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Geo-Electrical Investigation for Groundwater Exploration within the Federal Polytechnic Ado-Ekiti Continuing Education Center, Southwestern, Nigeria

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ABSTRACT

A detailed geoelectrical resistivity survey involving Vertical Electrical Sounding (VES) was carried out for groundwater exploration at the Continuing Education Centre of the Federal Polytechnic Ado-Ekiti, Nigeria. This was in view of the possibility that more entrepreneurship and skill acquisition centers could be sited within the study center of the school and the need to secure the place from acute water shortage for students, researchers and entrepreneurship instructors. The area lies within the crystalline basement complex of South-western Nigeria and bounded by Latitude 5.17°N-5.25°N and Longitude 7.58°E-7.67°E. The survey was carried out using PELI 1300 portable terameter while a total of 10 (Ten) VES with 10 m station interval in three even profiles were completed. Global Positioning System (GPS) equipment was used to locate the stations on the ground. The result of the interpretations revealed the presence of four geo-electric layers in the study area. The top lateritic soil has resistivity values ranging between 54.9 Ωm to 82.6 Ωm and thickness of 0.3 m to 1.89 m, the sandy clayey has a resistivity ranging between 9.44 Ωm to 9.48 Ωm with thickness of 0.133 m to 7.74 m, the weathered basement has a resistivity value ranging from 14.6 Ωm to 834 Ωm with thickness of 0.56 m to 15.1 m, while the fractured basement has resistivities greater than 900 Ωm. The analysis of the resistivity and the thickness map revealed that the main aquifer unit in the area was the weathered and highly fractured layers which were prominent among VES 2, VES 4, VES 5 and VES 10 with low resistivities which may be recommended and suitable for a highly proficient target for groundwater prospecting.

Keywords: Geo-electrical, Groundwater, Exploration, Ado-Ekiti, Terameter, Vertical electrical sounding.

INTRODUCTION

The shortage of water supply is a very common problem in most localities in Ado-Ekiti, especially where the study area is located. The area of study, continuing education center, popularly refers to as the satellite campus of the Federal Polytechnic Ado-Ekiti is one of the fastest-growing distant learning/Part-time campuses in Ekiti State. This is due to its strategic location which is about the midpoint between the southern and central parts of the state. It is located along Ilawe-Ekiti/NTA road where numerous allied companies, schools, quarries, and other government-owned agencies and parastatals are located. Hence, the demand for reliable and consistent water supply was high around the area. In view of this, there is a need to adequately protect the place from acute water shortage for the convenience of students, researchers, and other neighboring communities. Consequently, a vision for an independent source of water would be imperative. In line with this goal, a study of groundwater was conducted in the area of study.

Previous studies have shown that groundwater could be evaluated using an Electrical Resistivity Survey (ERS) [1-4]. ERS was found more diversified, popular, and cheaper and had the widest adoption for groundwater survey than any other geophysical method due to its simplicity and relatively high diagnostic value [6-10]. Previous work had been done around the area while utilizing the electrical resistivity technique. Oyedele and Olayinka [11] performed a statistical evaluation of groundwater potential in Ado -Ekiti and upheld that the observed trend was supportive for large scale groundwater development in the area while [12] conducted fifty-one (51) vertical electrical sounding surveys for groundwater potential and aquifer protective capacity of the overburden units of the same area with great success.

The electrical resistivity varies between different geological materials, depending mainly on variations in water contents and dissolved ions in water. Resistivity investigations can thus be used to identify zones with different physical properties that can be related to variations in geological conditions [12].

The resistivity method employed in this research is designed to yield information on formations or bodies having anomalous electric conductivity and it has been used for a long time to map boundaries between layers having different conductivities [13]. It is also employed in engineering geophysics to map bedrock, for determining the homogeneity of the terrain and possible sinkholes (faults), in groundwater studies to determine salinity and the depth to the water table [9].

LOCATION AND GEOLOGY OF THE STUDY AREA

The Continuing Education Center of Federal Polytechnic Ado-Ekiti, Nigeria is located about 1.0 km South-East of Ado-Ekiti township along Ilawe-Ekiti/ NTA road and bounded by the geographic latitude of 5°.17'N-5°.25' N and longitude 7°.58'E-7°.67'E (Figure 1). The study area is underlain by precambrian basement complex rocks of southwestern Nigeria with local geology predominantly granite-gneiss and migmatite [12-18]. The major rock units distinguished are the undifferentiated migmatite-gnesis-quartzite complex, charnokitte, older granite and unmetamorphosed dolerite dykes believed to be the youngest [16]. These rocks are inherently characterized by low porosity and near negligible permeability. The highest groundwater yield in basement terrains is found in areas where thick overburden overlies fractured zones [12]. These zones are often characterized by relatively low resistivity values [1].

