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# Geomagnetic and Geoelectric determination of Topography and Depth of constituent Bedrock in a Complex Environment.

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## *Abstract*

***Geomagnetic and geoelectric surveys were executed in a complex zone with the aim of determining the topography and estimated depth of constituent bedrock in the study area. The ground magnetic and geoelectric – Schlumberger's vertical electrical sounding – methods were applied for this study. The presence of a depression was observed between two high relief bedrocks establishing the presence of an undulating topography with the range in depth to bedrock being 2 – 20 m. It was suggested that appropriate measures be employed in the location if it is considered for complex engineering purposes.***

**Keywords:** Geomagnetic, Geoelectric, Topography, Environment, Depth.

## 1.0 Introduction

Geophysical methods are implemented in a wide range of applications to the inspection of dams and dikes [1, 2, 3] This is done routinely to ascertain the suitability of the earth material(s) at such sites for proposed structures that is in terms of bearing capacity and or hosting fitness [4]. In engineering geophysics, the question of the quality of building foundations is frequently addressed in the very late stages, when earthquake damage is either observed or expected [5, 6,]. In the case of construction, geophysics can be applied for exploration purpose to provide useful information regarding the early detection of potentially dangerous surface conditions. Geophysical methods are often used in site investigation to determine the overburden thickness and map subsurface conditions prior to excavation and construction. The electrical resistivity of a formation is directly related to the nature, quantity, quality and distribution of the formation water [7]. The ground magnetic method is usually employed in the location of subsurface structural changes in homogenous rocks and in the location of contact zones [8] and the electrical resistivity method can be used to find bedrock depth if the overburden and bedrock have different resistivities, which is usually the case [9]; thus necessitating the use of an integrated geophysical survey, involving ground magnetic survey method and the Schlumberger's vertical electrical sounding (VES) configuration in achieving the aim as stated above.

## 2.0 Theory

From ohm's law,

$$V = IR \quad (1)$$

$$R = \Delta V/I \quad (2)$$

$$\frac{\Delta V}{I} = \frac{\rho L}{A}$$

$$\rho = \frac{A\Delta V}{IL} \quad (3)$$

$$V = \frac{I\rho L}{A} \quad (4)$$

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For two current electrodes at the surface (figure 1a),

$$V_1 = A_1 / r_1 \tag{5a}$$

Where $A_1 = \dfrac{I\rho}{2\pi}$

The two current in the current electrodes are equal but opposite. Hence the potential difference (p.d) $V_2$ due to $C_2$ at P is :

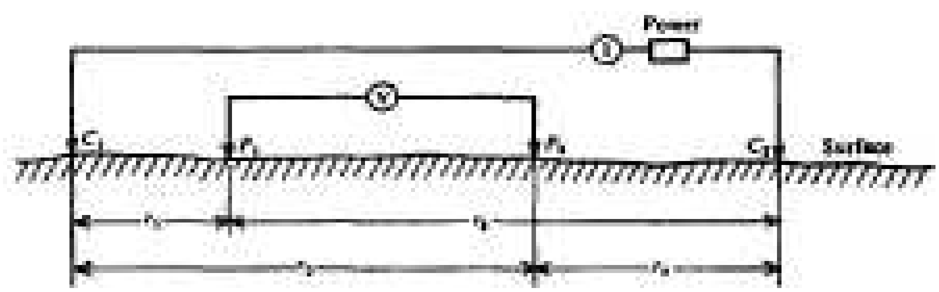
$$V_2 = A_2 / r_2$$

Where $A_2 = I\rho / 2\pi = -A_1$ (5b)

