Original Research Article

GEOPHYSICAL EXPLORATION FOR CLAY IN, IGBESA AREA AND ITS ENVIRON, SOUTHWESTERN NIGERIA.

Abstract

A 3-D resistivity survey was carried out in Igbesa area and its environs, a sedimentary terrain of South-western Nigeria. The wenner alpha electrode configuration was engaged through out in this study. Ten profiles were covered; each profile 25 metres apart. A 3-D square grid was generated using parallel 2-D lines. Five transverse lines were in the North –South direction and the others in the West –East direction.

An inverse model resistivity value that utilizes the smoothness constrained least-squares inversion of RES3DINV software was used. Seven iterations were undertaken and this produces an RMS error of 21.5 %. The high RMS error is attributed largely to resistivity variation obtained from the lithological materials within the study area. From the results obtained, clay was suspected only in a small portion in the east of the first layer which was approximately about 2.50m deep. Associated materials like clayey sand and lateritic clay were delineated at the surface to the third layer (i.e. a depth of approximately 9.0m), and at the surface to the fourth layer (i.e. a depth of about 17.0m) respectively.

Keywords: Clay, Clayey sand, Lateritic clay, 3-D slices, Res3Dinv.

1. Introduction

Clay minerals are typically formed over long periods of time by the gradual chemical weathering of rocks, usually silicate-bearing, by low concentrations of carbonic acid and other diluted solvents. These solvents, usually acidic, migrate through the weathering rock after leaching through upper weathered layers. In addition to the weathering process, some clay minerals are formed by hydrothermal activity. Clay deposits may be formed in place as residual deposits in soil, but thick deposits usually are formed as the result of a secondary sedimentary deposition process after they have been eroded and transported from their original location of formation. Clay deposits are typically associated with very low energy depositional environments such as large lakes and marine basins.

Clay and clay minerals have been mined since the stone age and has been indispensable in architecture, in industry and agriculture. Today they are among the most important minerals used in manufacturing and environmental studies. Clay is wide spread all over the world. In Nigeria, clay is widely distributed though not always found in sufficient quantity or suitable quality for modern industrial purposes. It occurs both as residual and sedimentary clay. More than 80 clay deposits have been reported in Nigeria. Clay deposits occur in Abak in Akwa Ibom State, Uruove near Ughelli in Delta State, Ifon in Ondo State, Mokola in Oyo State, Sokoto in Sokoto State, Gombe in Gombe State, Dangara in Niger State, Umuahia in Abia State, Onitsha in Anambra State e.t.c. Almost every State in Nigeria has at least one known deposit of kaolin. In Anambra State there is the Ozubulu deposit, Darazo kaolin deposit in Bauchi, Akpene-Obom deposit in Cross River State, Kankara in Kaduna State e.t.c. The three most extensively studied deposits are the Ozubulu kaolin deposits, Kankara deposits and the

Major Porter deposits, in Plateau State (Akhirevbulu and Ogunbayo). The focus of this work is to investigate for clay in Igbesa that could be of economic value.

2. Location and Geological Setting of the study area

This research was carried out in Igbesa, between longitude N006^{0} 32$^{'}$27.2$^{''}$ and N006^{0} 32$^{'}$30.4$^{''}$ and latitude E003^{0}7$^{'}$27.0” and E003^{0}07$^{'}$30.4”, with an average elevation of 59.75m covering about 146km^{2}**.** This community under consideration is located in the South-western part of Nigeria and falls within the Dahomey Basin, (from figure 1).

The Dahomey Basin is a combination of inland/coastal/offshore basin that stretches from southeastern Ghana through Togo and the Republic of Benin to southwestern Nigeria. It is separated from the Niger Delta by a subsurface basement high referred to as Okitipupa Ridge. Its offshore extent is poorly defined. Sediment deposition follows an east-west trend. In the republic of Benin, the geology is fairly well known. In the onshore, cretaceous strata are about 20m thick. A non-fossiliferous basal sequence rests on the Precambrian basement. This is succeeded by coal cycles, clays and marls which contain fossiliferous horizons. Offshore, a 1000m thick sequence consisting of sandstones followed by black fossiliferous shale towards the top has been reported. This was dated by Billman (1976) as being pre-Albian to Maastrichtian. The cretaceous is divisible into two geographic zones, north and south. The sequence in the northern zone consists of a basal sand that progressively grades into clay beds with intercalations of lignite and shales. The uppermost beds of the Maastrichtian are almost entirely argillaceous. The southern zone has a more complicated stratigraphy with limestone and marl beds constituting the major facies. This sequence rests on the basement; the transitional facies is marked by a conglomerate or white to grey sandy and kaolinitic clays derived as degradation products from the surrounding Precambrian rocks. Among the major lithostratigraphic units of the eastern Dahomey basin are the Araromi, Ewekoro, and Akinbo formations. The Dahomey basin is one of the sedimentary basins on the continental margin of the Gulf of Guinea, extending from southeastern Ghana in the west to the western flank of the Niger Delta Jones and Hockey, 1964; Omatsola and Adegoke, 1981. The basin is bounded in the west by faults and other tectonic structures associated with the landward extension of the fracture zone. Its eastern limit is similarly marked by the Hinge line, a major fault structure marking the western limit of Niger Delta (Adegoke, 1969; Omatsola & Adegoke,1981).

