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Geo-electrical investigation of ground water potential using vertical electrical sounding

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Abstract

Groundwater potential assessment using the vertical electrical sounding (VES) technique was carried out at Ekiti state Southwestern, Nigeria with a view to solving the problem of incessant failure of groundwater boreholes in the study area. A total of 10 VES were carried-out using Schlumberger electrode configuration. The data was interpreted quantitatively using the partial curve matching and computer iteration techniques to generate the first order geoelectric parameters. The borehole lithological log was used to constrain the conventional VES interpretation. The VES results aided by the borehole lithological log reveal four distinct subsurface geologic layers which correspond to Top soil, Lateritic clayey sand, Sand, Sandstone and Consolidated sandstone. The analysis shows that sands at the upper layer within the depth of 2.3 - 76.2 m are unsaturated while sands at depth not less than 100 m in some sampling points are saturated and denote the aquifer units in the study area. Boreholes/deep wells could be cited at these points at depth interval 80 - 100 m. This study has provided an insight to the subsurface condition of the aquifer systems and delineated areas for probable groundwater development in Ekiti State.

Keywords: Groundwater; Vertical Electrical Sounding; Geoelectric Parameters; Schlumberger electrode configuration; Aquifer systems

1. Introduction

Groundwater is of major importance to civilization because it is the largest reserve of drinkable water in the regions where humans live. Groundwater may appear at the surface in the form of springs, or it may be tapped by wells/boreholes [1]. Therefore, to have a sustainable groundwater development for our needs, the study of groundwater potentials becomes very important.

The true riches of any country depend on its ability to provide for its dwellers. Potable water is one of the major resources that a citizen of any nation can benefit from, if well harnessed [2].

Groundwater and other mineral resources such as hydrocarbons and solid minerals are of great abundance in Nigeria. The true riches of any country depend on its ability to provide for its dwellers. Potable water is one of the major resources that a citizen of any nation can benefit from [2]. This is so because water is a free course of nature. It is a gift of God to mankind. This wonderful resources have transcends so many generation because of its value to human life. Water is one of the major determinants of economic development. Water has found its usefulness in every human endeavour such as manufacturing industry, agricultural industry, transportation industry, construction industry, home usage and so on. Because of the importance of this resources new technology have been developed in search of this resources. Water search has extended from surface to ground exploration. There are parameters that characterized

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groundwater such as conductivity, porosity, permeability and transmissivity. All these parameters are determined using any geophysical methods such as magnetic methods, gravity methods etc.

Geoelectrical resistivity surveys are often used to search for groundwater in both porous and fissured media. Clean sands and gravels which have porosities always make good aquifers when saturated with fresh water which can easily be differentiated from lower- resistivity impermeable clays and marls and also from bedrock which is mainly of much higher resistivity [3]. Areas where the groundwater is significantly saline, the aquifers resistivity is reduced greatly and resistivity surveying can delineate the boundaries of the body of saline water [3] (Sharma, 1997).

Geoelectrical resistivity method has developed greatly and has become an important instrument in hydrological studies, mineral prospecting and mining as well as in environmental and engineering applications. [4, 5, 6].

Measurements for resistivity surveys are made by the streaming current into the ground through two electrodes type (potential electrode and current electrode), and measuring the resulting voltage difference across two potential electrodes. In its most basic form, the resistivity meter has a current source and voltage measurement circuit connected by cable to a minimum of four electrodes. The basic data obtained from the resistivity survey is the position of the current and potential electrode, current (I) injected into the ground and the resulting voltage difference (ΔV) between the potential electrode.

Current and voltage measurements are then converted into a type resistance (ρa) of clear values using the following formula

$$Pa= k\frac{\Delta v}{I} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where k is a geometric factor that depends on the configuration of current and potential electrodes [7].

In this research work, electrical resistivity method was employed for groundwater exploration according to [1].

2. Material and methods

Materials used on site include: Resistivity meter Model NO 252, Profiling rods, 2kg Sledge hammer, Current and Potential Electrodes, center Electrode, Measuring tape, Calculator, Data acquisition sheet, pen.

