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EVALUATION OF GROUNDWATER POTENTIAL USING ELECTRICAL RESISTIVITY METHOD IN OKENUGBO AREA, AGO - IWOYE, SOUTHWESTERN, NIGERIA.

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ABSTRACT

Okenugbo area of Ago-Iwoye, Southwestern Nigeria was investigated for the evaluation of groundwater potential. The study was aimed to evaluate the subsurface geologic and Geoelectric properties that might contribute to the availability of low groundwater within the area.

The study makes use of Eight (8) VES data acquired at random within this study area using Schlumberger Electrode Configuration. The VES Data acquired were interpreted into a model curve using Winglink. From this interpretation five (5) different curve types were obtained from the acquired data. They are namely; - HA-type, QH-type, HK-type, A-type, H-type. HA- type is the dominated type of the curve obtained with characteristics of $\rho_1 > \rho_2 < \rho_3 < \rho_4$ *at each layer.*

It was observed that the groundwater potential in this area is very low. The interpretation revealed that VES 2 and VES 3 will give high yield of groundwater of hand-dug well or borehole. VES 1 gives proximity of having groundwater due to the fracture shown to have a very low resistivity value of 67 ohm-metres. Any borehole located at VES 5, VES 6, VES 8 will be abortive due to their lithology formations. This study shows the variations in the lithologies and difference in geological and geophysical properties in the study using Schlumberger Configuration of Electrical Resistivity.

Keywords: groundwater, electrical resistivity, geological and geophysical properties

INTRODUCTION

Groundwater is the water that lies beneath the ground surface, filling the pore space between grains in bodies of sedimentary rock, filling cracks and crevices in all types of rock (Plummer et al., 1999). The primary source of groundwater is rain and snow that falls to the ground. A portion of this precipitation percolates down into the ground to become groundwater. Among the factors that determine the extent and rate of precipitation that soaks into the ground are climate, land slope, soil and rock type and vegetation. In general, approximately 15% of total precipitation ends up as groundwater, but that varies locally and regionally from 1 to 20%. Despite the fact that global water distribution shows that groundwater is about 0.61%, it is surprisingly, about 60 times as plentiful as fresh water in lakes and rivers on the surface (Plummer et al., 1999). Studies have showed that groundwater could be explored using electrical resistivity methods (Olorunfemi and Fasoyi, 1993; Olasehinde, 1999; Alile et al., 2008). Where it is difficult to locate aquifers such as water-saturated zones in hard rock, it is also difficult to select suitable sites for water drilling. The 2D resistivity technique has improved the chance of drilling successes by identifying the fractured and weathered zones in these areas (Singh et al., 2006). Therefore, the use of such technique for groundwater exploration has earned an important place in recent

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years despite some interpretive limitations (Dogara et al., 1998; Singh et al., 2006). It is therefore expected that the results obtained from this work would produce detailed groundwater condition and recommend areas within the observatory were deep tube wells could be located. This would definitely meet the objective of securing the observatory from acute water shortages for both observers and researchers.

LOCATION AND GEOLOGICAL INFORMATION OF THE STUDY AREA

The study area is essentially a part of the Nigerian basement complex regarded as Precambrian basement complex. The rocks present are mainly Granodiorite porphyroblastic, Granite, Gneisses and Migmatite Gneisses, Biotite Gneisses and Biotite, Hornblende Gneiss (Rahaman, 1972). The Gneisses constitute the major rocks intended by the other groups of rocks. Minor rock types include pegmatite and quartz veins. The basement complex is one of the three major litho-petro logic components that make up the geology of Nigeria.