Stratigraphic studies of Dahomey basin were conducted by various researchers among whom are Jones and Hockey, (1964); Adegoke.(1975); Omatsola and Adegoke, (1981). The general sequence for the rock unit from the top are the Coastal plain sands, Ilaro formation, Oshosun formation, Akinbo formation, Ewekoro formation, and Abeokuta formation lying on the Southwestern Basement Complex of Nigeria as shown in figure 2.

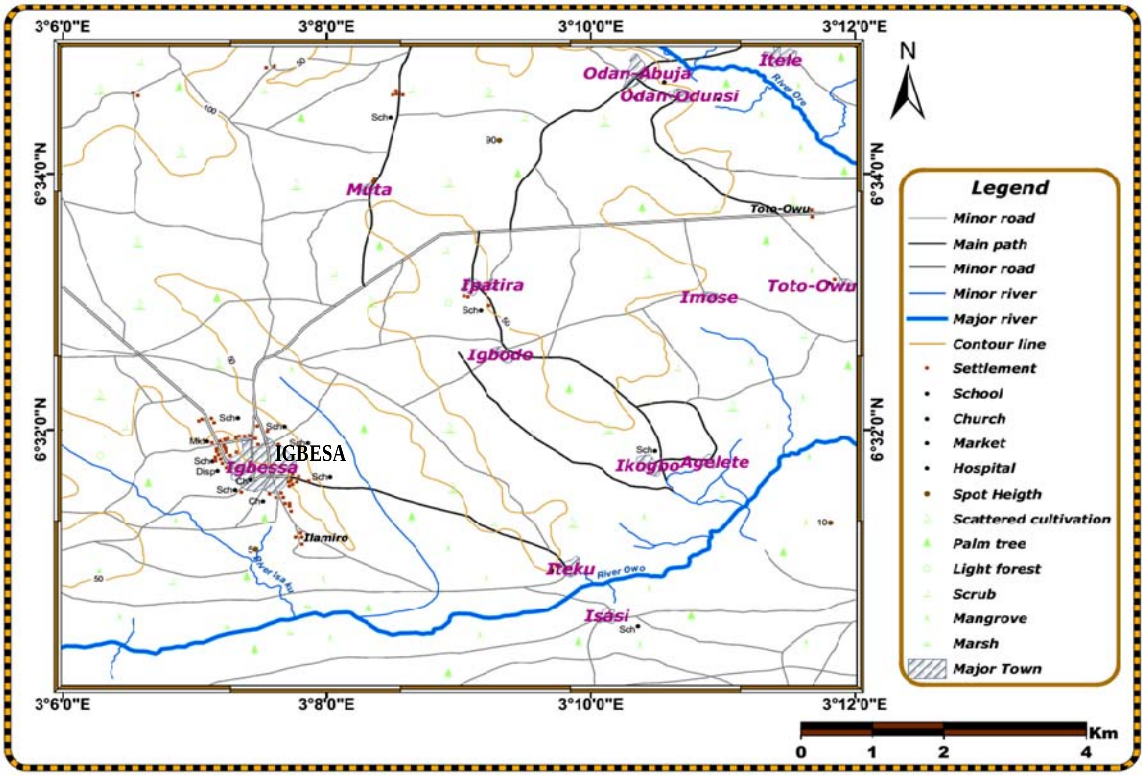


Figure 1: Location map of the study area

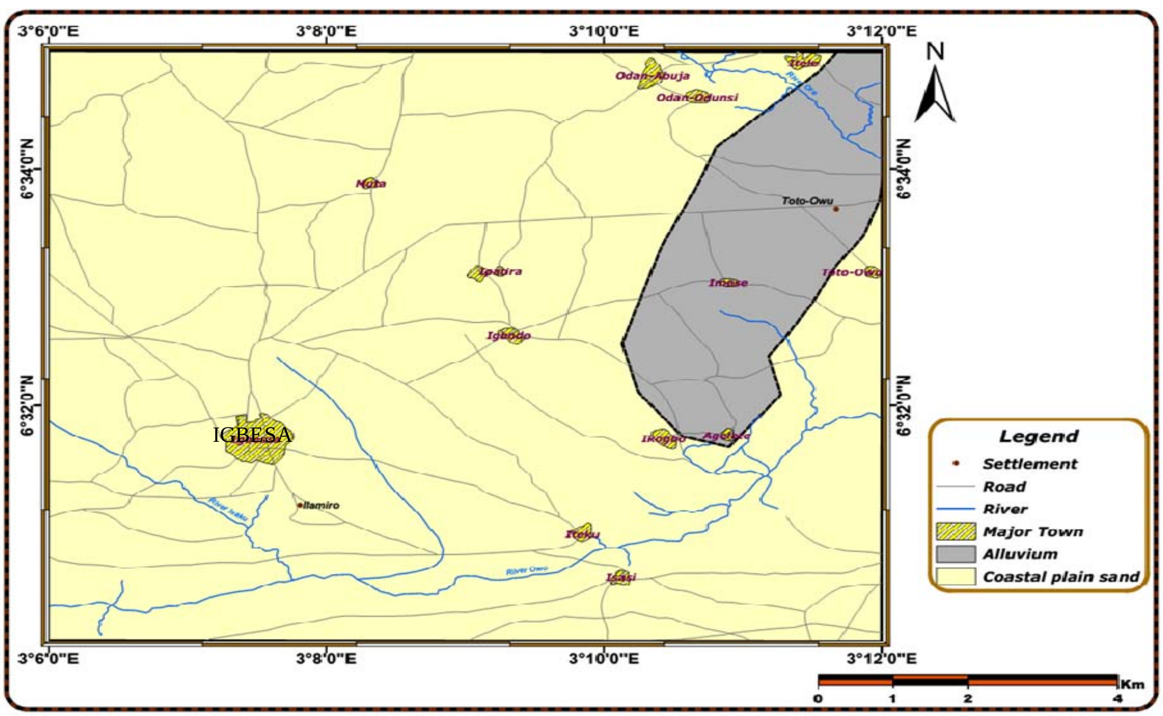


Figure 2: Geological map of the study area

3. Method

In this case, measurements are made only in one direction. The 3-D data set consists of a number of parallel 2-D lines. The data from each 2-D survey line is initially inverted independently to give 2-D cross-sections. Finally, the whole data set is combined into a 3-D data set and is inverted with RES3DINV to give a 3-D picture. While the quality of the 3-D model is expected to be poorer than that produced with a complete 3-D survey, such a “poor man’s” 3-D data set could reveal major resistivity variations across the survey lines. Until multi-channel resistivity instruments are widely used, this might be the most cost effective Solution to extract some 3-D information from 2-D surveys.

The wenner array was used in all the ten traverses; five in the north-south direction, and the other five in the west-east direction. The spacing between adjacent electrodes is 5 metres. The first step was to make all the possible measurements with the wenner array with electrode spacing of 5 metres. For the first measurements, electrode number 1, 2, 3, and 4 were used. Notice that electrode 1 was used as the first current electrode C1, electrode 2 as the first potential electrode P1, electrode 3 as the second potential electrode P2 and electrode 4 as the second current electrode C2. For the second measurement, electrodes 2, 3, 4, and 5 were used for C1, P1, P2, and C2 respectively. This is repeated down the line of electrodes until electrodes 18, 19, 20, and 21 were used for the last measurement with 5 metres spacing. For this system with 21 electrodes, there are $18(21-3)$ possible measurements with 5 metres spacing for the Wenner array.

