**International Journal of Information, Engineering & Technology**
Volume 12, Issue 5, PP 1-20, ISSN: 2360-9194, January, 2024
DOI: 4272-1454-381-2161
Double Blind Peer Reviewed International Research Journal
**Journal Series: Global Academic Research Consortium (garc)**
arcnjournals@gmail.com
https://arcnjournals.org

# Application of Direct Current Resistivity Method to Delineat Soil Lithology in Tudun Wada Maiduguri, North Eastern Nigeria

**Bashehu Abba Kawu[1], Mustapha Umar Sanda[2], Mohammed Kolo[3] and Yagana Bukar[4]**
[1,2&3]Department of Physics, Borno State University, Maiduguri, Borno State, Nigeria
[4]Department of science Laboratory Technology, Ramat Polytechnic Maiduguri, Borno State, Nigeria

**Abstract**: *This research work presents the result of the geophysical investigation carried out At Tudun Wada Area of Maiduguri Metropolis, North East Nigeria. The geophysical investigation was done using the Vertical Electrical Sounding (VES) with the aim to delineate the subsurface layers of the study area. A total of Ten (10) VES were conducted at different points on each side of the Tar road. Schlumberger electrode configuration were used, with symmetrical current electrode spread (AB/2) varying from 1 to 100 m. Geoelectric sections made from the sounding curves revealed three geoelectric layers with resistivity values first and second layer, ranging from 25 Ωm to 1100 Ωm, 9 Ωm to 70 Ωm respectively. These resistivity ranges were lithologically inferred to be topsoil, sand and sandy-clay, clayey-sand, with corresponding H – curve type only. The first geoelectric layer represent the topsoil with resistivity values varying from 25 Ωm to 1100Ωm and thickness of 5 m to 0.6 m, the moisture unit was represented as the second geoelectric layer composed mostly clay with electrical resistivity values ranging from 9 Ωm to 70 Ωm with thickness of 7 m to 0.8 m, while the third geoelectric layer with infinite depth is mostly represent sand & gravel, sandy claye with resistivity values range from 40 Ωm to 200 Ωm.*

***Keywords:*** *Lithology, Resistivity, Delineat, Direct current, Geoelectric section, Schulumberger*

## INTRODUCTION

### 1.1 Background of the study

Soil is a geological material which all structures and infrastructures are laid upon. Mineralogy is a study of minerals that controlled the soil and knowledge of it, is important to the safety and success of the structures. When soil has unbalance swelling and shrinking potential will give rise to foundation problems. Swelling pressure as a result of plasticity will results in serious up thrust on structures Ogundalu and Oyekan (2014).

Basically suitability of soils for building purposes depends on their strength to remain in place and with stand the permanent or transient loads that may be placed on them, Roy Bhalla (2017). A foundation is inherent to a structure that convey the weight to the soil below it. However, when the soil underneath does not possess the required bearing capacity, foundation failure may arises which eventually affects the structure Olayanju, *et al* (2017) and Adeoti, *et al* (2016). Probing of soil base on characterization will determine the strength of the soil is indispensable for better civil engineering structures (Folorunso *et al.,* 2012). The importance of subsoil investigations using geophysical survey is aim at evaluating the readiness of an area for the building structures and other civil engineering work. Most high rise building failure could be attributed to lack of geophysical investigation prior to constructions, which will divulge the nature of the subsoil and give sound information on the suitability for the building. Many buildings are constructed on soil that has inadequate bearing capacity to support the weight of the structure. The subsurface soils may consist of clay that shrink and expands due to change in moisture content. (Andrew *et al.,* 2013). If the moistening and drying of clay is not conform, foundation movement may occur (Andrew *et al.*, 2013). The use of the electrical drilling as an effective tool for gaining knowledge into the subsoil formation, in particular, for identifying deviation and determine the intricate nature of the lithology. (Colangelo *et al.,* 2008; Lapenna *et al.*, 2005).

One of the intricate of Soil is the moisture gain and will be threatened seriously, because the contracting potential of expanding soils is much greater than the shrinkage potential and this problem can come from plumbing leaks, subsoil water like wet weather or a high water table which may attributed to rainy season. Foundation settlement occur during drought as a results of loosing of water by soil and dries most quickly at the perimeter. The encounter between soils and solid materials is one of the chief unruly behavior in civil engineering practice, especially, shallow foundations, earth reinforcement and dams.

### 1.2 Statement of the Problem

The presence of clay content and its expansive and contracting properties in the soil of Tudun wada area has been attributed to the presence of Cracks on buildings. Also the high rise in water table affecting foundations of buildings during the rainy seasons is also a source of concern to the residents of this area. The research question is therefore, do the materials of the foundation have the necessary qualities to withstand the loads of buildings?

### 1.3 Objectives of the study

The specific objectives of the study are to:

*a.* investigate soil formation using electrical resistivity method to reveal the Geo-electric section.
*b.* identify depth of various Geo-electric sections in the study area, and
*c.* determine from the soil resistivity measurement, the nature of the soil.

### 1.4 Significance of the study

For any developmental activities, the soil base on it strength, is important and the main component in which solid foundation can be laid. Thus, the present study if successfully conducted will delineate the study area for the purpose of probable safe building structure.

### Scope and Limitation

The scope of the study is centered on Tudun Wada area, Maiduguri Metropolis and it is limited to time, field work and budget.

### 1.6 The Study area

Tudun Wada area is situated few maters behind the Department of Security Services (DSS) and bordered from east and west by Yerwa Government Girls Secondary School and PHCN Bulunkuttu Unit Maiduguri respectively. It is located between latitudes $11^0$ 50` and $50^0$ 24` N and longitudes $13^0$ 06` and $13^0$ 07` E. figure 2.

## LITERATURE REVIEW

### 1.1 Review of the Geology of the area

The Chad Basin is a big continental basin in the Central West Africa (Figure 3) that covers a total area of about 2,335,000 $km^2$ (Genik 1993). The basin spread over five countries, namely, Nigeria, Niger, Chad Republic, Cameroon and Central Africa Republic. The Bornu Basin in Nigeria, is a part of Chad Basin, is situated at south western sector of the Basin and, and covers about one-tenth of the total area. Joining Benue Trough with the northeastern part of SW-NE.

The Benue and Borno Basins are parts of the same domicile NE-SW fissure system which, according to (Guiraid, 1993) formed another three junction in the Lake Chad axis with two ill-predestined arms that are now conserved as the NW and NE to NS inclination. The two basins are distinguished by pressure-induced basement tectonics and by random of faulting. The most common structural formation in the basin are horsts and grabens, concealed hills and unwelcome volcanics. Faults are predominantly tensional and basement involve. (Abovvo, 1986). The majority of these faults terminate beneath a regional angular unconformity at the boundary between the Cretaceous and Tertiary. Movements along the faults may be strike-slip, with induced compressional folds such as drag folds or positive flower structures.