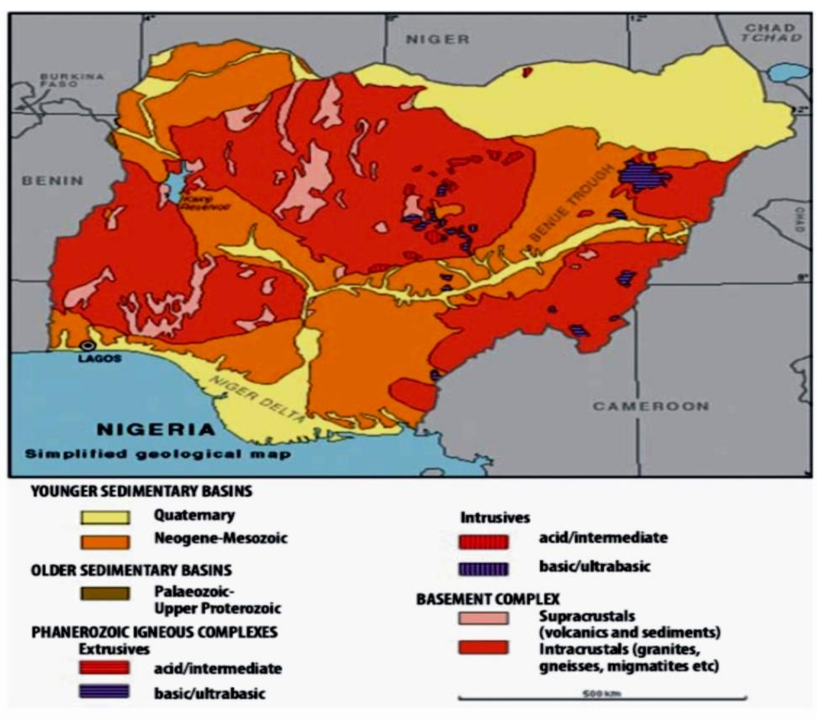

Figure 1: Regional Map of Nigeria (after Ajibade 1979)

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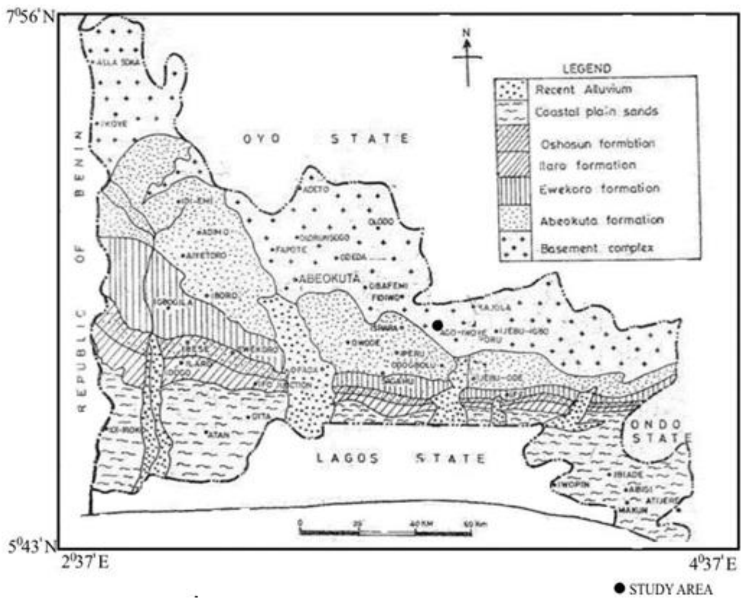

Figure 2: Map of Ogun State Showing the study Area (after Kehinde Phillips 1992)

The study area lies between Longitude N06°55.389'-N06°55.384' and Latitude E003°55.001' and E003°54.959' respectively. The area is located in Okenugbo, by- Fowoseje Comprehensive High School in Ago-Iwoye area of Ijebu in Ogun State. It lies in the Pre-Cambrian basement complex terrain of South-western Nigeria. The accessibility of the area is best described in terms of transportation network, which consists of minor roads with foot path across the whole area.

