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Integrated Geophysical Investigation and Characterisation of Aquifer Structures in a Complex Environment

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ABSTRACT

An integrated geophysical investigation was executed in Igarra, Nigeria with a view to characterising the possible aquifer structure and units in the area. The Ground Magnetic, Very Low-Frequency Electromagnetic and Electrical Resistivity methods were employed in this study along three traverses with length varying between 180 – 250 m. The presence of a geologic structure which is most probably a fractured zone was established. The aquifer unit in the area was characterised as being susceptible to contamination due to the general thickness of its Overburden cover.

Keywords: Integrated, Characterisation, Geologic, Aquifer structures, Susceptibility.

INTRODUCTION

Geologic discontinuities such as fractures, joints, faults or basement depressions play prominent roles in hydrogeological applications especially in Basement Complex environments because, they usaully act as good groundwater accumulation zones in such environments. The use of groundwater has saved many people from deadly diseases but at the same time brought some new problems [4]. The aquifers in the Basement Complex terrains usually occur at shallow depths, thus exposing the water within to environmental risks [6]. It is therefore important to understand the features of aquifer units in the study environment for possible groundwater abstraction projects. This necessitates the use of integrated geophysical methods – Ground Magnetics (usually employed as a reconnaisance tool in the location of contact zones, and or structural changes in homogenous rocks), Very -Low Frequency Electromagnetic(VLF-EM), and Electrical Resistivity (ER) method for the study. The electromagnetic and electrical resistivity methods have been employed more in groundwater studies usually at depths less than 250 m. because of the wide spread interest in using non-invasive geophysical techniques [3]. The Schlumberger's Vertical Electrical Sounding (VES) technique was however employed as the tool for the ER study.

Theory

The resistivity survey technique involve the passage of current into the ground by means of two electrodes (current electrodes) while he potential difference is measured using a second pair of electrodes (potential electrodes).

The Schlumberger VES configurations (Figure 1) apparent resistivity (ℓ_a) is obtained from the equation

$$\ell_a = \frac{RL^2}{2l}$$

Where:

ℓ_a is the apparent resistivity (ohm-m)

R is the ground resistance (ohm)

L $\left(= AB/_2\right)$ is half the current – current electrode separation (m).

l is half the potential – potential (MN) electrode spacing (m)

π is a constant $\left(22/7\right)$

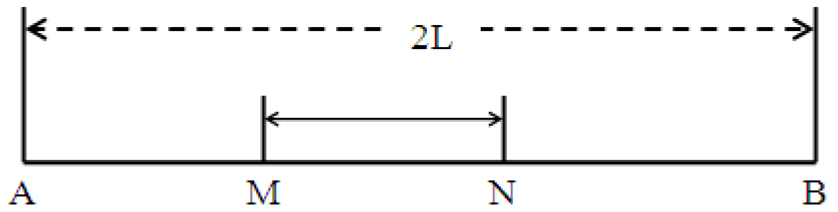


Figure 1.: Schlumberger electrode configuration.

Resistivity measurements are associated with varying depths depending on the separation of the current – potential electrodes in the survey [1].

LOCATION AND GEOLOGY

The study area is located in Igarra between Latitude 7^o 15^I and 17^o18^I N and Longitude 6^o 4^I and 6^o 5^I W in Nigeria and easily accessible by road. The climatic conditon is primarily the rainforest climate and it is characterised by two seasons – the wet and dry seasons. The wet season occurs between April – October while the dry season occurs between October – March. The mean annual rainfall is approximately 1250mm with a temperature range of 18 – 33^oC and a generally undulating topography. Geologically the area