### 2.1 Review of Electrical Resistivity Method of Geophysics

Fundamentally resistivity methods is the flow of low frequency current to the subsoil. In this technique, an electrical current is send into the ground. Potential electrodes (MN) will measure the resultant potential difference between them, which will us to record the electrical resistance of the material in the ground. Clearly, apparent resistivity is based on the obtained value of impedance i.e. ratio of potential to current and the array of the electrode spread known as G Factor. Extensive electrical drilling gives important information about the inner structure of the mantle and earth's crust. (Lowrey and Williams, 2007

**Ohm's Law**

The German scientist George Simon ohm establish in 1827 that the electric current: I in a conducting wire is proportional to the potential differences V across it. The linear relationship is expressed by the equation

$$V = IR \qquad (2.1)$$

where *R* is the resistance of the conductor in Ohm's. For a given material the resistance is proportional to the length L and inversely proportional to the cross-sectional area A of the conductor. These relations are expressed in the equation

$$R = \rho\frac{L}{A} \qquad (2.2)$$

The proportionality constant $\rho$ is the resistivity of the conductor measured in ohm's. If we substitute equation (2) in (1) and rearrange the terms, we will get the following expression:

$$\frac{V}{L} = \rho\frac{I}{A} \qquad (2.3)$$

From the above figure, we obtain Electric field

$$E = \frac{-dU}{dr} = \frac{V}{L} \qquad (2.4)$$

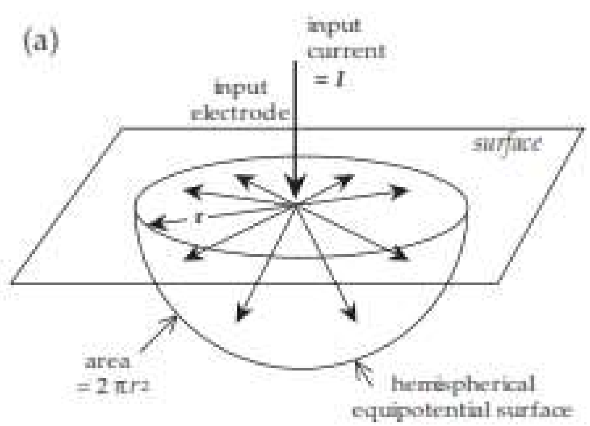
Current density

$$J = \frac{current}{area} = \frac{I}{A} \qquad (2.5)$$

we can now rewrite ohm's law as

$$E = \rho J$$

However, the quantities that are measured are V and I. However, if we consider the flow of current around an electrode that introduces a current I at the surface of a uniform half space. The electric field E at a distance r from the input electrode is obtained from ohm's law (Eq. (4))




The figure above is the illustration of a half uniform sphere with a surface area of

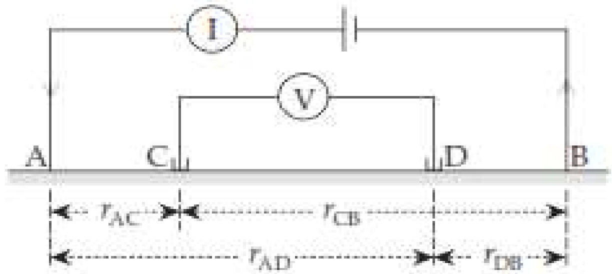
$$2\pi r^2 E = \rho J = \rho\frac{I}{2\pi r^2} \qquad (2.7)$$

Putting (2.7) into (2.4) yields the electrical potential *U* at a distance r from the input electrode:

$$\frac{dU}{dr} = -\rho\frac{I}{2\pi r^2} \qquad (2.8)$$

upon integrating Eq. (8) we obtain

$$U = \rho\frac{I}{2\pi r^2}$$




The figure above consists of an arrangement of a pair of current electrodes and a pair of potential electrodes. The current electrode A and B act as source and sink, respectively. At the detection electrode C, the potential due to the source A is $+{}^{\rho I}/_{(2\pi r_{AC})}$, while the potential due to sink B is $-{}^{\rho I}/_{(2\pi r_{CB})}$. The combined potential at C is

$$U_c = \frac{\rho I}{2\pi}\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) \quad (2.10)$$

Similarly, the resultant potential at D is

$$U_D = \frac{\rho I}{2\pi}[\left(\frac{1}{r_{AD}} - \frac{1}{r_{DB}}\right) \quad (2.11)$$

The potential difference measured by a voltmeter connected between C and D is

$$V = \frac{\rho I}{2\pi}\left[\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) - \left(\frac{1}{r_{AD}} - \frac{1}{r_{DB}}\right)\right] \quad (2.12)$$

All the quantities in the above equation can be measured at the ground surface except the resistivity which is given by

$$\rho = 2\pi\frac{V}{I}\left[\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) - \left(\frac{1}{r_{AD}} - \frac{1}{r_{DB}}\right)\right]^{-1} \quad (2.13)$$

where

$$G = \left[\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) - \left(\frac{1}{r_{AD}} - \frac{1}{r_{DB}}\right)\right]$$

is the geometric factor, the value obtained from (2.13) is called apparent resistivity (Lowrey and Williams, 2007). In the Schlumberger configuration, the current and the potential pairs of electrodes often have a common mid-point, but the distance between the adjacent electrodes differ. Let the separations of the current and potential electrodes be L and a, respectively. Then $r_{AC} = r_{DB} = (L-a)/2$ and $r_{AD} = r_{CB} = (L+a)/2$ Substituting in equation (13) we get

$$\rho = 2\pi\frac{V}{I} = \left[\frac{2}{L-a} - \frac{2}{L+a} - \frac{2}{L+a} - \frac{2}{L-a}\right]^{-1}$$
$$= \frac{\pi}{4}\frac{V}{I}\left(\frac{L^2 - a^2}{a}\right) \quad (2.14)$$

in this configuration, the separation of the current electrode is kept much larger than that of the potential electrodes $(L \ll a)$. Under these conditions, (2.14) simplifies to

$$\rho = \frac{\pi}{4}\frac{V}{I}\left(\frac{L^2}{a}\right)$$

## DATA COLLECTION AND PROCESSING

### 3.1 Data Collection

Data were collected at ten difference location i.e VES station 1 to 10 in the study area for the purpose of interpretation. Table 1 below depicts the raw data where each VES point with AB/2 starts from 1 to 100 m on either side of the sounding station while MN/2 was divided into two. First part began from 0.2 m up to 10 sounding points before it was adjusted and end with 1.5 m.