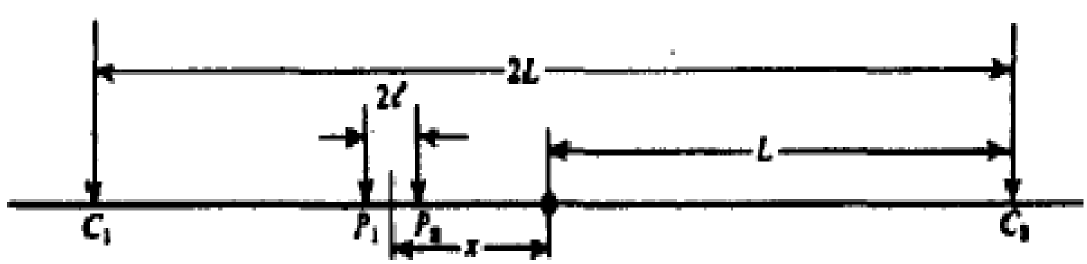
:. The p.d

$$\Delta V = \frac{I\rho}{2\pi}\left[\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \left(\frac{1}{r_3} - \frac{1}{r_4}\right)\right] \tag{6}$$

Where: ρ is the resistivity of the material (ohm-m)
R is the resistance of the material (ohms)
V is the potential across the material (Volts)
I is the input current (Amperes)
L is the length of the material (m)
A is the cross-sectional Area of the material ($m^2$)
r is the electrode separation (m)




(a)




(b)

**Figure 1. (**a) Two current and two potential electrodes on the surface of homogenous isotropic ground. (b). Schlumberger electrode configuration.

Equation 6 corresponds to the four electrode spread normally used in resistivity filed work. The current flow lines are distorted by the proximity of $C_2$.

For the Schlumberger VES configuration (figure 1b) the apparent resistivity $\rho_a$ becomes.

$$\rho_a = \frac{\pi R L^2}{2l}$$

Where, $\rho_a$ is the apparent resistivity (ohm-m)
R is the ground resistance (ohm)
L (=AB/2) is half the current-current electrode separation (m)
*l* is half potential-potential electrode separation (m)
$\pi$ is a constant (3.142)

## 3.0 Location and Geology

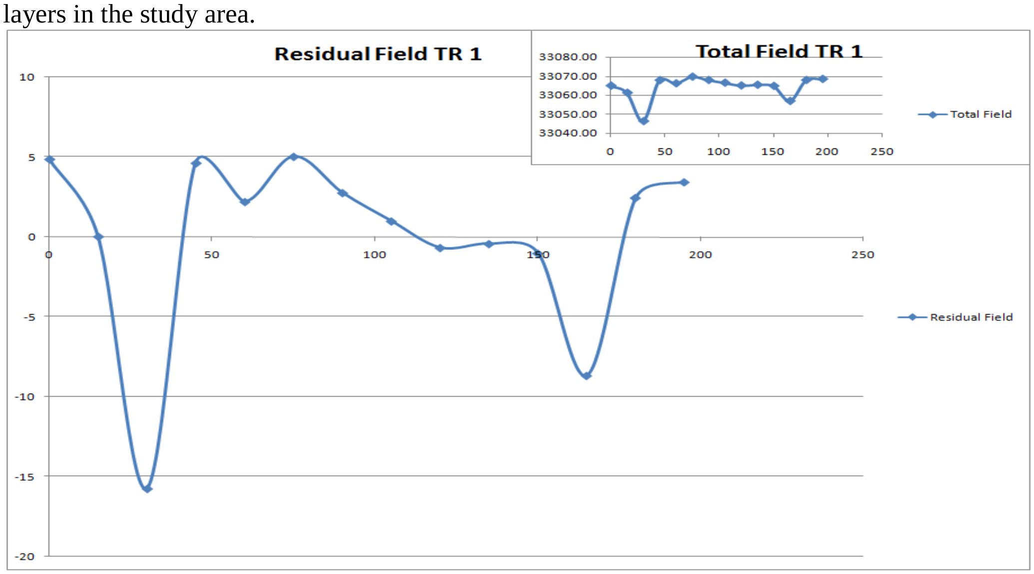
Geographically, the study area is located in Oyanmi between Latitude 7° 35' and7° 40' and Longitude 6° 7' and 6° 9' in Edo North and easily accessible by road. It has a climatic condition that is predominantly the rain forest climate which is characterised by the wet and dry seasons. Geologically, the area is underlain by the Precambrian Basement Complex – Schist, Calc-gneisses, pegmatites, quartzites, among others [8].

