The International Journal Of Engineering And Science (IJES)
|| Volume || 4 || Issue || 11 || Pages || PP -71-79|| 2015 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Geophysical Evaluation of Lateral Continuity of some part of Ikere Kaolin Deposit, Southwestern Nigeria

[1*] Ogundana, A.K , [2] Olutomilola, O. O., [3] Okunade, A, [4]Aladesanmi, A.O
[1,2,3,4,]Department of Geology, Afe Babalola University, Ado-Ekiti.

ABSTRACT
Geophysictal study of Ikere Kaolin deposit has being conducted to establish its lateral continuity within the study area. Profiling and Vertical electrical sounding methods were employed using Dipole - Dipole and Schlumberger configuration respectively. Five points were sounded and one profile was occupied. Four subsurface lithologic units were established namely; topsoil, laterite, Kaolin, and, basement. The curve types are simple K and KH. The topsoil, laterite and basement materials are characterized with high resistivity values while the kaolin materials are characterized with relatively low resistivity values. The average resistivity and thickness values for the topsoil are 94.8Ωm and.0.5m respectively. Laterite was encountered in all the locations with average resistivity and thickness values of 974.2Ωm and 1.9m respectively. Kaolin was encountered in four of the locations with average resistivity value of 61Ωm. Basement is relatively shallow in the study area, it was encountered in only two of the locations with an average resistivity and depth values to the top of basement of 435.5Ωm, and 5.7m respectively. Overburden materials are relatively thin within the area with an average thickness value of 2.3m.

KEYWORDS: *Geophysicalal, Profiling, Lateral continuity, Subsurface lithology.*

Date of Submission: 25 September 2015 Date of Accepted: 10 November 2015

I. INTRODUCTION

Kaolin is a white clay mineral of economic benefit which contains kaolinite (hydrated aluminosilicate mineral) with its name gotten from the Chinese hill 'kao ling' where it has been used in the production of chinaware since 500AD (Ajibade, 2000). It is also referred to as china clay. Kaolin is made up of silicon, aluminum and oxygen with chemical composition $Al^2O_32SiO_22H_2O$.

Polymorphs of Kaolin include dickite, halloysite and nacrite (kaolitic clays) i.e. they all have the same chemical composition but different internal structures (Zoltan & Williams, 2005). The flat particle shape that increases opacity, its chemical inertness and soft and non abrasive texture due to the absence of coarse impurities are the distinguishing properties of kaolin from other kaolitic clays (Atanda et al, 2012).

Kaoline is used for fire bricks which can withstand very high temperatures usually above 1500°C and are used to line blast furnaces and kilns in iron and steel industries, glass, ceramics, aluminum and petroleum industries (Iyasara et al ,2014) as they are made to resist all types of stresses (thermal, mechanical, chemical) such as erosion, creeping deformation, corrosion and thermal shocks i.e. ability to retain their original forms without cracking or flaking under sudden temperature changes (Commission, 2007). The mixture of kaolin and sawdust in the ratio of 1:1 by volume produces quality insulating fire bricks (Malu & Babson, 2007). The Ajokuta steel complex of Nigeria uses kaolin and river sand from the Niger River.

Kaolin is largely used in the paper industry as a coating pigment and fillers (Iyasara et al, 2014) which are used because they increase brightness, opacity, give the desired finish, make the paper whiter and enhance printing properties of the paper. Properties possessed by kaolin which is of great interest to the paper industry include its whiteness, low viscosity, non abrasiveness, controlled particle sixes and flat hexagonal plates (Murray, 2010) also it is preferred in this sector because of its optical properties, chemical inertness and it is inexpensive compared to other minerals.

Kaolin is a traditional raw material in the ceramic industry in the production of white ware (sanitary ware, household utensils amongst others); as it gives the ware a smooth surface finish, and electrical insulators (Benea & Gorea, 2004). It is also used as an extender pigment that provides color or whiteness. Kaolin is used in rubber and plastic industry, also in pharmaceutical industries as a protectant for the temporary relief of anorectal itching and diaper rash (Kaolin Uses, Benefits & Doseage, 2000). Kaolin has been used as an insecticide against various arthropods that affect crops.

