Current Journal of Applied Science and Technology

22(6): 1-11, 2017; Article no.CJAST.26621
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Evaluation of Clay Mineral Deposits in Ohiya, Southeast Nigeria Using the Self Potential Method and Lithologs

D. E. Azunna[1], G. U. Chukwu[1], E. U. Nwokoma[1*] and A. Akenami[2]

[1]Department of Physics (Geophysics), Michael Okpara University of Agriculture, Umudike, P.M.B. 7627, Umuahia, Abia State, Nigeria.
[2]Nigerian Geological Survey Agency, Owerri, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors GUC and DEA designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. Authors AA and EUN managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/26621
Editor(s):
(1) Wen Shyang Chow, School of Materials and Mineral Resources Engineering, Engineering Campus, Universiti Sains Malaysia, Malaysia.
Reviewers:
(1) Burhan Davarcioglu, Aksaray University, Turkey.
(2) Ben Haj Amara, University of Carthage, Tunisia.
Complete Peer review History: http://www.sciencedomain.org/review-history/20295

Short Research Article

Received 26th April 2016
Accepted 3rd June 2016
Published 31st July 2017

ABSTRACT

A self potential survey was carried out on the study area. Four prospects were considered. The prospects investigated had a total area of 2.34 km^2. 18 profiles were obtained from the prospects alongside three other random considered profiles. A total of 315 SP measurements were obtained using the direct potential method with a 10 m increase in the electrode spacing along each of the profiles. Obtained data show a potential range of -2 mV to -600 mV and 1 mv to 251 mV. On analysis, SP spectral signatures and the tomography map reveals that there were also non-conductive materials like silt, sandstone, sand, etc. which constitutes impurities and the overburden. The Iso-Potential contour map of the study area also reveals Nkwoebo, Egbeada and Umuoram as areas of likely kaolin abundance. Litho-logs of excavated sites were obtained to give us a quantitative clue of the mineral in the investigated prospects. It was observed that the overburden thickness is about 1.22 m, the thickness of kaolin deposit to be above 12.2 m and the average bulk reserve is about 74,360,000 metric tons.

**Corresponding author: E-mail: esomchinwokoma@gmail.com;*

Keywords: Kaolin; self; potential.

1. INTRODUCTION

Kaolinite (Aluminum Silicate hydroxide) is a clay mineral, part of the group of industrial minerals chemically composed of aluminum, silicon and water with the chemical formular $Al_2Si_2O_5(OH)_4$. Rocks that are rich in kaolinite are known as kaolin or China clay. Kaolinite is mined as kaolin and is sometimes called kaolin.

Kaolinite is formed typically by intense weathering and it occurs in abundance in soils that have formed from the chemical weathering of rocks in hot, moist climates. Chemical weathering of aluminum silicate minerals like feldspar gives rise to kaolin. This alteration may be caused by the process of ordinary weathering of feldspar first, into clay mineral to kaolin with less water. It can also be formed by the action of gases on the feldspar deposit formed as a result of intrusion of granite associated with some special set of mineral such as cassiterites and other minerals of pnermatolytic origin [1]. Table 1 describes the physical properties of kaolinite.

Kaolin has various uses in industry, agriculture, medicine, geology and in earth sciences. Industrially, it is chiefly used in the manufacture of paints and paper. It is used as a filter for paint, to extend titanium dioxide (TiO_2) thereby modifying the gloss level of the paint. The degree of whiteness of any paint therefore depends on the quality of Kaolin being used in its manufacture It can also be used in agriculture; in organic farming as a spray applied to crops to deter insect damage and to prevent sun scald especially in apples. This controls the damage to fruits and vegetables from insects, termites and fungi [2].

Glossy papers used in most magazines are produced with kaolin. Aside paint and paper, it can be used in the manufacture of soap, ink, textile, ceramics, tyre, toothpaste, smoking pipes, facial masks. It can also be used as; a light diffusing material in white incandescent light bulbs and as adsorbents in water and waste water treatment. Medically, kaolin can be used in manufacturing pharmaceutical products and to induce blood clotting in diagnostic procedures. It is however edible and can be eaten for health or to suppress hunger. Consumption is greater among women especially during pregnancy [3].

1.1 The Study Area

Ohiya lies between Latitude 05°29' and 05°.33' North and Longitude 07°.26 and 07°.28' East covering an area of about 15.7 km^2. The location map is as shown in Fig. 1. Ohiya is underlain by the Benin Formation comprising of shale/sand sediments. It is made up of poorly sorted, friable and fluvio-lacustrine sand deposits with minor intercalations of clays. It is mostly coarse-grained, pebbly, poorly sorted and contains pods and lenses of fine grained sands, sandy clays and clays. It is a part of the coastal plain sands of the Cenezoic Niger-Delta region of Nigeria [4]. Locally, it is composed mainly of clays and alluvium deposits. The kaolin deposits are consolidated and are surrounded by sand, silt and clays as shown in the geologic map in Fig. 2.