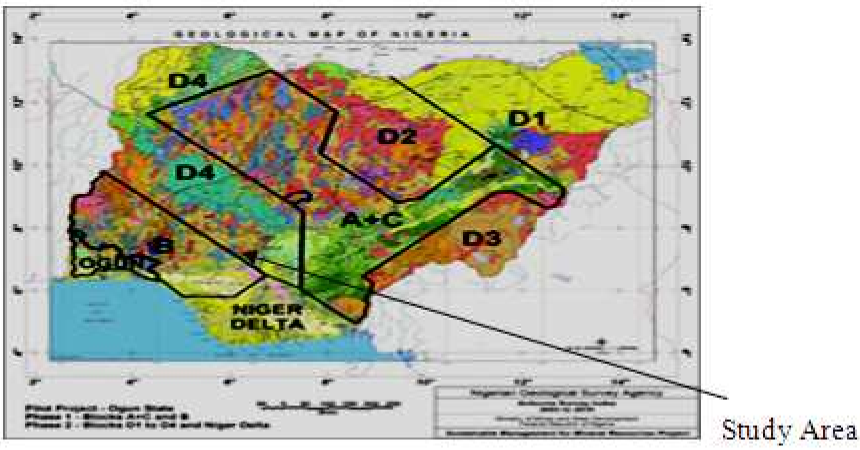


Figure 2.: Generalised Geological map of Nigeria showing the study area.

is generally underlain by rocks of the Precambrian Basement Complex(Figure 2) – Schists, Calc-silicate gneisses, marbles,metaconglomerates,quartzites, biotites, grand-iorites,charnokites, epgmatites, unmetamorphosed dolerite, granites, vein quartz (occurs as igneous intrusion and emplaced along fractues and veins) among others.

MATERIALS AND METHODS

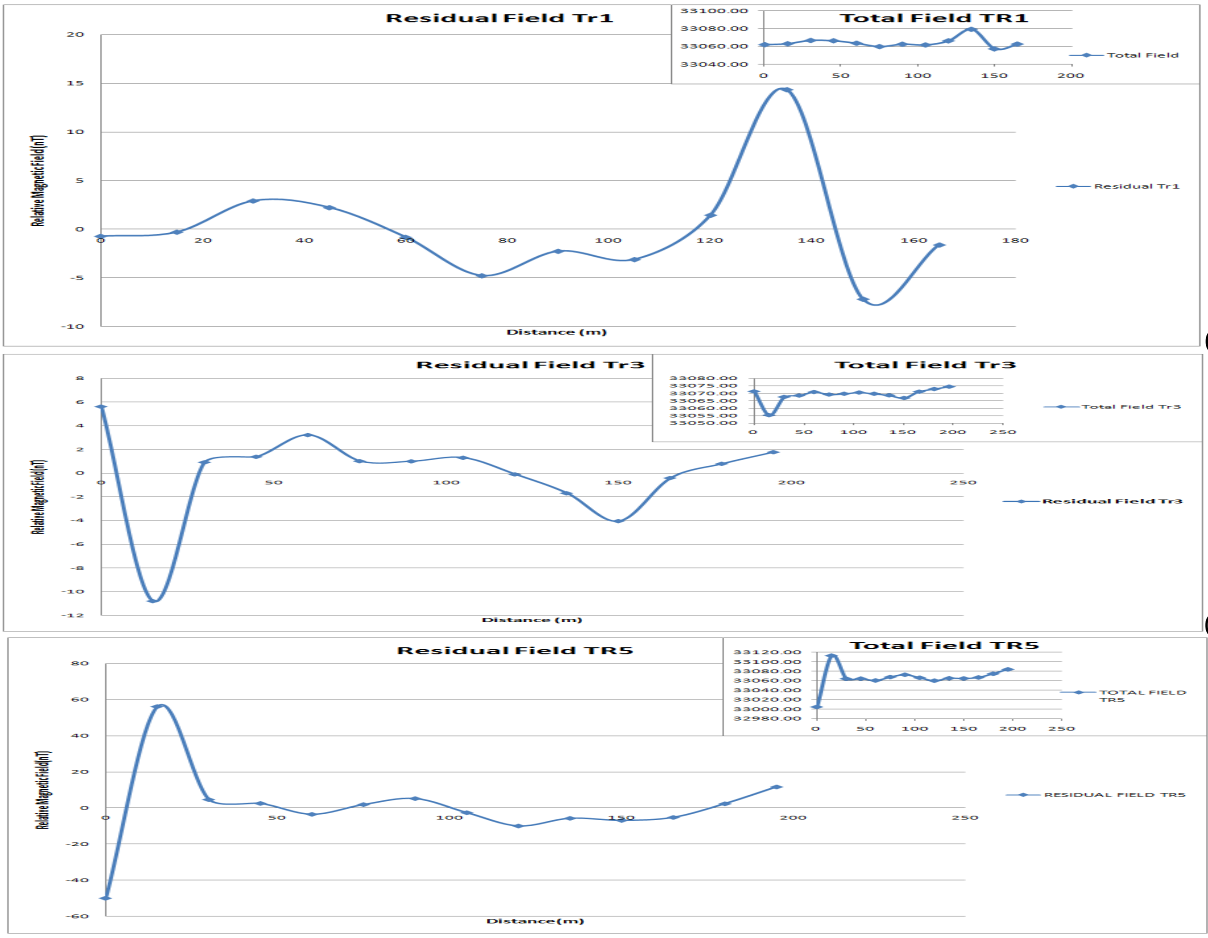
The GEM Systems Proton Precession Magnetometer was employed for the ground magnetic survey with a station separation of 15m while the ABEM WADI VLF-EM equipment was used in the aquisition of the VLF-EM response of the area using a frequency band of 22.2kHz, signal strength of 14 with a station separation of 15m and the Schlumberger's Vertical Electrical Sounding (VES) technique was employed in the geoelectric sounding using a station separation of 25m and a current- current electrode separation of 65 – 100m. A total of three traverses were occupied with distances varying between 180 – 200 m respectively.