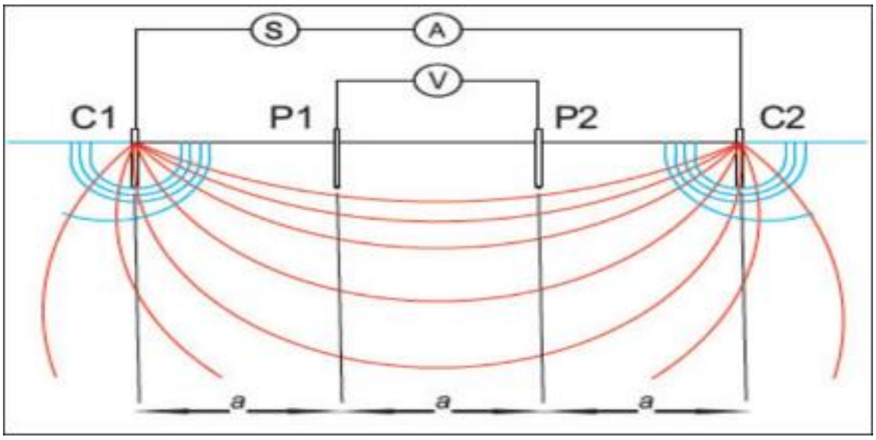

Figure 1 Field Electrode Layout for Schlumberger Array

Profiling of each area was done by the use of a specially made brass rod called Profiling rod or profiling string and also known as Bungi, this particular brass made material helps in locating a fractured patterns of the subsurface rocks. It was said to have a swinging effect to some secondary rocks which are believed to have intruded into the primary rock (The Basement Complex). This particular material swings when it gets to fractured zones. 2 points were located in the site.

The Schlumbeger and Wenner depth sounding are used to investigate the change of resistivity with depth [8, 9]. The measured unit is the apparent resistivity, ρa, which is the product of a geometrical factor, K, and the quotient of the measured potential, ΔU, and the source current, I. The apparent resistivity is plotted versus AB/2 or AB/3 in meters on bilogarithmic paper resulting in a VES curve. The VES curve showed the change of resistivity with depth, since the effective penetration increases with increasing electrode spacing. The interpretation of the VES curve is both qualitative and quantitative.

The qualitative interpretation involved visual inspection of the sounding curves while the quantitative interpretation utilized partial curve matching technique using 2-layer master curve which was later refined by a computer iteration technique Resist version [10] that is based upon an algorithm of [11]. This was done with the aid of application called WinResist which was installed into a Computer. The application gave the curve with iteration and there were overburden predictions for the points that were located. The curves were used to predict the expected yield at the site. The report was written and best point and depth of drilling with expected yield was included in the report as recommendation.

3. Results

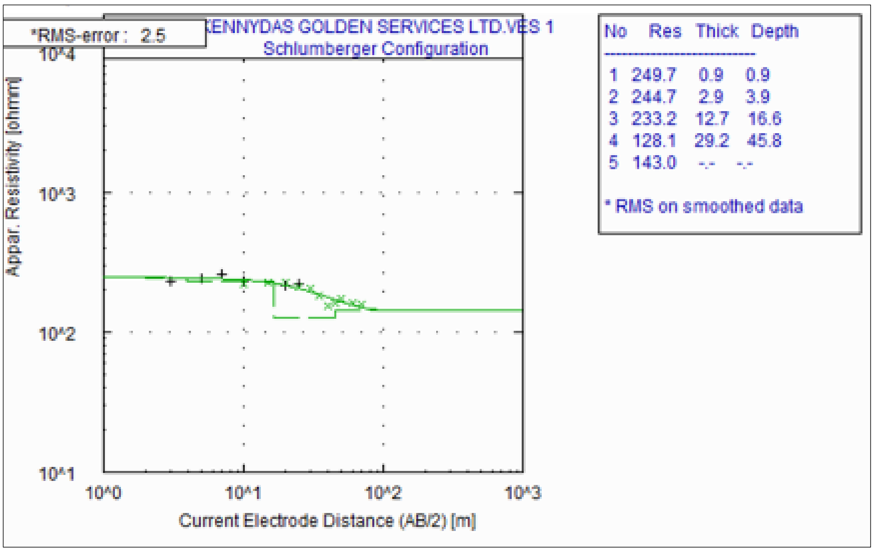

Figure 2 Interpretation of VES 1 data at Kennydas Golden Services Ltd. Site, Ado Ekiti, Ekiti State