Table 1. Physical properties of Kaolinite [5]

Physical quantity	Description
Luster	Pearly to dull earthy
Fracture	Earthy
Hardness	2 to 2.5 on Moh's scale of hardness. It can leave marks on paper
Streak	White
Size	Very fine, less than 2 microns
Tenacity	Flexible but inelastic
Specific gravity	2.6 (average)
Crystal habit	Foliated and earthy masses. Crystals of any size are rare and it is usually microscopic
Cleavage	Basal, perfect in one direction

Ohiya has a high relative humidity of over 70% and it is characterized by high temperature of about 29°C – 31°C. It has an annual rainfall of about 4000 mm per annum with two seasons – dry and wet seasons. Wet season starts from mid April to October and dry season from November to Mid April. It has double maxima rainfall peaks in July and September with a short dry season of about three weeks between the peaks locally known as "August Break." [6].

The relief pattern of the study area shows an undulating pattern. It has high and low elevation and valleys. The Northern part has the highest elevation with an elevation of about 350 ft to 430 ft above sea level while the middle part filled with valleys and gullies with an elevation of 330 ft and below. The elevation begins to rise again as we move Southwards as illustrated in the three-dimensional relief map shown in Fig. 3.

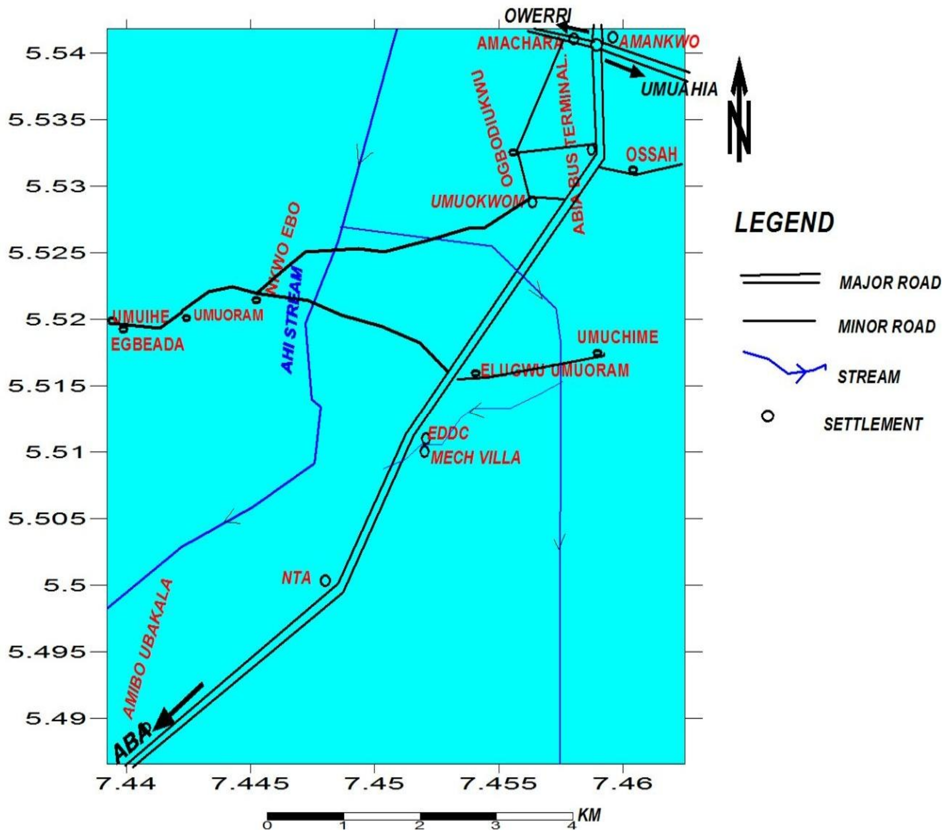


Fig. 1. Location map of the study area

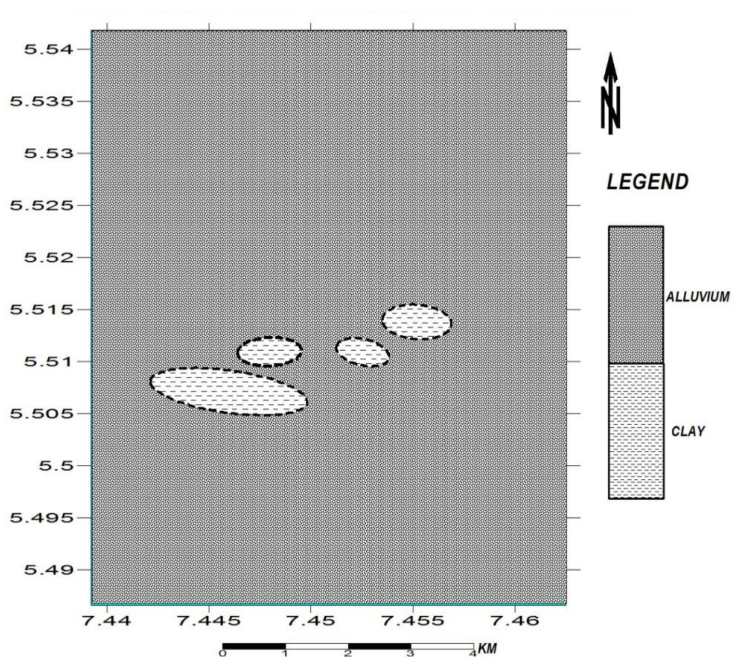


Fig. 2. Local geologic map of Ohiya

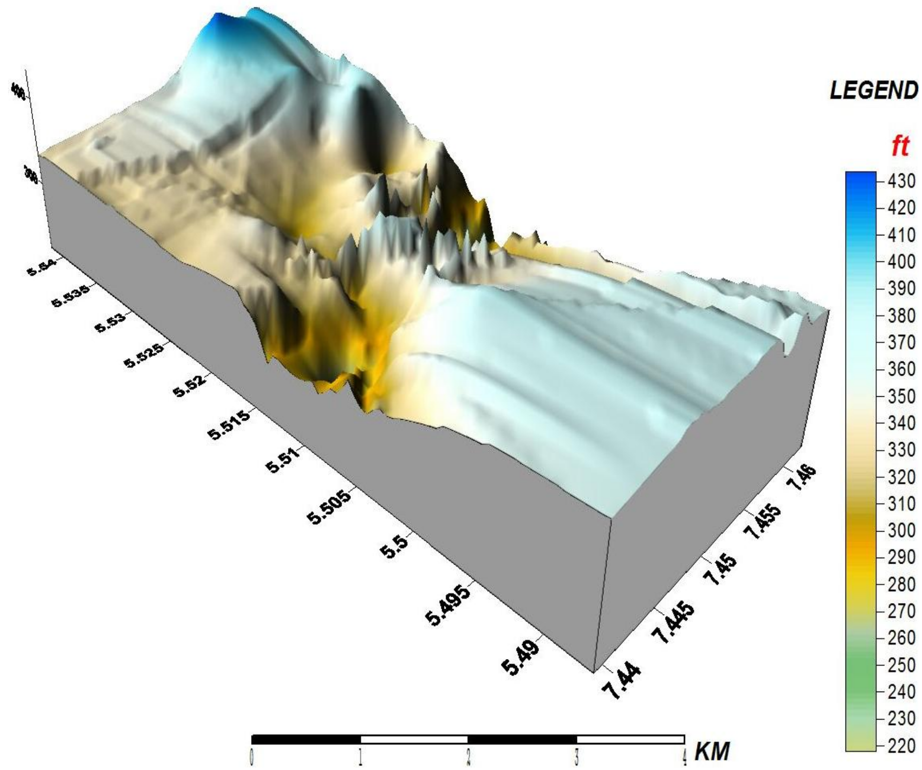


Fig. 3. 3-D relief map of Ohiya

The topography has an uneven slope with the Southern and Northern parts having a gentle slope while the Eastern and the Western parts have a very steep slope. This is where we can see the concentration of lowlands and valleys.

2. MATERIALS AND METHODS