RESULTS AND DISCUSSION

The result of the geomagnetic data is presented as profiles (Figure 3) showing the variation in magnetic amplitude of the anomaly signature. The magnetic lows are characterised by low amplitude and low intensity. The magnetic profile along traverse 1 shows magnetic highs between 20 – 55m and 118 – 145m with magnetic lows between 55-118m and between 145 – 165m respectively. The magnetic profile along traverse 3 shows magnetic highs between

25 – 120m and 160 – 190m with magnetic lows between 5 – 25m and 120 – 160m respectively. The magnetic profile along traverse5 shows magnetic highs between 8- 50m, 60 – 100m, and 175 – 200m, with magnetic lows between 50 – 60m and 100– 175m respectively. The magnetic lows are indicative of depressed zones; the inflection points are indicative of geologic boundaries or contacts between two rock types, structural changes within the same rock type and the presence of lineaments such as network of joints, fractures and or faults.

The representative result of the Fraser model filtered data plots as well as the Karous-Hjelt filter 2-D inversion current density plots of the VLF-EM method for traverse 1,2 and 5 are presented in figure 4. The 2-D inversion shows variation in conductivity with depth [7]. High conductive values reveal the presence of conductive subsurface structures while the low values reveal resistive structures. The apparent current density section along traverse 1 reveals the presence of conductive anomalies between15 – 60m and 90 – 115m respectively. The apparent current density section along traverse 3 reveals conductive anomalies between15 – 68m and 80 – 130m respectively and the apparent current density section along traverse 5 reveals the presence of conductive anomalies between 50- 65m, 80 – 95m, and 105 – 155m. The conductive anomalies indicate the presence of conductive subsurface structural trends of inferred fractures.



(a) (b) (c)

Figure 3 (a –c).: Geomagnetic profile along traverses 1, 3, and 5 along the Study Area.

The characteristic curve types obtained in the area are the A- and H-type curves. The A components of the curves are interpreted as the relatively resistive layers while the H components are interpreted as the conductive layers in the study area. The delineated geoelectric parameters were used in the generation of the bedrock relief map, isopach map of overburden materials and isoresistivity map of the study area and interpreted accordingly. The bedrock relief map (Figure 5) indicates two zones of high relief to the East and West segments of the map and slightly to the North. A low-lying zone can also be seen trending North-South between the high relief zones. The low-lying feature indicates the presence of a geologic structure which is most probably a fractured zone or geologic contact. The isopach map of overburden material (Figure 6) reveals the presence of thick overburden materials (> 7m) on the Northern zone of the map(between 3 and 5) and to the south-east zone (between traverse 1 and 3) while all other sections contain shallow overburden materials (<7m). The shallow overburden zones indicate the area where the aquifer units are highly susceptible to contamination while the thick overburden zones indicate areas with little susceptibility of the aquifer units to contamination. In the Basement Complex Environment, thick overburden is usually associated with high groundwater yield [5, 2] The isoresistivity map (Figure 7) which was generated using the resistivity of the weathered second layer, shows zones of low resistivity (<1000 ohm-m) on almost all areas on the map except on the North-east zone where the resistivity value is high (>1000 ohm-m).