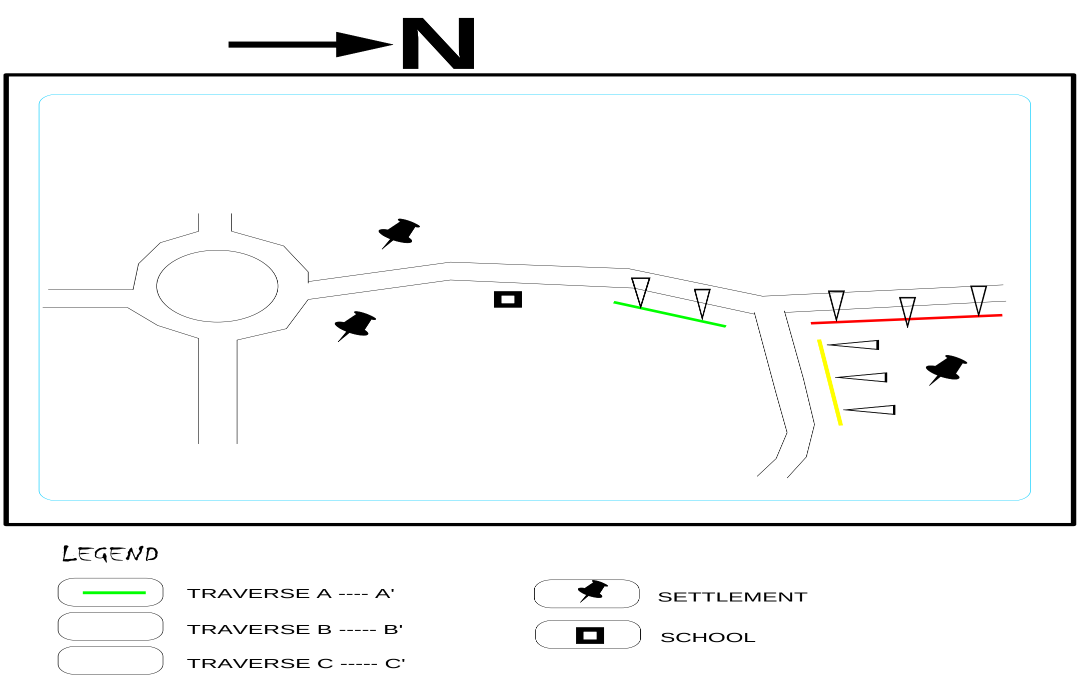

Figure 3: Accessibility map of study area showing VES locations

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Within the basement complex of south western Nigeria , the general level of surface rises Northward from about 0-500ft above the coast northward to the area of crystalline rocks. The relief is moderately low hills forming ridges, in some places an undulated plain dotted with small isolated hills or hills rock are noticed generally within Ago-Iwoye [National Atlas of Federal Republic of Nigeria]

The study area is characterized by a Monsoon type of climate which varies between wet and dry seasons. The wet season begins in late March or early April and in late September or early November. The dry season is from November to early November to early March and the average rainfalls is about 250-450mm.Also the average rainfall during the wet season is 750-1000mm at a temperature of 27°C (National Atlas, Federal Republic of Nigeria)

MATERIALS AND METHODS

Basic theoretical considerations: The fundamental equation for resistivity survey is derived from Ohm's law (Grant and West, 1965; Dobrin and Savit, 1988)

$$\rho = \frac{RA}{L} \qquad (1)$$

where, ρ is resistivity, R is resistance, L is length of homogenous conducting cylinder and A is cross sectional area.

For the solid earth, whose material is predominantly made up of silicates and basically non-conductors, the presence of water in the pore spaces of the soil and in the rock fractures enhances the conductivity of the earth when an electrical current I is passed through it, thus making the rock a semi-conductor. Since the earth is not like a straight wire and it is anisotropic, then Eq. 1 is thus customized to:

$$\rho = \frac{\Delta V}{I}.2\pi r \qquad (2)$$

where, ΔV is change in voltage and r is the radius of current electrode's small hemisphere.

Since, the earth is not homogeneous, Eq. 2 is used to define an apparent resistivity ρ_a which is the resistivity the earth would have if it were homogeneous (Grant and West, 1965):

$$\rho_a = \frac{\Delta V}{I}.2\pi r \qquad (3)$$

where, 2πr is then defined as a geometrical factor (G) fixed for a given electrode configuration.

The Schlumberger configuration was used in this study. The geometric factor G is thus given as:

$$G = \pi \frac{\left[\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2\right]}{2\left(\frac{MN}{2}\right)} \qquad (4)$$

Where, AB is current electrode spacing and MN is spacing between potential electrodes.