A pair of non-polarizable electrodes, Ohmega 1000 terameter and two reels of wire were assembled in a field survey to get self potential data. One end of each of the reels of wire is connected to the terminals of the tetrameter. The other end of the first reel of wire is connected to the electrodes at the base station at zero offset distance (x) while the other end of the second reel of wire is connected to the roving electrode. The reel of wire is unreeled as the roving electrode is moved from point to point along the survey line. Four prospects were investigated as well as three other randomly taken profiles. The direct potential method was used because the reel of wire is sufficiently long to cover the traverses in each measurement location.

A grid was made on each prospect with many profiles. In prospect one, nine (9) profiles were covered while in prospects two, three and four, we had four, three and two profiles covered respectively. Prospects one to four have areas of 1.29 Km^2, 0.3046 Km^2, 0.1492 Km^2 and 0.6014 Km^2 respectively which implies that a total of 2.3452 Km^2 was covered. The lengths of the profiles were from 100 m to 200 m of length depending on the terrain. SP measurements were taken along each of the profiles with a 10m increase in the electrode spacing in all the profiles.

Litho-logs were also obtained from excavation and sight observation for quantitative analysis. In all, 315 SP Data sets were obtained for study and analyses. The map of the prospects investigated is as shown in Fig. 4.

3. RESULTS AND DISCUSSION

Some of the obtained SP values are as shown in Table 2. The SP values for each of the profiles were analyzed. A plot of self potential against the offset distance (x) gives the spectral signature which gives us information on the conductivity of clay in the subsurface. One of the many Spectral signatures in each of the prospects is as shown in Fig. 5.

