NIPES

Journal of Science and Technology Research

Journal homepage: www.nipesjournals.org.ng

Investigation of the Depth to Basement and Basement Topography at Narayi Area of Kaduna State

Afuwai Gwazah Cyril[a], Banda Caleb[b]

[a,b]Physics Department, Kaduna State University, Kaduna PMB 2339, Kaduna State, Nigeria

Article Info

***Keywords*:**
Resistivity, basement topography, ves

Received 22 January 2020
Revised 02 February 2020
Accepted 13 February 2020
Available online 02 March 2020

ISSN-2682-5821/© 2020 NIPES Pub. All rights reserved.

Abstract

The interpretation of 15 Schlumberger Vertical Sounding (VES) data along 3 profiles were carried out in Government Day Secondary School Narayi, Kaduna State. This is an attempt to investigate the Depth to Basement and the Basement topography of the area. The Ohmega Terrameter was the principal instrument used. No booster was used. The Schlumberger electrode configuration was used in the data acquisition. The method consists of expanding AB (distance between the current electrodes) while MN (distance between the potential electrodes) is kept fixed. The VES curves were interpreted using IPI2Win resistivity computer software. The survey area is dominated by mainly four layers (topsoil, weathered basement, fractured basement and fresh basement). The results of the interpreted VES data showed an uneven distribution of the basement layer, with resistivity values ranging from 4.75Ωm - 220000Ωm. The basement layer is predominantly fresh granitic rocks. The depth to basement ranges from 10.8m – 21.96m with an average depth of 15.42m. Clay constituents are needed to be excavated at an average depth of 6m from the topsoil before laying any foundation.

1. Introduction

Large scale buildings require careful planning and also a solid and stable foundation built on a layer of hard rock structure with a certain depth and in accordance with the capability of the soil to the weight of the building to be built. Laying the foundation on an unstable soil surface can lead to cracks in buildings even collapsing.

News of collapsed high-rise structures has been reported worldwide. Several cases leading to the loss of lives and properties has been reported. One of the major contributing factors resulting to the collapse of these engineering structures (residential and non-residential buildings) is lack of proper investigation of the basement topography of the subsurface region which could be too weak or too compressible to provide adequate support. Since civil engineering projects are dedicated to the realization of quality and manageable work within a short time, geophysical study is imperative in such project. Hence, a need for pre-foundation studies so as to avoid collapse of large-scale structures. It is therefore important to complement civil engineering methods with effective, efficient and economical geophysical investigation in providing required information. The application of geophysics to the study of engineering constructions is refer to as "Engineering Geophysics". The method is economical and time saving compared to the traditional method of drilling and rock sampling.

Resistivity geophysical methods are used to investigate the location and depth of these mineral rocks which can be the underlying basement of the area. Geophysical methods that can be used to determine the depth as well as the terrain of the basement includes: Gravity method, Magnetic method, Electrical Resistivity method, Ground Radar, Seismic refraction and Reflection [1].

The geophysical method used for this research was electrical resistivity method. The research was conducted using Vertical Electrical Sounding (VES) survey at the study area to investigate the depth to bedrock and also the basement topography of a portion of the geographical area. This work is focused on probing the depth to bedrock and also mapping out the basement of Government Secondary School Narayi, Kaduna state and to know the competence of the bedrock to support concrete foundation for any proposed infrastructure. The aim of the study is to investigate the depth to basement and the basement topography using Vertical Electrical Sounding (VES) at Government Secondary School Narayi, Kaduna State.

2. Methodology

2.1 Theory of Electrical Resistivity Survey

In the DC resistivity surveying, an electric current is passed into the ground through two outer electrodes (current electrodes), and the resultant potential difference is measured across two inner electrodes (potential electrodes) that are arranged in a straight line, symmetrically about a centre point. The ratio of the potential difference to the current is displayed by the Terrameter as resistance. A geometric factor $\boldsymbol{K}$ in metres is calculated as a function of the electrode spacing. The electrode spacing is progressively increased, keeping the centre point of the electrode array fixed. A and B are current electrodes through which current is supplied into the ground, **M** and **N** are two potential electrodes to measure the potential differences between the two electrodes and P is the VES station to be sounded. The potential difference between the two potential electrodes is measured. The apparent resistivity is given by

$$\boldsymbol{\rho_a = k\left(\frac{\Delta V}{I}\right)} \qquad (\mathbf{1})$$

With K a geometric factor which only depends on electrode spacing and is given by

$$\boldsymbol{K = \pi\left(\frac{L^2}{2b} - \frac{b}{2}\right)} \qquad (\mathbf{2})$$

Electrical resistivity method is defined by their frequency of operation, the origin of the source signals and the manner by which the sources and receivers are coupled to the ground. The method is generally governed by Maxwell's equations of electromagnetism [2]. In the direct-current (DC) frequency, the diffusion term is zero and the field is thus governed entirely by Poisson equation. Electrical methods of geophysical investigations are based on the resistivity (or its inverse, conductivity) contrasts of subsurface materials. The electrical resistance, $\boldsymbol{R}$ of a material is related to its physical dimension, cross-sectional area, $\boldsymbol{A}$ and length, $\boldsymbol{l}$ through the resistivity, $\boldsymbol{\rho}$ or its inverse, conductivity, $\boldsymbol{\sigma}$ by

$$\boldsymbol{\rho = \frac{1}{\sigma} = \frac{RA}{l}} \qquad (\mathbf{3})$$

Low-frequency alternating current is employed as source signals in the DC resistivity surveys in determining subsurface resistivity distributions. Thus, the magnetic properties of the materials can be ignored [3] so that Maxwell's equations of electromagnetism reduced to:

$$\nabla.\vec{E} = \frac{1}{\varepsilon_\circ} q \qquad (4)$$

$$\nabla \times \vec{E} = 0 \qquad (5)$$

Where $\vec{E}$ is electric field in V/m, q is the charge density in C/m^3 and $\varepsilon_\circ$ (8.854 X 10^{-12} F/m) is the permittivity of free space. These equations are applicable to continuous flow of direct current; however, they can be used to represent the effects of alternating currents at low frequencies such that the displacement currents and induction effects are negligible. Usually, a complete homogeneous and isotropic earth medium of uniform resistivity is assumed. For a continuous current flowing in an isotropic and homogeneous medium, the current density $\vec{J}$ is related to the electric field, $\vec{E}$ through Ohm's law

$$\vec{J} = \sigma\vec{E} \qquad (6)$$

The electric field vector $\vec{E}$ can be represented as the gradient of the electric scalar potential,

$$\vec{E} = \nabla\Phi \qquad (7)$$

The apparent resistivity is the ratio of the potential obtained in-situ with a specific array and a specific injected current by the potential which will be obtained with the same array and current for a homogeneous and isotropic medium of 1Ωm resistivity. The apparent resistivity measurements give information about resistivity for a medium whose volume is proportional to the electrode spacing [4]. Resistivity is affected more by water content and quality than the actual rock material in porous formations. While aquifers that are composed of unconsolidated materials their resistivity decreases with the degree of saturation and salinity of the groundwater [5].