After completing the sequence of measurements with 5 metres spacing, the other sequences of measurements with 10, 15, 20, 25, and30 metres electrode spacing were made. This procedure was followed in all the ten transverses where this experiment was undertaken. The distance between adjacent transverse is 25 metres. In order to get the best results in this field survey, all possible measurements were made as fast as possible, as these would affect the quality of the interpretation model obtained from the inversion of the apparent resistivity measurements (Dahlin and Loke, 1998). Note that as the electrode spacing increases, the number of measurements decrease.

4. Results and Discussion

3-D resistivity imaging results in slices

The x-axis runs approximately from along the west-east and the y-axis along the north-south directions respectively.

Layer One (Depth: 0.00 – 2.50m)

There was the presence of a small and elongated portion of clay/surface water which was about 40.0m long in the north-east. Clayey sand was suspected in three locations, two in the north-west and one in the extreme south-west (Barker *et. al*., 1992).
Laterite with varied apparent resistivity ranging from about $326.0\,\Omega m$ to1, $200.0\,\Omega m$ was concentrated in the west, most especially in the north-west. Inhomogeneous mixture of laterite and lateritic sand were found scattered within the layer with apparent resistivity values of about $1{,}200.0\,\Omega m$ to $1{,}500.0\,\Omega m$ (Kearey *et. al,* 2002). Patches of sandstone were delineated at the centre and east of the layer with apparent resistivity values of approximately $2{,}000.0\,\Omega m$ to $4{,}400.0\,\Omega m$ (figure 3).