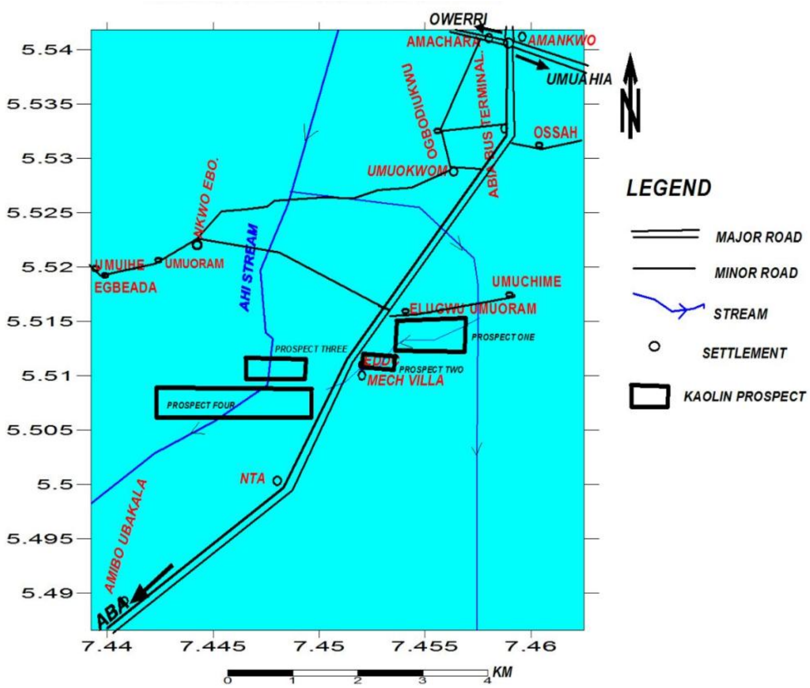


Fig. 4. Kaolin prospects investigated

Positive potential values depict the presence of non conductive materials like silt, sand sandstone, etc while the negative values indicate the presence of conducting minerals like clay. From the SP spectral signatures kaolin is likely to be seen in abundance within prospects 1, 3 and four as well as the areas of random profiling. It can as well be seen in prospect two but might be mixed by great amount of impurities in form of host rock.

The Iso-potential map of the study area (Fig. 6) is contoured with an interval of 50mV which reveals major areas of kaolin/clay abundance which was later delineated in Fig. 7. It can be deduced that kaolin/clay deposit is likely to be abundant in these localities: Nkwoebo, Egbeada and Umuoram as can be inferred from the map.

3.1 Tomography

The nature of the kaolin deposit in the prospect areas can be seen using the tomographic chat shown in Fig. 8.

A slice through the SP values reveals that values above zero shows the overburden. The colour variation reveals the anisotropic nature of the electrical properties of the kaolin implying that conductivity depends on the offset distance. The SP values ranges from about -2 mV to -600 mV and from 0 to 200 mV.

3.2 Quantitative Analysis

To get the quantitative information of the kaolin deposits in the study area, a litho-log was obtained from three different excavated areas as shown in Figs. 9 and 10.

From the litho-logs obtained from site excavation, an average overburden of 1.22 m (4.0 ft) was discovered and a depth (d) of kaolin obtainable is about 12.2 m (39.37 ft).

3.3 Kaolin Bulk Reserve

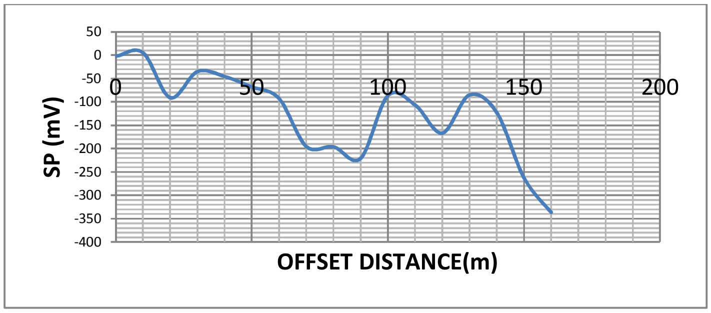
The bulk reserve/tonnage of a mineral is given by the product of the volume, depth and specific gravity. Since the prospects covered have a total area of 2.3452 sqKm (2,345,200 sqm) and the average depth of kaolin deposit ascertained from the litho-log is about 12.2 m. Then;

Volume of the kaolin in the prospects investigated = 12.2 x 2,345,200

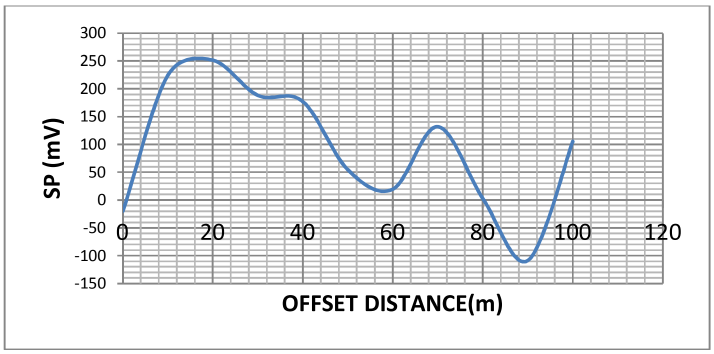
= 28,611,440 m^3 = 28,600,000 m^3 (in the nearest hundred of thousand).