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RESULTS AND DISCUSSIONS

VES data obtained were iterated using computer software Winglink for its partial curve matching. Based on the geoelectrical characteristics of the subsurface as expressed by the curve morphology, the Vertical Electrical Sounding curves obtained are classified into five (5) different curve types.

1.1 HA- type curve

The HA-type curves are the most predominant curve accounting for 50% of the total curves and the geoelectric sequence is such that $\rho_1 > \rho_2 < \rho_3 < \rho_4$. The HA- type geoelectric sequence in the study area consists of a top soil with thickness range between 0.63 – 1.92m as in VES 3 and VES 6 respectively. This topsoil is directly underlain in most sounding point by clayey sand formation. The 3rd layer followed is the weathered layer which in turn being succeeded by the fresh basement as the forth layer which is the infinite layer. The maximum depth mapped with the HA-type curve is placed at 25.8m as in VES 6.

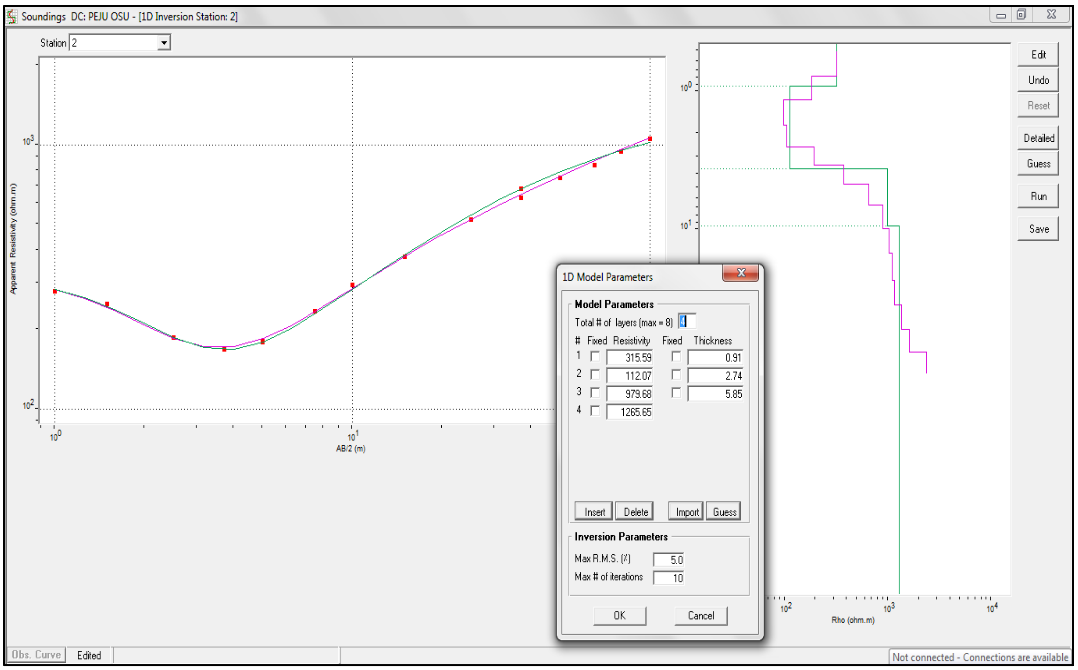

Figure 4: Typified HA- Curve in the study

In the figure above, the 1D model inversion is such that the second layer has the least apparent resistivity mapped. This low resistivity (112Ωm) is not an indication of water but rather a typifying lithological characteristic of clay formation. More so, the surface water examined from hand dug wells are at a far depth than the 3m depth of the formation. At the third layer mapped, there is a likeliness of groundwater occurrence as could be inferred from the layer resistivity. Although, this is not conclusive because the resistivity value (980 Ωm) only a weathered layer extending to the subsequent layer.

In VES 3, the 1D model inversion is such that the second layer has the least apparent resistivity value (95 Ωm). This very low resistivity value characterising the geoelectric layer extends to a depth of about 6.5m which is the maximum depth of hand dug wells in the study area. The third layer beneath is also being characterize by a very low resistivity value which gives an indication of either a fractured zone or weathered formation saturated with water. The fresh layer mapped is a basement rock characterize by apparent resistivity value of 3983 Ωm and a depth greater than 11m. Borehole or hand dug well at this location is likely to be of high yield for reasons discussed above.