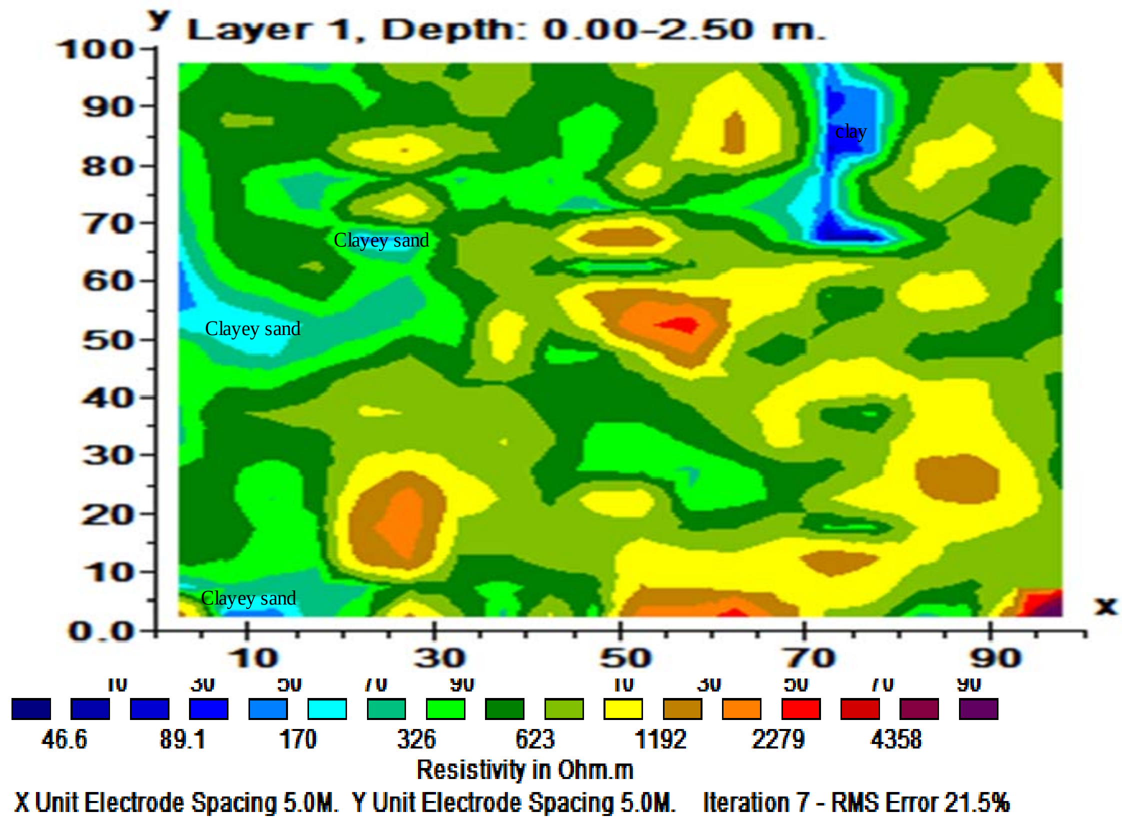


Figure 3: A 3-D resistivity inversion slice along x-y coordinates at a depth of (0.00 -2.50m).

Layer Two (Depth: 2.50 – 5.38m

There were four parches of clayey sand scattered within the layer with apparent resistivity values of about 100.0 Ωm to 200.0 Ωm (Loke *et.al*, 2003), as shown in figure 4.These were enclosed by lateritic clay/laterite which was mostly concentrated in the western side of the layer at a distance of 0.00m to 60.0m in the x-axis, and with apparent resistivity values ranging from about 200.0 Ωm to 900.0 Ωm (Loke and Barker, 1995). The eastern part of the layer was highly resistive, having inhomogeneous distribution of lateritic sand and sand with characteristic apparent resistivity values of about 908.0 Ωm to over 4,358.0 Ωm.