The average specific gravity of kaolin is 2.6. Then the average tonnage or bulk reserve of the prospects

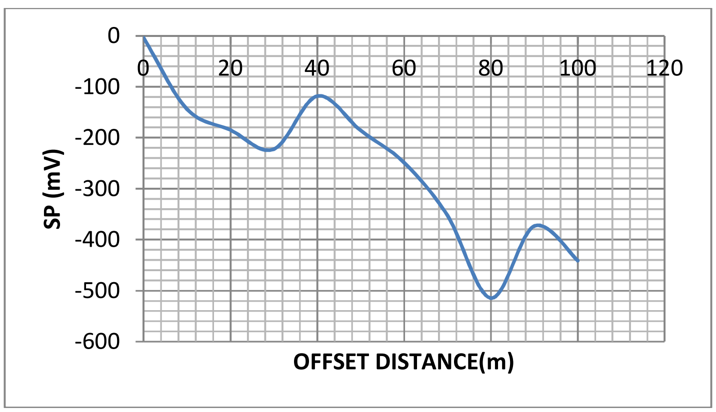
= 28,600,000 x 2.6
= 74,360,000 metric tons



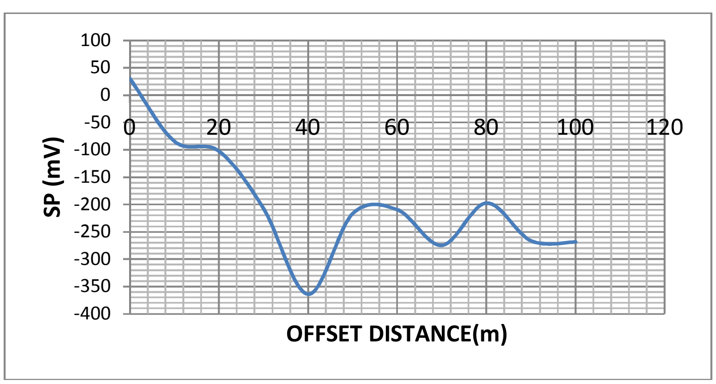
a) Prospect one



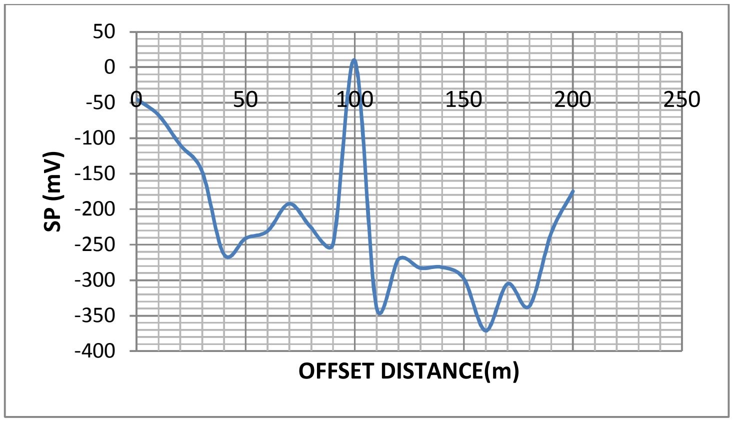
b) Prospect two



c) Prospect three



d) Prospect four



e) Random profile

Fig. 5. SP Spectral signatures of kaolin prospects in Ohiya

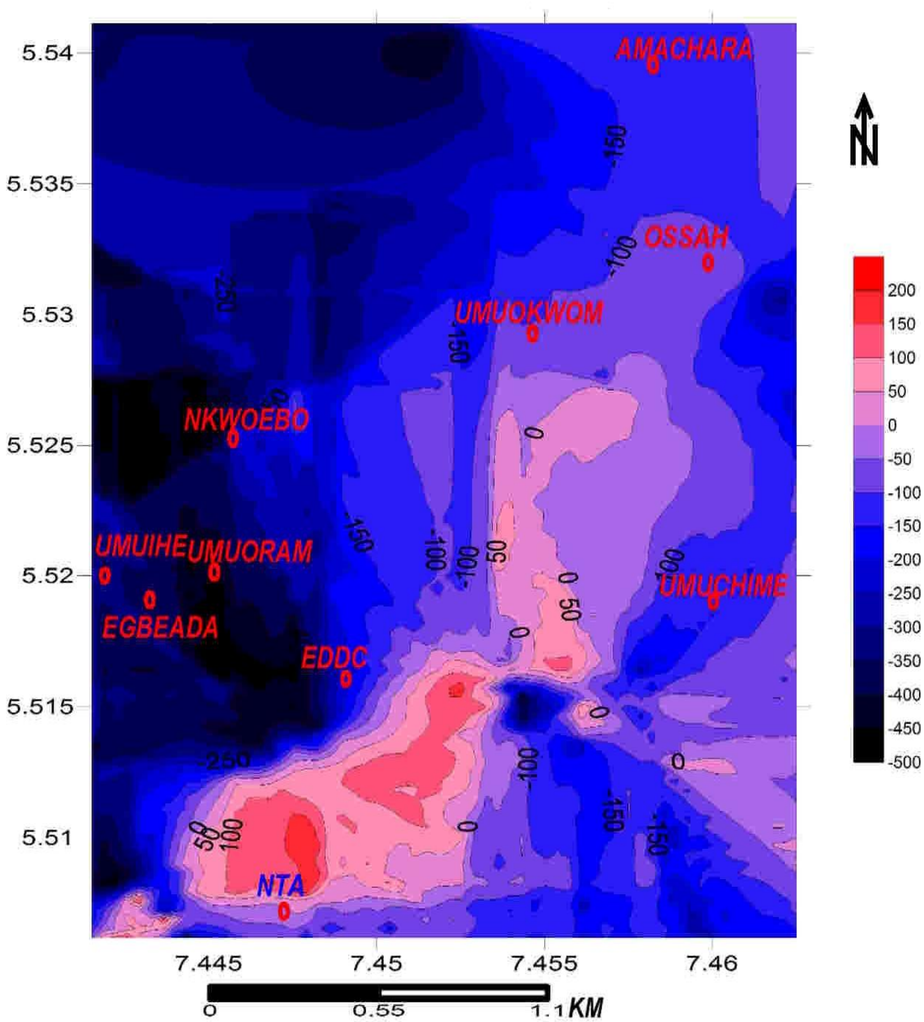


Fig. 6. Iso-potential map of Ohiya