Kaolin and other clay minerals contains quartz and long term exposure to this results in silicosis and lung cancer leading to deaths from chronic bronchitis and pulmonary emphysema but they are less toxic to aquatic organisms. Although there has been no report on the effects resulting from extensive use of kaolin in cosmetics, long term occupational exposure from dust in mines, processing plants and industries may lead to benign pneumoconiosis known as kaolinosis (Zoltan & Williams, 2005).

Occurrences of kaolin have been recorded in different parts of the country and specific abundant deposits have been identified in parts of Enugu, Anambra, Kaduna, Katsina, Plateau, Ondo, Ogun, Oyo, Ekiti, Bauchi, Sokoto, Borno amongst many other states, of these reserves, about 800 million tones of probable/proven deposits have been quantified (RMRDC, 2010)

Almost every state in Nigeria has a known deposit of kaolin e.g. the Ozubulu deposit of Anambra, the porter deposit of plateau, the Kankara deposit of Kaduna, the Darago deposit of Bauchi, the Akpere-obom deposit of Cross river among many others with the most widely studied being the Obuzulu, Kankara and Porter deposits (Badmus & Olatinsu, 2009).

Industrial requirement for kaolinite in Nigeria has been estimated to be over 360,000 metric tonnes while annual current stood at 110,000 metric tonnes from local production, a supply gap of over 250,000 metric tonnes exists annually. In general, the distribution of the uses of kaolin is as seen above (Talabi et al, 2012).

Many studies have been carried out on kaolin by various researchers such as: Atanda et al (2012). Talabi et al (2012), Egbai (2011, 2013), Badmus & Olatinsu (2009), Akinyemi et al (2014) among many others.

Atanda et al 2012 used geochemical method (Atomic absorption spectrometry AAS) to study Ikere-Ekiti kaolin and clay, Ile-ife clay and Iwo kaolin. The analyses found Iwo clay and Ile-Ife Kaolin impure but found Ikere-Ekiti kaolin and clay suitable for porcelain production due its high alumina content and purity.

Talabi et al 2012 also used geochemical methods (x-ray fluorescence analytical technique and granlometric analysis) to evaluate the compositional features and industrial application of Ikere Kaolin based on its mineralogy, chemical composition and physical characteristics and found it suitable to be an industrial raw material in refractory, pottery paper and paint industries.

Egbai (2011, 2013) worked on Kaolin deposits in the Sedimentary terrain using a geophysical method (Vertical electrical sounding VES) to determine the thickness, existence and quantity of kaolin stating that the large quantity found in Ozanogogo Delta State can be mined commercially, he also carried out the same survey at Ukwu-Nzu and Ubulu-Uku in Aniocha North LGA and established the reserve to be 401,235.84 tonnes and 69535.44 tonnes respectively, stating that the reserve might not be enough for commercial purposes because of its low quantity but could be mined at a local level.

Geophysical methods (Airborne electromagnetic AEM and Airborne Magnetic AM surveys) in combination with regional gravity surveys and ground geophysical measurements have also proven to be effective in the exploration of Kaolin and Ilmenite in Finland (Lohva & Lehtimaki, 2005) to delineate boundaries and properties of the deposits.

The geoelectric investigation in Lakiri village Southwestern Nigeria using Schlumberger configuration of geophysical prospecting has revealed the occurrence of vast deposit of Kaolin clay that can serve as raw materials for industries e.g. building and porcelain. Badmus and Olatinsu 2009 also revealed the quality of the kaolin clay both chemical and physical properties as additives for both industrial and mining purposes and the ground water potential of this area has been affected by the presence of this solid mineral as most aquifers are overlain by thick over burden material of fresh deposit of clay & kaolin clay.

The characteristic properties of the kaolin within Ise-Orun and Emure LGA of Ekiti State were examined using geochemical methods (x-ray diffraction XRD, differential thermal analysis DTA, atomic absorption spectrometry AAS, and x-ray fluorescence XRF), beneficiated and processed for ceramic automobile parts, friction lining materials and other related industries because of their thermal shock, wear, resistance and material cost (Aderiye, 2014)

Scanning electron microscopy and energy dispersive x-ray spectroscopy using back scattered secondary imaging were used to determine the chemical compositions, size and morphology of the clay bonded carbon refractory produced from Ifon clay and carbonized palm kernel shell in Ifon, Southwestern Nigeria and the results showed the clay composition to be of kaolinite, microcline, muscovite, plagioclase and quartz and the composite grade containing 40% carbonized palm kernel shell and 60% Ifon clay had the best combination of mechanical properties of all composites produced (Aramide & Oke, 2014).