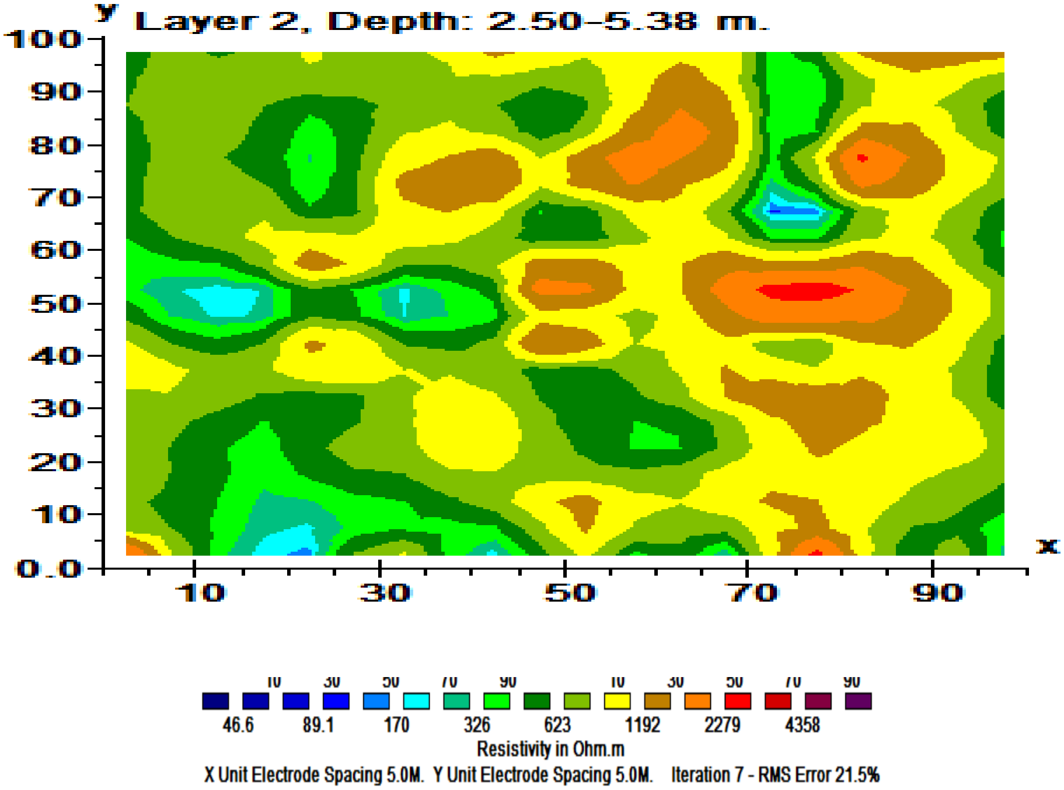


Figure 4: A 3-D resistivity inversion slice along x-y coordinates at a depth of (2.50 -5.38m)

Layer Three (Depth: 5.38 – 8.68m)

Low resistivity material was delineated in the south indicating the presence of clayey sand which was presence at a distance of about 0.0m to 47.0m in the x-axis with apparent resistivity values of about 100.0 Ωm to 200.0 Ωm (Lawson and Hanson,1974) Uneven distribution of lateritic clay occurs mostly in the west with apparent resistivity values of 300.0 Ωm to 550.0 Ωm . Laterite of apparent resistivity values of about 850.0 Ωm to 1,200.0 Ωm was spread all over the layer especially in the north and centre (figure 5). The enclosed irregular and unaligned wet sand, and a deposit of dry sand which appears as a spot in the north have approximate apparent resistivity values ranging from about 1, 00.0 Ωm to above 4,500.0 Ωm (Scales, 1985)..

