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Interpretation of groundmagnetic data in Oke-Ogba Area, Akure, Southwestern Nigeria

[1]Sunmonu Lukman Ayobami, [1*]Adagunodo Theophilus Aanuoluwa, [1]Olafisoye Emmanuel Rotimi and [2]Oladejo Olagoke Peter

[1]Department of Pure and Applied Physics, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, Oyo State, Nigeria.
[2]Department of Physics, Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria.

ABSTRACT

Groundmagnetic method was used to delineate into the subsurface in Oke-Ogba area, Akure, which falls within latitude 07^0 14$'$ to 07^0 19$'$ North and longitude 005^0 06$'$ to 005^0 12$'$ East Southwestern Nigeria, with a view to determining the competent areas for engineering purposes and the promising areas for hydrogeologic prospects. A total of four traverses were established for the purpose of the groundmagnetic study, and the results were presented as groundmagnetic profiles of varying magnetic intensities. The result of investigation revealed that the intensities and characteristics nature of the magnetic anomalies as expressed by all profiles are indicative of the different rock types producing them. Qualitative and quantitative interpretation of individual magnetic anomaly and geological knowledge of the survey area yielded information on the depth of geological features (e.g. rock contact, faults or fractures), structures and magnetic properties of rock units. From the preliminary interpretation, the existence of some structural features such as a likely fault, fracture and contacts between rocks as well as relatively mineralized zones that might contain magnetic minerals of essential magnetite origin is revealed. It was also revealed that Oke-Ogba area, Akure, Southwestern Nigeria is averagely competent for both engineering purposes and hydrogeologic purposes.

Keywords: Groundmagnetic Interpretation, Magnetic Highs, Magnetic Lows, Engineering Purposes, Hydrogeologic Prospects, Oke-Ogba Area.

INTRODUCTION

The origin of the earth's magnetism is commonly believed to be the liquid outer core, which cools at the outside as a result of which the material becomes denser and sinks towards the inside of the outer core and new warm liquid matter rises to the outside, thus, convection currents are generated by liquid metallic matter which move through a weak cosmic magnetic field which subsequently generates induction currents [1, 2]. It is this induction current that generate the earth's magnetic field [3, 4]. Most rocks of the earth's crust contain crystals with magnetic minerals, thus most rocks have a certain amount of magnetism which usually has two components: induced by the magnetic field present while taken measurement, and remnant which formed during geologic history [4, 5].

The purpose of magnetic survey is to locate rocks or minerals having unusual magnetic properties which reveal themselves as anomalies in the intensity of the earth's magnetic field [6]. Groundmagnetic study is used for detail mapping in order to understand the subsurface geology of an area [1, 4, 7]. It has been used extensively in basement mapping [8]. The technique requires measurements of the amplitude of magnetic components at discrete points along traverses distributed regularly throughout the survey area of interest. In groundmagnetic study, three components are measured which are horizontal, vertical and total components. The vertical components and the total components are mostly used in the past studies to delineate faults, fractures, depth to magnetic basement and other geological structures [1, 4, 8]. In this study, Total Magnetic Intensity (TMI) or total components were measured at discrete points along traverses in order to investigate on the geologic features like fault, fracture and rock contact distribution within the study area.

Susceptibility values are important for the quantitative differentiating rock types. The magnetic susceptibility of rocks is controlled by the amount of magnetic minerals in them, grain size and mode of distribution. Ferrimagnetic substances give rise to higher magnetization and hence higher susceptibility [3, 7, 9].