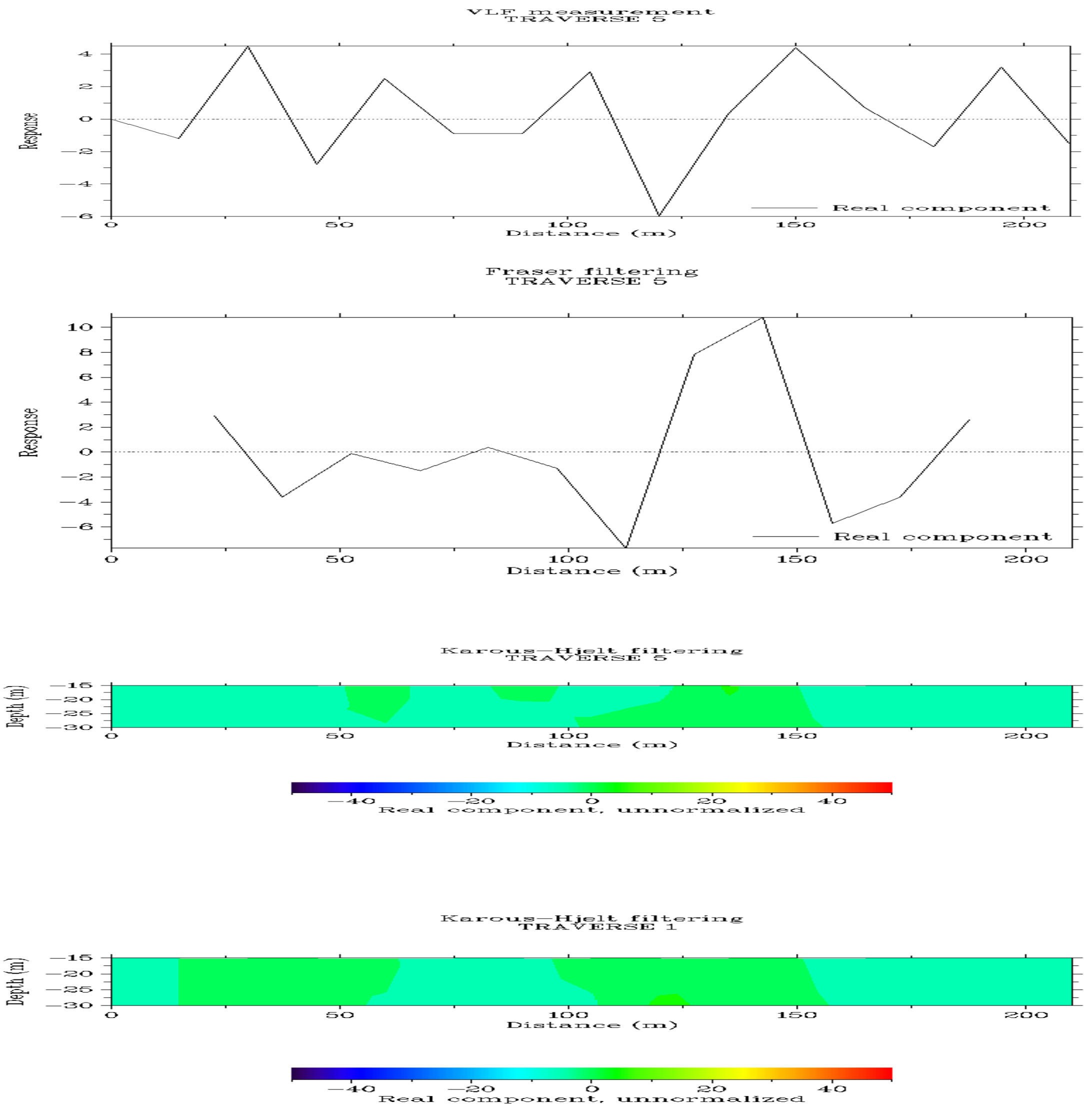


Figure 4.: Sample Karous-Hjelt filter (Traverse 5) and 2-D inversion current density section(Traverse 5and 1).

Bodies of low resistivity can be seen trending North-west to South-east and West of the map. The low resistivity zone indicates the presence of water saturated media in the area.