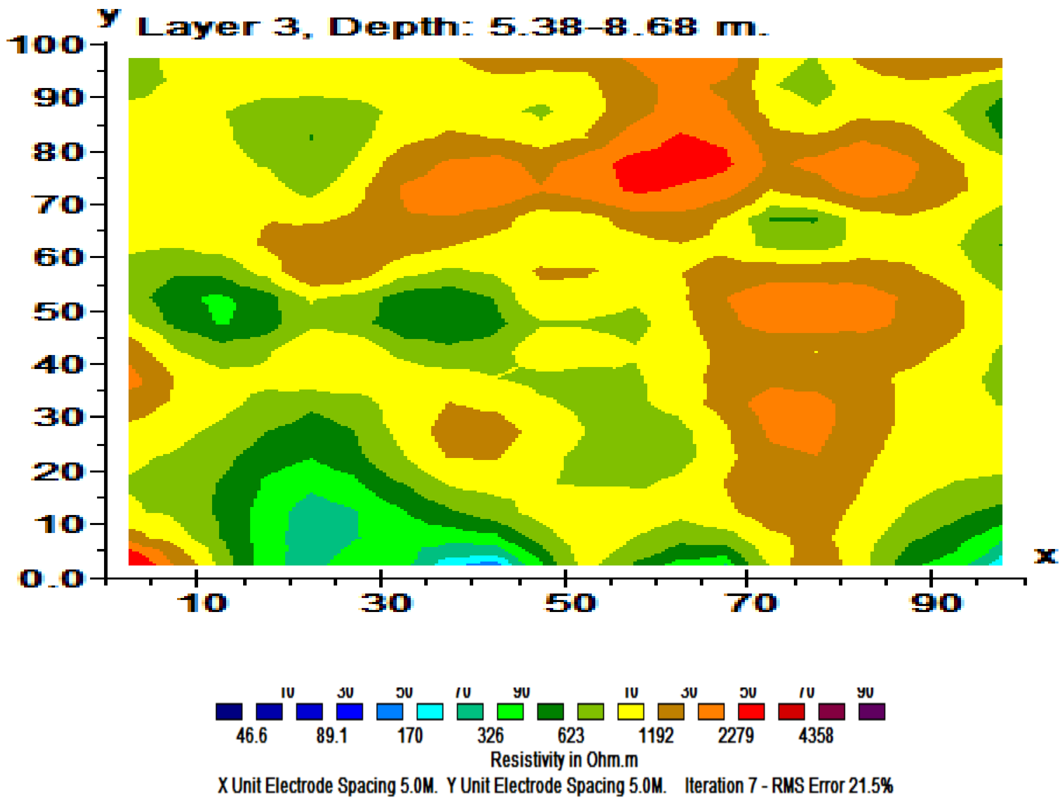


Figure 5: A 3-D resistivity inversion slice along x-y coordinates at a depth of (5.38 - 8.68m).

Layer Four (Depth: 8.68 – 12.50m)

Apparent resistivity increases northward in this layer. In the extreme south, there was low resistive material interpreted to be lateritic clay with apparent resistivity values range of about 320.0 Ωm to 900.0 Ωm (Golub and van Loan, 1989). Over sixty percent (60%) of the entire layer was occupied by moderate laterite spreading from the north to the south. Suspended at the mid-north, and having some patches down south was a material depicted to be lateritic sand with an apparent resistivity values ranging from about 1,000.0 Ωm to 1,500.0 Ωm as shown in figure 6. Like layer three, a spot in the north with apparent resistivity values above 1,500.0 Ωm indicated the presence of sand (Schwarz *et. al*,1973).

Layer Five (Depth: 12.50 – 16.90m)

Laterite with an apparent resistivity values range of about 1,000.0 Ωm to 1,500.0 Ωm is depicted in the south-west within a distance of 20.0m to 48.0m along the x-axis (i.e. in the south-west of the layer). Three parches of laterite were also delineated in the east. High resistive contaminated laterite spreads across the layer especially in the east with apparent resistivity values of about 900.0 Ωm to 1,192.0 Ωm (Broyden, 1972). There were huge deposits of lateritic sand in the west (but more concentrated in the north west) with an apparent resistivity values ranging from about 1,192.0 Ωm to1,500.0 Ωm (More and Trangenstein, 1976) as shown in figure7.

