International Journal of Scientific Innovations and Sustainable Development, Volume 2, Number 1, 2012

ISSN: 2276-8203

GEOLOGY, MINERALOGY AND CHEMICAL COMPOSITION OF RESIDUAL CLAY OCCURRENCES IN TUNGA GADE, KUCHI, TUFA, AND MALLAM KARO AREAS OF NORTHWESTERN NIGERIA

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ABSTRACT

The present study is necessitated as a result of industrial demand for clay as raw material for ceramics and refractory. Four residual clay occurrences in the Basement Complex of northwestern Nigeria were investigated to examine their mineralogical and chemical characteristics. The study area fall within the north western Precambrian Basement Complex comprising granite, schist and gneiss. Combine AAS and XRD techniques were employed in the determination of the chemical and mineralogical composition of the clay occurrence. The residual clays in the study area are differentiated into white gritty and yellowish brown variety, with thickness ranging between 5 and 10 meters. Mineralogical results indicate kaolinite as major clay mineral and quartz as major non-clay mineral. Chemically, silica content values of the white residual clay of Tunga Gade and Tufa renges between 47. 80% and 50.01% while the brownish variety of Kuchi and Mallam Karo is between 53.90% and 55.90%, alumina content of these clays is between 29.62% and 36. 27%. Presence of goethite in Kuchi and Mallam Karo clays is responsible for it yellowish brown color. The high SiO_2 and low Na_2O, Fe_2O and MgO could yield good material for the manufacture of refractory. Field evidence suggested that the clay is formed in-situ with average thickness of 5-10 meters. Reserve estimation and industrial properties are recommended as follow-up investigation.

***Keywords:* Geology, Mineralogy, Chemical, Residual Clay.**

INTRODUCTIONS

Clay bodies are widely distributed on the Precambrian basement complex of Nigeria (Ajayi and Agagu, 1981; Emofurieta and Salami, 1988; Ehinola et.al, 2009). In the northwestern part of Nigeria, most especially Minna area, is noted for two main categories of clay occurrences, residual clays in the basement and sedimentary clays in Bida Basin (Alabi, 2009), in the basement-sedimentary transition zones (Elueze and Bolarinwa, 2001) and in Niger Delta (Elueze et. Al 2004). These clays are generally consumed as industrial raw materials in the cement, ceramic, paper, pesticide, fertilizer, refractory and pharmaceutical industries.

The study area is underlain by the Older granite, schist and migmatite gneiss complex. Grante and related migmatite predominate, but granodiorite, quart-diorite, diorite and syanite have also been recorded. The low grade schist is a relic of single super crystal cover which was unfolded into the basement complex (Russ, 1957). Trustwell and Cope 1963, classified schist in the area into Kusheriki schist formation, Brinin Gwari formation and Kushaka formation. In Minna area there two types of migmatite; those formed by high grade metamorphism and anatexix and those formed by migmatite injection.

With increase in population and demand, there is need for provision of house hold equipment including ceramics and houses. Therefore, there is need to evaluate the residual clays within the basement complex around Minna, northwestern Nigeria (Fig. 1), this will be a scientific contribution towards increasing the local raw material sources.

METHODOLOGY

MAPPING, SAMPLING AND ANALYSES

Geological mapping of the area was carried out using geological compass clinometers, hammer and Garmin etrex Geographical Positioning System (GPS). The mapping exercise involved description, measurement and sampling of out crops. Fresh sample of outcrops were studied in hand specimen.

Twenty representative spot samples were collected from different vertical sections of the clay bodies.

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Mineralogical and chemical analyses were by X-ray diffraction (XRD) and Atomic Spectrometric (AAS) methods. Powdered samples of the clays were analyses using Philips – PW 1800 model X-ray machine with a 55MA/40KV power supply using Cu tube anode in a courteous scanning process at an angle of 1.000° and 70.000° θ2. The diffraction patterns were recorded at scan rate of 1°20/min/cm with a Ni – filtered Fe K – alpha radiation. The diffractograms were interpreted by comparing peaks of notable intensities with those of standard minerals established by the Joint Committee of Powder Diffraction Standard (JCPDS, 1980). The area method was also employed in calculating the relative proportion of the identified minerals. Abundances of major and trace elements of twenty representative sample of the clays were determined, using an alpha 4 chem tech atomic absorption spectrometer (AAS). After digestion of the clay samples, Si, Al, Fe, Mn, Mg,Ca, Na, K, and Ti concentrations in the clay samples were measure with single element light source. Calibration for each element was achieved using four AAS standard solutions of known concentrations. Two consecutive runs were carried out for each measurement and the standard deviation recorded. Elemental values were recalculated to oxides by conversion factors. P_2O_5 was determined by colorimetric method.