## 4.0 Methodology

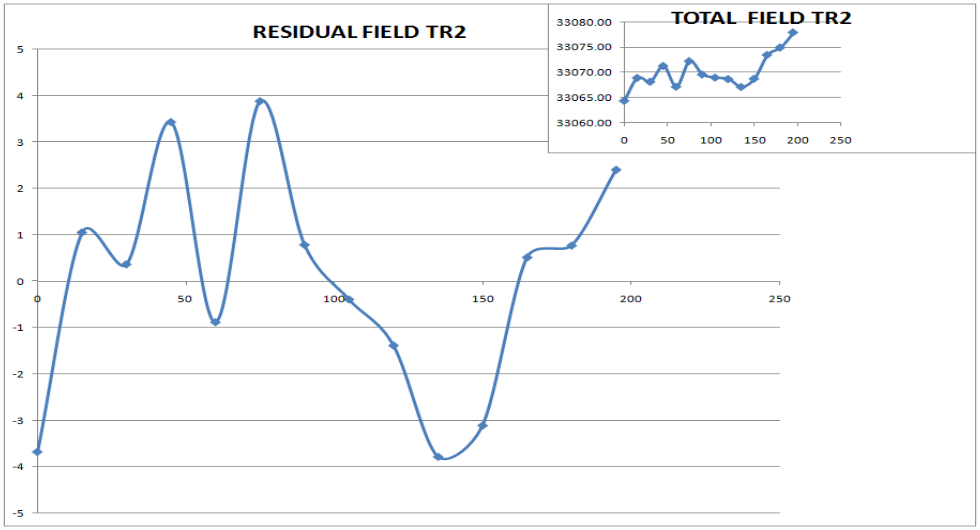
The geomagnetic survey was executed with the GEM Systems Proton Precession Magnetometer employing a station interval of 15 m along two profiles. The geoelectric depth sounding was executed using AB/2 in the range of 1 – 100 m with a station separation of 25 m employing the Schlumberger's electrode configuration. The data acquisition was executed along an S – N direction with a total profile distance of 200 m and inter-profile spacing of 50m.

## 5.0 Results and Discussion

Profiles 1 and 2 (Figure 2) are the results of the geomagnetic survey in the study area. The profiles display the magnetic amplitude variation of the surveyed area. Low amplitudes are usually characterised by low magnetic signatures. Low magnetic amplitudes can be observed between 15 – 40 m and 115 – 175 m with high magnetic amplitudes observed between 0 – 15 m, 40 – 115 m and 175 – 200 m along profile 1; low magnetic amplitudes can be observed between 0 – 10 m, 59 – 69 m and 100 – 160 m while high magnetic signatures can be observed between 10 – 59 m, 69 – 100 m and 160 – 200 m along profile 2. 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. Magnetic lows are indicative of zones of depression [8]. The characteristic curve types obtained in the study area are the H- and A- type curves (Figure 3). The A components of the curves are interpreted as relatively resistive layers while the H components are interpreted as conductive layers in the study area.