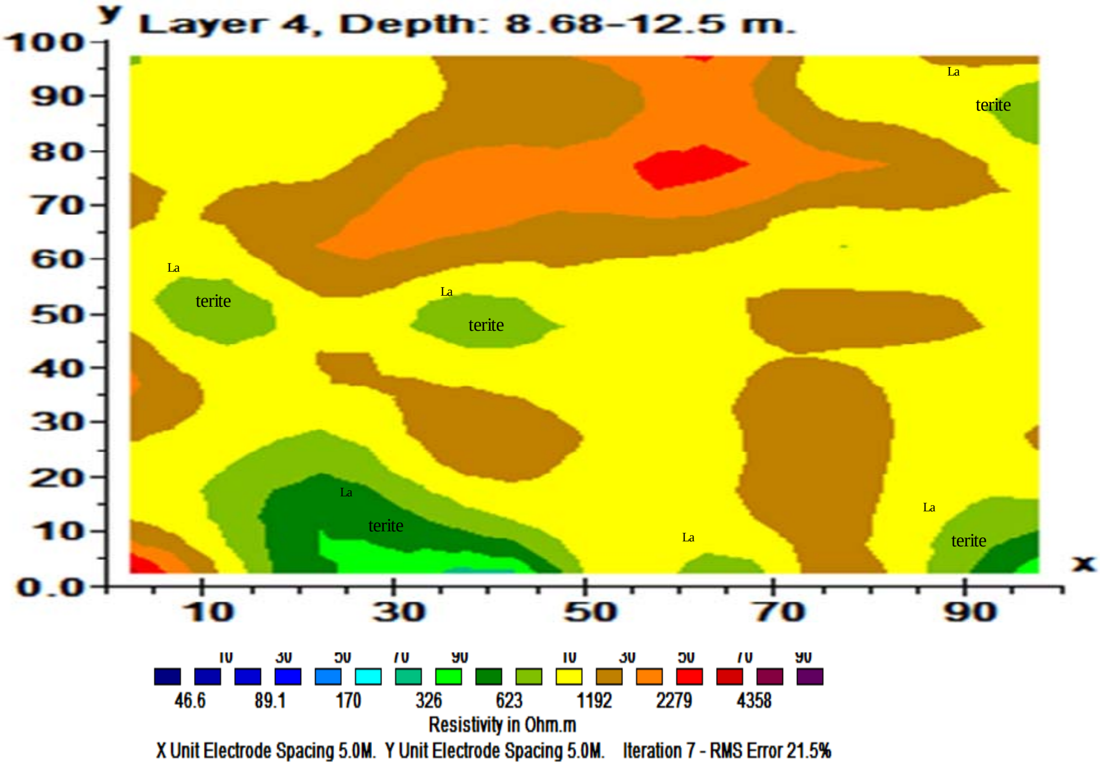
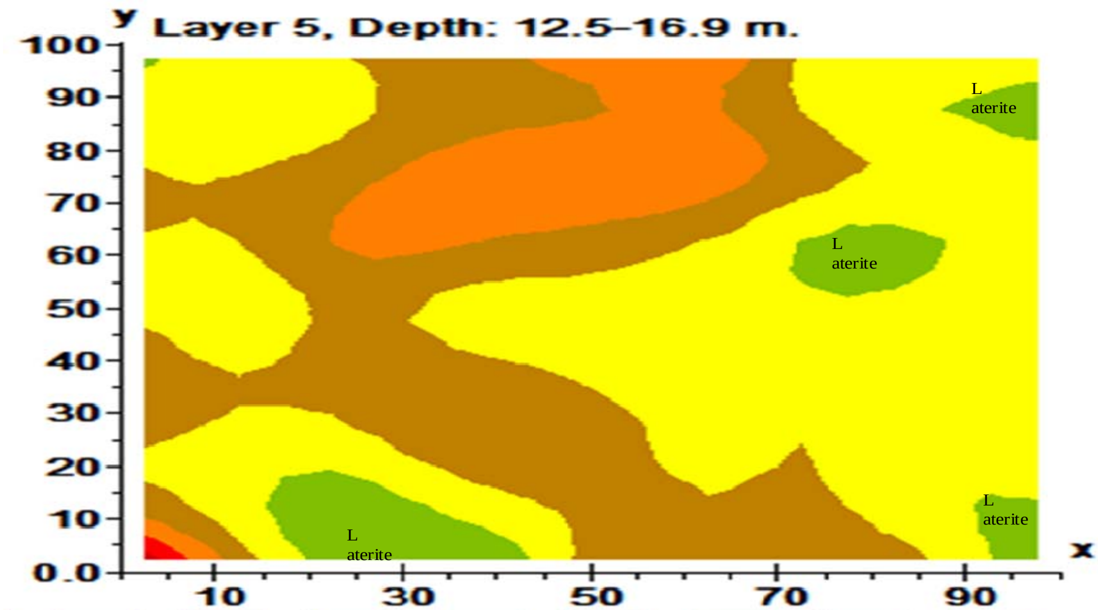


Figure 6: A 3-D resistivity inversion slice along x-y coordinates at a depth of (5.38 -12.50m)



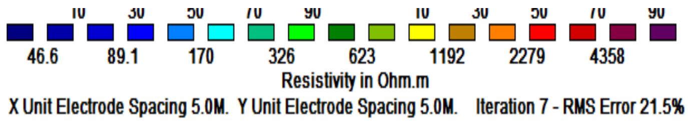


Figure 7: A 3-D resistivity inversion slice along x-y coordinates at a depth of (12.50 - 16.90m).

Layer Six (Depth: 16.90 – 21.90m)

Laterite with an apparent resistivity values ranging from 450.0 Ωm to 900.0 Ωm (appearing as a hanging structure) was enclosed by a highly resistive contaminated laterite with an apparent resistivity values ranging from 900.0 Ωm to 1,192.0 Ωm (Sheriff, 1991). Like layer five, there were huge deposits of lateritic sand in the west with an apparent resistivity values ranging from about 1,192.0 Ωm to1,500.0 Ωm as shown in figure 8.