The inter-granular water (H_2O^-) was determined as percentage loss in weight of the clay samples after drying in an oven at 110°C for four hours. The structural (H_2O^+) was determined at loss on ignition (L.I) after heating the dried clay samples in muffle furnace for four hours at 1100°C.

The detailed analytical conditions are as stated in Perkin elmer's Cook Book of chemical Analysis (1982). The mineralogical and chemical analyses were done at National steel Raw materials exploration Agency Kaduna, Nigeria.

RESULTS AND DISCUSSION

GEOLOGY OF THE AREAS AREA

Field studies show that the rock types in the study area comprises of migmatite-gneiss, schist, gneiss and granite. Tunga Gade area is compose of migmatite gneiss which is characterized by mafic and felsic bands, flat lying felsic granitic rock intrude into the gneiss. Meso-structure of fold, joint and facts are observed on the gneiss. Average dip of the gneiss is 45°E. other rock types in Tunga Gade area include marble which extends to Kwatuti area and quartzite.

In Kuchi area, schist and biotite granite are the major rock types. Weathered schist occur as ridges and flat lying bodies, the general trend of the rock measured on the foliated but weathered outcrops is generally in the northeast – southwest direction. The schist in hand specimen contains flakes of muscovite feldspar. The medium dark color granite occur as flat lying body intruding the schist and consist of quartzite veins most running in north-south direction.

Tufa area is composed of north – south trending granite gneiss and muscovite schist with intrusion of pegmatite within the granite gneiss. The granite gneiss occur as ridges while the schist occur as flat lying outcrops along river channels. In handspecimen the granite gneiss is porphyritic showing bands of dark and light minerals. The schist is weathered and contained flaks of muscovite mineral. The pegmatite that intrude into the granite gneiss is highly feldspartic .

In Mallam Karo area, schist and porphyritic granite are the dominant rock type while migmatite gneiss form a small suit within the dominant rocks. Meso-structures such as folds, pinch and swells, concordant and discordant quartz veins intrusions are present on the schist. General strike direction is north – South and average dip angle of 45°E.