From the three maps (Figures 5, 6 and 7), it can be seen that the zones with low isoresistivity and thick overburden materials closely correlate with the low-lying zone on the bedrock relief map. The thick overburden region also correlates with the linear feature on the isoresistivity map indicating that the area with thick overburden is a low resistivity region and ideal for groundwater abstraction.

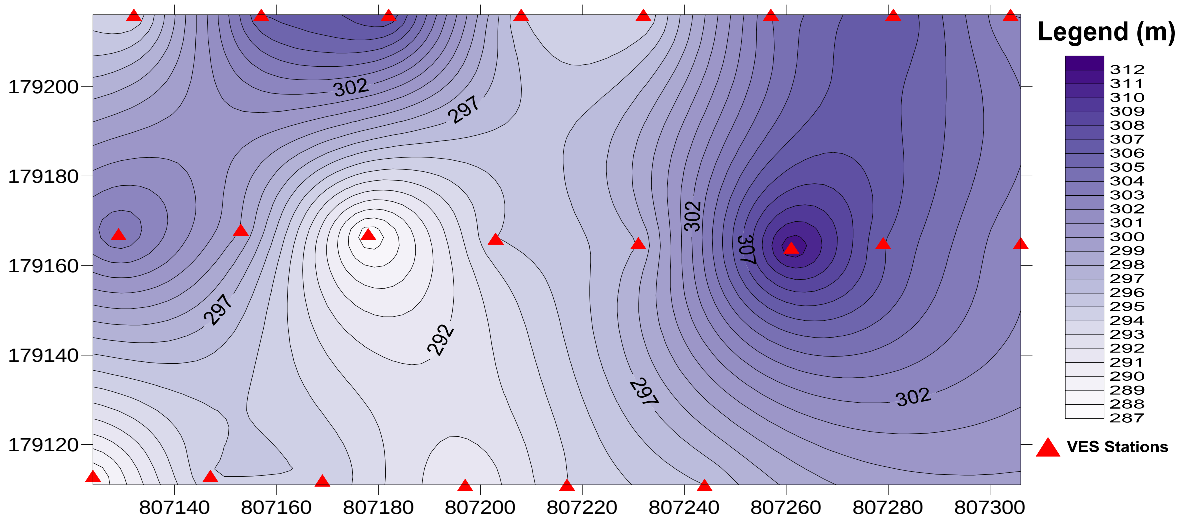


Figure 5.: Bedrock Relief Map of the Study Area.

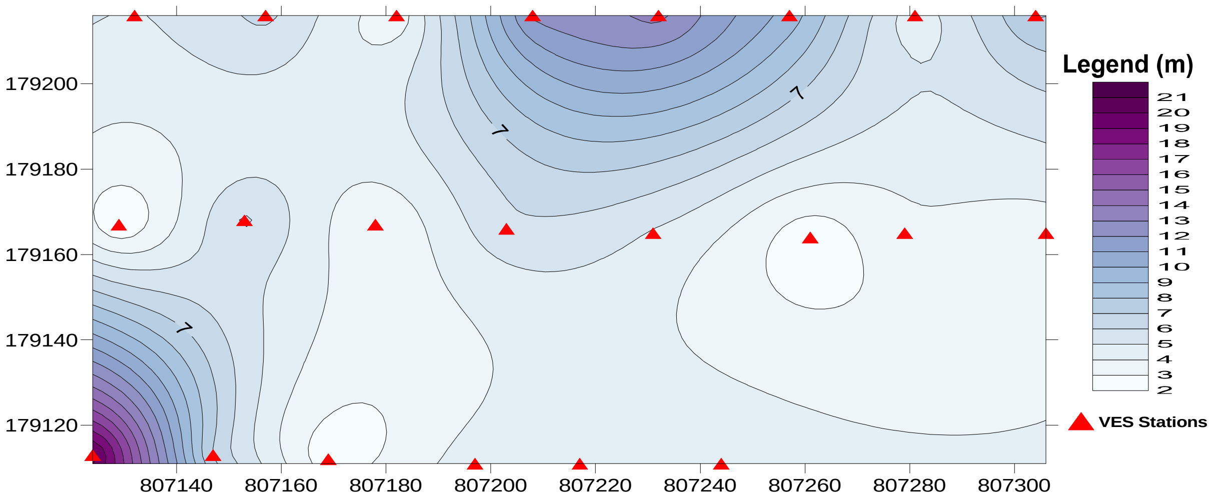


Figure 6.: Isopach Map of Overburden of the Study Area.