Elueze et al 2004, talked about the residual clay occurrences in the Precambrian complex of Iwo and Ijebu districts of Southwestern Nigeria using mineralogical and chemical analyses (X-ray diffraction XRD and Atomic absorption spectrometric AAS, wet sieve analysis and attenberg limits) to examine their mineralogical, chemical composition and geotechnical properties in order to evaluate their economic values. The x-ray diffraction studies showed Kaolinite as the dominant clay with Illite and Montmorillonite in trace amounts, also Quartz, Feldspar and Goethite were found as the main non clay constituents. The economic evaluation of these clays which could serve as industrial raw materials for structural wares, colored ceramics and refractories occurs within 5-8m to the surface therefore could be mined through open pit method (Elueze et al, 2004)

Clay samples from 10 locations in Calabar, Southeastern Nigeria were evaluated to determine their suitability for industrial applications. The samples were pulverized, dried, sieved and quantitatively analyzed (Attah & Oden, 2010). Physical properties determined were viscosity, density, plasticity index, particle size and firing characteristics. X-ray analysis identified kaolin as the dominant clay with occasional Illite and Quartz as the dominant non clay mineral. The impurity found within the clays indicated low grade (non refractory) due to the low alumina content. All the clays investigated were of uniform grade and are quite fine in size and from the physical properties.

The residual clay deposits situated at Orin, Igbara odo, Ikere and Ado- Ekiti were studied using several physiological and mineralogical analyses which suggested kaolin clay deposit as a product of hydrothermal and insitu weathering of Aplite and Granite having Quartz, Potassium Iron oxide and Aluminium Phosphatic minerals (Akinyemi, et al., 2014).

Geophysical and geostatistical methods were combined to quantify the clay deposits in Idofe, Imope, Iganran, Aparaki and Falafanmu in Southwestern Nigeria. The vertical electrical sounding (VES) determined the resistivity and thicknesses of the clay at 80 points while the geostatistical method estimated the volume of clay to be 35,062,528.03m^3 (Mosuro et al, 2011)

However, this study has employed geophysical methods in evaluating the lateral continuity of some parts of this deposit.

II. LOCATION AND GEOLOGY OF THE STUDY AREA

2.1 Location

Ikere Ekiti is one of the local government areas of Ekiti state located between latitude 7°00'N and longitude 5°15'E. Ikere town covers an area of about 2 km and is flanked in the west by Ise Ekiti. The study area is located in the North-Eastern part of Ikere town along Ikere- Ise road and is accessible through the town road network.

2.2 Climate, Geology and Hydrogeology of The Area

The study area has a humid tropical climate characterized by alternating raining and dry seasons (short dry seasons and long wet seasons) with the annual temperature ranging from 28°C to 30°C and a mean annual rainfall of 1500mm. (Talabi, Ademilua, & Akinola, 2012). Evaporation is usually low from June through September ranging from 3.3mm-4.0mm per day. The high relative humidity that favours tropical weathering is normally over 90% in the early morning but falls within 60 and 80% in the afternoon (Okwoli, Onoja, & Udoeyop, 2014). The fresh vegetation of the study area is was as a result of the raining season as it was in between sparsely to heavily vegetated although some parts were altered due to agricultural practices.

Ikere Ekiti falls within the basement complex terrain of Southwestern Nigeria. Although it has an appreciable thickness of sedimentary rock formation, it is underlain by crystalline rocks of the basement complex. The main rock types found in the study area are charnockites which are part of the older granites. The Older Granites are believed to be pre-, syn- and post-tectonic rocks which cut both the migmatite-gneiss-quartzite complex and the schist belts. They range widely in age (750–450 Ma) and composition. They represent a varied and long lasting (750–450 Ma) magmatic cycle associated with the Pan African orogeny. They are the most obvious feature of the Pan African orogeny (Obaje, 2009).