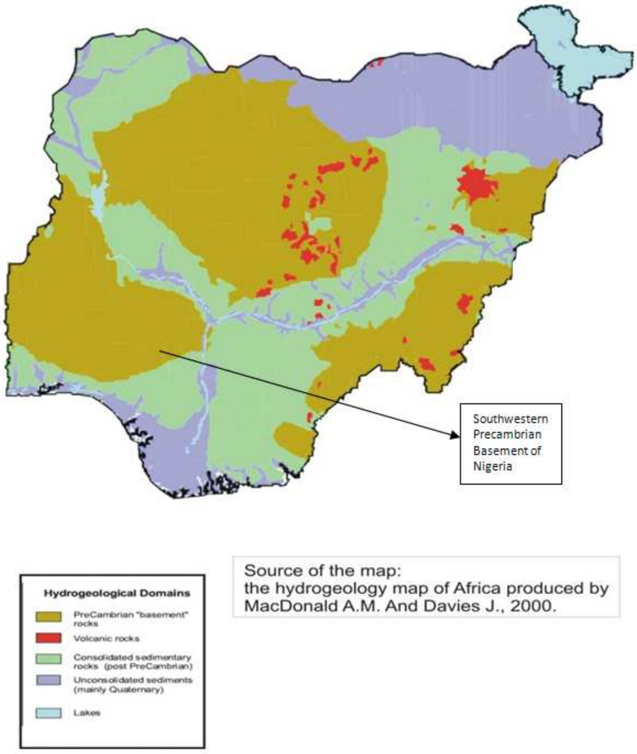

Figure 1: Grouped geological map of Nigeria (extracted from Geological map of Africa produced by MacDonald and Davies, 2000 [11]).

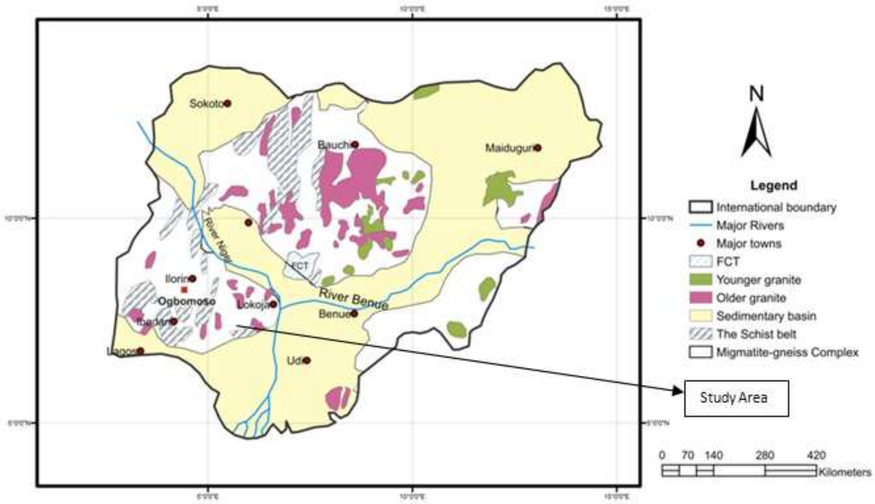

Figure 2: Regional geological map of Nigeria (Modified after Ajibade et al., 1988 [13]).

SITE DESCRIPTION AND GEOLOGICAL SETTING

Oke-Ogba area lies within latitude $07^0\ 14'$ to $07^0\ 19'$ North and longitude $005^0\ 06'$ to $005^0\ 12'$ East. It is situated at the Southern part of Akure township and on a rugged and gentle undulating terrain characterized by outcrop of granite and charnokite rocks. The climate of the area comprises short dry season and long wet season. The wet season last from April to November with a peak in June and July. These are vindicated by dense evergreen forest vegetation. The dry season last from November to March with December and January being the driest months. The temperature varies between 25^0C and 30^0C throughout the year with high humidity during the wet season and low humidity during the dry season [10]. Oke-Ogba falls within the Southwestern portion of Nigeria Precambrian basement complex (figure 1) [11] which lie within Pan African mobile belt, East of West African Craton. The basement complex is believed to be polycyclic [12]. Locally, the study area is underlain by basement rock types such as slightly migmatite gneiss complex rocks (figure 2) that are slightly migmatised to non-migmatite metasedimentary and meta-igneous rocks, charnokites and granite rocks. These rocks occur as iceberg, isolated and continuous hills. Low lying outlying outcrops of magmatite gneiss and quartzite boulders were also seen in the survey site. The topsoil ranges from sandy clay to dark loamy soil and gravel aggregates.

