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Geochemical and Industrial Potentials of Some Clay Deposits from Oduna and Igo Community in Ovia North East Area of Edo State, Nigeria

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Abstract Clay deposits at Oduna and Igo in Ovia North–East of Edo State Nigeria were evaluated and compared to establish their industrial application and utilization as suitable industrial raw materials. The abundance of significant element oxide shows that SiO2 (62.95-65.96) and Al2O3 (28.07-32.33) constitute much of the bulk chemical composition, with SiO2 ranging from (62.95-65.96) % and Al2O3 ranging from (28.07-32-33) %. Fe2O3, K2O, Ti2O, P2O5, CaO, MgO, and MnO are other oxides, respectively, but they were relatively small amounts. Although notable disparities exist in the SiO2 and Al2O3 content between the clays, the Igo samples were more siliceous than the Oduna samples. Evaluation of the industrial utilization of the clays based on the chemical characteristics compared with the chemical specification of other industrial clays revealed that they are suitable for producing refractory bricks because of the sufficient amount of silica and alumina present in the clays. Appropriate treatment and beneficiation will be needed to meet the industrial application requirements, such as cosmetics, plastic, paper, paint, and rubber.

Keywords: *geochemical analysis, industrial clays, Igo, Oduna*

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1. Introduction

Clays are essential materials that have been used in plastic, ceramics, and engineering industries. Clay's are fine-grained sediments that become permanently hard when baked or fired. [21] classified clay as a material with a particle size of less than 2µm micrometers and a family of minerals with similar chemical compositions and standard crystal structural characteristics. The nature of clay and its composition determines its quality and commercial value and, to a large extent, its engineering behavior. The engineering performance of clay mineral deposits can be related to their physical properties, such as particle size distribution, plasticity, shrinkage, non-clay mineral composition, organic material content, and geological history [5,17]. Previous studies have shown the importance of Lithofacies, stratigraphic, textural attributes, geochemical and chemostratigraphy analysis of sedimentary rocks units from Southeastern Nigeria not just for their mineralogical characteristics but for their ancient deposition environment and economic potential [1,2,3,4,7,8,9,12,13,15].

This study aims to Geochemically characterize and compare clay deposits from Oduna Community in Ovia North East Local Government Area of Edo State to establish their industrial application and utilization.

2. Background of Study

Oduna and Igo are both communities in Ovia North East Local Government Area of Edo State, Nigeria, respectively. The Oduna clay deposit is outcropping at a section of an estimated depth of about 150m above sea level with a latitude N06°13'19.9" of the Equator and longitude E005°26'13.5" of the Greenwich Meridian with an elevation of 32m high above sea level while Igo clay deposit outcrop at a section of an estimated depth of 110m with latitude N06°16'17.5" of the Equator and longitude E005°31'30.2" of the Greenwich Meridian with an elevation of 51m above sea level.

The geology of the study areas is of Benin formation and is characterized by reddish to reddish brown lateritic massive fairly indurated clay and sand. This is often marked with reticulated mudrocks. This cap the underlying more friable pinkish, yellowish white often gravelly-pebble sands clayey soils, sand, and clay. The sedimentary sequences are poorly bedded with discontinuous clay horizons at various depths.