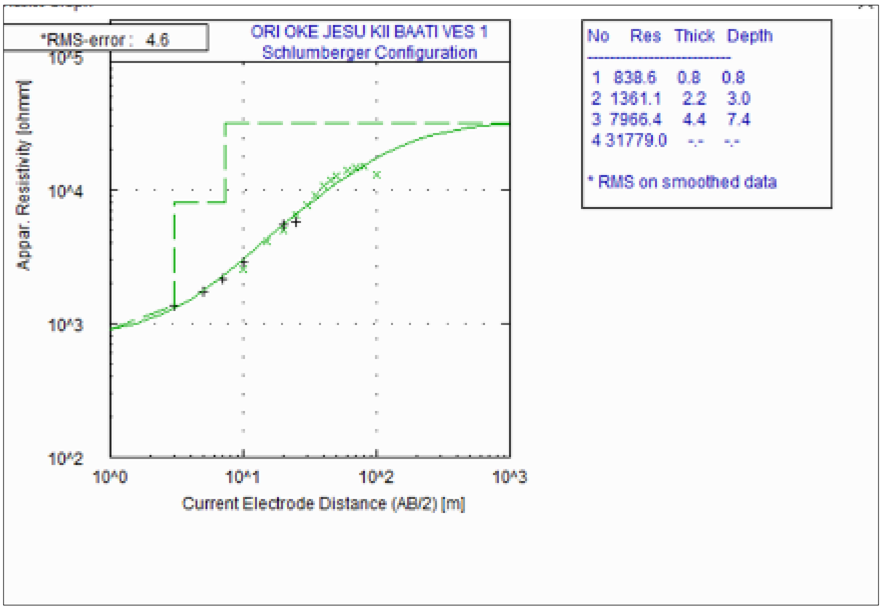

Figure 3 Interpretation of VES 1 data at Ori Oke Jesu Kii Baati, Aramoko Ekiti, Ekiti state