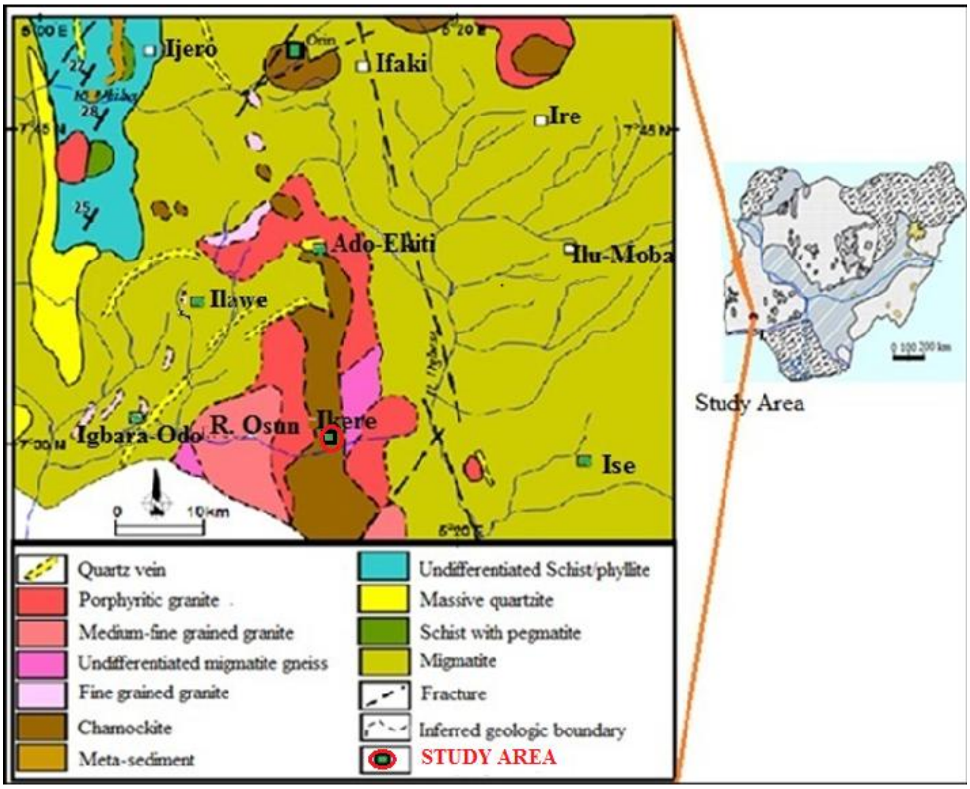


Fig. 1. Geology Map Of The Study area (Talabi et al)

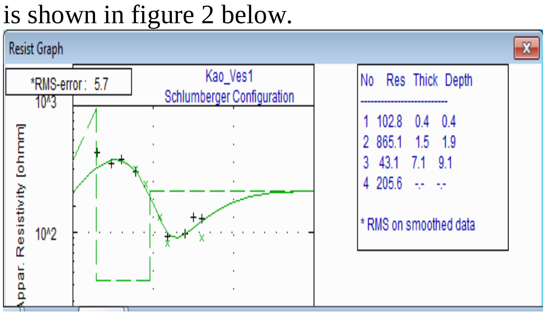
III. Methodology, Data acquisition and Interpretation

A reconnaissance survey of study area was carried out for site familiarization and planning. This was followed with geophysical investigation of the deposit. Geophysical methods are indirect site investigation techniques and predominantly non-intrusive. Two methods namely Resistivity Sounding and Resistivity Profiling were adopted. Soil resistivity meter (PASI) was used for the geophysical tests. It is highly reliable and reproducible. Resistivity sounding was adopted in resolving resistivity variation with depth, thus sounding helped in delineating the various subsurface lithological units while resistivity profiling was adopted in resolving horizontal resistivity variation in this study, hence profiling helped in establishing the lateral continuity of the various subsurface lithological units.