But for VES 4 and 6 the second layer is characterizing by apparent resistivity value of 77 and 605Ωm respectively. The third and fourth geoelectrical sequence in both locations indicates the weathered and fresh basement formation. From the 1D inversion model of the curves it is apparent to say

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that hand dug well or borehole in this location would be of no yield.

1.2
QH- type curve

The QH-type curves are four layer sounding curves constituting 12.5% of the total VES curves. The VES curve morphology (figure 5) is such that $\rho_1 > \rho_2 > \rho_3 < \rho_4$. The geoelectric sequence generally shows a topsoil layer underlain by a clayey sand formation. This top layer ranges has a resistivity of 3675Ωm with thickness range of only 0.35m while the underlain layer is about 236 Ωm with thickness of only 1m. The third and fourth layers delineated have a resistivity value of 67 and 65017Ωm. The third layer is more indicative of a fractured basement as to a weathered basement. This is indicative by the abrupt change in resistivity value from a very low apparent resistivity value to very high apparent resistivity value. The fracture delineated could possibly be a water aquifer but this is not conclusive because of its close proximity to the surface.

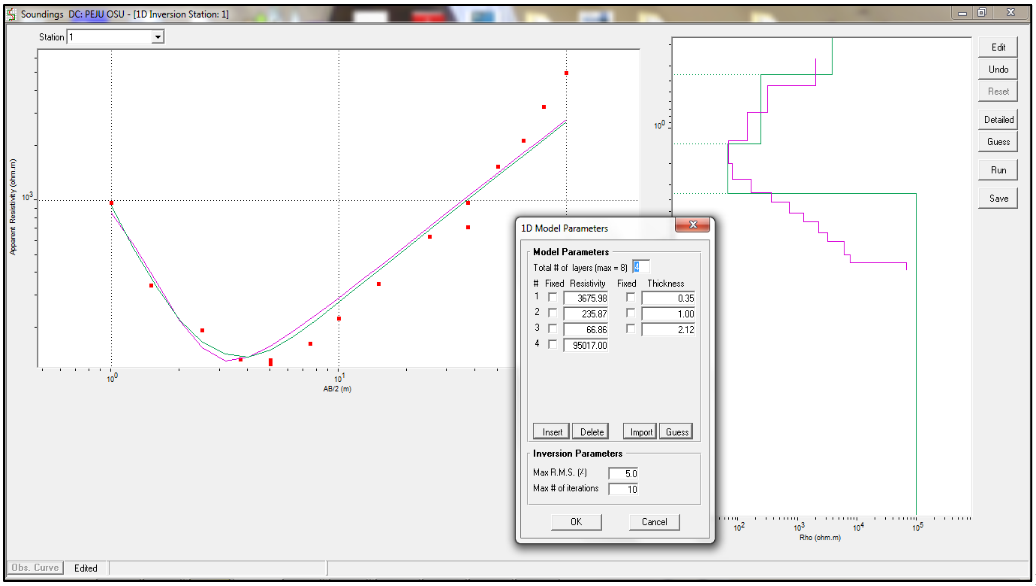

Figure 5: Typified QH- Curve in the study

1.3
HK- type curve

The HK - curve types account for 12.5% are four layer sounding curves constituting 12.5% of the total VES curves. The VES curve morphology (figure 6) is such that $\rho_1 > \rho_2 < \rho_3 > \rho_4$. From the 1D inversion, the second layer has the least resistivity value. This layer is delineated only about 0.55m away from the surface and the layer thickness is just about 0.43m with apparent resistivity value of 27Ωm. Thus, the low apparent resistivity value mapped is only a result of change in the topsoil composition from a sandy clay formation to clay. The third and fourth geoelectrical sequence is characterized by a very high resistivity value 14877 and 2084Ωm. groundwater exploration at this VES point is likely to be abortive with no yield.