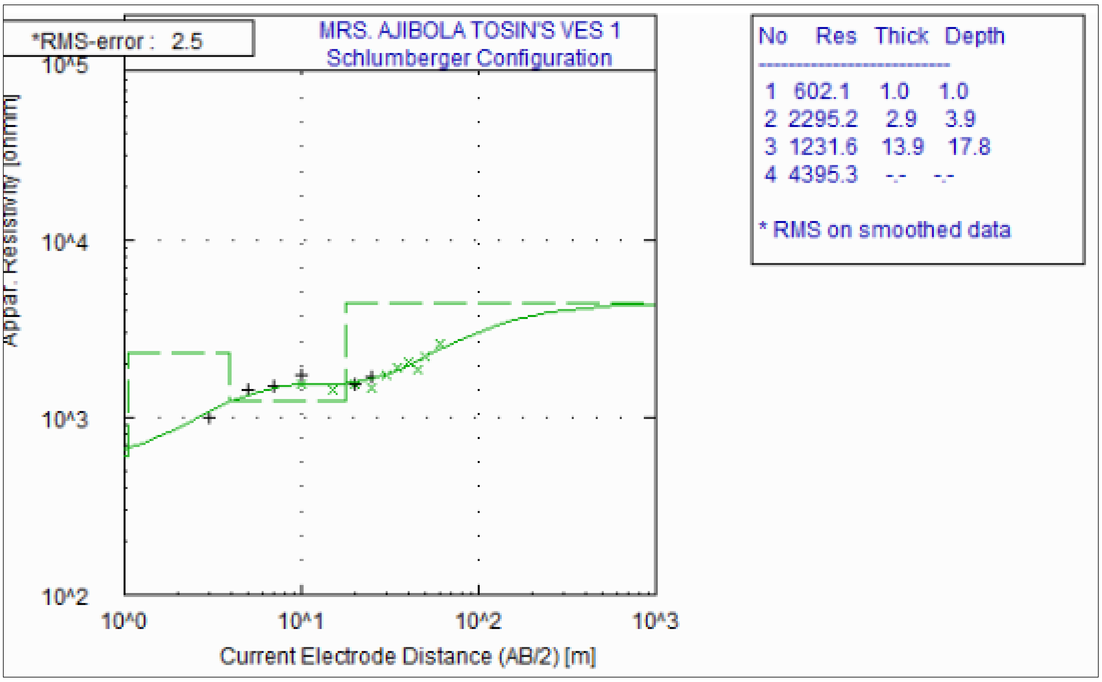

Figure 4 Interpretation of VES data at Mrs. Ajibola Tosin's site, Iyin Ekiti, Ekiti State

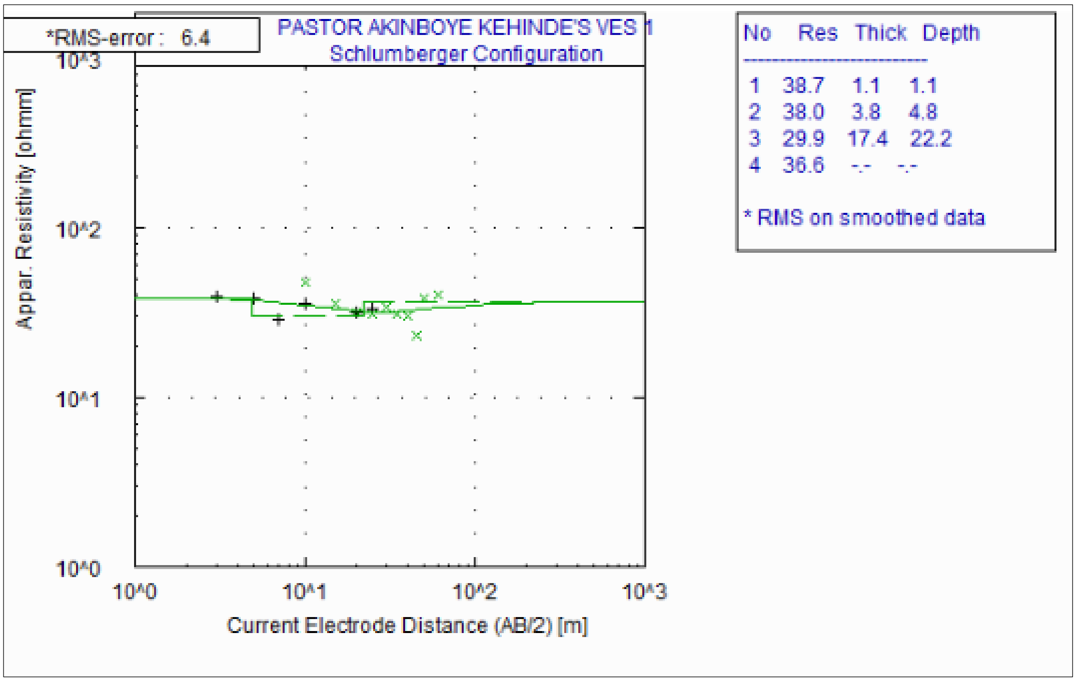

Figure 5 Interpretation Of VES 1 Data at Pastor Akinboye Kehinde's House, Ado Ekiti, Ekiti State