IV. RESULTS AND DISCUSSIONS

4.1 Vertical Electrical Sounding

A total of 5 VES locations across 1 traverse was spread over the study area. The processed data were interpreted, resulting curve types were assessed, existing subsurface lithologic units were established, and the geoelectric properties of the various subsurface layers were used in delineating the overburden and kaolinitc units in the study area. The results are presented in the form of table (Table 1), geoelectric curves (Figure 2) and sections (Figure; 3a & b, 4). Four different subsurface lithologic sequences were established namely; topsoil, laterite, kaolin and basement. The curve types range between simple K and KH. The topsoil, laterite and basement materials are characterised with high resistivity values while the kaolin materials are typified with relatively low resistivity values. A summary of the results of interpretation, on which the findings were hinged, is shown in figure 2 below.



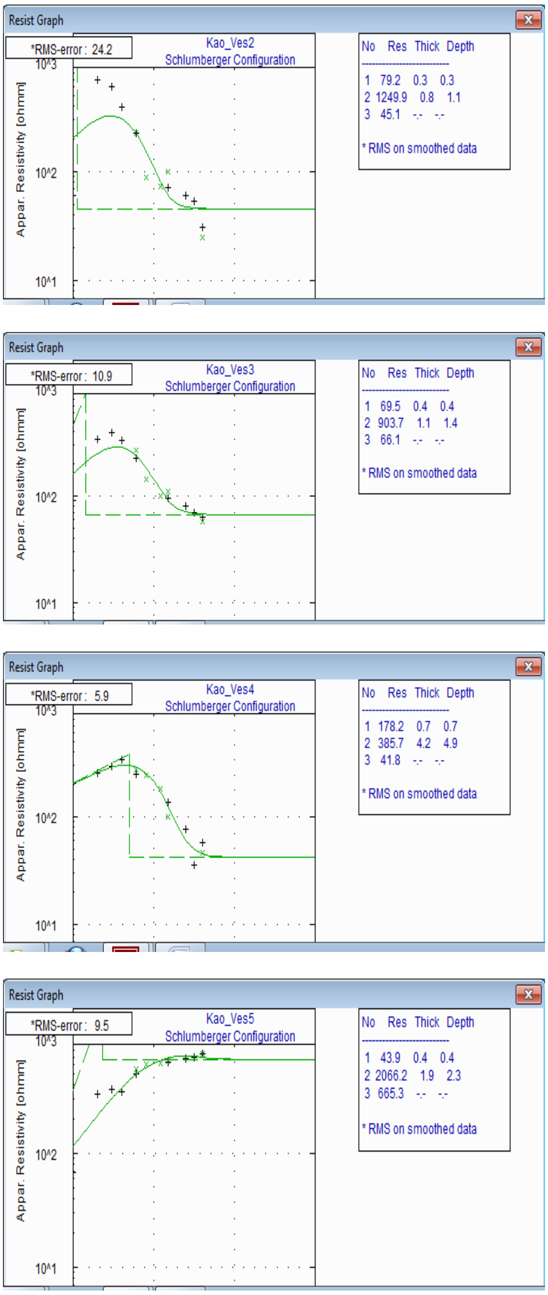


Fig. 2. Geoelectric curves from data interpretations

Table 1: Correlation Table

VES POINT		**1**	**2**	**3**	**4**	**5**
CURVE TYPE		**KH**	**K**	**K**	**K**	**K**
LITHOLOGY						
TOP SOIL	TOP	0	0	0	0	0
	BASE	0.5	0.3	0.4	0.7	0.5

	THICKNESS	0.5	0.3	0.4	0.7	0.5
	Ωm	103	79	70	178	44
LATERITE	TOP	0.5	0.3	0.4	0.7	0.5
	BASE	1.9	1.1	1.4	4.9	2.3
	THICKNESS	1.5	0.8	1.1	4.2	1.9
	Ωm	265	1250	904	386	2066
KAOLIN	TOP	1.9	1.1	1.4	4.9	-
	BASE	9.1	-	-	-	-
	THICKNESS	7.1	-	-	-	-
	Ωm	91	45	66	42	-
BASEMENT	TOP	9.1	-	-	-	2.3
	Ωm	206	-	-	-	665

4.1.1 Geoelectric Units

The geoelectric sections (Figures 3a & b) show the variations of resistivity and thickness values of layers within the depth penetrated in the study area. Four subsurface layers were revealed: Topsoil, Laterite, Kaolin, and presumed Basement.