The apparent resistivity is the ratio of the potential obtained in-situ with a specific array and a specific injected current by the potential which will be obtained with the same array and current for a homogeneous and isotropic medium of 1Ωm resistivity. The apparent resistivity measurements give information about resistivity for a medium whose volume is proportional to the electrode spacing. Resistivity is affected more by water content and quality than the actual rock material in porous formations. Since the measured resistivity is usually a composite of the resistivity of several layers, the apparent resistivity may be smaller or larger than the real resistivities or in rare cases identical with one of the two resistivity values in a homogeneous surface. The apparent resistivity is the same as the real resistivity in a homogeneous subsurface, but normally a combination of contributing strata. The value of the apparent resistivity obtained with small electrode spacing is called the surface resistivity.

2.2 Ohmega Terrameter

The Ohmega resistivity meter is a high-quality earth resistance meter that gives accurate measurement over wide range of conditions. It has a minimum power output of 8watts. The manual selection set up is up to 200mA. This receiver incorporates automatic gain steps which provide a range of measurement from 0.001Ω to 360kΩ. This measurement is powered by large battery capacity which can take days before recharging. The Ohmegaterrameter is supplied with 4 stainless steel electrodes for 100m cables on lightweight reels and battery charger (Plate1).

Plate 1 Terrameter, wire cables and reel

2.3 Survey Area

The research project was conducted at Government Secondary School Narayi, Kaduna State. The coordinates of the study area: Latitude 10°28.275N - 10°29.15N and Longitude 07°28.649'E - 07°29.14'E. The specific location where the survey was done is an open field within the school premises. Students and other local football team play football at the study area. About 50% of Nigeria is covered by crystalline rocks and about 90% of this belong the basement complex which is said to be Precambrian in age. It is observed that the dominant rock types in the crystalline basement complex of Nigeria are Migmatites, gneisses, schists, quartzites and Granites [4]. The study area lies within the basement complex of Nigeria (Figure1.) Narayi Area (Figure 2) in Kaduna State is underlain by a basement complex of igneous and metamorphic rocks of mainly Jurassic and pre-Cambrian ages.

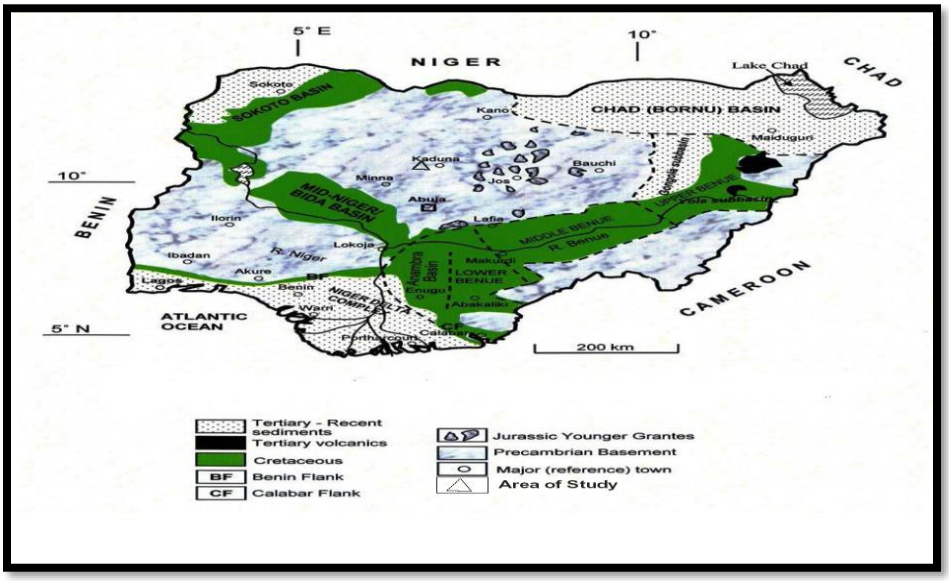


Figure 1 *Basement geological map of Nigeria showing the study area*

Figure 2 Satellite map of the area (Source: Google Earth 2019)

3. Data Collection

15 VES point along 3 profiles was taken within a maximum electrode spreading of 140m. The full schlumberger configuration was adopted with maximum half electrodes current spread (ab/2) projected between 1m, 1.5m, 2m, 3m, 4m.5m, 7m, 7m, 10m, 15m, 20m, 30m, 45m, 45m, 70m. While the half potential electrodes separation was (MN/2) was increased from 0.3m, 1m and 5m.
The 15 VES were carried out, where the center electrodes were kept fixed while the electrodes spacing kept increasing outwardly in a linear array. The wider spacing the deeper information as possible of the surface structure and lithological disposition of the area. The resistances values are obtained from the Ohmega Terrameter by multiplying the geometric factor K which was the function of the electrodes spacing to obtain the apparent resistivity values. The electrode array use to obtain these values is the schlumberger array. Apart from the principal instrument use to acquire the data, that is the Ohmega Terrameter, other equipment includes the four metallic electrodes, crocodile clips, wire cables, measuring tape, hammer and GPS.

4. Results and Discussion

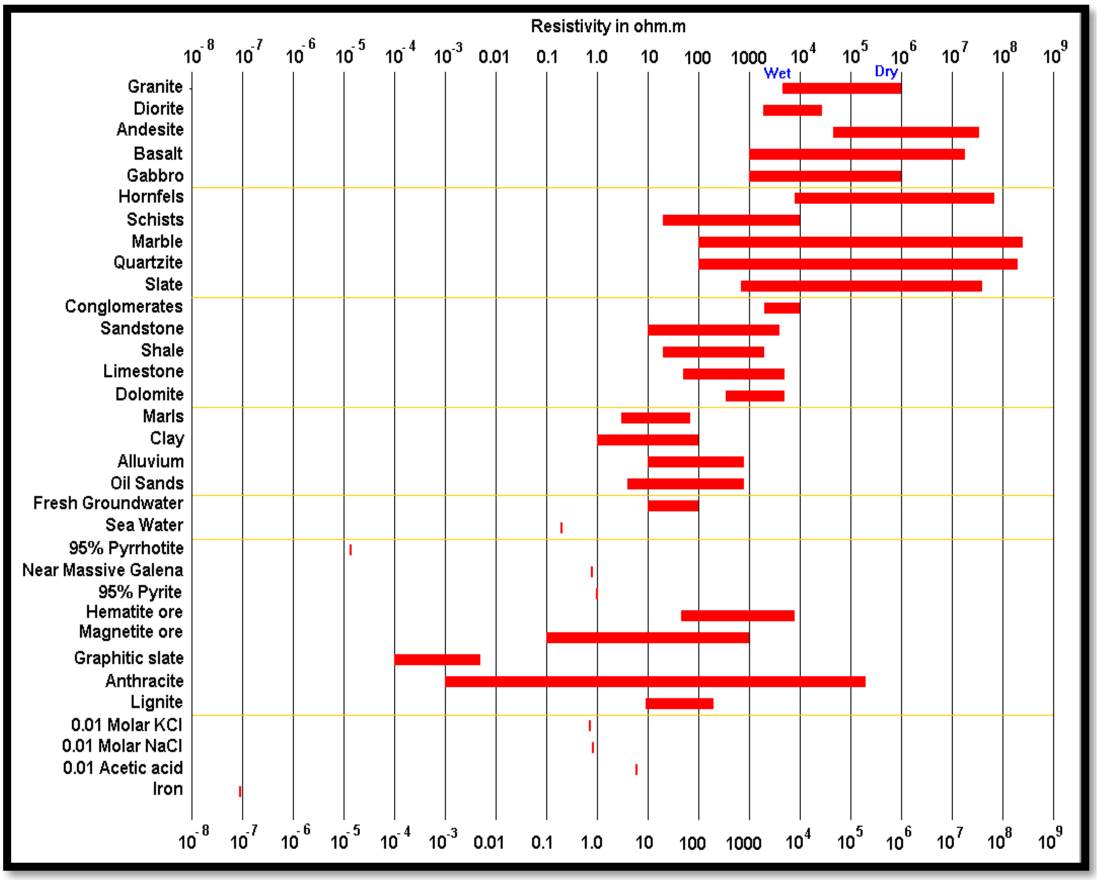
4.1 Electrical Properties of Earth Materials Adopted for the Study