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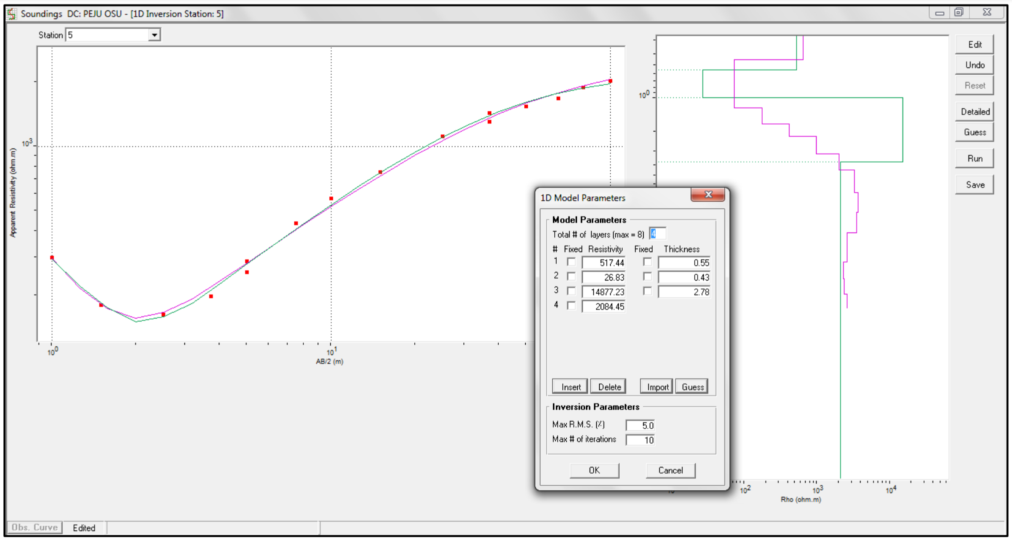

Figure 6: Typified HK- Curve in the study

1.4 A-type curve

The A-type curve also constitutes 12.5% of the total VES curves. The A-type curve is a three layer geoelectrical sequence with curve morphology (figure 7) such that $\rho_1 < \rho_2 < \rho_3$. The curve is characterized by a top layer underlain by higher resistive formation. The apparent resistivity value ranges from 171 – 1450Ωm with a total thickness of about 19m being investigated. The 1D inversion model is such that gives no indication of groundwater occurrence thus hand dug well or bore hole sited in this location is likely to be abortive with no yield.

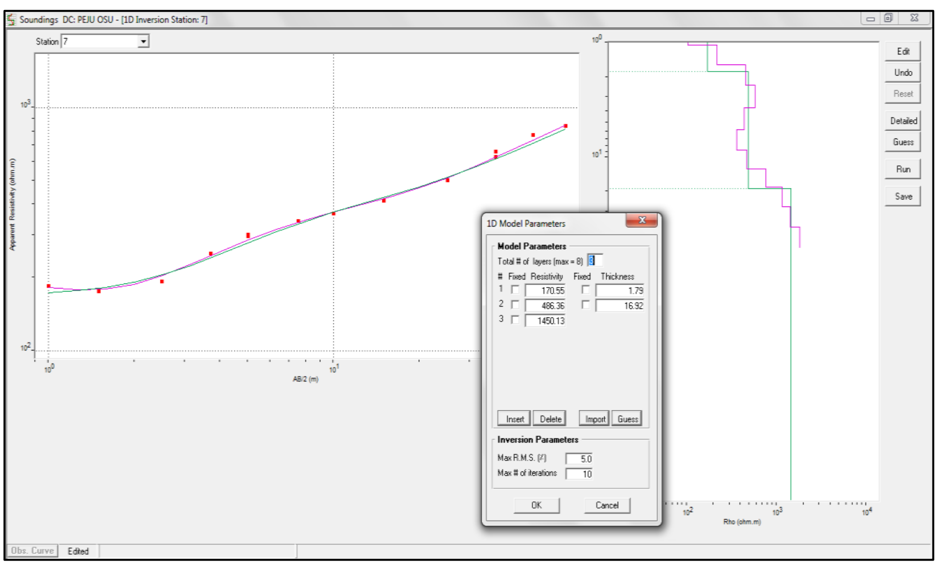

Figure 7: Typified A- Curve in the study

1.5 H-type curve

The H-type curve also constitutes 12.5% of the total VES curves. The H-type curve is a three layer geoelectrical sequence with curve morphology (figure 8) such that $\rho_1 > \rho_2 < \rho_3$. The curve is