**Table 3.1:** Apparent resistivity Data

| AB/2 | MN/2 | VES 1 | VES 2 | VES 3 | VES 4 | VES 5 | VES 6 | VES 7 | VES 8 | VES 9 | VES10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.2 | 70.01 | 71.01 | 800 | 55.01 | 50.01 | 30.01 | 70.01 | 58.01 | 900.5 | 25.86 |
| 1.5 | 0.2 | 67.83 | 37.54 | 558.6 | 53.54 | 45.47 | 28.31 | 10.72 | 32.48 | 492.4 | 26.3 |
| 2 | 0.2 | 60.84 | 37.74 | 498.1 | 52.22 | 40.3 | 22.38 | 10.74 | 18.35 | 146.5 | 25.93 |
| 2.5 | 0.2 | 49.15 | 36.87 | 373.3 | 52.08 | 38.27 | 19.98 | 10.3 | 13.83 | 79.29 | 25.44 |
| 3 | 0.2 | 38.66 | 37.44 | 257.9 | 54.75 | 36.42 | 18.98 | 10.82 | 12.97 | 72.26 | 26.07 |
| 4 | 0.2 | 30.11 | 35.58 | 149 | 54.64 | 34.41 | 16.88 | 9.46 | 12.56 | 60.41 | 25.55 |
| 5 | 0.2 | 27.15 | 34.69 | 97.71 | 52.51 | 31.45 | 15.01 | 9.98 | 12.14 | 47.9 | 24.41 |
| 6.5 | 0.2 | 25.15 | 35.06 | 76.79 | 53.33 | 32.45 | 16.72 | 11.23 | 13.24 | 47.86 | 25.06 |
| 8 | 0.2 | 23.01 | 30.13 | 77.69 | 51.83 | 33.46 | 18.09 | 5.69 | 17.56 | 50.29 | 22.9 |
| 10 | 0.2 | 20.82 | 28.65 | 65.72 | 49.23 | 37.6 | 20.49 | 14.03 | 16.88 | 50.18 | 22.3 |
| 8 | 1.5 | 20.15 | 25 | 64.75 | 48.23 | 36.78 | 20.23 | 15.23 | 15.98 | 50.29 | 21.45 |
| 10 | 1.5 | 19.26 | 25.18 | 63.69 | 48.89 | 37.18 | 21.89 | 16.78 | 18.21 | 49.98 | 23.43 |
| 13 | 1.5 | 20.03 | 25.02 | 68.99 | 47.13 | 40.81 | 26.74 | 15.52 | 19.95 | 49.85 | 22.49 |
| 16 | 1.5 | 20.95 | 25.62 | 70.34 | 47.13 | 41.22 | 32.88 | 16.52 | 23.36 | 51.23 | 24.33 |
| 20 | 1.5 | 25.82 | 30.79 | 75.92 | 40.71 | 43.26 | 35.17 | 19.73 | 28.01 | 50.6 | 24.67 |
| 25 | 1.5 | 28.3 | 32.99 | 75.69 | 38.92 | 47.87 | 52.67 | 24.08 | 36.56 | 51.83 | 27.95 |
| 30 | 1.5 | 29.45 | 34 | 75.04 | 35.38 | 45.31 | 55.11 | 31.65 | 45.42 | 55.25 | 37.42 |
| 40 | 1.5 | 30.94 | 33.23 | 90.81 | 30.61 | 49.5 | 68.92 | 40.32 | 58.65 | 70.74 | 46.91 |
| 50 | 1.5 | 32.28 | 32.81 | 96.1 | 29.46 | 48.89 | 87.15 | 45.22 | 65.53 | 83.75 | 47.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | 1.5 | 30.44 | 30.89 | 100.1 | 27.94 | 52.16 | 95.99 | 50.07 | 77.95 | 88.04 | 60.35 |
| 80 | 1.5 | 33.56 | 29.93 | 110.2 | 28.04 | 53.91 | 100.8 | 50.06 | 82.71 | 90.32 | 61.63 |
| 100 | 1.5 | 35.12 | 35.56 | 120.2 | 35.02 | 52.93 | 131 | 48.2 | 89.38 | 100.2 | 63.61 |

Data generated from the Vertical Electrical Sounding using Schlumberger configuration were presented as Geoelectric sounding curve and Geoelectric section. Geoelectric section shows the subsurface layers, resistivity, depth and thickness while Geoelectric Sounding Curves were obtained by plotting the apparent resistivity value against AB/2 using Computer software IX1D for interpretation. All of which were iterated thereafter on the computer with the same software program, to minimize as much as possible the errors which yield near better curves. The interpretation of vertical electrical sounding (VES) data for the survey is quantitative. The following table 2 below shows the display of the interpreted data.

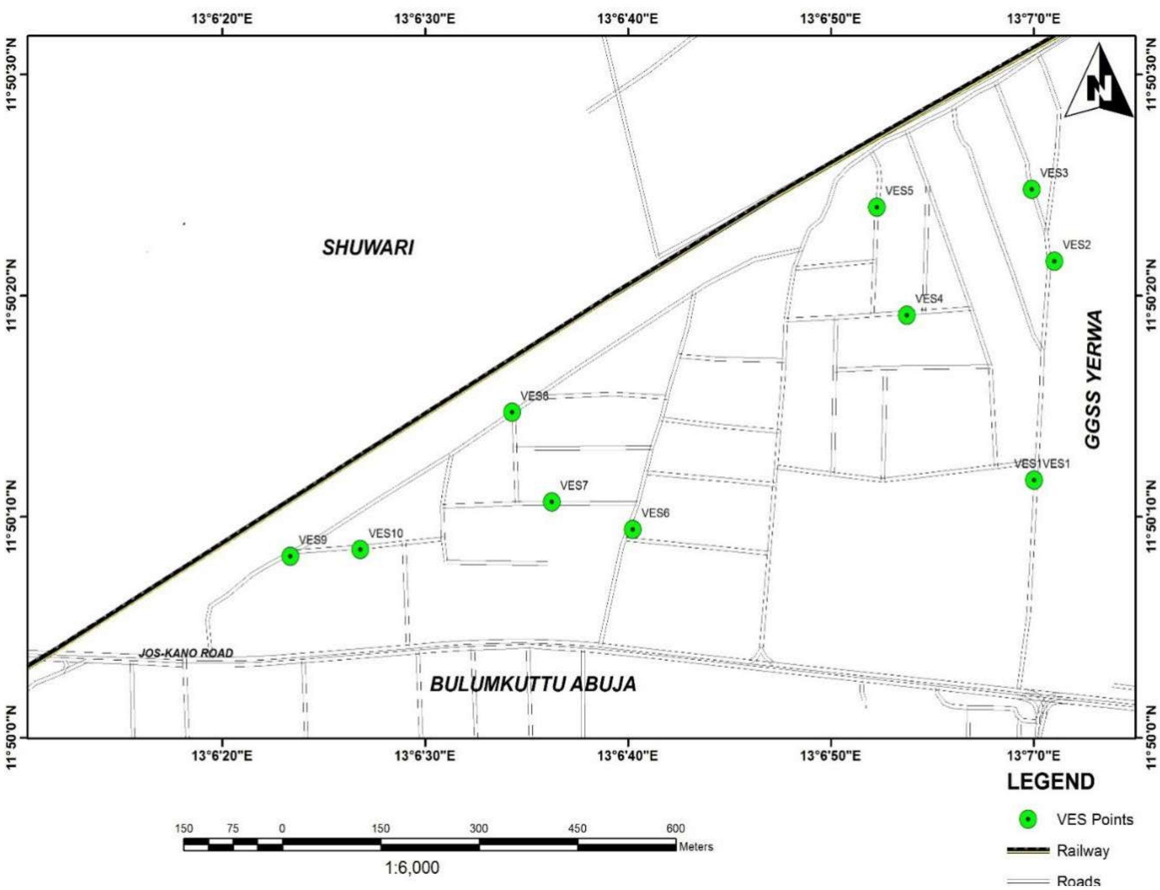



**Figure 3.2:** Map of the study area showing the Ten VES points

**Results and Discussion**

Below are the Interpreted results of the Ten VES points with their resistivity values, thickness and depth. Characteristic curve type of same throughout the sounding points with fittings errors of less than 10%. All of the VES points revealed three layers; first, second and infinite layer all are related because of homogenous nature of the earth sub-surface material in the area. The lithology exhibited are mostly clay, fresh water sandy clay etc.

**3.1 VES 1:**

The VES show a three layer succession with first two layers having thickness of 1.2 m and depth 20 m respectively, and the last layer of infinite thickness with an H curve characteristic indicating a dry layer under laid by water saturated layer, figure (4.1) below shows the Graph and the Curve Model. If the first and second layer made up of same materials will they have the same resistivity value? But the other section is saturated. If in the same vein the material of third layer with resistivity of 40 Ωm which is over laid by moist region is same as the preceding layers with value 20 Ωm can have a low resistance which indicate moisture content of the layer. The sounding point has a fitting error of 4.94%.