Electric current flows in earth materials at shallow depths through two main methods. They are electronic conduction and electrolytic conduction. In electronic conduction, the current flow is via free electrons, such as in metals. In electrolytic conduction, the current flow is via the movement of ions in groundwater. In environmental and engineering surveys, electrolytic conduction is probably the more common mechanism. Electronic conduction is important when conductive minerals are present, such as metal sulfides and graphite in mineral surveys. The resistivity of common rocks, soil materials and chemicals, Foster et al., 2000 [6], are shown in Table 1. Igneous and metamorphic rocks typically have high resistivity values. The resistivity of these rocks is greatly dependent on the degree of fracturing, and the percentage of the fractures filled with ground water. Thus a given rock type can have a large range of resistivity, from about 1000 to 10 million Ωm, depending on whether it is wet or dry. This characteristic is useful in the detection of fracture zones and other weathering features, such as in engineering and groundwater surveys. Sedimentary rocks, which are usually more porous and have higher water content, normally have lower resistivity values compared to igneous and metamorphic rocks. The resistivity values range from 10 to about 10,000 Ωm, with most values below 1000 Ωm. The resistivity values are largely dependent on the porosity of the rocks, and the salinity of the contained water. Unconsolidated sediments generally have even lower resistivity values than sedimentary rocks, with values ranging from about 10 to less than 1000 Ωm. The resistivity value is dependent on the porosity (assuming all the pores are saturated) as well as the clay content. Clayey soil normally has a lower resistivity value than sandy soil. However, note the overlap in the resistivity values of the different classes of rocks and soils. This is because the resistivity of a particular rock or soil sample depends on a number of factors such as the porosity, the degree of water saturation and the concentration of dissolved salts. The resistivity of groundwater varies from 10 to 100 Ωm. depending on the concentration of dissolved salts. Note the low resistivity (about 0.2 Ωm) of seawater due to the relatively high salt content. This makes the resistivity method an ideal technique for mapping the saline and fresh water interface in coastal areas. One simple equation that gives the relationship between the resistivity of a porous rock and the fluid saturation factor is Archie's Law. It is applicable for certain types of rocks and sediments, particularly those that have low clay content. The electrical conduction is assumed to be through the fluids filling the pores of the rock. Archie's Law is given by

$$\rho = a\rho_w\varphi^{-m} \qquad 1$$

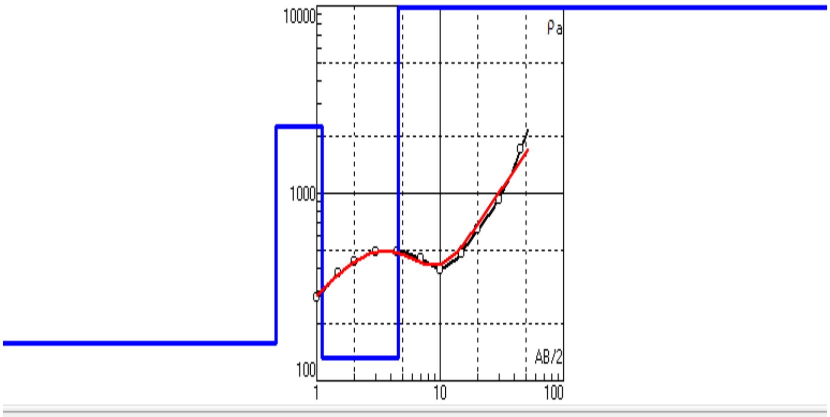
where ρ is the rock resistivity, ρ_w is fluid resistivity, φ is the porosity (fraction of the rock filled with the fluid) while *a* and *m* are two empirical parameters, Keller and Frischknecht 1966 [7]. For most sedimentary rocks, *a* is about 1 while *m* is about 2, for sucrossive rocks e.g. clean consolidated sandstones and carbonates. The resistivities of several types of ores are also shown. Metallic sulfides (such as pyrrhotite, galena and pyrite) have typically low resistivity values of less than 1 Ωm. Note that the resistivity value of a particular ore body can differ greatly from the resistivity of the individual crystals. Other factors, such as the nature of the ore body (massive or disseminated) have a significant effect. Note that graphitic slate has a low resistivity value, similar to the metallic sulphides, which can give rise to problems in mineral surveys. Most oxides, such as haematite, do not have a significantly low resistivity value. One of exceptions is magnetite. The resistivity values of several industrial contaminants are also given in Table 1. Metals, such as iron, have extremely low resistivity values. Chemicals that are strong electrolytes, such as potassium chloride and sodium chloride, can greatly reduce the resistivity of ground water to less than 1Ωm even at fairly low concentrations. The effect of weak electrolytes, such as acetic acid, is comparatively smaller. Hydrocarbons, such as xylene (6.998×10^{16} Ωm), typically have very high resistivity values. However, in practice the percentage of hydrocarbons in a rock or soil is usually quite small, and might not have a significant effect of the bulk resistivity. As an example, oil sands in Table1 have the same range of resistivity values as alluvium.

Table1. Resistivity values for earth materials adopted for this work [5]



4.2 Results of Profile 1 VES 01

VES 01 was probed and four layers were detected. The first layer has resistivity value of 353Ωm and thickness of 0.47m at depth of 0.47m. The earth materials at this layer are found to be weathered sand. The second layer has a resistivity value of 2254Ωm and thickness of 0.6m at a depth of 1.11m. The earth materials at this layer are found to be granitic rocks according to [7]. The third layer has a resistivity value of 131Ωm and thickness of 3.44m at depth of 4.55m, which is the depth to basement and the weathered layer at VES 01. The earth materials at this layer are found to be sandy clay. The fourth layer has a resistivity value of 110000Ωm (Figure 3). This layer is the fresh basement at an infinite depth.

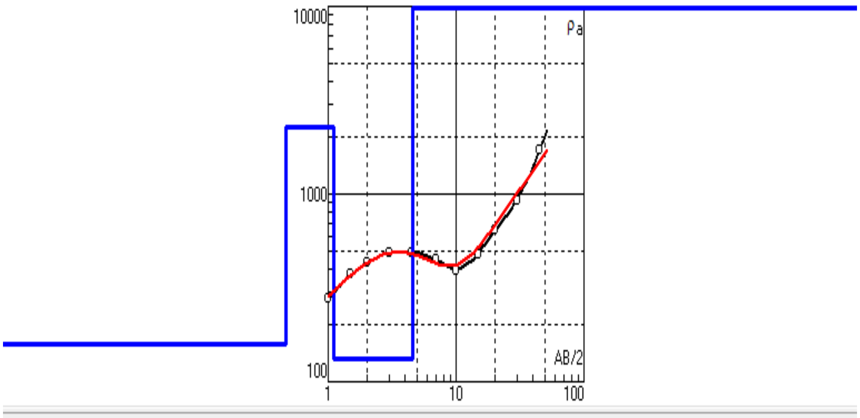


N	ρ	h	d	Alt
1	353	0.469	0.469	-0.469
2	2254	0.644	1.11	-1.11
3	131	3.44	4.55	-4.55
4	1.1E+5			

Figure 3. The Sounding curve and interpretation model for VES01 along Profile 1.

