.70	99.99
	OZB-2	64.19	12.49	6.22	-	2.15	1.02	0.92	-	1.58	4.60	6.82	99.99
	OZB-3	63.21	11.13	8.78	0.11	2.49	0.80	0.31	-	1.77	4.90	6.49	99.99
	OZB-4	68.09	10.16	5.27	0.16	1.67	0.74	0.89	-	1.79	4.97	6.24	99.98
	Average	63.93	12.45	6.94	0.14	2.08	0.81	0.78	0.04	1.71	4.67	6.56	

SiO_2 contents in Ozubulu samples range from 60.22% to 68.09%, with a mean value of 63.71%, Table 5. This is a rather high SiO_2 contents compared to other results around South Eastern region (Ekpunobi, *et al*, 2013). Al_2O_3 contents range from 10.16% to 16.00%, with a mean value of 12.45%. All the sample tested from Ozubulu showed positive result for iron oxide, ranging from 6.22% in the lowest to 8.78% in the highest area. The mean value is 6.94%. Deposits with high iron oxide contents are unsuitable for ceramic products that are unglazed, this is because the unglazed surface which ought to be whitish or creamy in colour would be coloured. Titanium oxide was detected only in two of the four samples analysed, OZB-3 with a content of 0.11%, and OZB-4 with a content of 0.16%. Manganese oxide was equally detected only in a sample, OZB-1, with a value of 1.70%. The loss on ignition ranges from 6.24% to 6.82%. The low LOI value indicates that the samples have less carbonaceous materials.

Variation in Oxide Composition across Four Locations

The range of SiO_2 contents between deposits at Nsukwe, Ikwuano, Okigwe, and Ozubulu is from 48.32% to 63.93%, with a mean of 57.88%. The standard deviation between the four locations is 7.34, with a coefficient of variation of 0.13, see table 6 and figure 2. The SiO_2 values are very close to the mean. These samples could be blended to achieve a better desired quality. The range of SiO_2 contents suitable for ceramic manufacturing is between 33.50% and 45.90% (Table 7). The SiO_2 contents from the four locations are higher than needed for ceramic products but suitable for the manufacturing of refractory bricks, paints, and sanitary wares. The clay materials from the four sample locations are only suitable for refractory and paint manufacturing. The mean SiO_2 content of 57.88% is higher than most results from South-east and from South-south but lower than those from South-west and North-central, (Table 8). AL_2O_3 contents range from 11.13% to 31.45%, with a

mean of 20.24%. This value is far higher than the value of 1.20% recorded for some clay deposits from South east, (Ekpunobi *et al*, 2013), but within the range of clay deposits from the South-south, South-west, and North-central regions, (Table 8). Okigwe and Ozubulu have Al_2O_3 contents lower than demanded in the manufacturing companies, (Table 7). However, both Nsukwe and Ikwuano have Al_2O_3 contents required in the manufacturing of paints, plastic, ceramics, tiles and refractory bricks, (Table 7). Fe_2O_3 contents range from 2.28% to 6.94%, with a mean value of 4.89%. Samples from Ikwuano, Okigwe, and Ozubulu showed high iron oxide contents which makes the materials not suitable for the production of plastic, ceramics, refractory bricks, sanitary wares, except in the production of paint. High contents of iron oxide reduce the quality of clay deposits. Only samples from Nsukwe have good iron oxide contents suitable for the manufacturing of ceramics, refractory bricks, sanitary, and table wares.
Coefficient of Variation (CV) of oxides amongst the four locations showed that important oxides like SiO_2, Al_2O_3, Fe_2O_3, K_2O and MgO have CV less than unity (Figure 3). This suggests that the deposits could be blended to achieve precise quality of raw materials. However, the remaining detected oxides, TiO_2, P_2O_5 and MnO, have CV higher than 1. This shows that these oxides in the clay materials exhibit wider dispersion.

Table 6: Variation in Average Oxide Composition of Clay from Abia, Imo and Anambra States, (Alfred, 2023)

Oxide (%)	Nsukwe Average (Abia)	Ikwuano Average (Abia)	Okigwe Average (Imo)	Ozubulu Average (Anambra)	Mean	Standard Deviation	Coefficient of Variation
SiO_2	55.90	48.32	63.35	63.93	57.88	7.34	0.13
Al_2O_3	25.92	31.45	11.13	12.45	20.24	10.03	0.50
Fe_2O_3	2.28	5.13	5.20	6.94	4.89	1.93	0.39
TiO_2	0.23	0.72	2.44	0.14	0.88	1.07	1.21
CaO	2.45	0.23	0.04	2.08	1.20	1.24	1.03
P_2O_5	0.21	0.27	4.32	0.82	1.41	1.96	1.40
K_2O	0.62	0.48	2.79	0.79	1.17	1.09	0.93
MnO	0.08	0.03	0.36	0.05	0.13	0.15	1.19
MgO	0.43	0.79	1.14	1.71	1.02	0.55	0.54
Na_2O	2.15	2.88	0.18	4.67	2.47	1.86	0.75
LOI	6.69	9.70	9.05	6.56	8.00	1.61	0.20