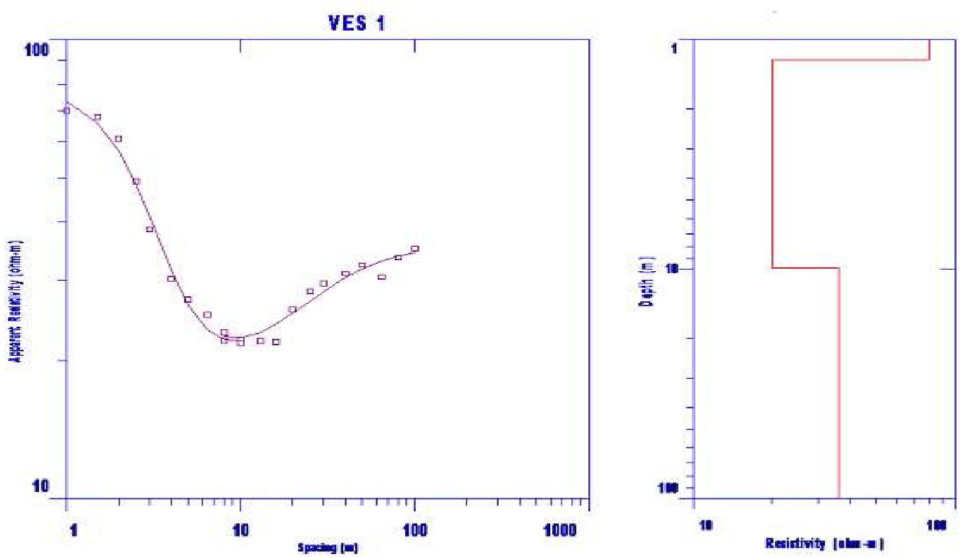
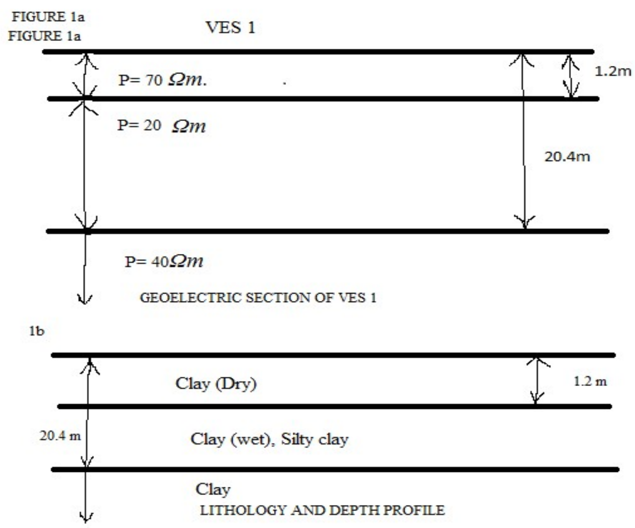



**Figure 4.1:** The above diagram shows Graph and the Model curve of VES 1

Geo- electric section was obtained where it contain only the electrical parameter. Suggested earth material that has the electrical resistivity values of 70, 20, and 40 Ωm are dry clay, wet clay overlying a dry clay. Figure (1a and 1b).

Based on the suspected rock types found in this VES point any foundation laid below 20m is within a clay region and might likely to crack.




### 3.1.1 VES 2

It has a three-layer case revealing a high resistance of 80 Ωm in the first layer under laid by moisture layer with resistivity of 20 Ωm. If the both layers contain the same material will they have same low resistivity? But with one section saturated with water. Figure 4.2 below reveals the Graph and the Model curve and has a fittings error of 2.95%. The lithology in this sounding point are sandy clay, wet clay and clayey sand and is curve H type.

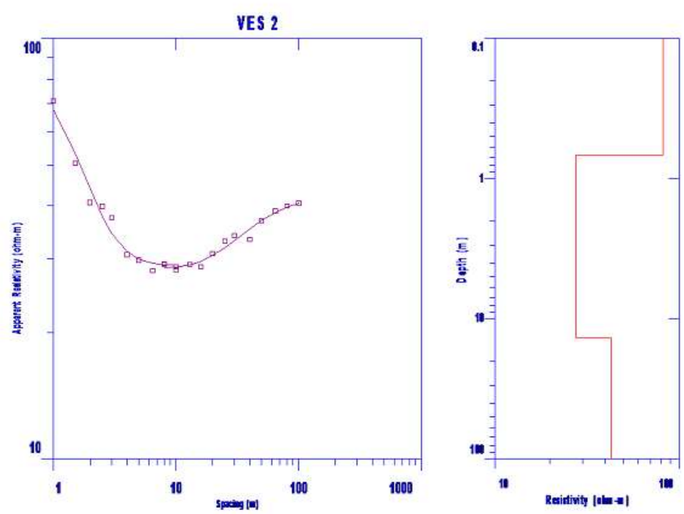
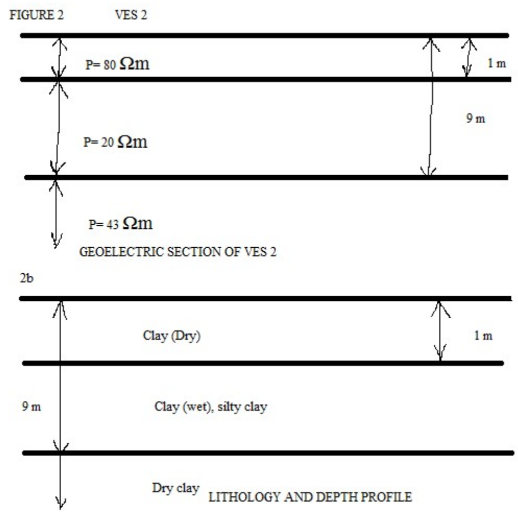



**Figure 4.2:** The above figure shows the Graph and Model curve of VES 2
Geoelectric section in this VES point contain electrical parameters of 80 Ωm, 20 Ωm, 43 Ωm and the suggestive rock that has this values probability are clay which is dry, overlying wet and dry clay. The geologic material found in this area may not be suitable for civil engineering because of tendency to crack. Figure (2a & b) gives the lithology and the depth profiles




### 3.1.2 VES 3:

Three layer cases were sample in this VES point with 4.38% error. It is thinner with thickness of 1.2 m than the previous two points but related in same pattern with high resistivity of 90 Ωm under laid by moist region with resistance of 70 Ωm at just depth of 20 m. If these two layers have same materials will they have same low resistivity? But one part is moist. If in the same way the second and third layer are dominated by same material, will they have similar resistivity but section of it is, saturated with water. This is H type sounding point with laterite, sandy and silt formation. Figure 3