4.3 Results of Profile 1 VES 02

The Sounding curve and interpretation model for VES02 along Profile 1 is shown in Figure 4. Three layers were detected at VES 02. The first layer has resistivity value of 131Ωm and thickness of 7.6m at depth of 7.6m. The earth materials at this layer are found to be sandy clay. The second layer has a resistivity value of 53.9Ωm and thickness of 2.78m at a depth of 10.4mwhich is the depth to basement. The earth materials at this layer are found to be clay. The third layer has a resistivity value of 36132Ωm (Figure 4). This layer is the fresh basement at an infinite depth.



N	ρ	h	d	Alt
1	131	7.6	7.6	-7.59
2	53.9	2.78	10.4	-10.3
3	36132			

Figure 4. The Sounding curve and interpretation model for VES02 along Profile 1

4.4 Results of Profile 1 VES 03

Figure 5 shows the sounding curve and interpretation model for VES03 along Profile 1. VES 03 has four layers. The first layer has resistivity value of 6.53Ωm and thickness of 0.39m at depth of 0.39m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 18393Ωm and thickness of 5.01m at a depth of 5.41m. The earth materials at this layer are found to be fresh granitic bedrocks. The third layer has a resistivity value of 18393Ωm and thickness of 7.51m at depth of 12.9m, which is the depth to basement layer at VES 03. The earth materials at this layer are found to be fresh granitic bedrock. The fourth layer has a resistivity value of 5783Ωm. This layer is the granitic fresh basement at an infinite depth.

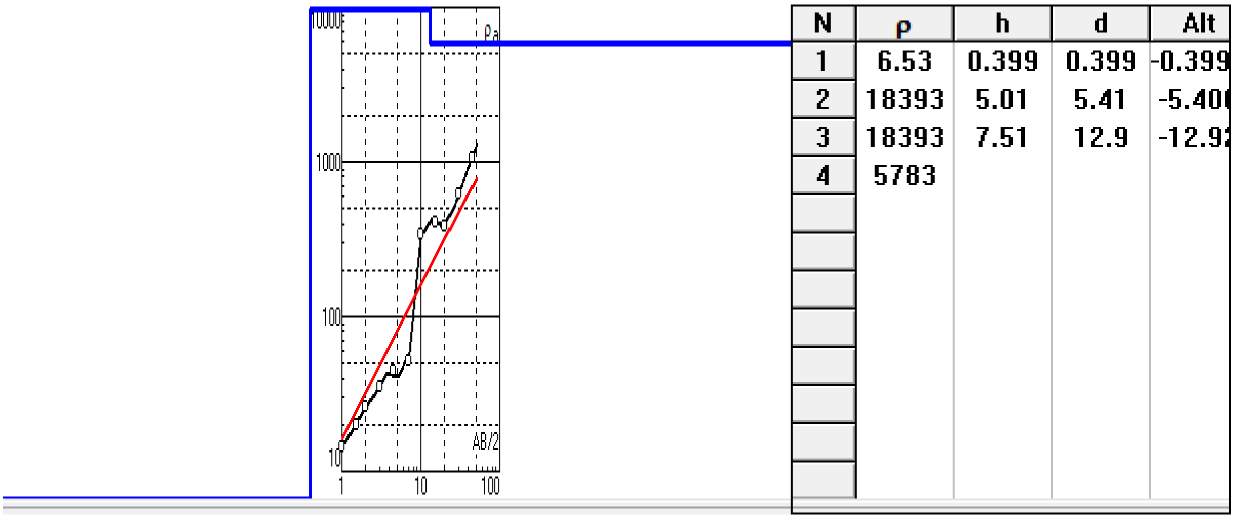


Figure 5. The Sounding curve and interpretation model for VES03 along Profile 1

4.5 Results of Profile 1 VES 04

The result of the fourth VES point along profile one showed four (4) subsurface layers. The first layer has resistivity value of 50.5Ωm and thickness of 0.29m at depth of 0.29m. The earth materials at this layer are predominantly clay. The second layer has a resistivity value of 345Ωm and thickness of 13.5m at a depth of 13.8m. The earth materials at this layer are found to be weathered sand. The third layer has a resistivity value of 220000Ωm and thickness of 20.7m at depth of 34.6m, which is the depth to basement layer at VES 04. The earth materials at this layer are found to be fresh granitic rocks. The fourth layer has a resistivity value of 220000Ωm (Figure6). The earth materials at this layer are found to be fresh granitic rocks. This layer is the fresh basement at an infinite depth.

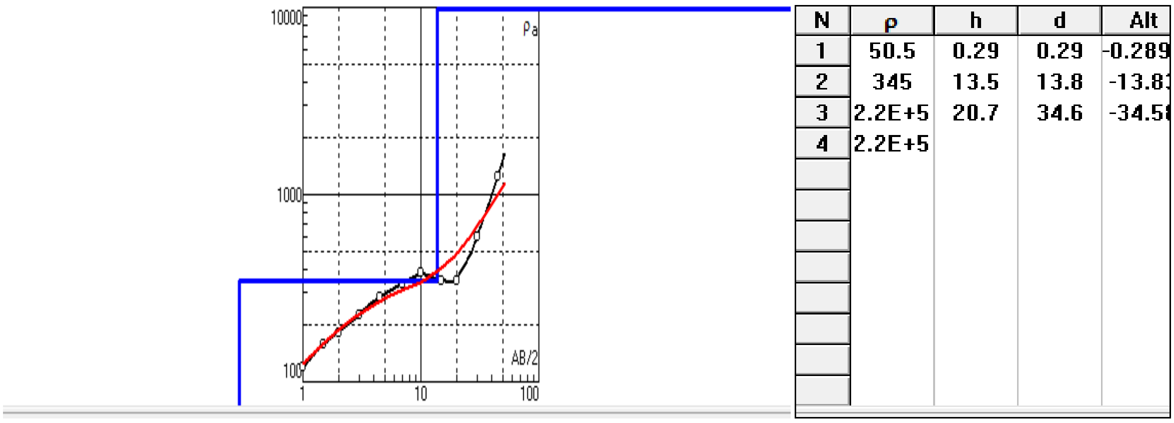
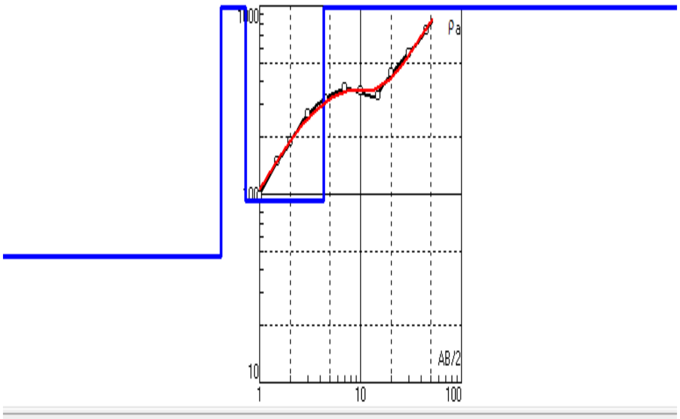


Figure 6. The Sounding curve and interpretation model for VES04 along Profile 1

4.6 Results of Profile 1 VES 05

The first layer at VES 05 has resistivity value of 46.5Ωm and thickness of 0.42m at depth of 0.42m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 6028Ωm and thickness of 0.32m at a depth of 0.73m. The earth materials at this layer are found to be granitic rocks. The third layer has a resistivity value of 91.9Ωm and thickness of 3.55m at depth of 4.28m, which is the depth to basement layer at VES 05. The earth materials at this layer are found to be clay. The fourth layer has a resistivity value of 3333Ωm (Figure7). The earth materials at this layer are found to be granitic rocks.