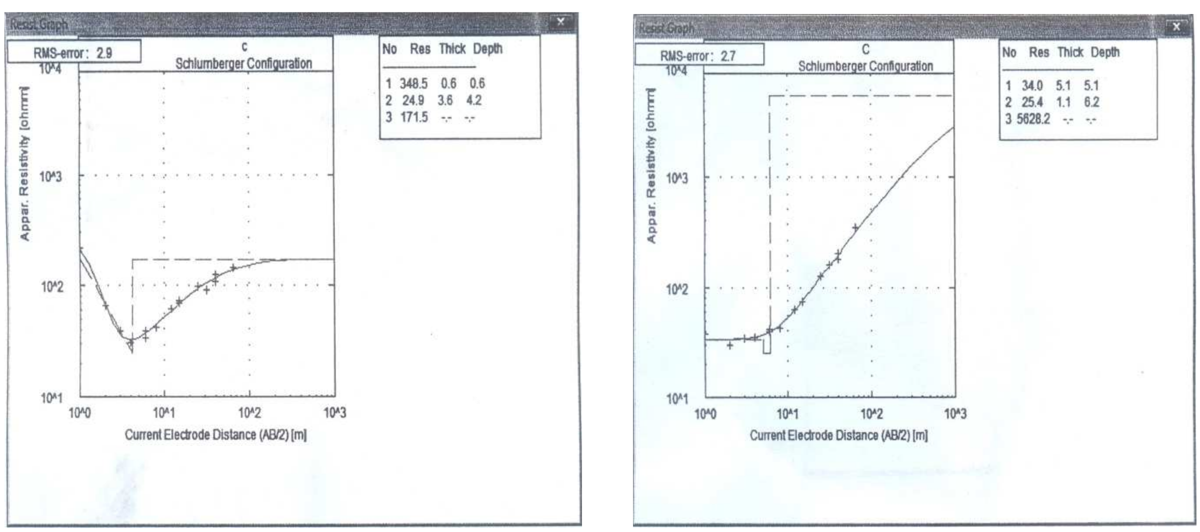

(a)



(b)

**Figure 2 (a and b).:** Geomagnetic Signatures along profiles 1 and two across the Study Area.

The geoelectric parameters deduced from the VES interpretation results were used in the generation of bedrock relief, bedrock resistivity and overburden maps of the study area. The bedrock relief contour map (Figure 4a) displays two high relief features of between 300 – 312 m above sea level (ASL) on the East and Northwest zones having a low relief zone of between 287 – 299 m lying between them. The high relief features are the constituent bedrocks in the study area with their resistivity values in the range of 1200 – 5200 Ohm-m as



(a) H – type curve. (b) A –type curve.