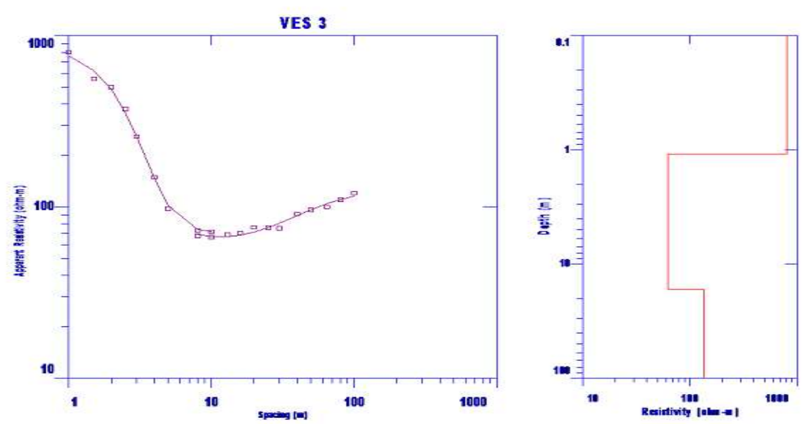
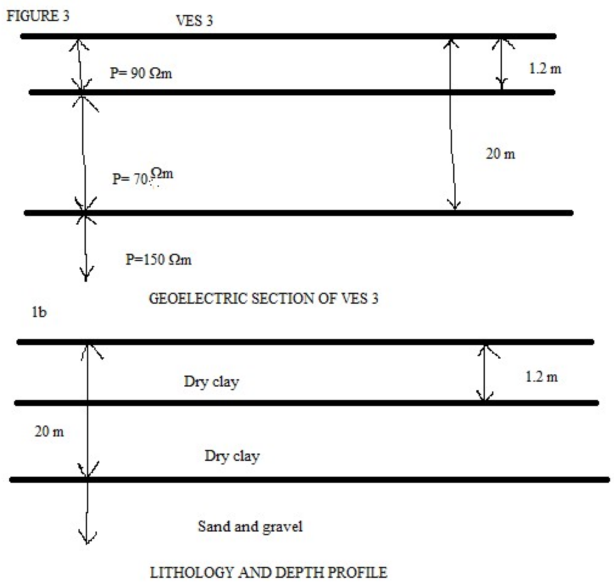



**Figure 4.3:** The above figure shows the Graph and Model curve of VES 3

Geologic section of this VES point might not be suitable for foundation to be laid because it has clay up to 20 m depth suggested by electric resistivity values of 90, 70 and 150 Ωm. Figure (3a & b) gives the lithology and the depth profile.




### 3.1.3 VES 4:

The VES show a three-layer succession with first two layers having thickness of 10 m and 12 m depth and the last layer of infinite thickness. This sample point is same as the previous ones, is H type curve too. Low resistivity value 20 Ωm was recorded will it be attributed to all three layers if supposedly are made up of same material with one part saturated with water? This VES point has a lithology of sandy clay, clay and sand. Figure (4.4) below shows the curves.

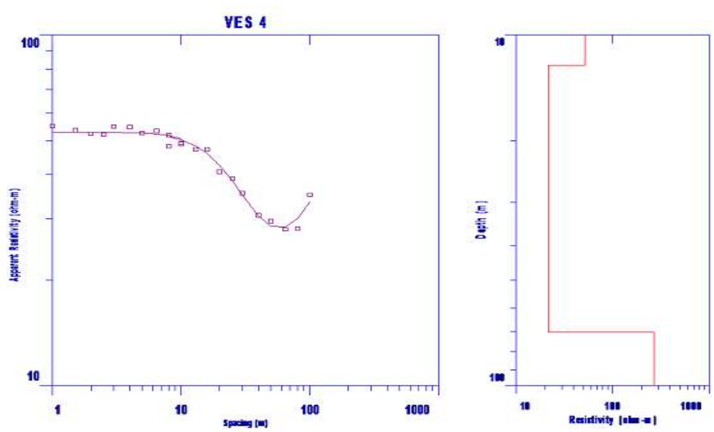
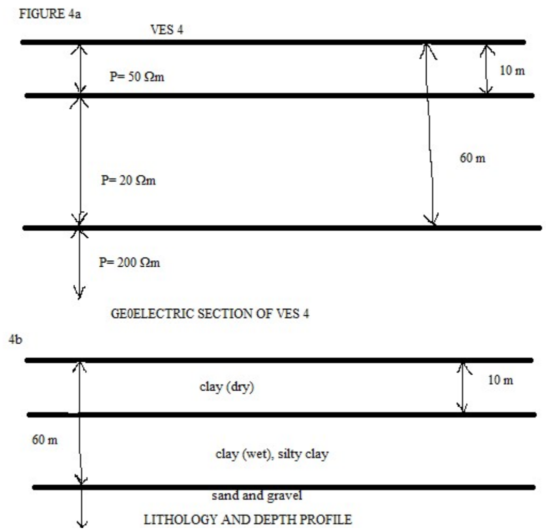



**Figure 4.4:** The above figure shows the Graph and Model of VES 4

Electrical resistivity values of 50, 20, and 200 Ωm for the Earth material in this section was assumed to name of the formation which are clay dry and wet and sand and gravel. This is suggesting unsuitability of the soil for building construction. Figure (4a & b) shows the lithology and the depth profile.




### 3.1.4 VES 5:

This profile recorded a three layers case and has a similarity with preceding VES points but it is thinner in first layer with thickness less 1 m with resistivity of 55 Ωm under laid moist layer with value 18 Ωm figure (4.5). If the layers is occupied by same material will they have same low resistance with one part domicile with moisture? The infinitely layer with 55 Ωm, if having a similar low resistance with the layer two, can it be, the material in the layer three be same, with one part saturated with water? The formations are suspected to be dry clay, wet clay and dry clay with a H type curve having a 3% fitting error

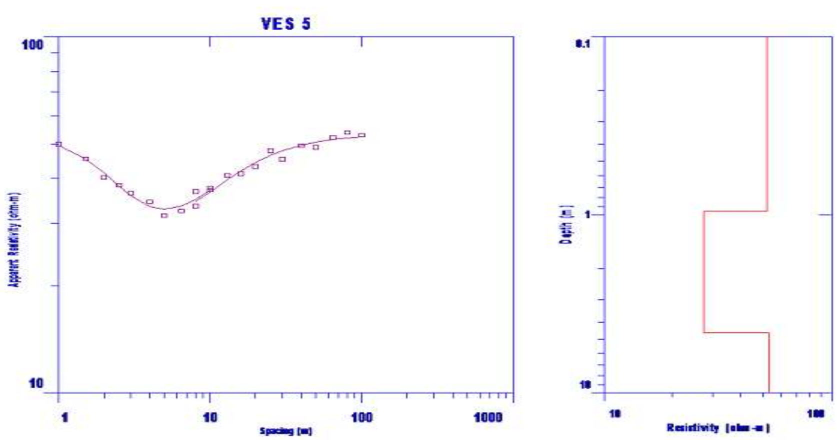
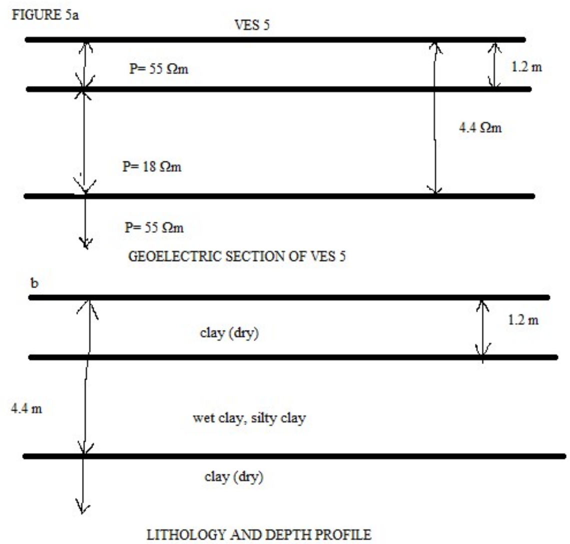



**Figure 4.5:** The above figure shows the Graph and Model of VES 5

Suggested based on the resistivity values of 55, 18, 55 Ωm. This section was dominated by clay both dry and wet. Civil engineering work of any type might be susceptible to crack. Figure (5a & b) illustrate the lithology and depth profile.