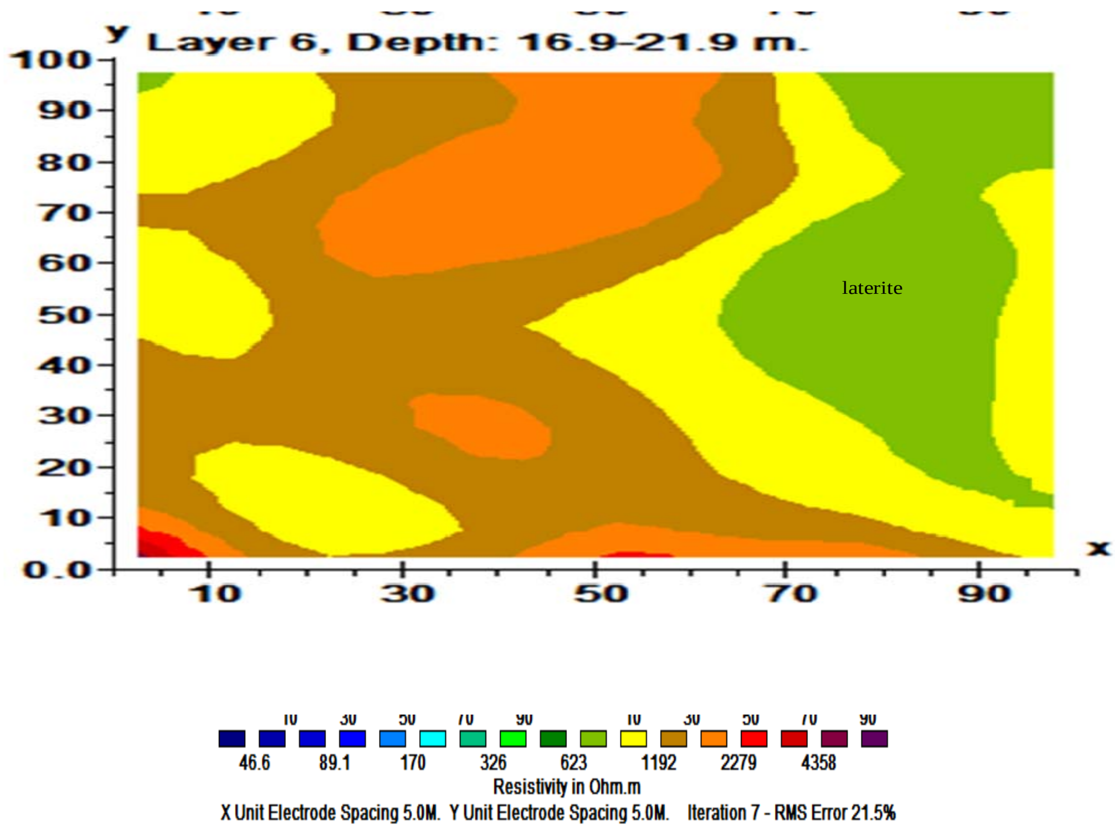


Figure 8: A 3-D resistivity inversion slice along x-y coordinates at a depth of (16.90 - 21.90m).

Summary and Conclusion

Table 1: Rocks and minerals and their corresponding apparent resistivities.

S/N	Rocks/Minerals	App. Res. (Ωm)
1.	Clay/Surface water	1.00 -100
2.	Lateritic clay	100.00 – 567.00
3.	Laterite/ Moderate laterite	567.00 – 1033.00

4.	Lateritic sand	1,033.00 – 1,500.00
5.	Wet sand	200.00 – 3467.00
6.	Ordinary Sand/sandstone	Above 3467.00

From the results obtained, clay with an apparent resistivity values ranging from $45.0\,\Omega m$ to $100.0\,\Omega m$ was suspected only in a small portion in the east of the first layer which is approximately about 2.50m deep. Clayey sand with an apparent resistivity values range of about $100.0\,\Omega m$ to $200.0\,\Omega m$ was found at the surface to a depth of about 8.68m. Lateritic clay is delineated at a depth of 2.50m to 12.50m (second, third and fourth layers) with an approximate thickness of about 10.0 m, and apparent resistivity values range of $200.0\,\Omega m$ to $500.0\,\Omega m$. Moderate as well as highly resistive laterite were depicted in all the six layers investigated (from a depth of 0.00m to 21.90m) , and apparent resistivity values range of about $500.0\,\Omega m$ to $1{,}000.0\,\Omega m$. From the surface to a depth of 21.90m (all the six layers) are lateritic sand and ordinary sand with approximate resistivity values range of $1{,}000.0\,\Omega m$ to $1{,}500.0\,\Omega m$ and above $1{,}500.0\,\Omega m$ respectively.

It was discovered that although there was suspected deposit of clay at a shallow depth but the quantity is minima and as such it was not economical viable and cannot be exploited for industrial purpose.

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