N	ρ	h	d	Alt
1	46.5	0.415	0.415	-0.415
2	6028	0.317	0.732	-0.731
3	91.9	3.55	4.28	-4.28
4	3333			

Figure 7. The Sounding curve and interpretation model for VES05 along Profile 1

4.7 Results of Profile 2 VES 01

Figure8 gives the Sounding curve and interpretation model for VES01 along Profile 2. VES 01 has four subsurface layers. The first layer has resistivity value of 44.5Ωm and thickness of 0.29m at depth of 0.29m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 44.5Ωm and thickness of 0.43m at a depth of 0.71m. The earth materials at this layer are found to be clay. The third layer has a resistivity value of 516Ωm and thickness of 15m at depth of 15.7m, which is the depth to basement layer at VES 01. The earth materials at this layer are found to be lateritic soil. The fourth layer has a resistivity value of 42738Ωm (Figure 8). The earth materials at this layer are found to be fresh bedrocks.

N	ρ	h	d	Alt
1	44.5	0.285	0.285	-0.285
2	44.5	0.428	0.713	-0.712
3	516	15	15.7	-15.7
4	42738			

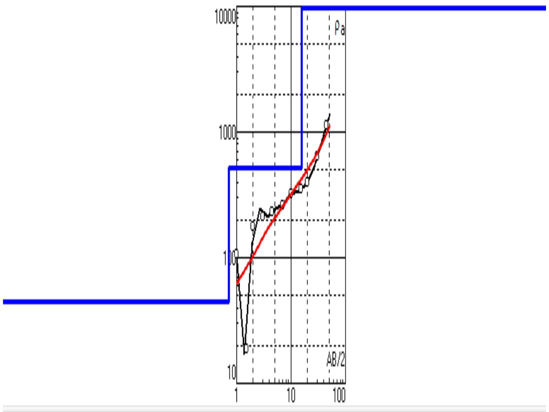
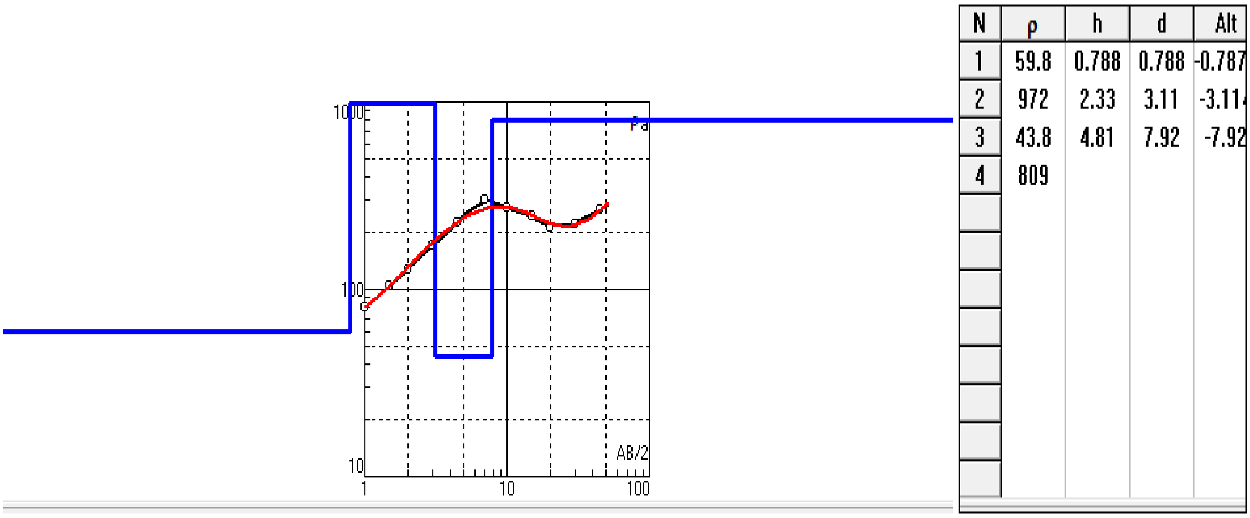


Figure 8. The Sounding curve and interpretation model for VES01 along Profile 2

4.8 Results of Profile 2 VES 03

Figure 9 gives the Sounding curve and interpretation model for VES02 along Profile 2. VES 03 has 4 layers. The first layer has resistivity value of 59.8Ωm and thickness of 0.79m at depth of 0.79m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 972Ωm and thickness of 2.33m at a depth of 3.11m. The earth materials at this layer are found to be lateritic soil. The third layer has a resistivity value of 43.8Ωm and thickness of 4.81m at depth of

7.92m, which is the depth to basement layer at VES 03. The earth materials at this layer are found to be clay sandy soil. The fourth layer has a resistivity value of 809Ωm. The earth materials at this layer are found to be gravels.

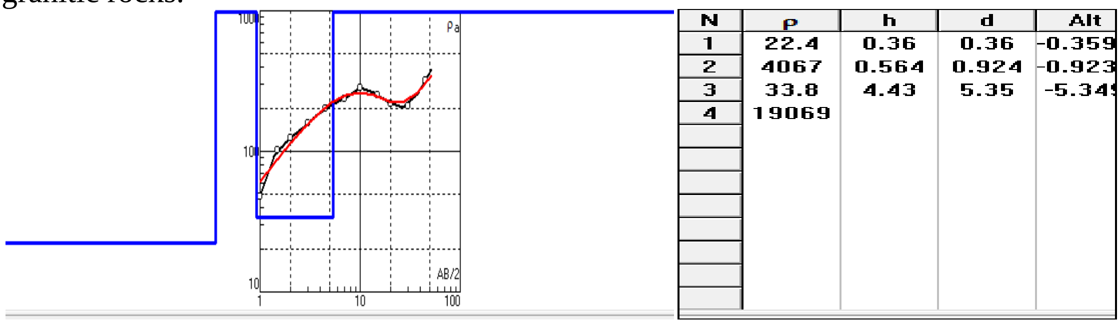


N	ρ	h	d	Alt
1	59.8	0.788	0.788	-0.787
2	972	2.33	3.11	-3.11
3	43.8	4.81	7.92	-7.92
4	809			

Figure 9. The Sounding curve and interpretation model for VES02 along Profile 2

4.9 Results of Profile 2 VES 04

The fourth VES point along Profile 2 was found out to have four layers. The first layer has resistivity value of 22.4Ωm and thickness of 0.36m at depth of 0.36m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 4067Ωm and thickness of 0.56m at a depth of 0.92m. The earth materials at this layer are found to be granitic rocks. The third layer has a resistivity value of 33.8Ωm and thickness of 4.43m at depth of 5.35m, which is the depth to basement layer at VES 04. The earth materials at this layer are found to be clay. The fourth layer has a resistivity value of 19069Ωm (Figure 10). The earth materials at this layer are found to be fresh granitic rocks.