MATERIALS AND METHODS

The instrument used for the groundmagnetic survey is the Geometries Proton Precession Magnetometer, model G-856. This proton magnetometer produces an absolute and relatively high resolution of the field and displays measurement in digital lighted readout. A total of four traverses were established for the groundmagnetic survey, and the results were presented as groundmagnetic profiles of varying magnetic intensities. The instrument however gives magnetic intensity values in gamma and was used for groundmagnetic prospecting of Oke-Ogba area along four traverses in North to South and East to West directions. The traverse length range from 210m to 340m with interstation spacing of 10m. The magnetic readings were corrected for non-mean, near surface effect, and drift correction. The noises were removed by filtering the data using three-point moving average filter [14]. The eventual magnetic data were presented as profiles by plotting the relative magnetic values against station separations for each profile. Linear trend analysis of each magnetic traverse was obtained which was used to construct (2-D) contour map and (3-D) surface plot for more qualitative interpretation. Quantitative interpretation involved the use of half-width of the amplitude method for the estimation of overburden thickness [8]. The estimated magnetic depths to the basement along each traverse were determined and presented in table 1.

RESULTS AND DISCUSSION

The results of the data gotten from groundmagnetic survey of Oke-Ogba area, Akure were discussed in terms of quantitative and qualitative interpretations. The quantitative interpretation involves the estimation of the overburden thickness to the top of the magnetic basement, and is as shown in table 1. It indicated varied basement topography with depth ranging from 3.0 to 19.5m. The topography of the study area revealed that the basement consist of consolidated rocks. Areas that are underlying with thin overburden in the study area are good for engineering purposes while areas that are not good for geotechnical purposes will be useful for hydrogeologic purposes.

The qualitative interpretation involves interpretation of the magnetic traverses, magnetic contoured map (2D plot) and magnetic surface map (3D plot). 2-D and 3-D data were derived from Linear Trend Analysis of the magnetic traverses in the study area [15]. These two maps (figure 4 and 5) were plotted using Surfer 8 software [16].

Table 1: Depth estimates of groundmagnetic traverses relative to the ground surface from Oke-Ogba area, Akure using Half-Width of the amplitude method.

Traverses	Depth to the magnetic sources (m)						
	A	B	C	D	E	F	G
Traverse 1	5.5	19.5	12.5	6.5	10.0	12.5	-
Traverse 2	5.0	10.5	3.5	5.0	3.0	3.0	5.0
Traverse 3	11.0	4.0	3.5	5.0	4.0	-	-
Traverse 4	8.0	17.0	11.5	8.0	-	-	-

Magnetic Traverses

Traverse 1

The traverse covers a total length of 340m (figure 3a) and trends in West to East direction. The traverse shows series of magnetic highs and lows with magnetic highs at A, B, C, D, E, and F and magnetic lows at T, U, V, W, X and Y. Magnetic highs at A, C, D, E, and F are suspected to be due to near surface magnetic minerals such as crystalline rocks (igneous or metamorphic) with a suspect outcrop like igneous or metamorphic at B. With the magnetization level across this traverse, locations A to F are the better place for engineering purposes. An inflection point is noticed between location C and D which is suspected to be contact between two rocks. The magnetic lows at T to Y are suspected to be due to the presence of non-magnetic minerals such as fault, fracture, crack or contact between two rocks. However, these locations will not be good for engineering purposes but will be suitable for hydrogeologic purposes.

Traverse 2

The traverse covers a total length of 230m (figure 3b) and trends in South to West direction. The traverse shows areas with magnetic highs at A, B, C, D, E, F and G which are suspected to be due to near surface magnetic minerals such as crystalline rocks (igneous or metamorphic). These locations are the better places for engineering purposes. Magnetic lows are experienced at T, U, V, W, X, and Y. Locations T to X are suspected to be due to the presence of non-magnetic minerals like faults, crack or contact between two rocks while location Y is suspected to be fracture because of the wide gap in the region. Distance 160 m to 170 m from the starting point is interpreted as inflection point which is suspected to be contact between two rocks. Except at location V that might not be favourable because of its magnetization level, other locations that showed magnetic lows are suitable areas for hydrogeologic purposes.