Climate and topography

The area is situated within the tropical rain forest region, with a prevailing climatic of dry and wet seasons. The area is known for its constantly high annual temperatures and heavy rainfall from April to October. The dry months of November to March usually receive very low rainfall. The average annual rainfall in this area was 1300 mm, with average wet days of about 100. The annual temperature varies between 18°C to 34°C. The terrain in the study area is gently undulating, with topographic elevation ranging between 350 m and 370 m above sea level. The soil type consisted of gravel, lateritic soil, alluvial soil, clay, sandy clay, and top-soil and low- lying outcrops at the lowland area, with a few inselbergs at the outskirt [16].

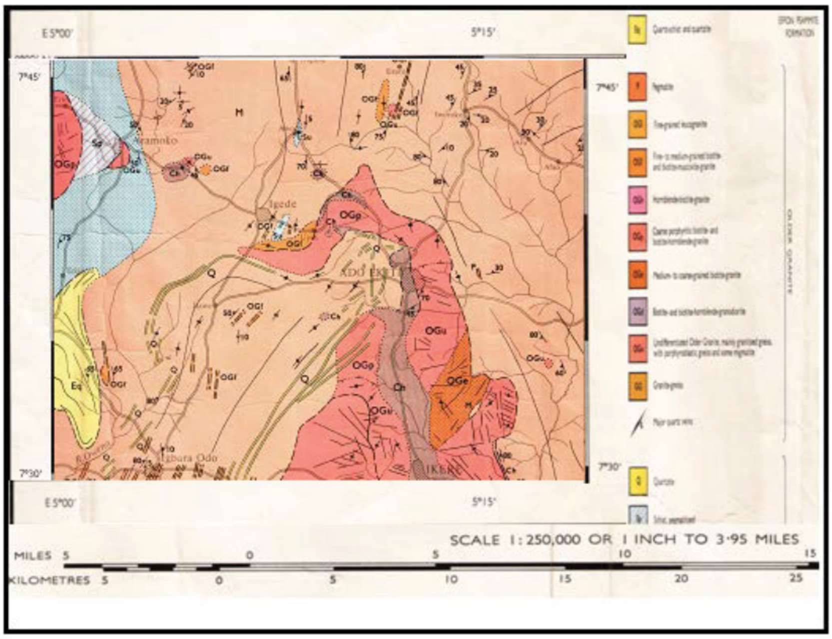

Figure 1. Geological map of Ado-Ekiti Township (After [13,16])

Drainage and vegetation

The area is drained by numerous streams and rivulet such as Ireje, Elemi, Omisanjana, and Awedele Streams. They flow into River Ose and River Owena which in turn empty into the Atlantic Ocean [18]. The area is an equatorial climate and vegetation with story layer arrangements of trees such as Mahogany, iroko, and obeche.

MATERIALS AND METHOD

In this study, a total of Ten (10) VES stations and data were carried out and acquired using the Schlumberger Array with maximum current electrode separation of 100 m around the study area. VES using Schlumberger array was adopted to study the variations in the resistivity distribution of the study area with respect to change in depth. The instrument used for the field resistance measurement is the low-frequency PELI 1300 portable terameter. Other accessories used with the terameter includes the booster, four metal electrodes, cables for current and potential electrodes, harmers, measuring tapes, datasheet, walking talking and phones for very long spread. In this technique, vertical variations in the ground apparent resistivity were measured with respect to a fixed potential center electrode array by gradually expanding and increasing the current electrode spacing with the aim of probing the subsurface at greater depth [13,16]. The wider the current electrode were separated from each other the deeper the penetration of depth of investigation [6]. When the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large, the potential electrodes must also be displaced outwards otherwise the potential difference becomes too small to be measured with sufficient accuracy.

The current and potential electrode measurements of positions are marked such as $\frac{AB}{2}$ and $\frac{MN}{2}$ respectively. Where $\frac{AB}{2}$ = Current electrode spacing and $\frac{MN}{2}$ = Potential electrode spacing.