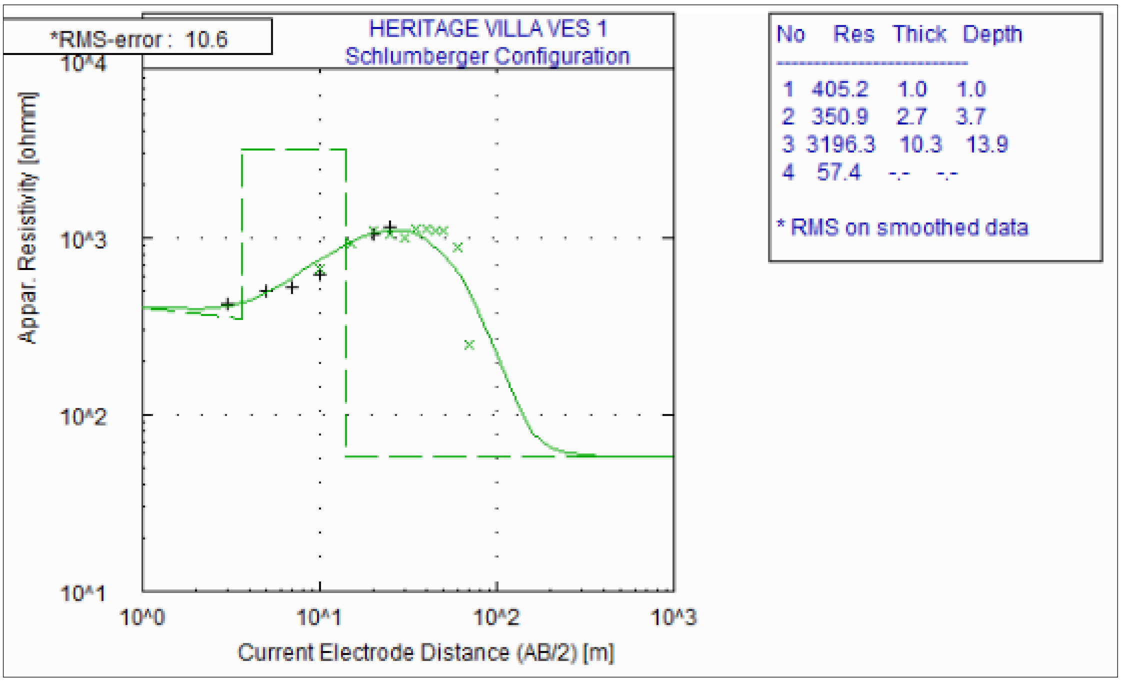

Figure 6 Interpretation of VES 1 Data at Heritage Villa, Igede Ekiti, Ekiti State