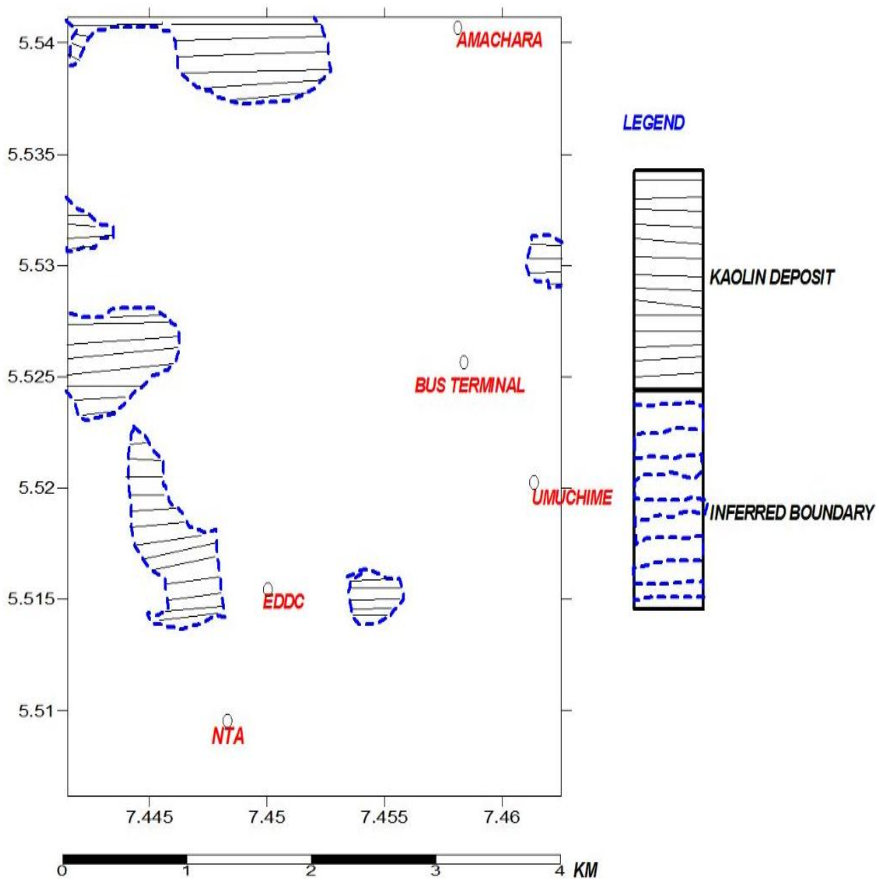


Fig. 7. Kaolin clay deposit inferred from sub-surface mapping

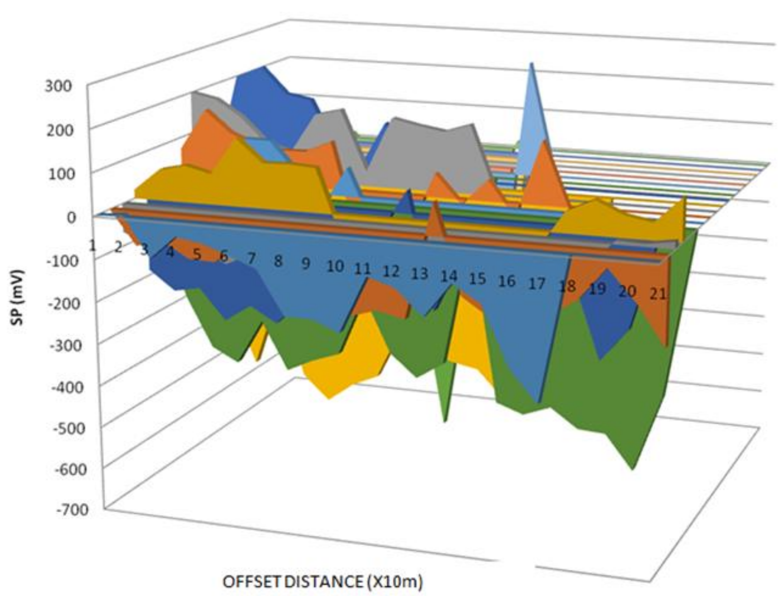


Fig. 8. SP tomography of prospect areas

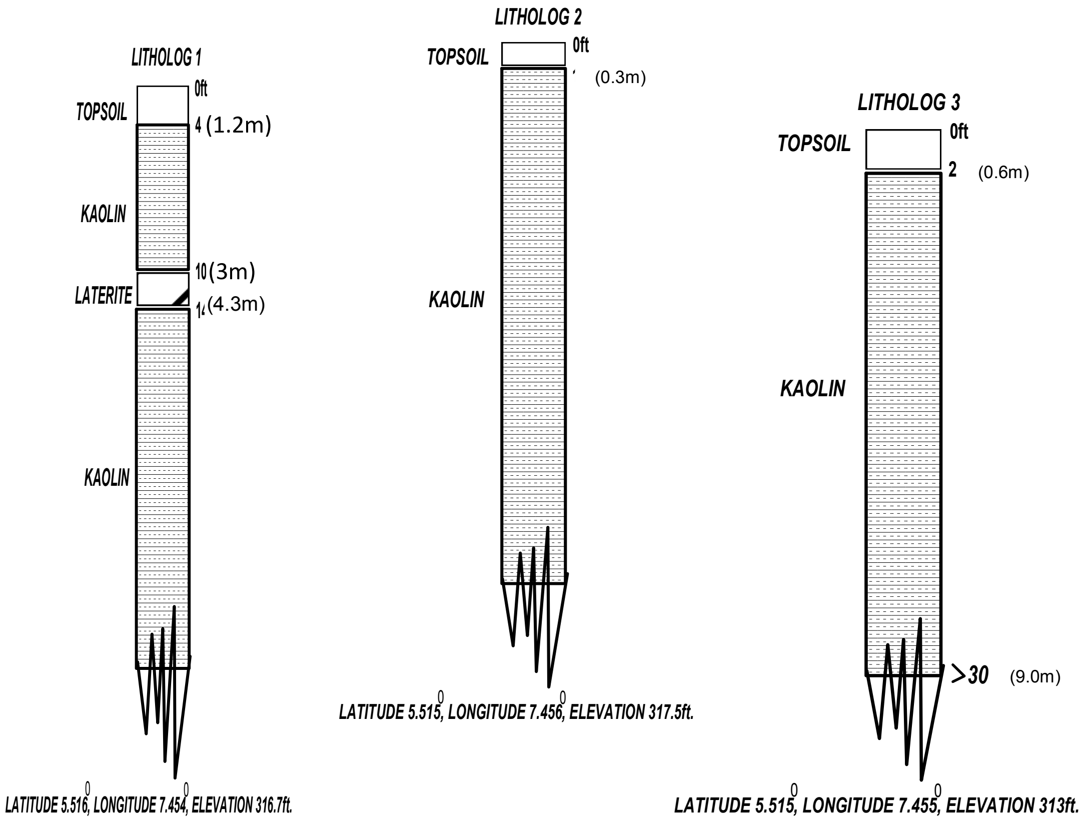


Fig. 9. Litho-log from surface geologic mapping

Table 2. Some SP values of clay in Ohiya

X (m)	SP values (mV)				
	Random	Prospect 1	Prospect 2	Prospect 3	Prospect 4
0	-44.82	-2.018	-19.77	-4.097	30.32
10	-67.14	5.375	224	-144	-84.38
20	-109.5	-90.87	251.1	-185	-102.4
30	-146.4	-34.98	188	-222.6	-207.4
40	-263.3	-45.43	176.9	-118.6	-363.9
50	-240.9	-67.95	54.56	-186	-216.5
60	-230.7	-92.69	19.57	-249	-209.4
70	-192.1	-195.2	131.8	-352.7	-274.5
80	-225.7	-196.2	3.083	-514.4	-197.2
90	-249	-220.6	-108.5	-373.1	-266.3
100	9.394	-86.4	105.4	-441.2	-268.4
110	-338.5	-106.4	-	-	-
120	-270.4	-166.7	-	-	-
130	-282.6	-84.98	-	-	-
140	-281.6	-122.7	-	-	-
150	-297.8	-262.3	-	-	-
160	-371	-336.5	-	-	-
170	-305	-	-	-	-
180	-336.5	-	-	-	-
190	-233.8	-	-	-	-
200	-174.8	-	-	-	-