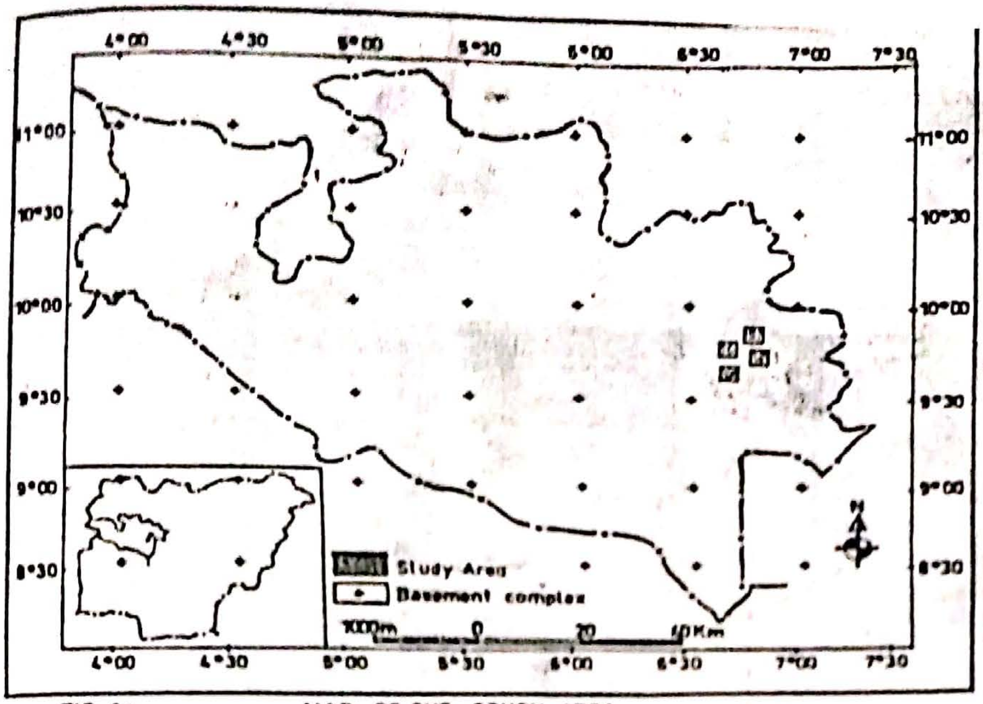


FIG. 11 MAP OF THE STUDY AREA

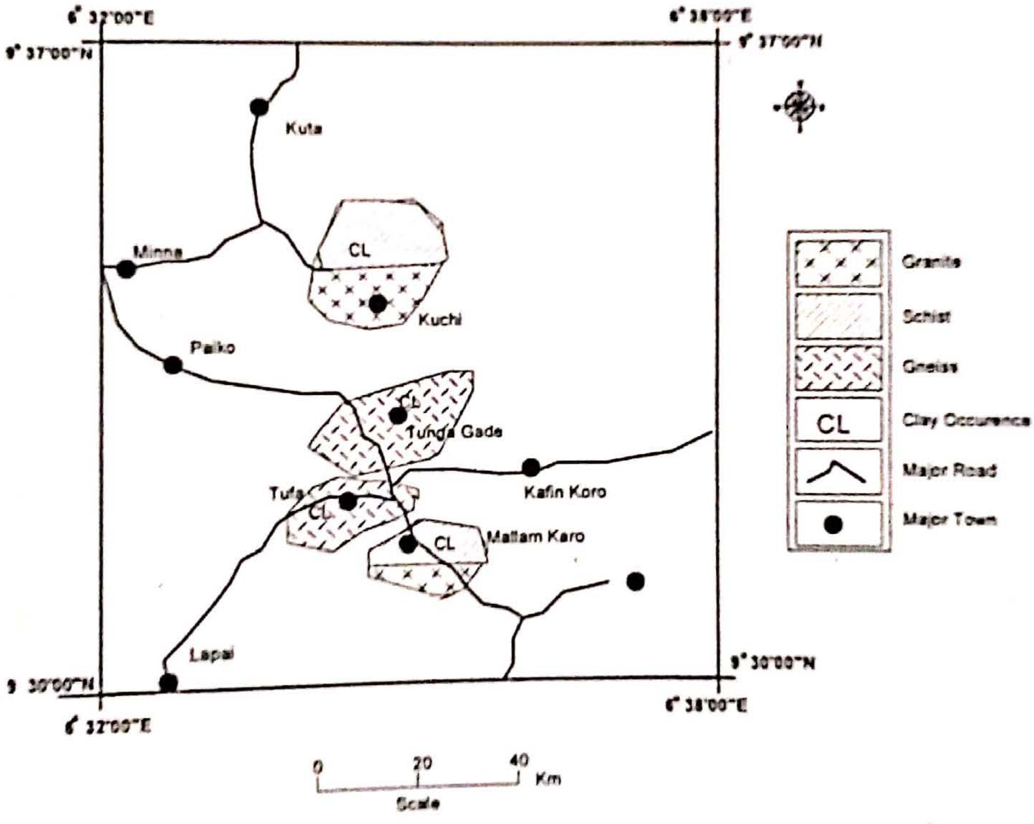


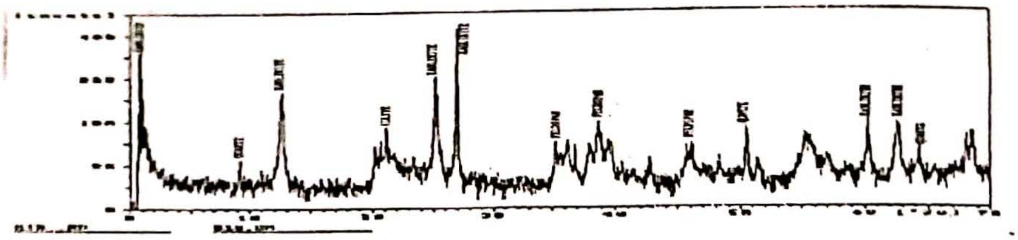
Fig 2 : Geological Map of the Study area and Clay site