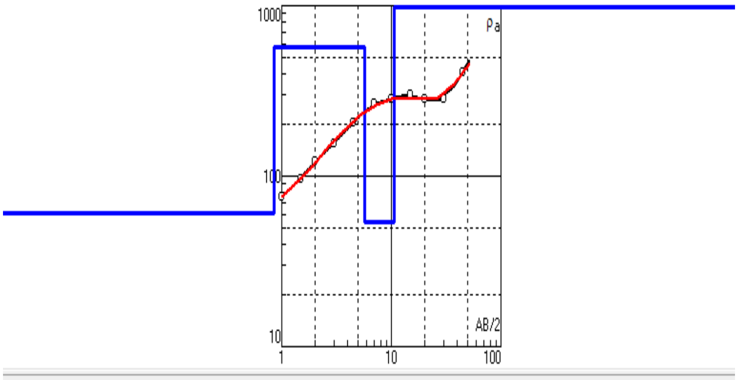


N	ρ	h	d	Alt
1	22.4	0.36	0.36	-0.359
2	4067	0.564	0.924	-0.923
3	33.8	4.43	5.35	-5.34
4	19069			

Figure 10. The Sounding curve and interpretation model for VES04 along Profile 2

4.10 Results of Profile 2 VES 05

VES 05 was probed and four layers were detected. The first layer has resistivity value of 60.5Ωm and thickness of 0.85m at depth of 0.85m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 573Ωm and thickness of 4.82m at a depth of 5.67m. The earth materials at this layer are found to be lateritic soil. The third layer has a resistivity value of 53.8Ωm and thickness of 4.88m at depth of 10.5m, which is the depth to basement layer at VES 05. The earth materials at this layer are found to be clay. The fourth layer has a resistivity value of 38557Ωm (Figure11). The earth materials at this layer are found to be fresh bedrocks. This layer is the fresh basement at an infinite depth and infinite thickness.

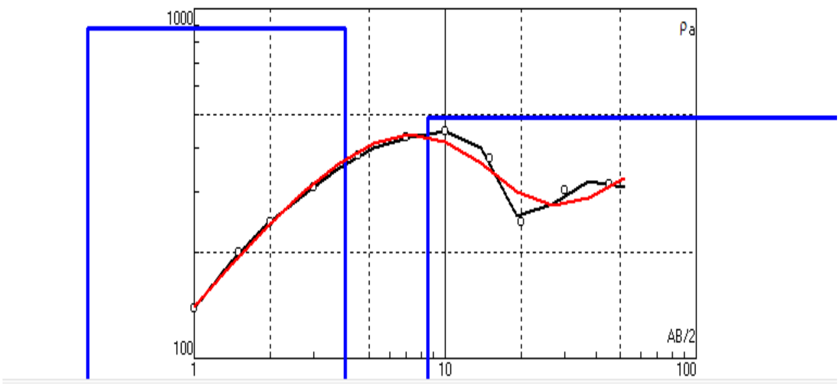


N	ρ	h	d	Alt
1	60.5	0.845	0.845	-0.844
2	573	4.82	5.67	-5.66
3	53.8	4.88	10.5	-10.5
4	38557			

Figure 11. The Sounding curve and interpretation model for VES05 along Profile 2

4.11 Results of Profile 3 VES 01

According to Afuwai, 2014 [1] within the basement complex of Nigeria, where the study area is located has predominantly four layers, namely; topsoil, weathered layer, fractured layer and the fresh basement. VES 01 along profile one has four subsurface layers. The first layer has resistivity value of 61.4Ωm and thickness of 0.38m at depth of 0.38m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 878Ωm and thickness of 3.64m at a depth of 4.01m. The earth materials at this layer are found to be lateritic soil. The third layer has a resistivity value of 71.4Ωm and thickness of 4.48m at depth of 8.49m, which is the depth to basement layer at VES 01. The earth materials at this layer are found to be clay. The fourth layer has a resistivity value of 488Ωm (Figure 12). The earth materials at this layer are found to be Sandy soil.

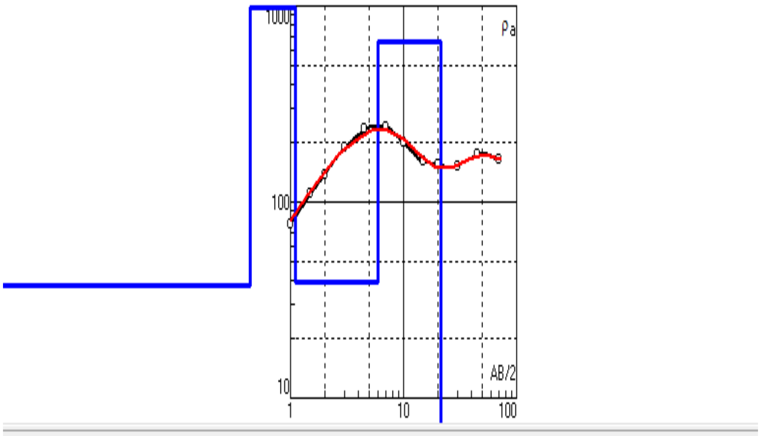


N	ρ	h	d	Alt
1	61.4	0.378	0.378	-0.377
2	878	3.64	4.01	-4.01
3	71.4	4.48	8.49	-8.49
4	488			

Figure 12. The Sounding curve and interpretation model for VES01 along Profile 3

4.12 Results of Profile 3 VES 02

VES 02 has five layers. The first layer has resistivity value of 37.3Ωm and thickness of 0.44m at depth of 0.44m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 2074Ωm and thickness of 0.67m at a depth of 1.11m. The earth materials at this layer are found to be Granitic rocks. The third layer has a resistivity value of 38.8Ωm and thickness of 4.82m at depth of 5.94m. The earth materials at this layer are found to be clay. The fourth layer has a resistivity value of 660Ωm and thickness of 15.5m at depth of 21.5m. The earth materials at this layer are found to be lateritic soil. The fifth layer has a resistivity value of 6.58Ωm (Figure13). The earth materials at this layer are found to be clay.

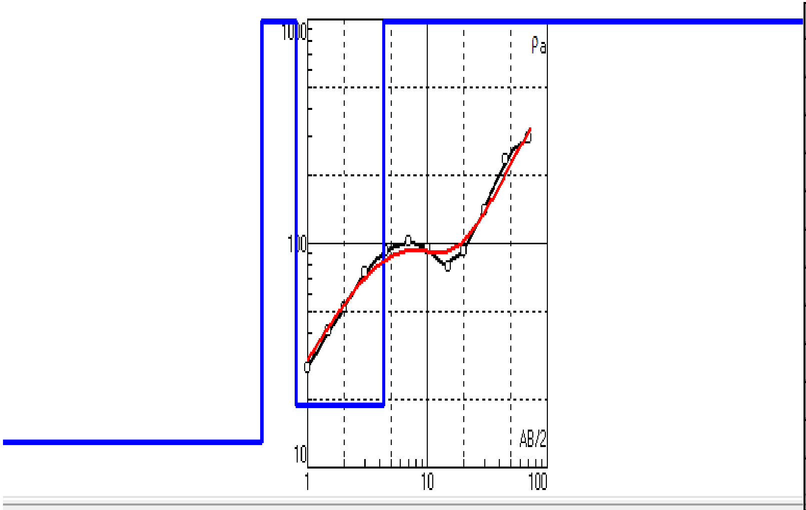


N	ρ	h	d	Alt
1	37.3	0.439	0.439	-0.439
2	2074	0.674	1.11	-1.11
3	38.8	4.82	5.94	-5.93
4	660	15.5	21.5	-21.4
5	6.58			