The resistivities of the different layers were measured using the terameter which is capable of sending current into the earth subsurface through a pair of conducting electrodes, automatically compute and display the apparent resistivity of the subsurface structure under investigation [17].

$$R = \frac{\rho I}{2\pi . I}\left\{\frac{2a}{s^2 - \frac{a^2}{4}}\right\} \tag{1}$$

$$\rho = R.\pi\left\{\frac{s^2 - \frac{a^2}{4}}{a}\right\} \tag{2}$$

Where S is the distance between the current electrodes (m)

a is the distance between the potential electrodes (m)

ρ is the layer resistivity

I is the current (Amp)

The apparent resistivity value is the product of the geometric factor and the resistance recorded in the resistivity meter. The geometric factor, G, for Schlumberger configuration was used.

$$G = \pi\left\{\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{2\left(\frac{MN}{2}\right)}\right\} \tag{3}$$

Where

G=Geometric Factor

AB is the current electrode distance

MN is a potential electrode distance

It is therefore expected that the result obtained from this work will produce a detail groundwater condition and recommend area within the campus were deep tube well could be located.

RESULTS AND DISCUSSION

The apparent resistivities obtained at the VES stations were plotted on a log-log graph sheet against their corresponding half current electrode spacing $\frac{AB}{2}$ and interpreted using the computer iteration technique which produced series and variety of curves as shown in Figures 2-6.