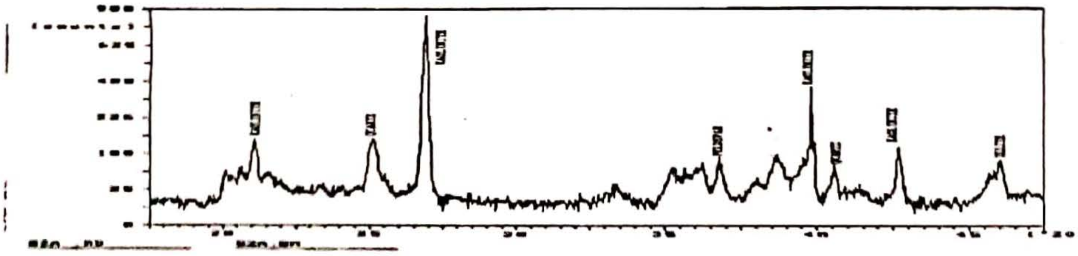
Clay occurrences and characteristics

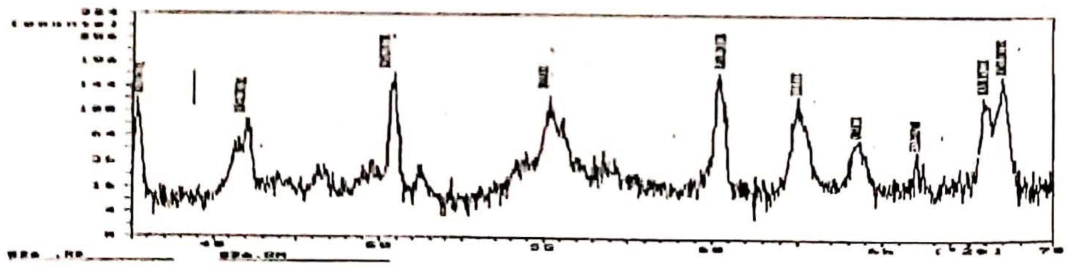
In four area map, the Major occurrences are within the basement complex of the northwestern Nigeria (fig 2). The residence clays in study area can be differentiated into two based on color and texture. The white and gritty type occurred in Tunga Gade and Tufa, while the reddish brown variety occurred in Kuchi and Mallam Karo.

On the basis of textural and compositional characteristics, the clay occurrence in Tunga Gade is about 6metres thick overlies magnetite gneiss basement. Apart from the top soil which varies from 0.3 to 1.5metres, and dark grey in color due to high organic content. The clay is whitish in color with minor amounts of angular quartz crystals and partially decomposed feldspar grains at the lower part of the profile. Clay occurrence is Tufa is quite similar in texture and field to that of Tunga Mallam.

Clay occurrence of Kuchi and Mallam Karo are similar in field and textural attributes. The clays overlies schist basement in these locations, the weathering profile over schist basement can be divided into three gradational horizons. The first is the top soil, which varies from 0.5m to about 1metre and dark in color. The second layer is composed of hard reddish goethite rich lateritic material. The third horizon is below the lateritic layer and above the partially decomposed parent rock. The zone is reddish brown in color and composed dominantly of clay material with muscovite flakes. The upper part of this layer is motted, while the lower part is more fragmented. In both locations, average thickness of clay material varies from 4metres to 6metres. Field measurement revealed average thickness of clay bodies in the study area to range between 5 – 10metres. Therefore, they could be mined through open cast method.







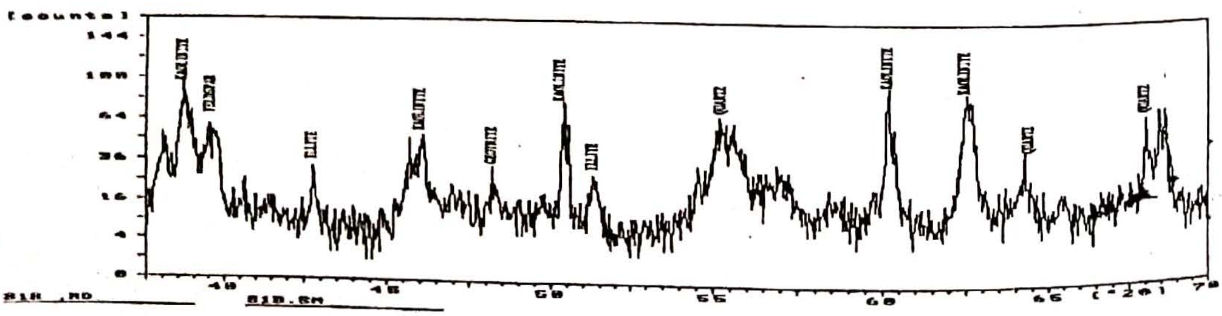


Fig 3. X – ray diffraction traces for clay samples (A – Tunga Gade, B – Tufa, C – Kuchi, D – Mallam Karo).