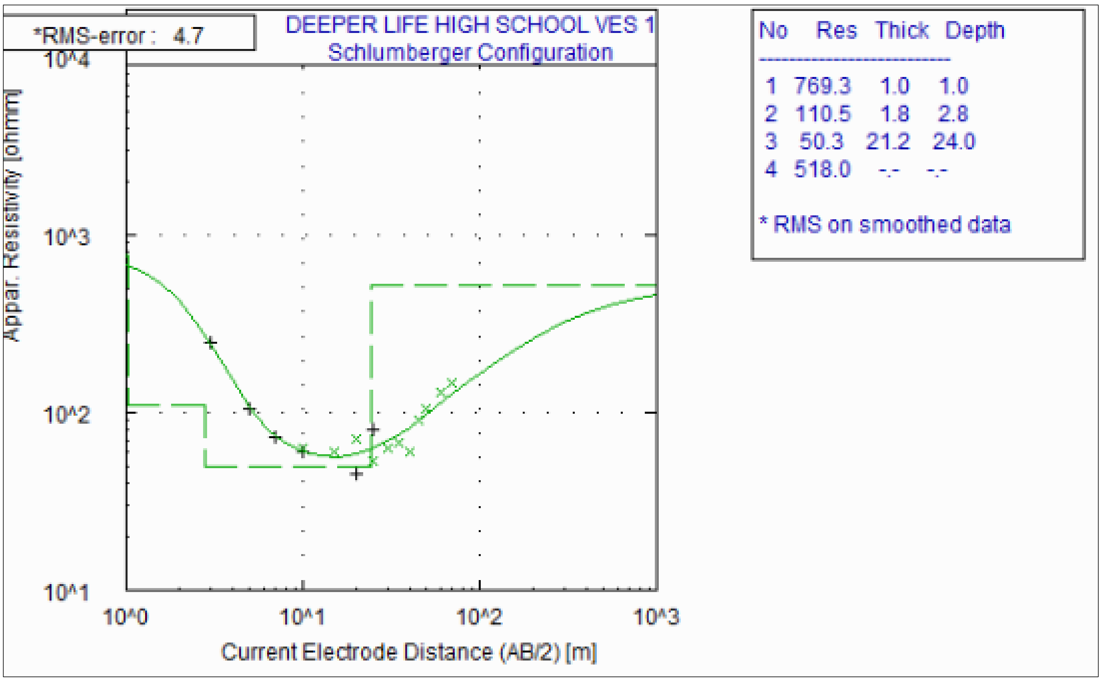

Figure 7 Interpretation of VES 1 Data at Deeper Life High School, Ado Ekiti, Ekiti State

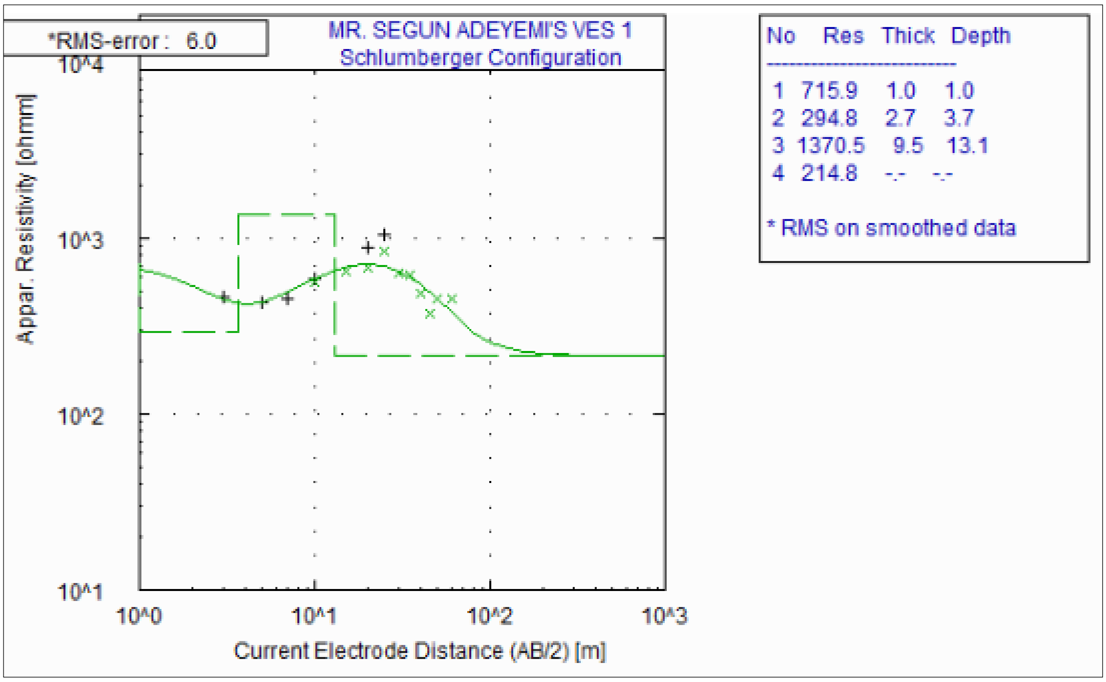

Figure 8 Interpretation of VES 1 data at Mr. Segun Adeyemi's Iyin Ekiti, Ekiti State