### 4.1.5 VES 6:

This sounding point with fitting error of 5.92% has succession of three layers. It has similarity with above layers but the first and second layer with thin values 1 m and 6.5 m depth respectively. The first and second layers are suspected to have same materials because of low resistivity values of 35 Ωm and 10 Ωm. In the other hand third layer is very pervious because it has a very high resistivity of 250 Ωm. The lithology may be wet clay, clay or fresh water and sand and gravel. It is type H curve. Figure (4.6)

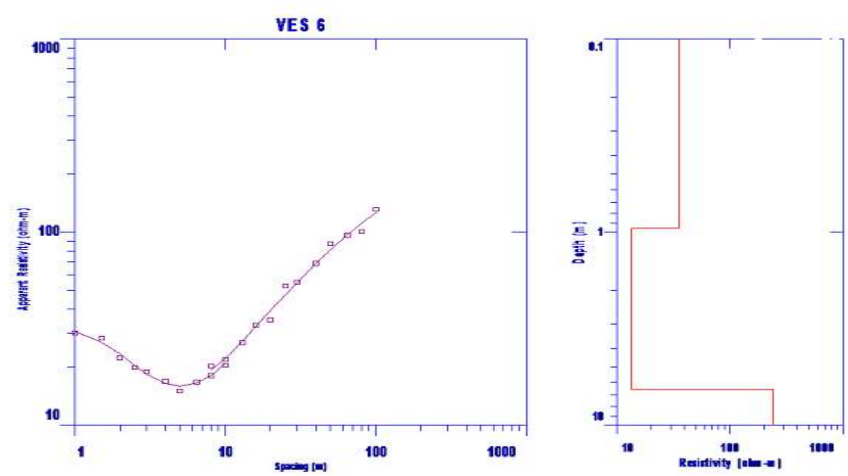
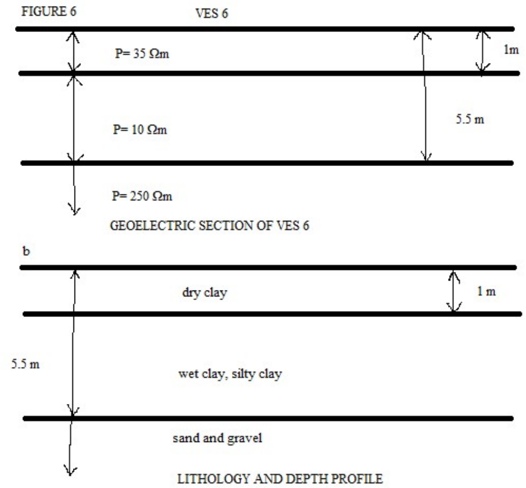



**Figure 4.6:** The above figure shows the Graph and Model curve of VES 6

Electrical resistivity values of this section are 35, 10, and 250 Ωm. The geologic section are infer to be wet clay, wet clay or fresh water and sand and gravel. At a depth below 7m, if foundation are laid there is a tendency to crack because of the nature of the rock in the area. Lithology and the depth profile in figure (6a & b) shown.




### 4.1.6 VES 7:

Three-layer case recorded with fitting error up to 7.75% figure (4.7). The first and second layers have low resistivity of 30 Ωm and 9 Ωm with thickness of 0.9 m and depth of 7 m respectively. In third layer the resistivity gone up to 90 Ωm because of permeable nature of the material. It is type H curve. Fig. (4.7)

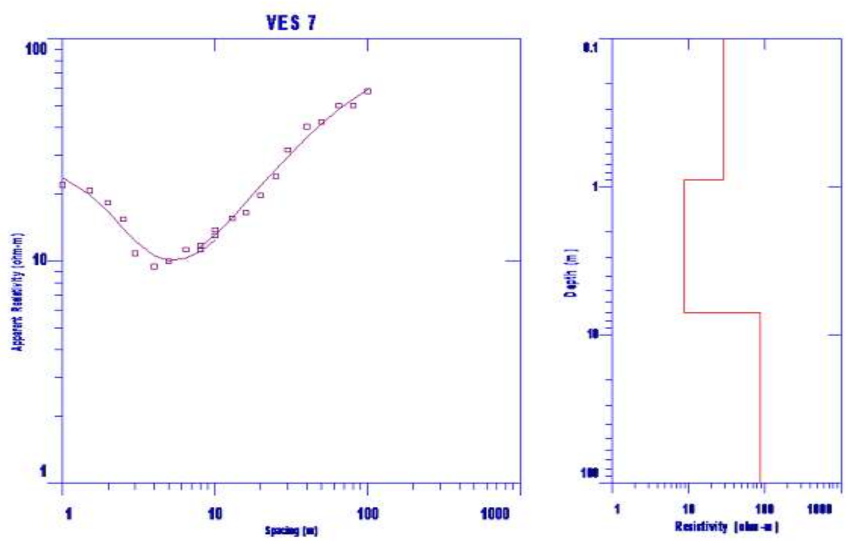
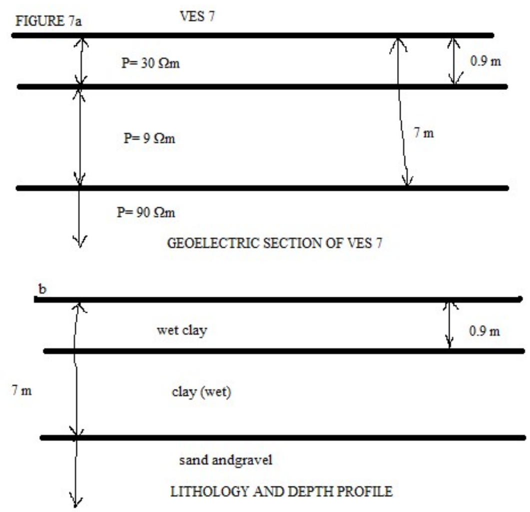



**Figure 4.7:** The above figure shows the Graph and Model curve of VES 8

Geo-electric parameter of this section was obtained and use it to name the Earth material that has the electrical resistivity values of 30, 9, 90 Ωm respectively. This is probably suggesting a claye area and there is a likelihood of crack to manifest on the structural wall. Figure (7a & b) gives the lithology and the depth profile




### 4.1.7 VES 8:

This sounding point has a sequence of three layers profile with a fitting error of 6.46%. Resistance value of 120 Ωm under laid low resistance of 10 Ωm at less than 7m depth. If the two layers supposedly, having the same material will the resistivity be conformed to low with one section of it is saturated with moisture. The infinite layer under laid by low resistance, has a high resistivity of 190 Ωm dominated by sand and gravel material while the first two are suspected to made up of sand and wet clay or fresh ground water. Layer two of the proceeding VES point is related to this second layer in the formation which fresh ground water. Figure (4.8)