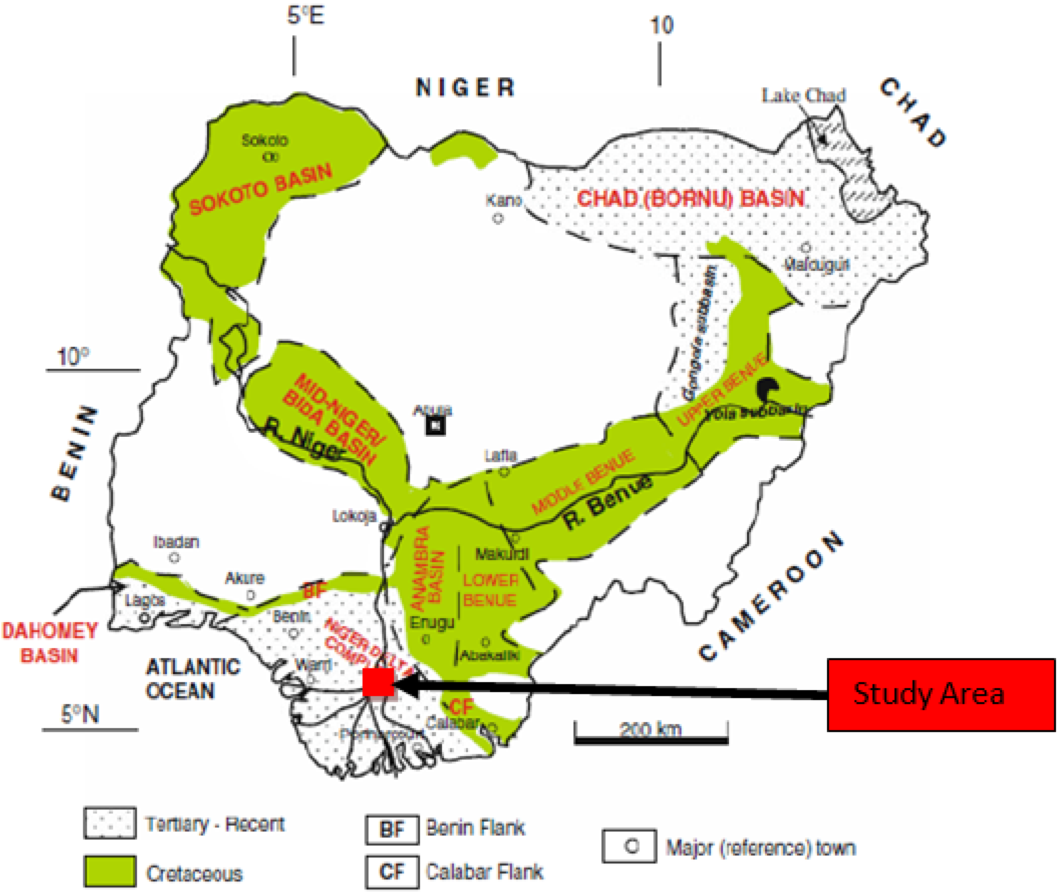

Figure 1. Geological sketch Map of Nigeria Showing the Location of the Study Area (After Obaje, 2009)

3. Materials and Methods

The field occurrence of the clay and the associated rocks was studied, locating rock outcrops, and identifying the rocks on the field. Fresh representative samples of the clay deposit exposed in the area were obtained, the sampling pattern was designed to reveal significant geochemical variation within the clay body.

X-ray fluorescence analysis was the method for the determination of the geochemical composition. This study analyzed ten fresh composite samples, seven from Oduna and three from Igo.

4. Results and Discussion

Results of the chemical analysis showing the different oxides of major elements contained in the clay samples analyzed are presented in Table 1 below.

Table 1. Chemical Composition of the Studied Clays (Means and Ranges)

ELEMENTAL OXIDES	ODUNA (Oxide %)		IGO (Oxide %)	
	Range (n=7)	Mean	Range (n=3)	Mean
SiO_2	(48.80-73.35)	62.95	(60.81-69.58)	65.96
AL_2O_3	(18.80-48.07)	32.33	(24.41-30.90)	28.07
$K_2 O$	(0.04-0.57)	0.18	(0.01-0.24)	0.08
$Fe_2 O_3$	(0.93-5.58)	2.29	(1.09-1.42)	1.26
CaO	(0.20-1.65)	0.51	(0.12-1.09)	0.76
Ti_2O	(0.73-0.99)	0.83	(0.65-0.93)	0.78
MgO	(0.50-4.51)	1.59	(0.08-0.70)	0.43
Na_2O	(0.02-0.72)	0.21	(0.01-0.15)	0.05
MnO	(0.01-0.02)	0.01	(0.00-0.11)	0.01
P_2O_5	(0.0-0.17)	0.11	(0.16-0.17)	0.11

The result of the chemical analysis was compared with typical composition of China clay (SSC), Afam clay, plastic fired clay (PFC) and average clay-shale (AVCS) as shown in Table 2.