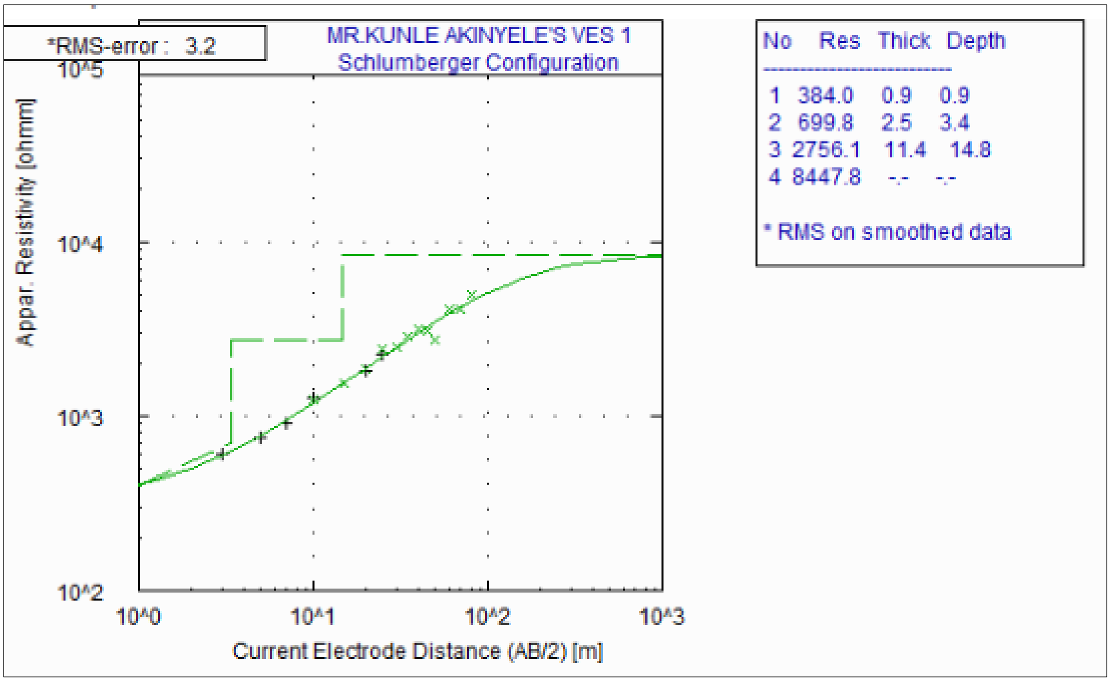

Figure 9 Interpretation of VES 1 data at Mr. Kunle Akinyele's, Efon Alaaye, Ekiti State

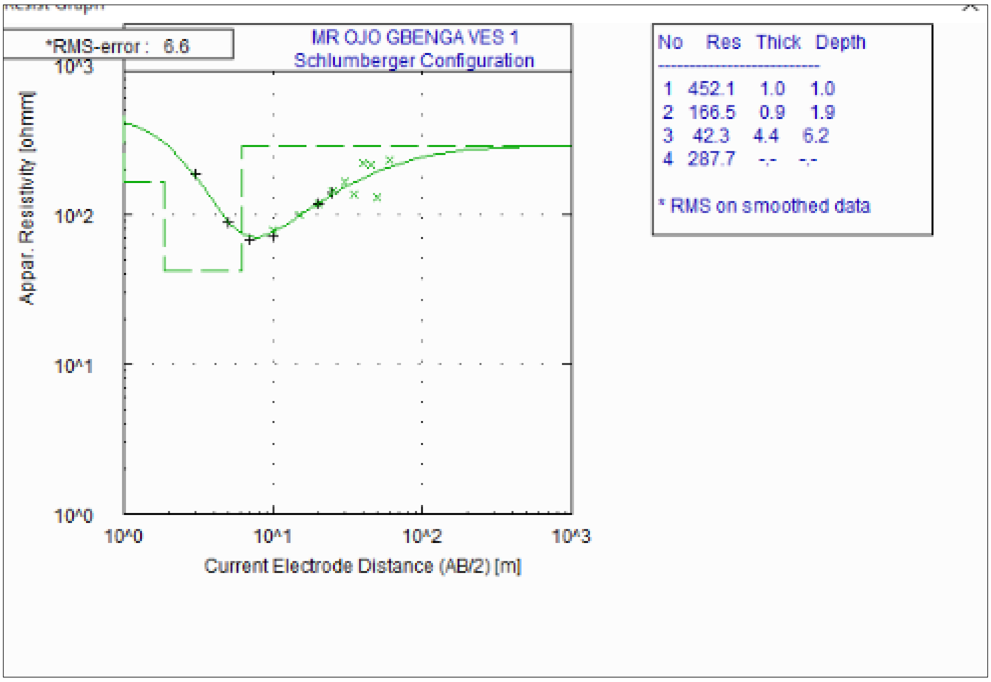

Figure 10 Interpretation of VES 1 Data at Mr. Ojo Gbenga's Site, Ado Ekiti, Ekiti state