Table 1. Average mineralogical composition (in %) of raw clay samples

Mineral composition %	Tunga Gade	Kuchi	Tufa	Mallam Karo
Kaolinite	68	70	65	70
Quartz	25	20	25	20
Goethite	-	3	-	2
Feldspar	5	2	8	2
Illite	2	5	2	5

Table 2. Chemical composition of Tunga Gade, Kuchi, Tufa and Mallam Karo clay samples

Oxides	Tunga Gade	Kuchi	Tufa	Mallam Karo
SiO_2	47.80	55.80	50.01	53.90
Al_2O_3	36.27	29.62	33.97	30.01
Fe_2O_3	1.48	1.59	1.40	1.51
Mno	0.16	0.04	0.71	0.07
MgO	0.20	0.15	0.22	0.18
CaO	0.98	1.12	0.89	1.14
Na_2O	0.09	0.10	0.06	0.09
K_2O	0.12	0.09	0.17	0.07
TiO_2	0.52	1.23	0.55	1.21
P_2O5	0.07	0.04	0.08	0.02
H_2O^-	2.41	1.90	2.50	2.00
H_2O^+	9.64	8.09	8.98	9.60
Total	99.74	99.77	99.54	99.8

Mineralogical analysis results presented in Table 1, show that kaolinite is the major clay mineral while illite occur in minor concentration. Quartz is the major non-clay constituent that exhibit notable intensities while feldspar is in minor concentration in the samples. Distinctive kaolinite peaks are recorded at 2Ø values of 1.5°, 11.5°, 23.5°, 26.0°, 60.0°, 61.50°, 21.0°, 27.0°, 49.5° and 43.5°. Illite peaks are found at 21.0° and 46.0°. Quartz peaks reflect at 09.5°, 50.5°, 62.5°, 25.0° and 40.5° in Tunga Gade and Tufa clay samples (figure 3A and 3B).

In Kuchi and Mallam Karo samples kaolinite peaks are recorded at 24 values of 41.5°, 50.5°, 60.0°, 66.0°, 38.5°, 47.0°, and 62.5°. Illite are recorded at 46.0°, 52.0° and 62.5°. Quartz peaks are reflected at 55.0°, 64.0°, 55.5° and 64.5°. Feldspar peaks occur at 66.5° and 39.5°. Geothite peak are reflected at 42.5° and 43.0° values respectively (figure. 3C and 3D).

This mineralogical characteristic suggest that the residual clay profile developed over the basement complex and can be of good raw materials for ceramic, pottery, refractory or filler, with the associated quartz and feldspar as fluxes.

The result of chemical analysis result is presented in table 2. Silica values of the white residual clay of Tunga Gade and Tufa is between 47.80% and 50.01% while the reddish brown variety of Kuchi and Mallam Karo is between 53.90 and 55.80. The alumina content ranges between 33.97% and 36.27% in Tuga Gade and Tufa sample, and 29.62% and 30.01% in Kuchi and Mallam Karo samples. Total iron content range from 1.40 – 1.59% in all samples. Concentration of other oxides is very low, generally low than 1%. Presence of goethite in Kuchi and Mallam Karo clay samples is responsible for the reddish brown colour. The high SiO_2 and low Na_2O, total iron and MgO could yield good materials for the manufacture of refractory and ceramics (Nurse, 19960, Cole, 1960).

CONCLUSIONS

Field evidence, mineralogical and chemical analyses suggest that the clay is formed in-situ. Field measurement revealed average thickness of clay bodies in the study areas to range between 5 – 10metres. Therefore, they could be mined through open cast method.

RECOMMENDATION

The area extent and exploratory drilling to establish the clay reserves, also industrial properties (firing, specific shrinkage, loss on ignition and water absorption capacity) are recommended as follow-up investigation.

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CEN-2012-142/J.O. Noah/centrejournal@yahoo.com/28/03/2012/FRB/