Topsoil

The topsoil is relatively thin across the study area with an average resistivity and thickness values of 94.8Ωm and 0.5m respectively.

Laterite

Laterite was encountered across the area with average resistivity and thickness values of 974.2Ωm and 1.9m respectively.

Kaolin

Kaolin was encountered in four locations across the area but the thickness could not be established in most parts. The average resistivity value is 61.0Ωm.

Basement

The basement is the fresh bedrock and is the last layer. It is relatively shallow in the study area, it was encountered in two locations and the average resistivity and depth values to the top of basement are 435.5Ωmand 5.7m respectively.

Overburden

The overburden in assumed to include all materials above the Kaolin. The depth to the Kaolin varies from 1.1 to 4.9m and the average depth to the Kaolin is 2.3m (Table 1 and Figure 3a & b). Overburden thickness was established in all locations and the average thickness value is 2.3m.

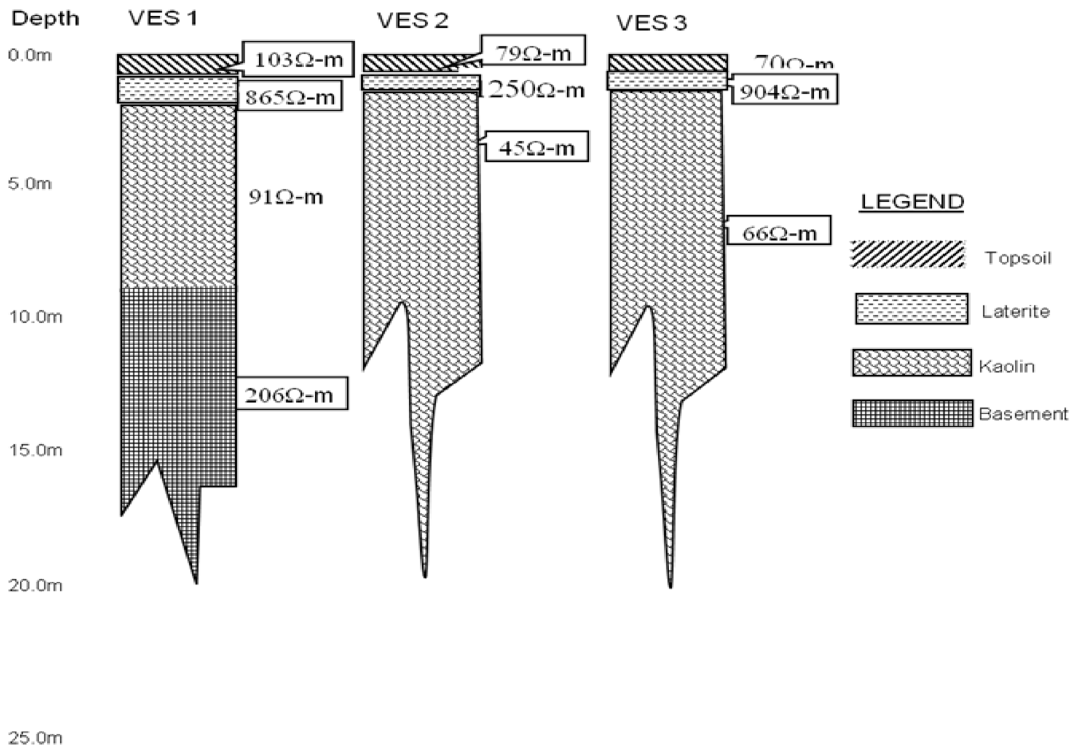


Fig. 3a. Geoelectric Section of the study area

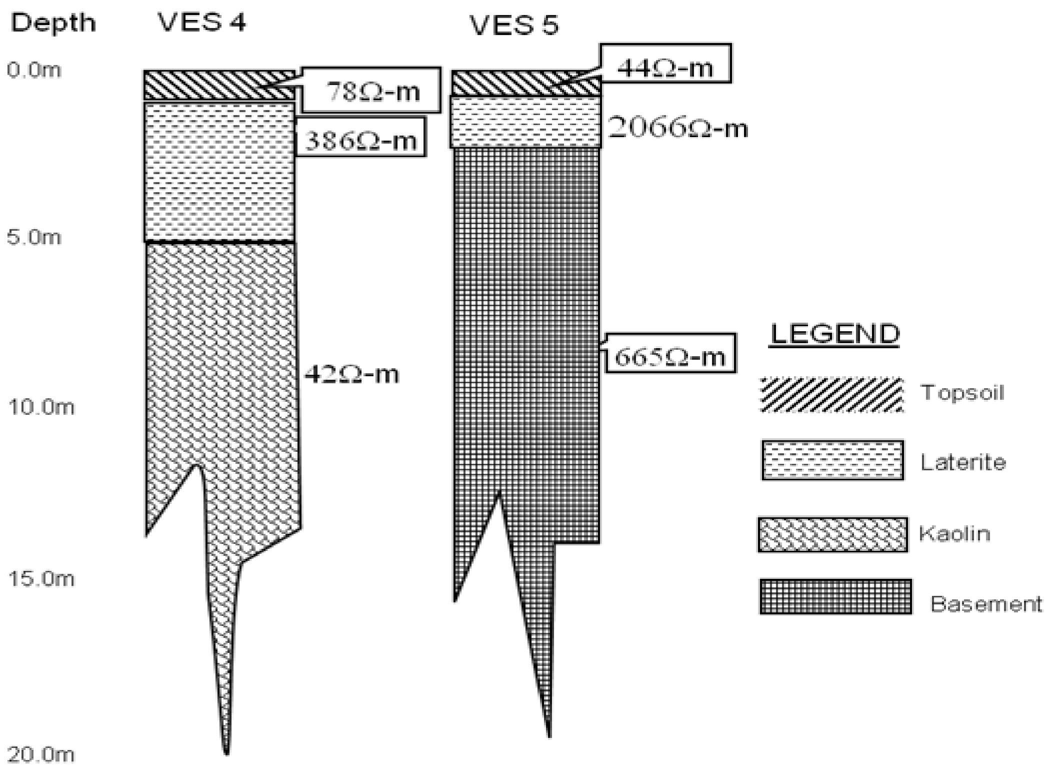


Fig. 3b. Geoelectric Section of the study area

4.2 Horizontal Profiling