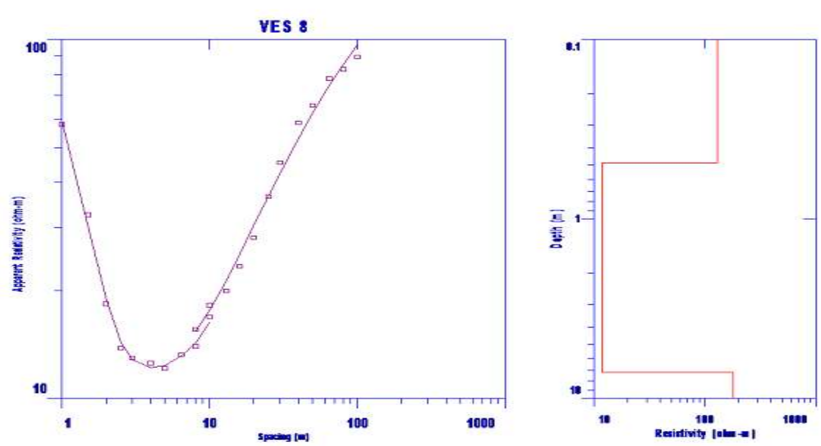
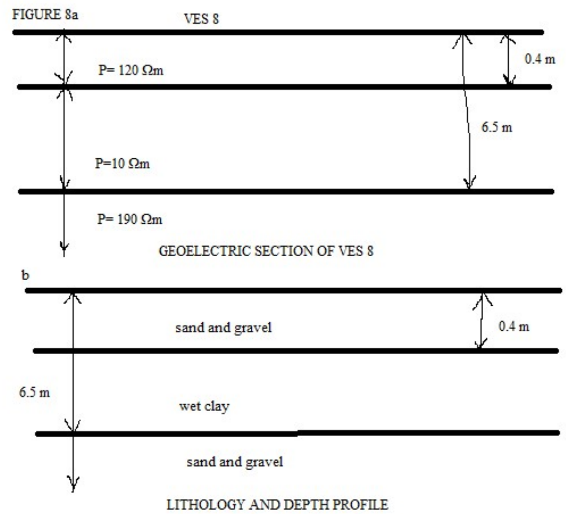



**Figure 4.8:** The above figure shows the Graph and Model curve of VES 8

The name of the rock type correspond to the electrical parameters of 120, 10, and 190 Ωm, are suspected to be sand and gravel at a depth of less than 7 m, while in the second layer with depth not more than 7 m is dominated by wet clay which overlaid a sand and gravel. Figure (8a & b) illustrate the lithology and depth profile. Building foundation sited within this range may likely to crack.




### 4.1.8 VES 9:

This shows a three layer case. Layer one has a high resistance of 1100 Ωm at very thin thickness of less than 1 m indicating very dry zone under lay by moist layer at a depth of 20 m. beneath this layer is another dry section with high resistivity of 160 Ωm. There is a similarity between this and the last sounding point. In this case layer two occupied by different material from layer one and three. It has a lithology of gravel and sand dry clay and it is type H curve and with fitting error of 9.50%. Figure (4.9)

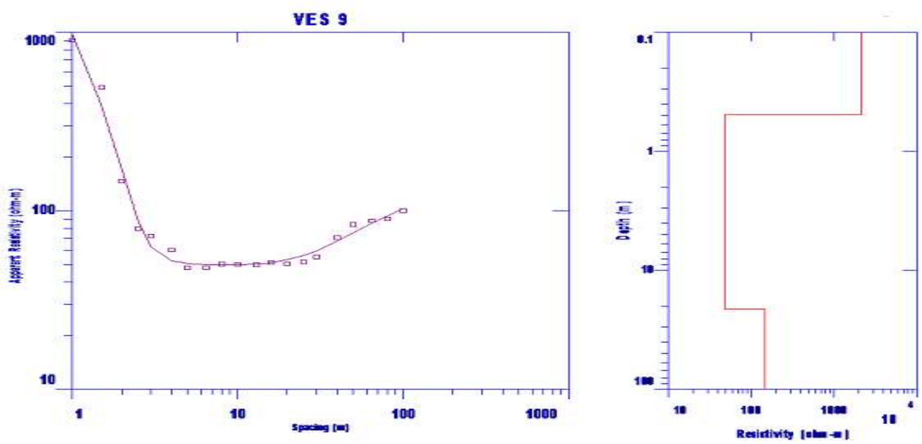
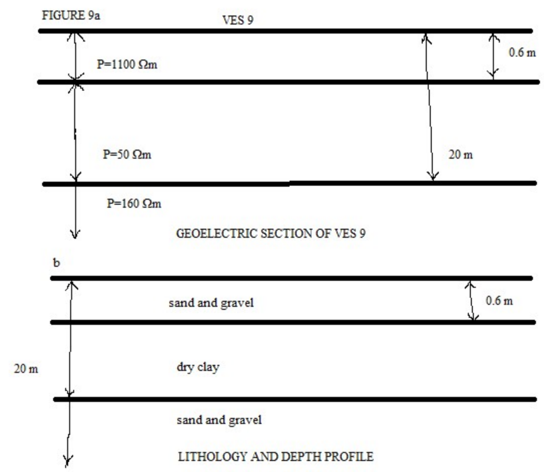



**Figure 4.9:** The above figure shows the Graph and Model curve of VES 9

Geo- electric section was obtained where it contain only the electrical parameter and was used to identify Earth materials with electrical resistivity values of 1100, 50, and 160 Ωm. The suggested rocks could be sand and gravel in the first layer at depth of less than 1m overlying a dry clay up to the depth of 20 m. Figure (9a &1b) showing the lithology and the depth profile.




### 4.1.9 VES 10:

In this VES point three layers were sample having a fitting error 4.95%. This profile has a very good relationship with the preceding ones but thicker in layer one than the previous VES point and has a resistivity of 25 Ωm with thickness of 5 m under laid another water saturated zone at a depth of 9 m with resistivity of 10 Ωm but in third layer the resistivity gone up to 100 Ωm. probably the materials in layer one and two are the same or similar because of the low resistivity value they have. The lithology is infer to be fresh water or clay on both layers and dry clay in infinite layer and a type H curve. Figure (4.10) below shows the Curves

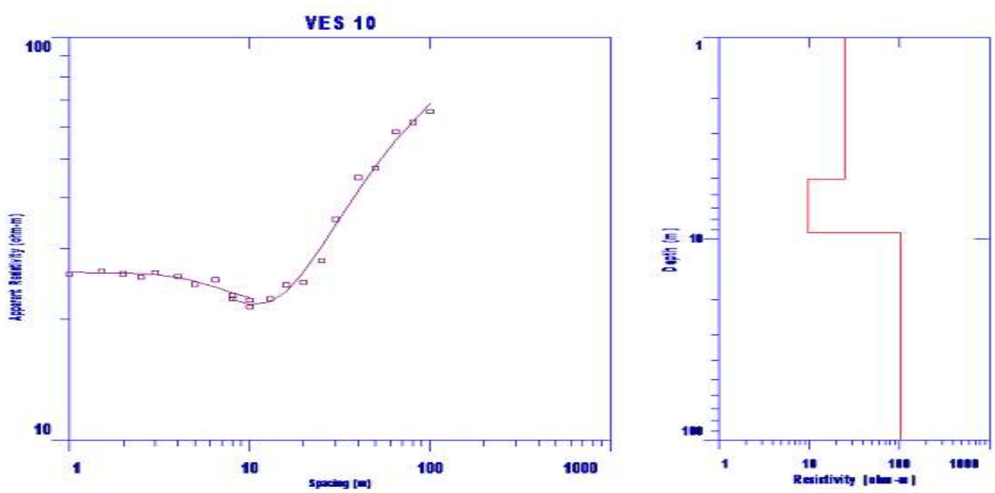
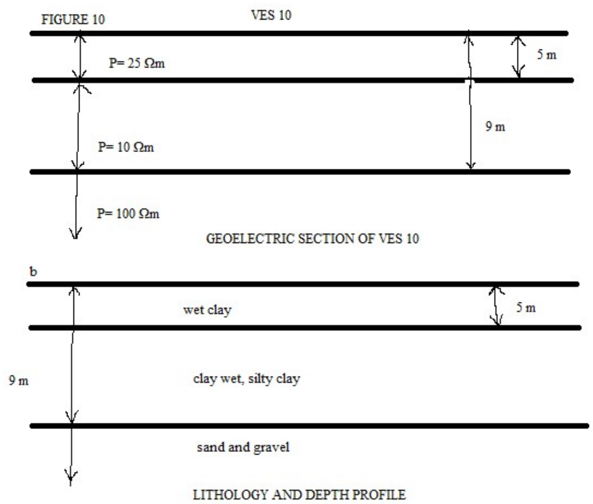



**Figure 4.10:** The above figure shows the Graph and Model curve of VES 10

Suggested name of the formation in this VES point is wet clay overlaying another wet clay based on the electrical parameter 25, 10, and 100 Ωm at a depth not up to 10 m. Figure (10a & b) gives the lithology and the depth profile.