**Figure 3 (a and b).:** Characteristic Curve Types in the Study Area.

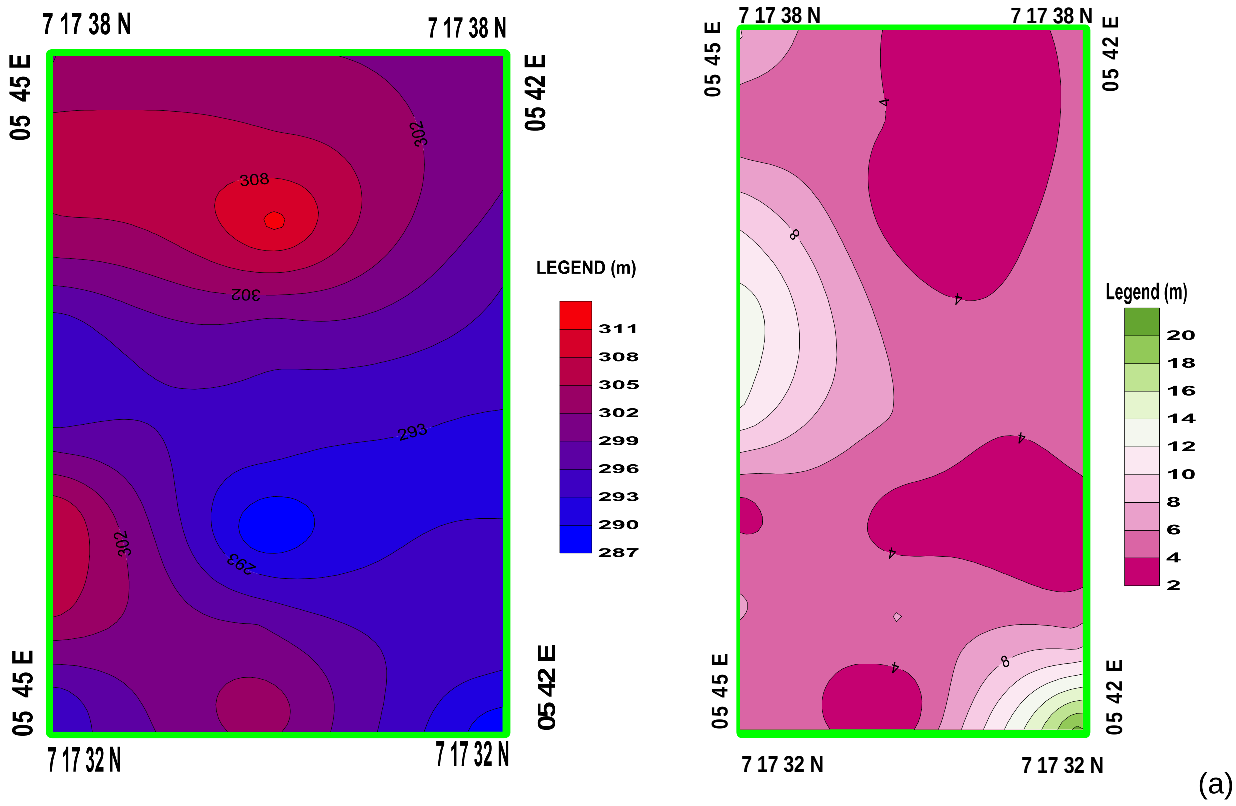



***Figure 4.:(a)Bedrock Relief Map and (b) Isopach Map of Overburden of the Study Location.***

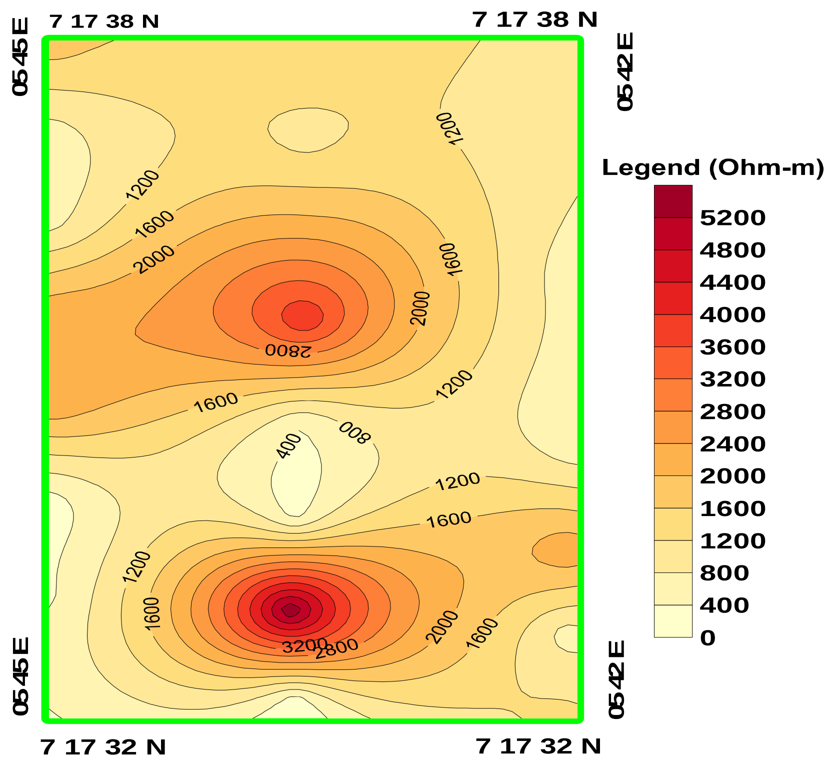



***Figure 5.: Bedrock Resistivity Distribution map of the location.***

can be seen from the bedrock resistivity contour map (Figure 5). The depth to the bedrock was deduced using the isopach map of overburden (Figure 4b) which was deduced from the thickness of all materials that overlie the bedrock and subtracted from the elevation above sea level of the study area. Form the contour map; it can be observed that the depth to the constituent bedrock varies between 2 – 20 m. Thin overburden materials (<10 m) occur in the North and South of the study area, indicating high bedrock relief while thick overburden materials (>10 m) occur on the West – East zones spanning across the study location and slightly oriented to the Southeast; indicating the presence of low bedrock relief. This variation in depth to bedrock indicates the presence of a depression in the study area which goes further to show that the constituent bedrock in the study area is undulating.

## 6.0 Conclusion

From the methods employed, it has been shown that the bedrock is deeper in areas with thick overburden cover and shallow in areas with thin overburden cover. This shows that the study area is an area with undulating topography; with thick overburden cover lying in the depressed zone between the high bedrock reliefs areas as can be seen in figure 4. Appropriate measures should therefore be taken in the development of the study area for complex engineering structures.

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