Figure 13. The Sounding curve and interpretation model for VES02 along Profile 3

4.13 Results of Profile 3 VES 03

The first layer at VES 03 along profile 3 has resistivity value of 13Ωm and thickness of 0.41m at depth of 0.41m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 1380Ωm and thickness of 0.38m at a depth of 0.79m (Figure 14). The earth materials at this layer are found to be lateritic soil. The third layer has a resistivity value of 18.9Ωm and thickness of 3.5m at depth of 4.3m, which is the depth to basement layer at VES 03. The earth materials at this layer are found to be clay. The fourth layer has a resistivity value of 14139Ωm which is interpreted to be fresh Granitic rocks.

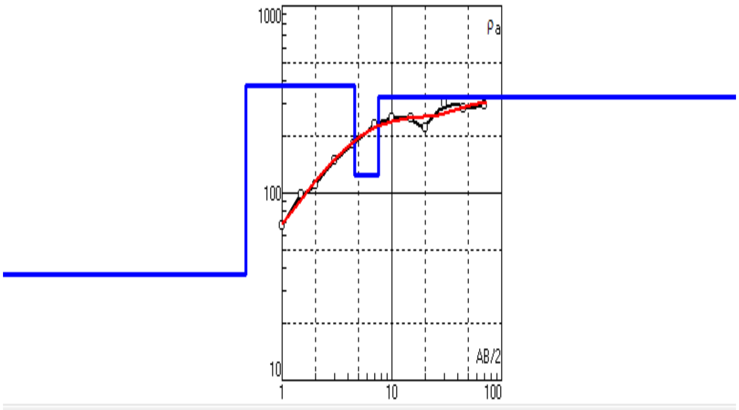


N	ρ	h	d	Alt
1	13	0.411	0.411	-0.410
2	1380	0.384	0.794	-0.794
3	18.9	3.5	4.29	-4.29
4	14139			

Figure 14. The Sounding curve and interpretation model for VES03 along Profile 3

4.14 Results of Profile 3 VES 04

Figure 15 shows the Sounding curve and interpretation model for VES04 along Profile 3. VES 04 was found to have four layers. The first layer has resistivity value of 37Ωm and thickness of 0.47m at depth of 0.47m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 374Ωm and thickness of 4.11m at a depth of 4.58m. The earth materials at this layer are found to be lateritic soil. The third layer has a resistivity value of 125Ωm and thickness of 2.93m at depth of 7.51m, which is the depth to basement layer at VES 01. The earth materials at this layer are found to be lateritic soil. The fourth layer has a resistivity value of 324Ωm which is interpreted to be sandy soil.

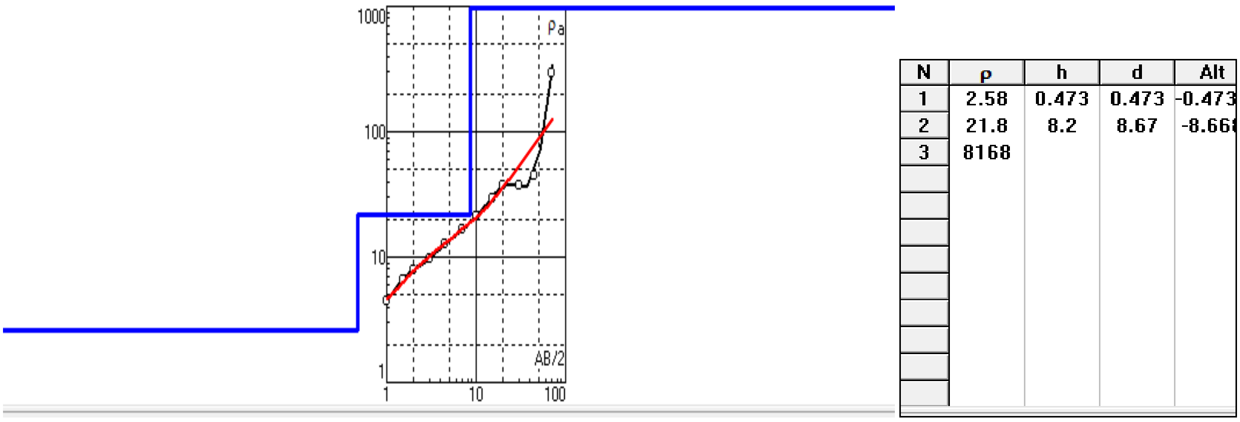


N	ρ	h	d	Alt
1	37	0.472	0.472	-0.471
2	374	4.11	4.58	-4.57
3	125	2.93	7.51	-7.51
4	324			

Figure 15. The Sounding curve and interpretation model for VES04 along Profile 3

4.15 Results of Profile 3 VES 05

VES 05 along profile 3 has 3 layers with the third layer the most resistive. The first layer has resistivity value of 2.58Ωm and thickness of 0.47m at depth of 0.47m. The earth materials at this layer are found to be clay. The second layer has a resistivity value of 21.8Ωm and thickness of 8.2m at a depth of 8.67m. The earth materials at this layer are found to be clay. The third layer has a resistivity value of 8168Ωm (Figure16) which is taken to be the fresh basement.



N	ρ	h	d	Alt
1	2.58	0.473	0.473	-0.473
2	21.8	8.2	8.67	-8.66
3	8168			

Figure 16. The Sounding curve and interpretation model for VES05 along Profile 3

4.16 Depth to Basement Topography along Profile One (1)

Five VES points were sounded along profile one. The depth to basement at VES 01, 02, 03, 04 and 05 were found to be 4.55m, 10.4m, 12.9m, 34.6m and 4.28m respectively with an average depth to basement of 13.35m. The Depth to basement topography along profile one (1) is shown in (Figure 17).

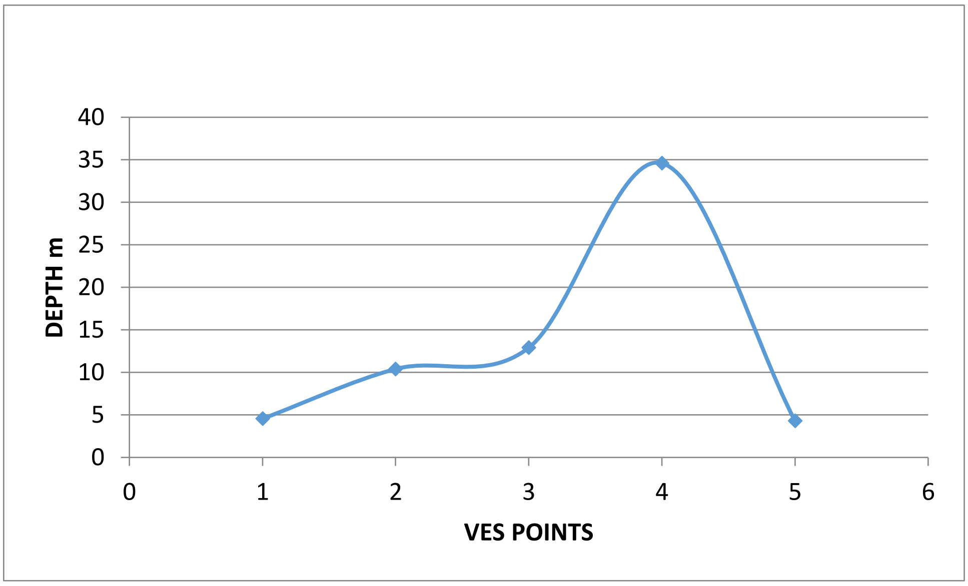


Figure 17. Basement Topography along Profile 1

4.17 Depth to Basement Topography along Profile Two (2)

Five VES points were sounded along profile two. The depth to basement at VES 01, 02, 03, 04 and 05 were found to be 15.7m, 70.3m, 7.9m, 5.4m and 10.5m respectively with an average depth to basement of 21.96m. The basement topography along profile two (2) is shown in (Figure 18).