Traverse 3

The traverse covers a total length of 210m (figure 3c) and trends in North to South direction. The traverse shows the same trend as that of the previous traverses. Areas with magnetic highs at A, B, C, D and E are suspected to be near-surface magnetic minerals like igneous or metamorphic rocks. These locations are good for engineering purposes. Areas with magnetic lows at T, U, V, W, X, Y, and Z are suspected to be areas with non-magnetic minerals like fault, fracture, crack or contact between two rocks. However, T, W, X and Y are the best locations for hydrogeologic purposes along this traverse. Distances 70m to 90m and 190m to 210m are inflection point which could be contact between rocks.

Traverse 4

The traverse covers a total length of 340m (figure 3d) and trends in South to North direction. Areas with magnetic highs at A, B, C and D are suspected to be near-surface magnetic minerals like igneous or metamorphic rocks. These areas are good for engineering purposes. Areas with magnetic lows at T, U, V, W, X and Y are suspected to be areas with non-magnetic minerals like fault, fracture, crack or contact between two rocks. The wide space at location U further confirms it to be fracture zone while distance 270m to 340m from the starting point is an inflection point which is suspected to be contact between rocks. Location U, V, W and X are favourable for hydrogeologic purposes while location Y could also be considered favourable too.

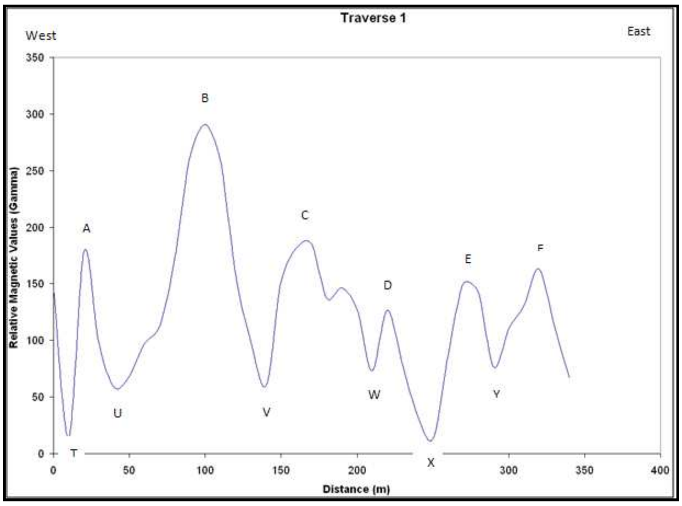

Figure 3a: Magnetic profile along traverse 1.

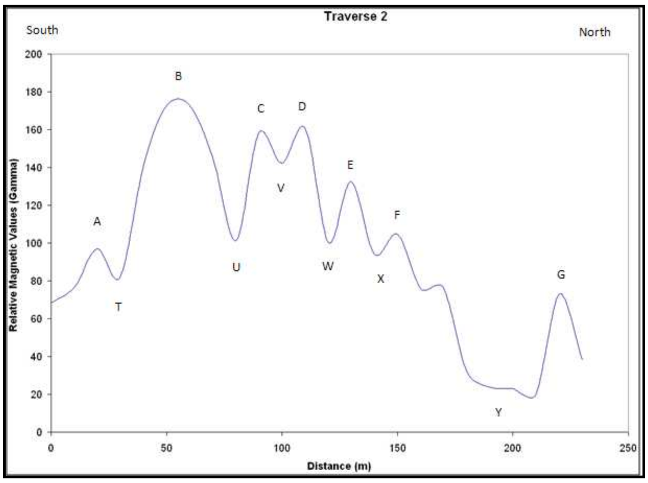

Figure 3b: Magnetic profile along traverse 2.