Table 2. Comparison of the average chemical composition of the studied clays with average chemical composition of other types of clay

ELEMENTAL OXIDES	ODUNA %	IGO %	China Clay (Huber, 1985)	AVCS (Pettijohn, 1957)	Afam clay (Jubril &Amajor, 1991)	PFC (Huber, 1985)
SiO_2	62.95	65.96	46.88	58.10	42.20	57.67
AL_2O_3	32.33	28.07	37.65	15.40	38.45	24.00
K_2O	0.18	0.08	1.06	3.24	0.06	0.50
Fe_2O_3	2.29	1.26	0.88	4.24	0.75	3.23
CaO	0.51	0.76	0.03	3.10	-	0.70
Ti_2O	0.83	0.78	0.09		0.01	-
MgO	1.59	0.43	0.13	2.44	0.05	0.30
Na_2O	0.21	0.05	0.21	-	0.18	0.20
MnO	0.01	0.01	-	-	0.01	-
P_2O_5	0.11	0.11	-	-	-	-

From our analysis, there was variation in the silica (SiO2) content, with Oduna having an average value of (62.95%) and Igo having an average value of (65.58%) respectively.

However, from Table 2, the Alumina (Al2O3) content of Oduna has an average value of (32.33%.) and Igo with an average value of (28.07%) which is lower than as compared to typical China clay (37.65%) but higher than AVCS and PFC clays respectively. The Fe2O3 concentration in the clay samples shows that Oduna has a higher average value (2.29%)) than Igo (1.26 %). The variation in Fe2O3 concentration of the studied clay compared to each other, as well as other types of clay, could probably be due to the degree of superficial oxidation and contamination by Fe-rich percolating water from the highly ferruginous facies capping the clay deposit.

The alkalis (k2O and Na2O), CaO, and MnO are relatively low in proportion and indicative of the high degree of weathering under tropical conditions from which the clay bodies were formed. The sample shows a low concentration of P2O5. The depletion of P2O5 could have been due to the lower amount of accessory phases such as apatite and variscite. The studied samples show a relatively low concentration of MgO compared with Brick clay, with a value of 8.50 [14]. The MgO concentration in all the samples is less than 3%, which may indicate their association with high calcite content carbonate.

Table 3. Major element oxides of the test samples compared with chemical industrial specification

ELEMENTAL OXIDES	ODU %	IGO %	Refractory bricks (Parker 1967)	Rubber Keller (1964)	Ceramics (Singer and Sonja 1964)	Brick clay (Murray 1960)
SiO_2	62.95	65.96	51-70	44.90	67.50	38.67
AL_2O_3	32.33	28.07	25-44	32.35	26.50	9.45
K_2O	0.18	0.08	-	0.28	1.10-3.10	2.76
Fe_2O_3	2.29	1.26	0.5-2.40	0.43	0.5-1.20	2.70
CaO	0.51	0.76	0.1-0.2	-	0.18-0.30	15.84
Ti_2O	0.83	0.78	1.0-2.80	1.80	0.10-1.0	-
MgO	1.59	0.43	0.2-0.7	-	0.1-0.19	8.50
Na_2O	0.21	0.05	0.8-3.50	0.18	0.20-1.5	2.76
MnO	0.01	0.01	-	0.01	-	-
P_2O_5	0.11	0.11	-	-	-	-

Comparing the major oxides of the studied clays with chemical industrial specification shows that they clay falls under the refractory bricks which is indicative of their industrial potentials.