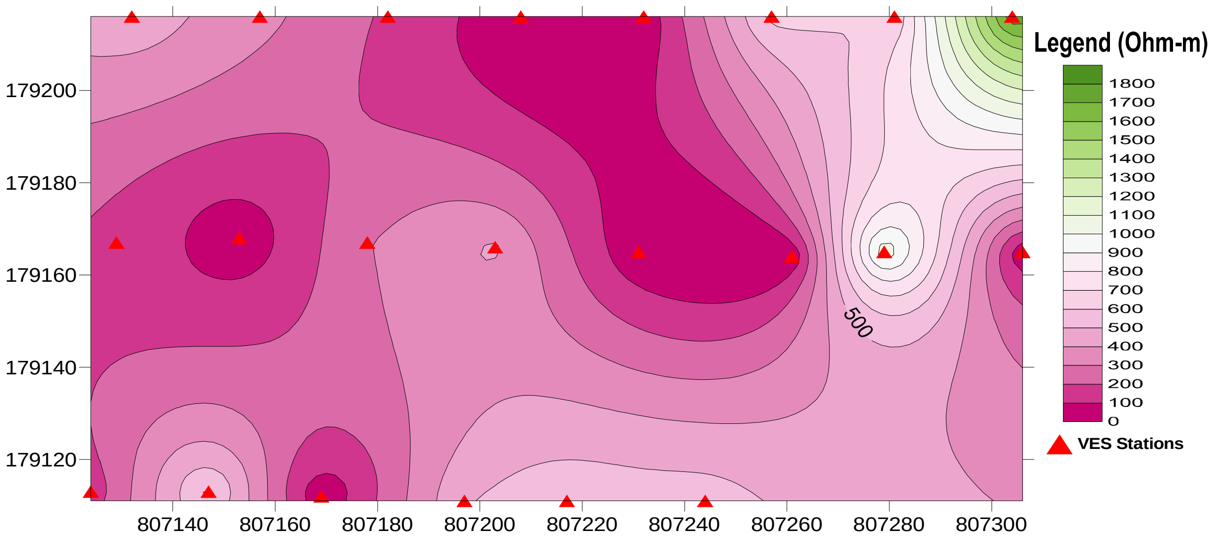


Figure 7.: Isoresistivity Map of the Study Area.

CONCLUSION

Conclusively, from the methods, the study area can be observed to contain a geologic structure which is most probably a fractured zone and usually acts as groundwater accumulation zones in a Basement environment. The depth to the aquifer units across the area is generally shallow (< 10m) making the aquifer units susceptible to contamination. Appropriate measures such as blind-casing and grouting of the annular space – space between the borehole casing and the ground –, should be employed in the development of groundwater abstraction bore hole(s) meant for the area**.**

REFERENCES

[1] Abiola s., Ogungbe, Joseph A., Olowofela, Olabode J., Da-Silva, Aderemi A., Alabi and Eugene O. Onori, *Advances in Applied Sciences Research*,**2010**,vol 1, (1) 174 – 181.
[2]Bala, A.E. and Ike E.C., *Journal of Mining and Geology* **2001**, Vol. 37(2) 177 – 184.
[3]Jegede S. I., Osazuwa, I.B, Ujuanbi O. and Chiemeke, C.C, *Advances in Applied Sciences Research*, **2011**, vol 2(6) 1 – 8.
[4]Jitumoni Borah, *Advances in Applied Sciences Research* **2011**,vol 2(5)318 – 322.
[5]Olorunfemi M.O., Ojo J. S., and Akintunde O.M. *Journal of Mining and Geology*, **1999**, Vol. 35(2) 207 – 228.
[6]Omosuyi G.O. *Ozean Journal of applied Sciences* **2010**, 3(1) pp. 19-28.
[7]Ozegin K. O., Oseghale A., Okolie E. C. and Ujuanbi O. *Int'l Jour. of Water Res. and Environ. Eng.* **2011**, 3(6) 126-131.