Result of the profile carried out is presented in the section below. The traverse is 100meters long. Four continuous subsurface lithologic units namely; Topsoil (blue), laterite (grayish-green), Kaolin (lemon-green) and basement (reddish purple) were established by the profile section. The results are presented in form of field, theoretical data and 2-D resistivity structures (Figure 4a, b & c). The 2-D resistivity plot revealed a relatively thin overburden and shallow basement across the study area.

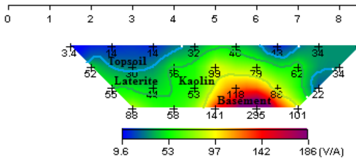


Fig. 4a: Field Data Pseudosection

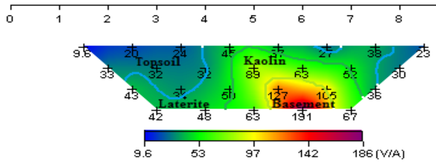


Fig. 4b: Theoretical Data Pseudosection

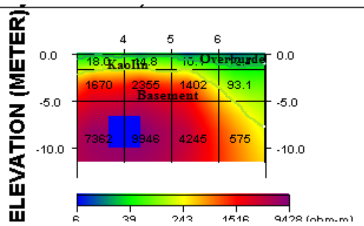


Fig. 4c: 2-D Resistivity Structure

V. DISCUSSION

The top soils are generally thin (within 0.3 – 0.7 m, with the average of 0.5m) in most parts and the average apparent resistivity value is 95 Ω-m while the laterite layers are relatively thick (within 0.8 – 4.2 m, with an average of 2.0m). The laterite average apparent resistivity value is 974.2Ω-m in some parts of the study area. The combination of the top soil and laterite zones constitute the overburden units within the study area with an average thickness of 2.3m. Kaolin was delineated in four of the sounding locations, however, the thicknesses of the units were only revealed in one of the locations (VES 1) and the apparent resistivity of the units ranges between (42 - 91 Ω-m) with an average value of 61 Ω-m.