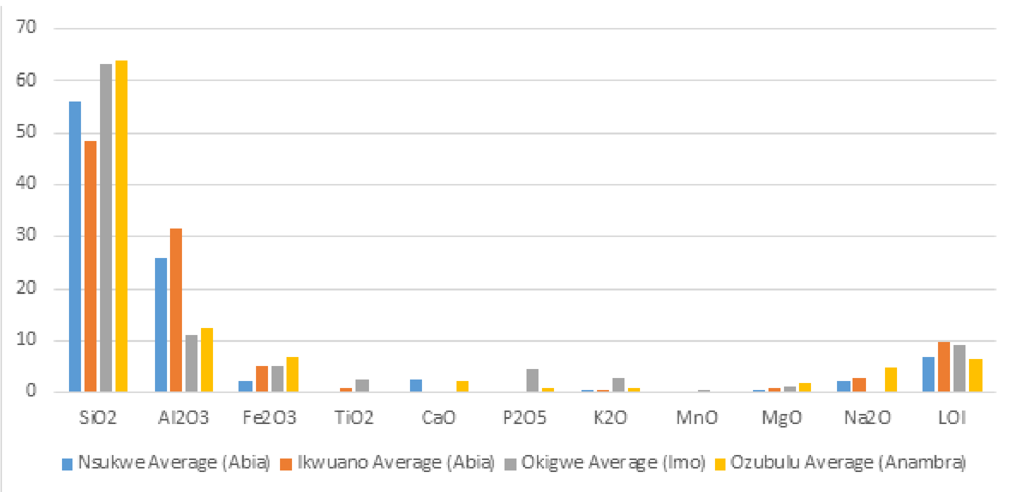

Figure 2: Oxide Comparison between the Samples, (Alfred, 2023)

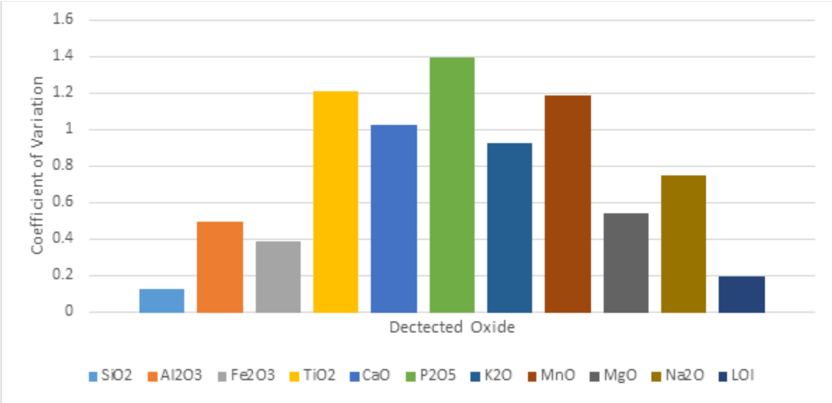

Figure 3: Coefficient of Variation of Detected Oxides across Four Locations, (Alfred, 2023)

Table 7: Specifications of Some Oxides in Clay Deposit Suitable for The Manufacturing of Some Selected Household Items (Daspan *et al*, 2009)

Oxide %	Plastics	Paints	Rubber, Paper, Textile	Ceramics	Refractory Brick	Brick Clay	Tiles	Sanitary Wares	Table Wares
SiO_2	45.78	45.30-47.90	44.90	45.90	67.50	51.00-70.00	70.00	54.00	46.00
Al_2O_3	36.46	37.90-38.40	32.35	33.50-36.10	26.00	25.44	19.00	30.00	31.00
Fe_2O_3	0.28	13.40-13.80	0.43	0.60	0.50-1.20	2.40	1.60	1.40	1.10
TiO_2	-	13.80	-	0.03	-	-	1.60	1.20	0.90
NA_2O	0.25	0.20-0.35	0.14	1.60	1.50	3.50	0.50	0.50	0.40
K_2O	0.25	0.40-1.00	0.28	1.60	1.10-3.10	-	2.00	3.10	2.20
CaO	0.50	0.03-0.25	-	0.50	0.30	0.20	0.20	0.30	0.40
MgO	0.04	0.20-0.30	-	0.40	1.19	0.70	0.40	0.40	0.40
LOI	-	-	-	12.40	-	-	5.40	8.80	-

Table 8: Oxide Content of Some Selected Clay Deposits in Nigeria

Oxide %	South East*	South South**	South West***	North Central****
SiO_2	46.00	53.93	60.35	62.26
Al_2O_3	1.20	24.61	24.76	29.44
Fe_2O_3	-	3.21	2.17	0.43
TiO_2	0.02	-	-	0.05
CaO	0.01	0.35	0.02	0.46
P_2O_5	-	-	0.07	-
K_2O	9.12	1.91	0.09	2.19
MnO	0.02	-	0.01	-
MgO	1.07	1.34	0.05	0.33
Na_2O	0.31	0.28	0.02	0.13
LOI	11.00	9.20	10.47	4.30

*Ekpunobi *et al* (2013)

** Bello *et al* (2017)

*** Adewole and Modupe (2017)

**** Jongs *et al* (2018)

Conclusion

All the fifteen samples analysed from three states of Abia, Imo and Anambra show different contents of oxides. Nsukwe, Okigwe and Ozubulu has SiO_2 contents greater than 45.90% as required in ceramic manufacturing. However, SiO_2 value of 48.32% is low for Ikwuano deposit. None of the deposits from the four locations, Nsukwe, Ikwuano, Okigwe and Ozubulu has Al_2O_3 content above 36.10% as required in ceramic industries. Equally, all the four locations have Fe_2O_3 contents greater than 0.60%. The high iron oxide contents make the use of the deposits in ceramic production a caution, as the deposit must first be de-ironed before further processing. None of the deposits have a complete set of the required contents in ceramic industries. Therefore a material mix of the deposits could produce a blend of desirable qualities.

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