Table 4. Chemical Analysis of the Clay Samples (Trace Element Concentration in ppm)

ELEMENTAL OXIDES	ODU1 %	ODU2 %	ODU3 %	ODU4 %	ODU5 %	ODU6 %	ODU7 %	IGO1 %	IGO2 %	IGO3 %
Sr_2O	0.01	0.03	0.03	0.02	0.04	0.03	0.03	0.0 6	0.03	0.07
BaO	0.04	0.02	-	0.03	0.01	0.04	-	0.03	-	0.04
CU	0.01	-	0.06	0.08	0.05	0.04	0.07	0.03	0.06	0.08
Ni	0.02	0.02	0.02	0.02	0.025	0.02	0.01	0.01	0.01	0.01
PbO	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02
Co	0.01	0.02	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01
CdO	0.04	0.06	0.05	-	0.05	0.055	0.06	0.07	0.05	0.05
ZnO	-	0.01	-	0.01	0.01	-	0.01	-	0.01	-
ZrO_2	0.01	-	0.12	0.01	0.11	0.02	0.04	0.10	-	0.11

*Odu = Oduna in Table 4.

These include Pb having a range of (0.01-0.02%), Sr (0.01-0.07%), Cd (0.04-0.07%) and Ni (0.01-0.02%). The enriched values of these elements are of controversial origin. This can be attributed to input from hydrothermal fluid during or after sedimentation or to slow accumulation from sea water over a long period of sedimentation.

Table 5. Averages Major Element Oxides of the Test Samples Compared with Chemical Industrial Specification

ELEMENTAL OXIDES	ODUNA %	IGO %	Paper (ANON,1972) AS COATING AND FILLERS		(Payne,1961) PAINT (Additives)
SiO_2	62.95	65.96	47.80	48.70	48.68
AL_2O_3	32.33	28.07	37.00	36.00	9.45
K_2O	0.18	0.08	1.10	2.12	2.76
Fe_2O_3	2.29	1.26	0.58	0.82	2.7
CaO	0.51	0.76	0.04	0.06	15.84
Ti_2O	0.83	0.78	0.03	0.05	-
MgO	1.59	0.43	0.16	0.25	8.50
Na_2O	0.21	0.05	0.10	0.10	2.76
MnO	0.01	0.01	-	-	-
P_2O_5	0.11	0.11	-	-	-

5. Economic Potential

The chemical composition constitutes crucial parameters in assessing the suitability of studied clays as industrial raw materials. Evaluation of the industrial utilization of the clay based on their chemical characteristics revealed that the studied samples are suitable for producing refractory brick; this is consequent on the sufficient amount of alumina and silica present in the clay. In this regard, the alumina content of the clays corresponds to the refractory industrial specification [18]. Also, the amount of alkalis MgO and CaO for both clay is above the requirement for the production of rubber and paper [11]. Their effect would be to lower the vitrification of the clays without necessarily detracting from their refractoriness.

The clay samples studied are suitable for glazed products because of their low amount of Fe2O3, which would not cause undesirable brown coloration as in the case of Okija and with a relatively high amount of Fe2O3 [17].

The concentration of colorants such as Cu, Ni, and Co are also low, implying that they will not negatively impact the finished product.

6. Conclusion

Geochemically, SiO2, and Al2O3 are the principal oxides; the clays studied have a similar range of SiO2 content, while Igo has lesser content of alumina than Oduna. Although notable disparities exist in the SiO2 and Al2O3 content between the clays, the Igo samples are more siliceous than the Oduna samples.

Evaluation of the industrial utility of the clays based on chemical characteristics revealed that they are suitable for producing refractory bricks. Nevertheless, it would require processing and beneficiation to remove the impurities present for them to be ideal for other industrial applications such as rubber, paper, paint, ceramics, and cosmetic industries.

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