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characterized by a top layer underlain by low resistive formation (69Ωm) and subsequently a higher apparent resistive formation (5100Ωm). The total depth delineated is only about 2.9m while the infinite layer is mapped as the fresh basement rock. The 1D inversion model is such that gives no indication of groundwater occurrence thus hand dug well or bore hole sited in this location is likely to be abortive with no yield.

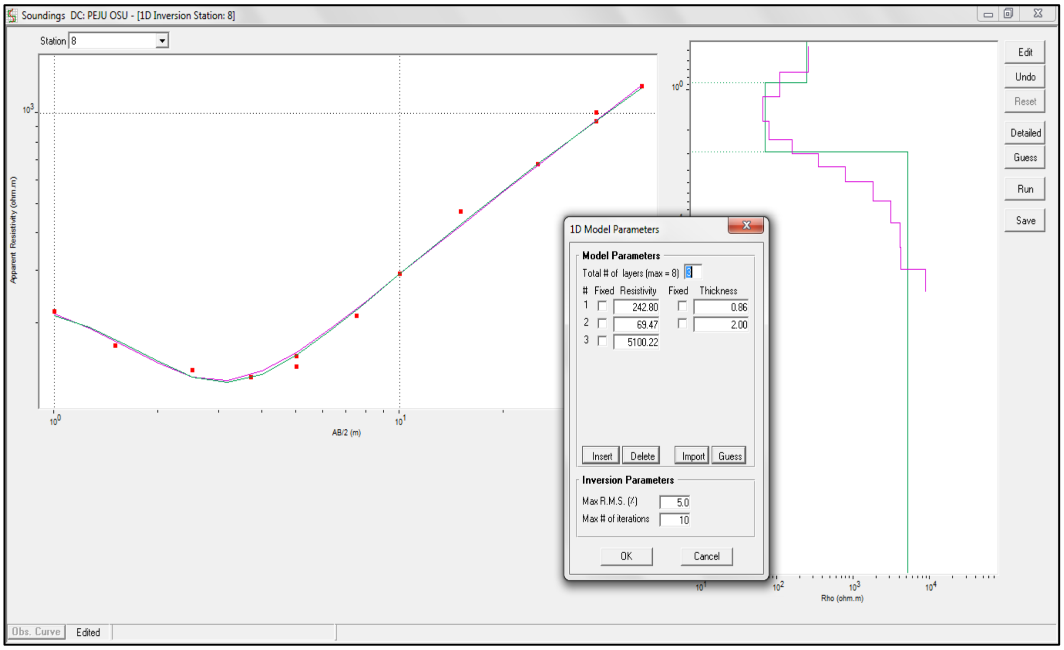

Figure 8: Typified H- Curve in the study

From the quantitative and qualitative interpretation of all VES curves, a maximum of five (4) distinct layers were identified. These layers are saturated with water at some point in in few locations as indicated by their resistivity values.

CONCLUSION

The results from their interpretation shows that VES 2,3,4 and 6 which has an ha-curve accounts for about 50% of the entire curve and it consists of a topsoil of thickness 0.63m-1.92m.For VES 1,the a resistivity of 112Ωm was recorded which is not an indication of the availability of groundwater. The VES 3 curve morphology indicate an apparent resistivity of 95Ωm which extends to a depth of about 6.5m.This indicate that borehole or hand dug well is likely to yield. VES 4 and 6 is characterized by apparent resistivity of 77Ωm and 605 Ωm respectively. From these results, it is apparent to say that hand dug well in this location will be of no yield. VES 7 is characterized by apparent resistivity o from 171Ωm -145Ωm with total thickness of 19m .The model shows no indication of groundwater occurrence. VES 8 constitutes about 12.5% of the total curve with total curve depth of 2.9m and apparent resistivity of 5100m.This does not indicate availability of groundwater.

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