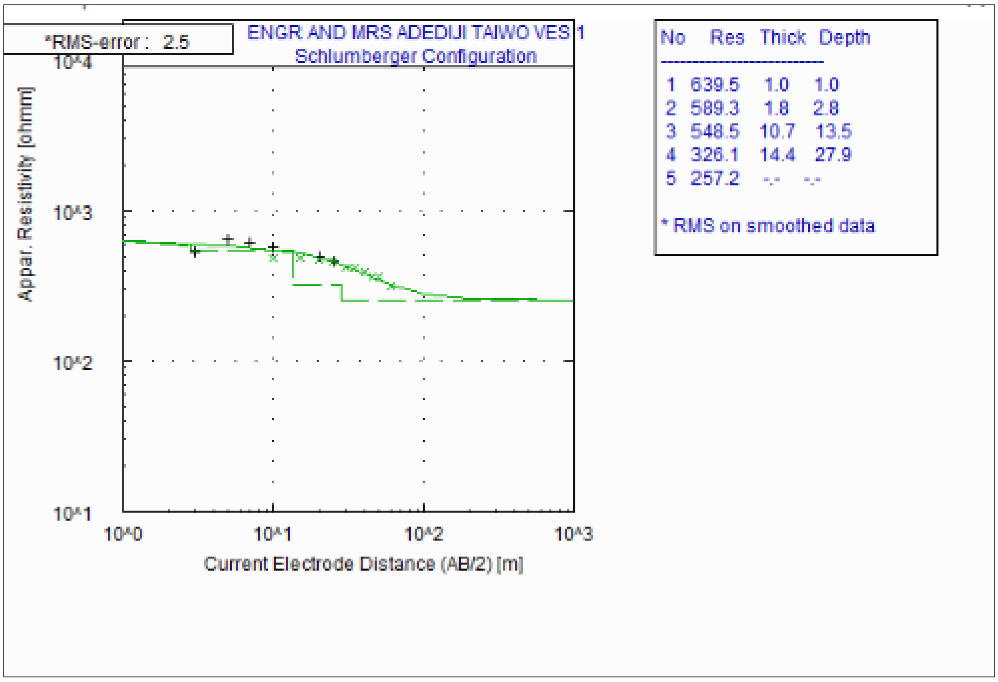

Figure 11 Interpretation of VES 1 Data at Engr. and Mrs. Adediji Taiwo's site, Ikere Ekiti, Ekiti State

4. Discussion

The apparent resistivity data obtained were plotted on a bi-logarithmic graph paper (FIG 1 - 10). The curves thus generated were interpreted using curve matching and computer iteration techniques.

Four main geoelectric layers were identified within the site. The first geo-electric layer is the topsoil. The thickness of this layer is about 0.8 meter. The second layer is the clay insitu. The thickness of the layer is about 2.3 meters. Weathered rock is the third geoelectric layer. The thickness of the layer is about 6.5 meters. The fresh basement is the last geoelectric layer the thickness is infinite.

5. Conclusion

Based on the field observation and the acquired interpreted data, borehole drilling within the sites explored is slightly feasible at VES 2 position, but the yield is expected to be low. A Total depth of 80 - 100 meters is hereby advised for drilling. The driller can terminate the hole on or before the depth depending on the site situation. Appropriate length of factory slotted screen is to be installed at the strategic position as the drilling log will indicate. The drillers are advised to case the hole with 152.4 mm diameter casings and screen. Proper gravel packing of the hole is highly required and cement grouting should be done. The drillers are advised to carefully screen the overburden as the average of the groundwater expected in the area is from the weathered and fractured basement. The hole should be flushed with compressed air till hole is clean and sand free.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors have no conflict of interest.

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