**Summary, Conclusion and Recommendation**

**5.1 Summary**

The Vertical Electrical Sounding carried out in 10 VES stations was used to derive the geo-electric section of various profile; which indicate the existence of three geologic layers in the study area in each VES points where the survey was carried out. This comprised of first layer, second layer and third layer. The layer one is suspect to be clay soil with resistivity of 25 Ωm at VES 10 with a thickness of 5m and span over to 1100 Ωm with a thickness of 0.6m, which is refer to as VES 9. The layer two has a resistivity ranges from 9 Ωm to 70 Ωm with thickness varies from 7 m to 20 m depth. The layer three has a resistivity ranges from 40 Ωm to 200 Ωm which move infinitely in depth.

Based on the aforementioned, it is observe that the geo - electric curve type identified in the area are all H type. Therefore, from the data analysis of the curve types. Curve H is most dominants in the area. However, the resistivity distribution reveals that, the resistivity is lowest in the most part of the area with value 9 Ωm at just less than 1 m which is found in the western part of the area.

**5.2 Discussion**

Based on the results interpreted the geophysical survey carried out was successful and the desired results was achieved with minimal errors. In all of the 10 VES points the fitting errors were less than 10% which indicate the reliably of the work, because the lesser the percentage error the more precise the work would be.

Clay soil can have a significant impact on building foundations due to its characteristics. Here are some effects of clay soil on building foundations: 1. Shrinking and Swelling: clay soils have high water retention capacity, causing them to expand when wet and shrink when dry. This cycle of swelling and shrinking can lead to movement and instability in the foundation. It may results in cracks, settling. And unevenness in the building. 2. Differential Settlement: due to uneven moisture distribution in the clay soil, differential settle may occur. This means that some parts of the foundation may sink more than others, leading to an uneven distribution of weight and potential structural damage. 3. Moisture Absorption: clay soils can absorb and retain large amounts of moisture, making them prone to saturation. Excessive moisture can weaken the foundation, reduce its load-bearing capacity, and increase the risk of foundation movement or failure. 4. Poor Drainage; clay soil typically has a low permeability, meaning it has a limited ability to drain water. The Poor drainage can potentially cause water accumulation near the foundation, increasing hydrostatic pressure and likelihood of damage. 5. Expansive Pressure: As clay soil absorb water, it exerts expansive pressure on the foundation walls. This pressure can lead to cracking or bowing of the wall, compromising the overall structural integrity of the building. (Kenneth and Michael, 2018).

**Conclusion**

Vertical Electrical Sounding (VES) technique carried out at 10 VES stations in Tudun Wada area of Maiduguri Metropolis Northeast Nigeria to reveal the soil potential of the area. Computer aided interpretation of the VES data showed three geoelectric layers in all sounding points. The result of successful Electrical Drilling indicates that top soils are mostly dominated by dry material suspected to be either sand or gravel while in the second layer significance amount of moisture content which was inferred to be clay material were seen.

**5.3 Recommendation**

Following recommendation were deduced from the study area base on the electric resistivity, suggestively foundation should not be laid less than 10 m depth in some part of the area, refer to as; VES 4 and 10, while in some part up to 20 m depth which point to VES 1, 3,and 9, avoid crack. A more detail geophysical investigation should be carried out on study area for further studies.

**REFERENCES**

Avbovbo, A.A. Ayoola, E.O, Osahon S. A. (1986). Depositional and Structural Styles in Chad Basin of Northeastern Nigeria. AAPG Bulletin, 70. doi: 10.1306/94886d21-170411d7-8645000102c1865d

Adeoti L, Ojo AO, Adegbola RB, Fasakin OO (2016) Geoelectric assessment as An aid to geotechnical Investigation at a Proposed residential development site in Ilubirin, Lagos, and Southwestern Nigeria. Arab J Geosci 9: 338.

Andrews ND, Aning AA, Danuor SK and Noye RM (2013). An overview of the geology and hydrogeology of Nigeria. *Applied Groundwater Studies in Africa, 13*, 171 197.

Andrews ND, Aning AA, Danuor SK and Noye RM (2013). Geophysical investigations at the proposed site of theKNUST teaching Hospital building using the 2D and 3Dresistivity imaging techniques. International Research Journal of Geology and Mining (IRJGM) 3(3), 113-123.

A. O. Ogundalu and G.L. Oyekan, june 2014, mineralogical and geological characterization of Maiduguri Black Cotton soil by X-Ray Diffraction (XRD), X-Ray Photoelectron (XPS) and Scanning Electron Spectroscopy (SEM). International Journal of Engineering and Technology vol. 4 no. 6, june 2014.

B.

Colangelo G, Lapenna V, Loperte A, Perrone A, Telesca L (2008). 2delectrical resistivity tomographies for investigating recent activation landslides in basilicata region (southern italy). Annals of Geophysics, 51(1):12 Dahlin T. (1996). 2D resistivity surveying for environmental and engineering applications. First Break. 14: 275-283.

Folorunso, A. F., Ayolabis.E A., Ariyo O., and Oyebanjo IO., (2012). Fault Presence Under a failing building complex mapped by Electrical Resistivity Tomography. 32 (2) 5.

Genik G.J.(2). (1993). Petroleum Geology of Cretaceous-Tertiary Rift Basins in Nigeria, Chad,
and Central African Republic. AAPG Bulletin, 77. doi: 10.1306/bdff8eac-171811d7-8645000102c1865d

Guiraud , M., 1993. Late Jurassic rifting- early cretaceous rifting and late cretaceous transpressional inversion in the Upper Banue Basin (NE Nigeria). Bull. Cemter Rech. Explor. Prod. Elf Aquitaine. 17(2), 371-388.

Lapenna V, lorenzo P, Perrone A, Piscitelli S, Rizzo E, Sdao F (2005). 2d electrical resistivity imaging of some complex landslides in the lucanianapennine chain, southern italy. Geophysics, 70(3).

Lowry and Williams (2007). Fundamentals of Geophysics: Cambridge University press.

Kenneth B. Andromalos and Michael D. Abkowitz (2018). Clay soil and foundations: The Role of clay Foundation Engineering: February 22nd 2018 Published: September 12th 2018 DOI: 10.5772/ intechopen. 75817.

Olayanju GM, Mogaji KA, Lim HS, Ojo TS (2017) Foundation integrity assessment using integrated geophysical and geotechnical techniques: Case study in crystalline basement complex, southwestern Nigeria. J Geophys Eng 14: 675- 690.

Roy S, Bhalla SK (2017) Role of geotechnical properties of soil on civil engineering structures. Sci Acad Pub 7: 103-109.