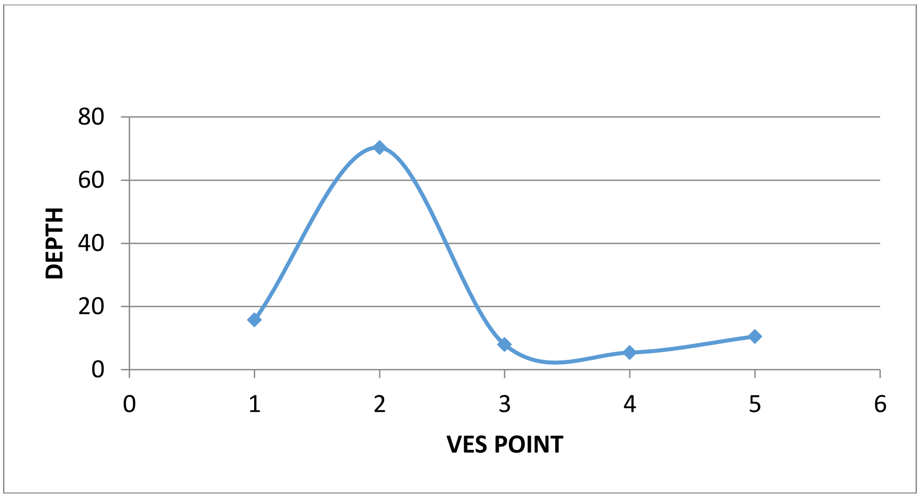


Figure 18. Basement Topography along Profile 2

4.18 Depth to Basement Topography along Profile Three (3)

Five VES points were sounded along profile three. The depth to basement at VES 01, 02, 03, 04 and 05 were found to be 8.5m, 21.5m, 4.3m, 7.5m and 8.6m respectively with an average depth to basement of 10.8m. The basement topography along profile three (3) is shown in (Figure19). Along this profile, VES 02 has the highest depth to basement with the lowest at VES03.

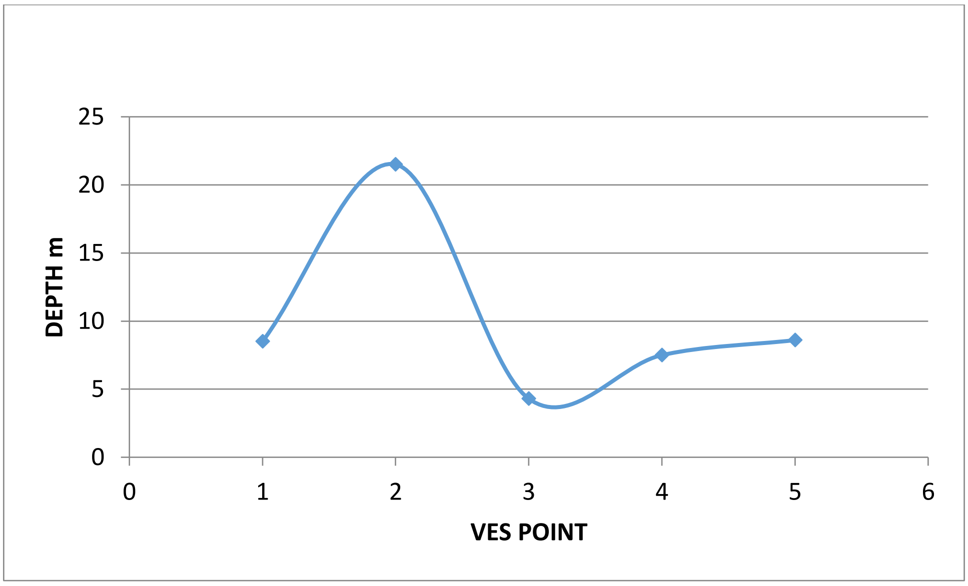


Figure 19. Basement Topography along Profile 3

5. Conclusion

At the end of the survey, 15 VES points along 3 profiles were investigated at the survey area. The average depth to basement ranges from 10.8m – 21.96m. The average depth to basement was found to be 15.42m. The basement topography showed an uneven distribution of subsurface structure with resistivity values ranging from 4.75Ωm-220000Ωm of fresh granitic rocks of earth material. Geo-electrical surveys using the Vertical Electrical Sounding (VES) method is highly recommended for investigation of the subsurface. The result of this research shows an average depth to bedrock at 15.42m. The topsoil constituents of the surveyed area are mostly clay. Hence, clay constituents should be excavated before laying building foundation. The bedrock topography appears to be very irregular and shows no continuity in subsurface structures within the study area.

References

[1] Afuwai, G.C., Lawal, K.M., Sule, P and Ikpokonte, A.E. (2014). Geophysical Investigation of the Causes of Borehole Failure in the Crystaline Basement Complex: A Case Study of Kaura Area of Kaduna State, Nigeria. Journal of Environment and Earth Science, 4(23). 131-141.

[2] Grant FS, West GF (1965). Interpretation Theory in Applied Geophysics. McGraw-Hill, New York.

[3] Shemang, E.M. (1990). Electrical Depth Sounding at Selected Well sites within Kubani River Basin, Zaria. Unpublished M.Sc Thesis, A.B.U, Zaria.

[4] Afuwai, G.C. 2019 Investigation of the inhomogeneity of subsurface structures at various VES points at Samaru-Zaria, Northern-Nigeria. Journal of Science and Technology Research 1(1) pp. 55-62

[5] Afuwai, G.C. (2019). Comparison of Geophysical Parameters of Geoelectric Section and Seismic Refraction Imaging along the Same Profile across a Borehole Location at Agban-Kagoro, Kaduna State Nigeria. FUDMA Journal of Sciences (FJS). Vol. 3 No. 3, September, pp 131 –138

[6] [6] Afuwai G.C. and Lawal K.M. (2013). Interpretation of Vertical Electrical Sounding Points around two boreholes at Samaru College of Agriculture ABU, Zaria-Nigeria. Scholars Research Library, Archives of Physics Research. 4(5). 49-54.

[7] Foster, S. S. D., Chilton P. J., Moench M., Cardy F. and Schiffler M. (2000). Groundwater in rural development, World Bank Technical Paper No 463, The World Bank, Washington D C.

[8] Keller, G. V. and Frisehknecht, F. C., (1966). Electrical methods in geophysical Prospecting pergamon Press. Pp 44