VI RECOMMENDATIONS

For detail exploration study of the lateral extent of kaolin deposit in Ikere – Ekiti, the area coverage of the study should be extended beyond known surface occurrence of kaolin deposit in the vicinity. Integrated exploration methods should be employed and pitting should be carried out to determine the thickness of kaolin layers (at selected locations based on earlier geophysical studies) within the study area for possible reserve estimate.

VII. CONCLUSION

Occurrence of kaolin deposit and its lateral continuity in Ikere-Ekiti has being confirmed using geophysical exploration method.

REFERENCES

[1] Aderiye, J (2014). Kaolin Mineral Materials for automobile ceramic brake pad manufacturing industry. International journal of technology enhancement and emerging engineering research, volume 2, pg 84-88.
[2] Ajibade, A.C. (2000). Geology: The subject of the future in Nigeria.
[3] Akinyemi, S.A. et al (2014). Mineralogy, physiochemical characteristics and industrial potential of some residual clay deposits within Ekiti State , Southwestern Nigeria, International journal of earth sciences, pg 70-88.
[4] Aramide et al (2014). Production and characterization of clay bounded carbon refractory from carbonized palm kernel shell. ACTA Tehnica Corviniensis – bulletin of engineering, pg 133-140.
[5] Atanda et al (2012). Electrical porcelain production from selected kaolin deposit in Southwestern Nigeria using slip casting. International journal of materials and chemistry, pg 86-87.
[6] Attah et al (2010). Physciochemical properties and industrial potential of some clay deposits in Calabar Area, Southwestern Nigerial. Journal of Mining and geology, pg 39-49.
[7] Badmus et al (2009). Geophysical evaluation and chemical analysis of kaolin clay deposit of Lakiri village, Southwestern Nigeria. International journal of physics sciences vol 4, pg 592-593.
[8] Benea et al (2014). Mineralogy and technological properties of some kaolin types used in the ceramic industry. Studia universities babes-bolyai, geologia, XLIX, pg 33-39.
[9] Commission, E. (2007). Ceramic manufacturing industry. Best available technique reference document.
[10] Egbai, J.C. (2013). Kaolin quantification in Ukwu Nzu and Ubulu Uku using electrical resistivity method. IJRRAS 14, pg 692-693.
[11] Elueze et al (2004). Mineralogical, industrial and chemical characteristics of residual clay occurrences in Iwo and Ijebu district, Southwestern Nigeria. Journal of mining & geology, pg 119-126.
[12] Iyasara et al (2014). Exploring ceramic raw materials in Nigeria and their contribution to nation's development. Americal journal of engineering research (AJER), pg 128-131.
[13] Kaolin uses, benefits & dosage. (2010). Retrieved June 2015, from Drugs.com herbal database.
[14] Lohva et al (2005). Geophysical investigation of Kaolin and Ilmenite deposits in Finland. Geological survey of Finland, special paper, pg 147-154.
[15] Malu et al (2007). Producing insulating refactory bricks with kaolin and sawdust. Journal of engineering and applied sciences, pg 1697-1699.
[16] Mosuro et al (2010). Application of Geophysical and geostatistical methods in the estimate of clay deposit reserve of Idofe and environs, Southwestern Nigeria. Mineral wealth, pg 41-48.
[17] Murray, H.H. (2010). Industrial application of kaolin. Tenth national conference on clays and clay minerals (pg 233-295). New Jersey: Georgia Kaolin Company.
[18] Obaje, N.G. (2009). Geology and mineral resources of Nigeria, lecture notes in earth sciences. New York: Springer.
[19] Okwoli et al (2014). Ground magnetic and electrical resistivity mapping of basement structures over charnokitic terrain in Ado-Ekiti area, southwestern Nigeria. International journal of science and technology, volume 3, no 10, pg 683-689.
[20] Talabi et al (2012). Compositional features and industrial application of Ikere kaolinite, southwestern Nigeria. Research journal in engineering and applied sciences, pg 328-329.