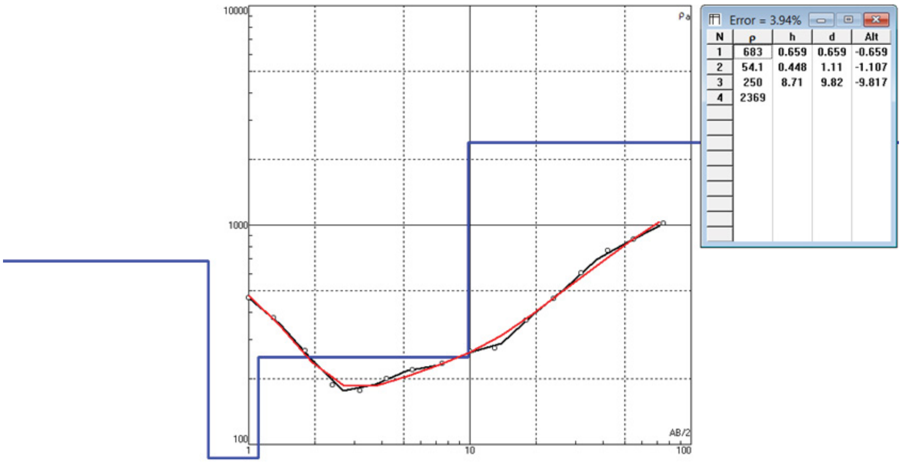

Figure 2. Resistivity plot for VES 1

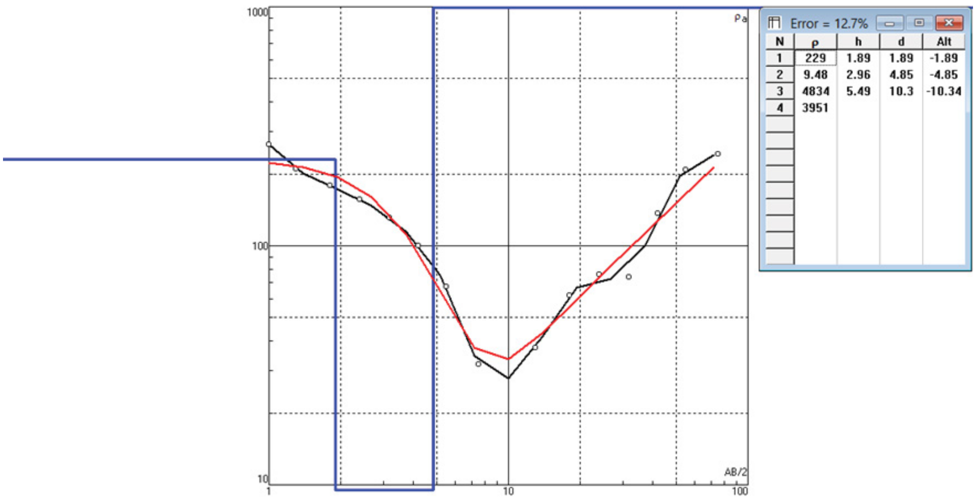

Figure 3. Resistivity plot for VES 2

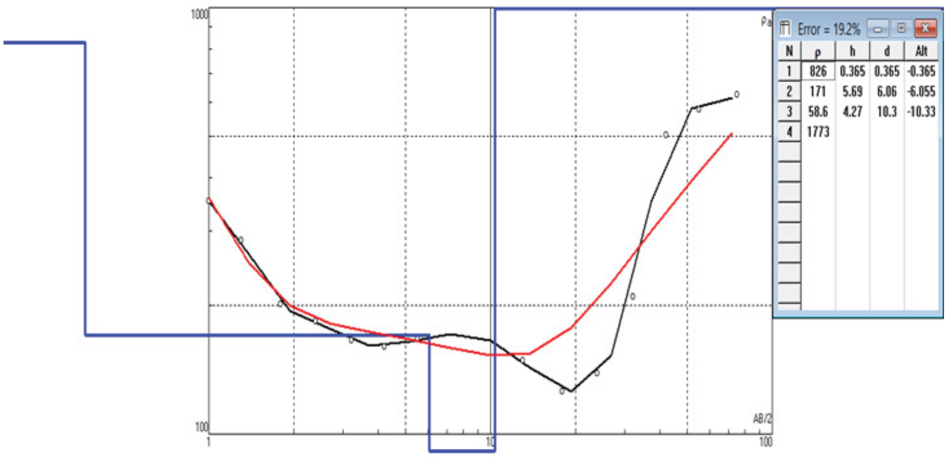

Figure 4. Resistivity plot for VES 3

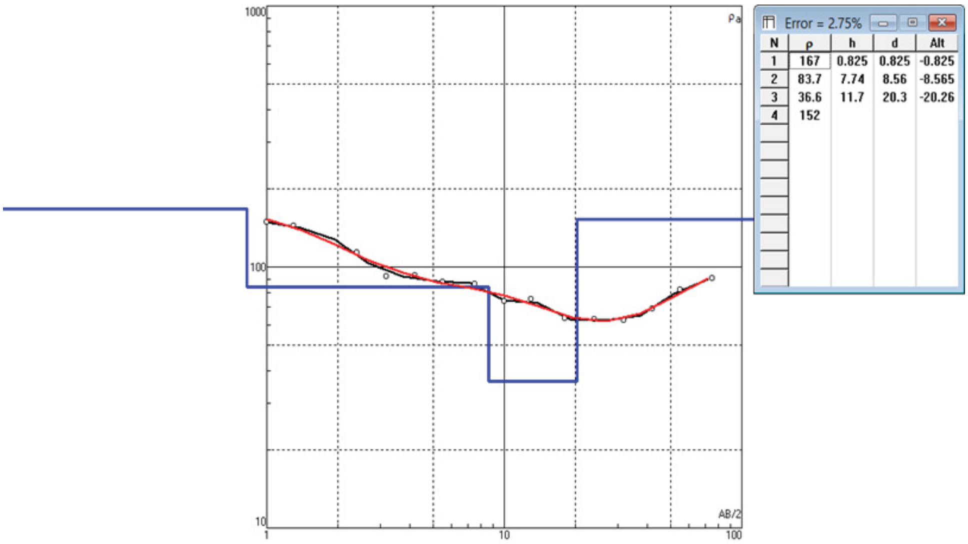

Figure 5. Resistivity plot for VES 4

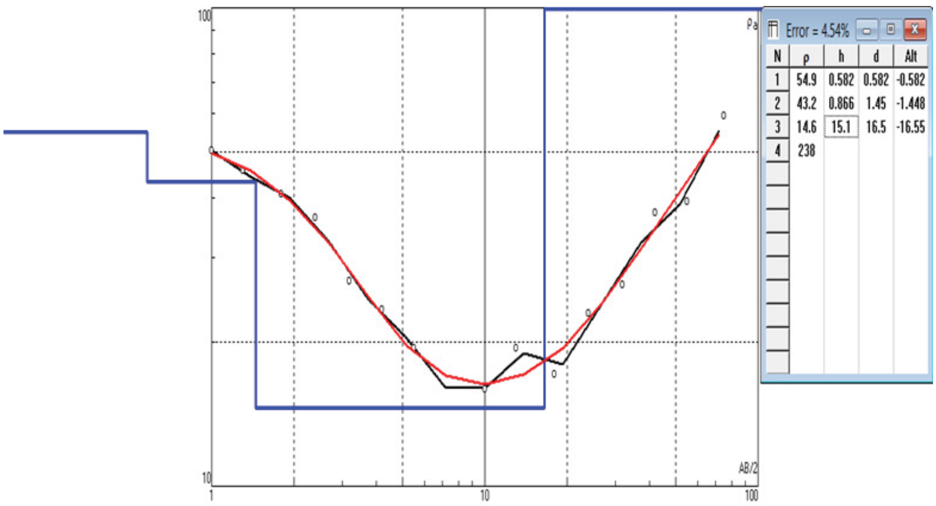

Figure 6. Resistivity plot for VES 5

In order to view the resistivity distribution of the whole surveyed area, the result of the soundings data was linearly and vertically interpolated into two-dimensional pseudo-section data plotting for the three profiles (Figures 7-9). The purpose of selecting multiple layers was to distinguish the different lithological units and to convert the resistivity values to a reasonable geological picture.