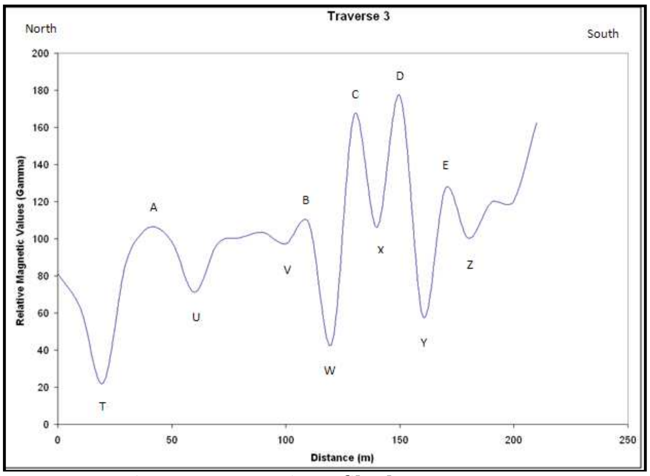

Figure 3c: Magnetic profile along traverse 3.

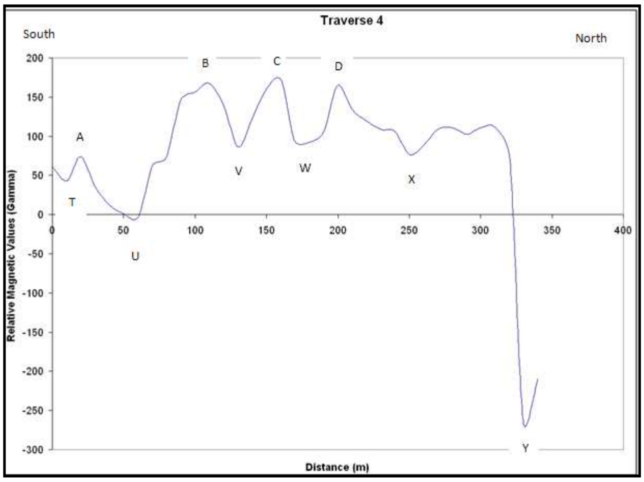

Figure 3d: Magnetic profile along traverse 4.

Linear Trend Analysis

The linear trend analysis for the total groundmagnetic data at Oke-Ogba area Akure was obtained using Equation 1 to 4 from Microsoft Excel package for the interpretations of the four traverses occupied in the study area.

$$y = -0.1028x + 142.25 \quad (1)$$
$$y = -0.3875x + 140.88 \quad (2)$$
$$y = 0.3209x + 67.062 \quad (3)$$
$$y = -0.1483x + 103.65 \quad (4)$$
$$\Delta r \text{ (residual)} = \Delta T \text{ (corrected field data)} - \Delta R \text{ (regional)} \quad (5)$$

Equations 1 to 4 were used to obtain the regional magnetic, ΔR values for the total groundmagnetic study of this area where x is the station position. The residual magnetic, Δr values were obtained using equation (5), ΔT . The results obtained were used to construct the residual 2-D (contour) and 3-D (surface) groundmagnetic maps of the study area.

2-Dimensional and 3-Dimensional Residual Groundmagnetic Map

2-D and 3-D residual groundmagnetic map of the study area using linear trend analysis for total groundmagnetic is as shown in figure 4 and figure 5. From the two maps, it showed that the study area is divided into 2 parts. Areas with low magnetic values (where magnetic intensities are lower than 100 Gamma) and areas with high magnetic values (where magnetic intensities are higher than 100 Gamma). Low magnetic intensities dominated the Southwestern, Southern and part of the Southeastern region of the study area while high magnetic intensities dominated the Central, Western, Northwestern, Northern, Northeastern and Eastern region of the study area (figure 4 and 5). Areas with high magnetic intensities area the competent areas for engineering purposes while areas with low magnetic intensities are the suspected areas for hydrogeologic purposes. From figure 5, it further shows that the Southwestern and Southern region of the study area are the promising areas for hydrogeologic prospect because of vivid low magnetic intensities been revealed on the map.