LITHO-LOG CORRELATION

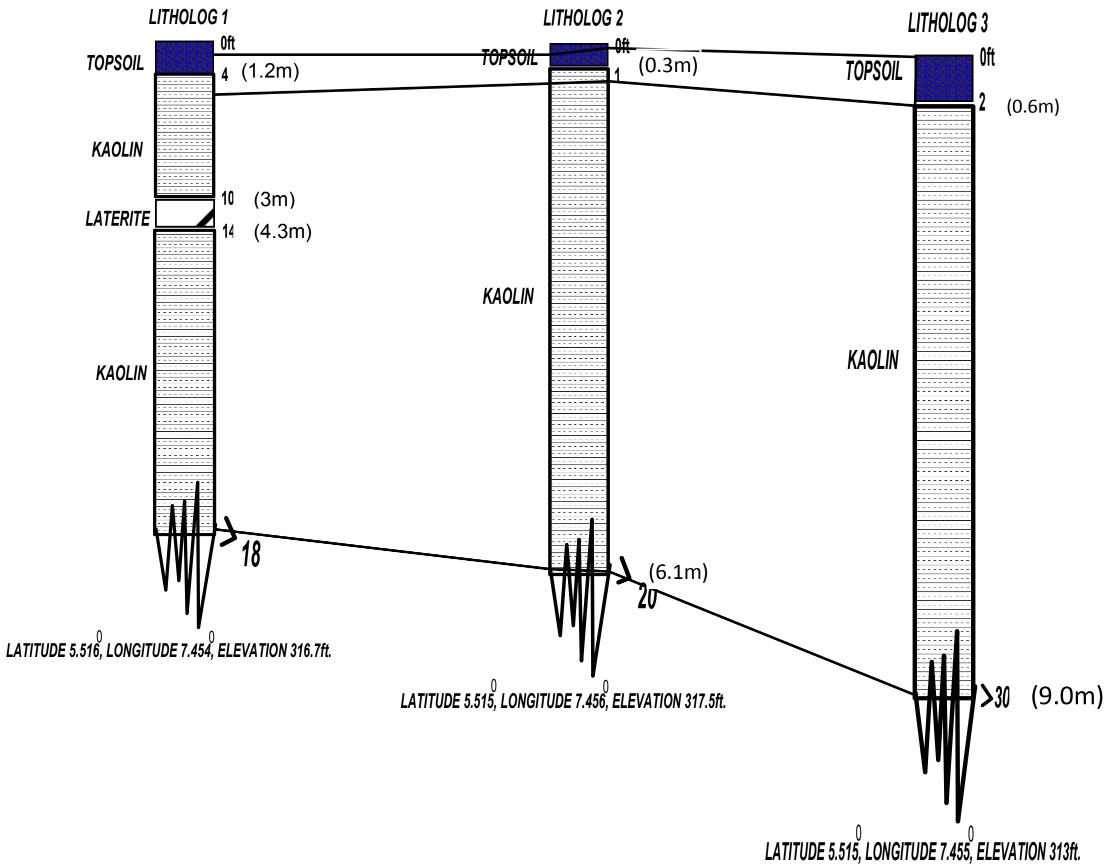


Fig. 10. Litholog correlation

4. CONCLUSION

Self potential which is the naturally occurring electrical potential of the earth results from geologic, geochemical and hydrological interactions. It has wide range of application especially in mineral prospecting. Kaolinite, a clay mineral formed from the chemical weathering of aluminum silicate minerals like feldspar is of great economic benefit. It is used in agriculture, medicine, geology and in earth sciences. It is also used by paint, paper and ceramics manufacturing industries.

It was observed that clay mineral in the study area has a self potential of between -2 mV and -600 mV. Spectral signatures of the profiles obtained show that there were other non-conductive materials like sand, silt, sandstone, etc. which were also noticed. The Iso-potential map of the study area reveals many other localities in the study area where kaolin/clay mineral is likely to exist abundantly which include, Nkwoebo, Egbeada and Umuoram.

However, since SP gives only qualitative information litho-logs were obtained from excavated sites to get a clue on the quantitative properties of the kaolin in the prospects investigated. It was observed that the kaolin is likely to have; an overburden of about 1.22 m (4.00 ft), a depth of about 12.2 m and a bulk reserve of about 74,360,000 metric tons. SP method is precise and efficient electrical method which can be used in mineral prospecting. If well used, it can give much information about minerals in the earth's sub-surface.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1 Egbai JC. Kaolin quantification in Ukwu-Nzu and Ubulu-Uku using electrical resistivity method. International Journal of Research and Reviews in Applied Sciences. 2013;14(13):792–701.

2 Oruobu D. Kaolin as bedrock of manufacturing industry. Business Times. 2004;22:12.

3 Leiviskä Tiina, Gehör Seppo, Eijärvi Erkki, Sarpola Arja, Tanskanen Juha. Characteristics and potential applications of coarse clay fractions from Puolanka, Finland. Central European Journal of Engineering. 2012;2(2):239–247.

4 Asseez LO. Review of the stratigraphy, sedimentation and structure of the Niger Delta. In: Kogbe CA. (ed.). Geology of Nigeria. Elizabeth Publ. Co.: Lagos, Nigeria. 1976;259–272.

5 Pohl Walter L. Economic geology: Principles and practice: Metals, minerals, coal and hydrocarbons – introduction to formation and sustainable exploitation of mineral deposits. Chichester, West Sussex: Wiley-Blackwell. 2011;331.

6 Amos-Uhegbu C, Igboekwe MU, Chukwu GU, Okengwu KO, Eke TK. Hydrogeo-physical delineation and hydrogeochemical characterization of the acquifer systems in Umuahia south Area, Southern Nigeria. British Journal of Applied Science and Technology. 2012;2(4):406–432.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20295