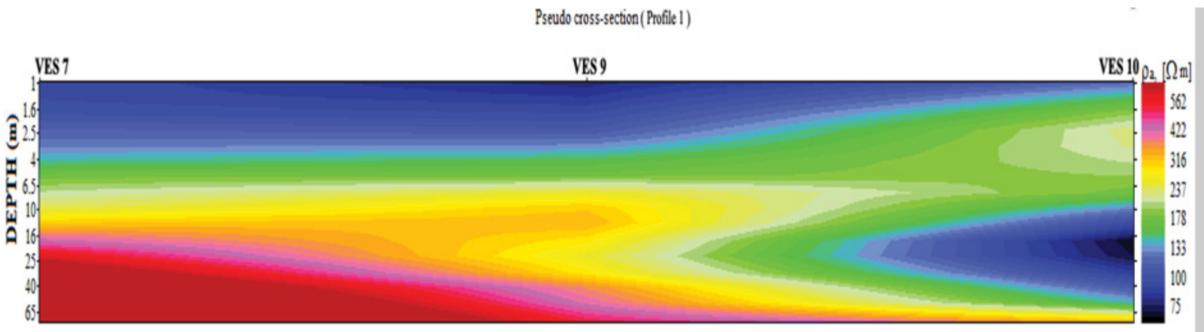

Figure 7. Pseudo-section resistivity contour map for profile 1

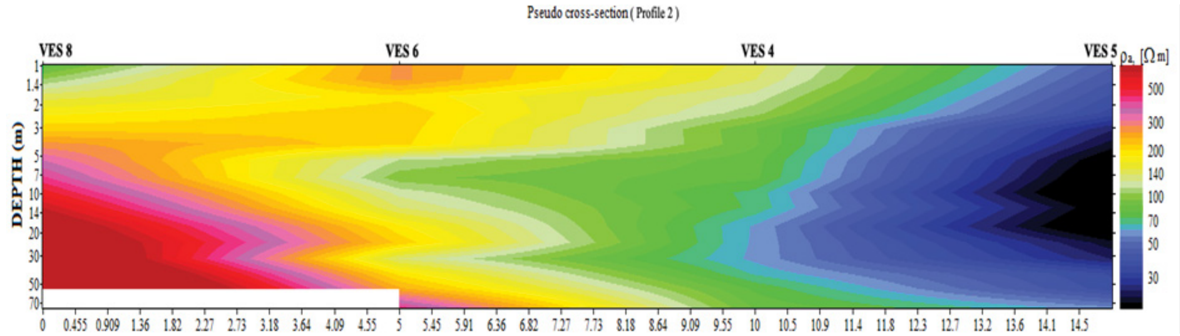

Figure 8. Pseudo-section resistivity contour map for profile 2

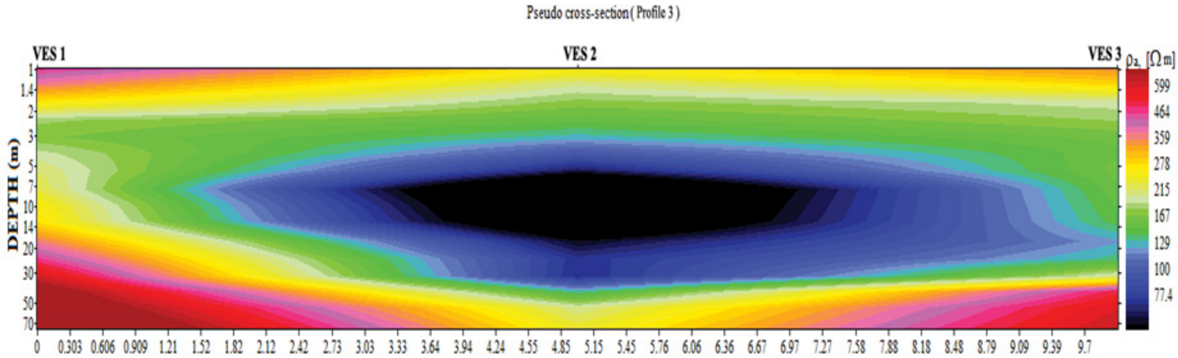

Figure 9. Pseudo-section resistivity contour map for profile 3

The interpretation of the field resistivity data obtained revealed that the study area was characterized by four (4) geo-electric layers which comprises of top lateritic soil with resistivity values ranging between 54.9 Ωm to 82.6 Ωm and thickness of 0.3 m to 1.89 m the sandy clayey had a resistivity ranging between 9.44 Ωm to 9.48 Ωm with thickness of 0.133 m to 7.74 m the weathered basement had a resistivity value ranging from 14.6 Ωm to 83.4 Ωm with thickness of 0.56 m to 15.1 m while the fractured basement had resistivities greater than 900 Ωm.

The layer type of the four subsurface geo-electric layers was based on examination of the lithological unit derived from the hand-dug well, that were drilled at the study area at the time of the survey. Although there are limited electrical resistivity studies around the study area, these results were observed to be in agreement with the earlier findings obtained from studies around the Ado-Ekiti environs [12,16]. The previous studies confirmed that the structural characteristic of the area varied between three to five geo-electric layers.

Considering the classification of the layers in this work, the resistivity distribution of the subsurface layer was not uniform. The resistivity values distributions of the study area generally varied from 51.1 Ωm to 62 Ωm (Figures 2-6). The figure showed that the apparent resistivity distribution values increased from the SW to the northern part of the study area. The rock texture in the study area was considered to be very dry and hard which was probably due to the high exposure to heat and sun. Figures 6-9 was produced to view the resistivity distribution value of the aquifer area and weathered basement which varied from stations to stations at different depths with the aim of delineating any fault as a result of structure located within the basement of the area. The resistivity variation for VES 7 and 9 (profile one) showed that the high resistivity dominated the area at a depth above 10 m. The lower resistivity distribution was obtained in VES 10 at the same depth range. However, the lower resistivity distribution at the upper layer may likely be due to the accumulation of surface water. Consequently, VES 6 and 8 and 4 and 5 from profile 2 showed that there were high and low resistivity variations respectively in those stations. Figure 9 revealed that there was a level of consistency in the high resistivity distributions for the first and last VES 1 and 3, stations for the profile 3 [12] had earlier described aquifer thickness as the most important condition to be considered for sitting a borehole [4] also affirmed that the deeper the aquifer thickness, the larger the amount of water it can hold. In view of this, the most favorable recommended target stations suitable for sitting a groundwater prospecting in the study area were the VES 2, 5 and 10 stations.

SUMMARY AND CONCLUSION

A total of Ten (10) VES stations involving three profiles were established and used to evaluate the subsurface hydrogeological conditions to a depth of about 100 m. Based on the interpretation of geo-electrical data, the following conclusions were drawn:

- The use of geo-electrical sounding provides an inexpensive method for characterizing and exploration of groundwater of the region

- Interpretation of the VES data indicated the presence four geo-electric layers which include the lateritic region with resistivity ranging from 54.9 Ωm-82.6 Ωm and thickness of 0.3 m-1.89 m which showed that the texture of the rock constituent was hard and dry due to high exposure to intense radiation from the sun, a relatively weak zones with apparent resistivity values ranging from 9.44 Ωm-9.48 Ωm with thickness of 0.133 m-7.74 m, and 14.6 Ωm-83.4 Ωm and thickness 0.56 m-15.1 m for the sandy clayey and weathered basement respectively while the fresh basement was greater than 900 Ωm
- Based on all the findings made in the interpretation of the VES data, VES 2, 4, 5 and 10 were discovered to be the most viable locations for the development of groundwater resources in the study area and
- The study area has a high potential for groundwater development

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