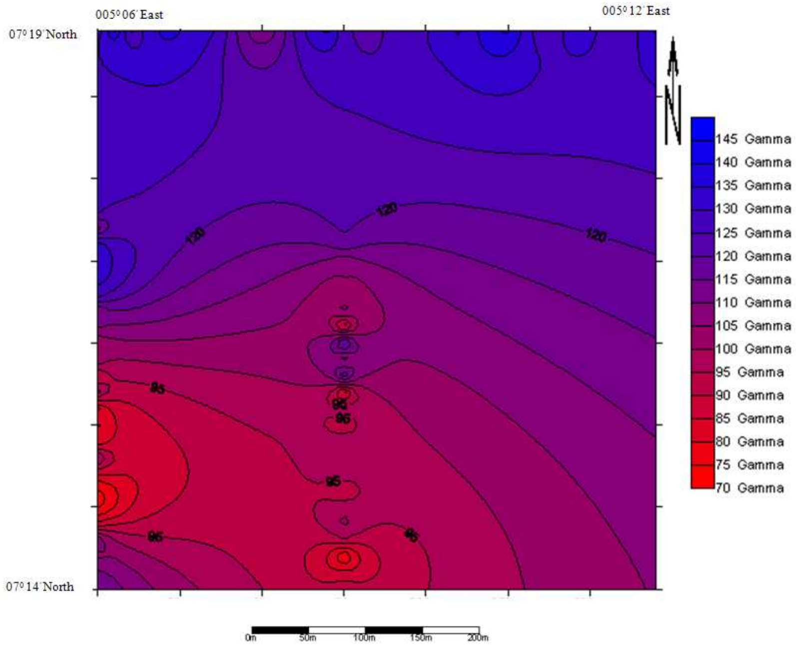

Figure 4: The 2-D (contoured) residual magnetic map of the study area.

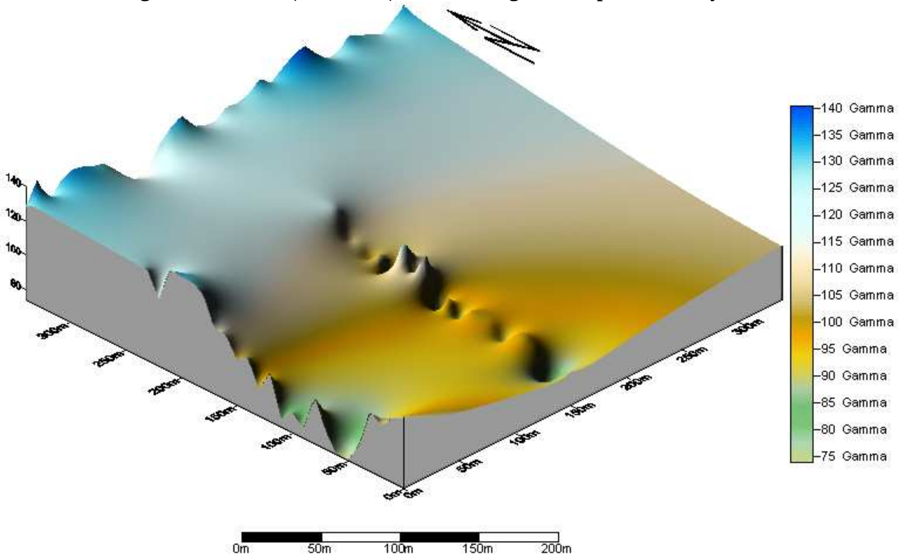

Figure 5: The 3-D (contoured) residual magnetic map of the study area.

CONCLUSION

Interpretation of groundmagnetic data in Oke-Ogba area, Akure, Southwestern Nigeria revealed materials with magnetic minerals like metamorphic and igneous rocks while in other areas revealed materials with non-magnetic minerals like faults, fractures, rock contacts and joints between two rocks along the traverses been investigated in the area. Figure 4 and 5 showed that the study area is averagely competent for engineering purposes as well as averagely competent for hydrogeologic purposes. This is achieved because areas with low magnetic intensities should be avoided when considering locations for engineering site. However, it is these areas with low magnetic intensities that will be favourable for hydrogeologic purposes especially borehole development.

A multidimensional approach to the studies (that is the magnetic profiles, residual 2-D map, residual 3-D map and depth to the basement estimation) has made the study both very qualitative and quantitative as information missed by any of the approach is revealed by the other and thereby necessitating justifiable conclusions. It is recommended that other relevant geophysical methods be used in the study area to confirm the predictions in this works.

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