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Subsurface study of geological pattern of Sumaje village, Nigeria

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Abstract

In this study, ground magnetic survey of Sumaje Village, Ogo Oluwa area of Oyo State, Nigeria using high resolution proton-precession geometric magnetometer model G-856AX measures total components of the ground magnetic. The field data was qualitatively and quantitatively interpreted. Profile 1 has the highest amplitude of 18.2 nT and profile 2 has the highest width of 32 m. The depth to the basement rocks ranges between 6.25 to 13.75 m. The highly mineralized region of the study area is between traverse 1 to 5. Magnetic anomaly obtained varied between a minimum negative peak value of about -14.3 nT and a maximum positive value of about +3.8 nT. The maximum depth to basement rock is about 13.75 m. Ground magnetic contour map, 3-D map, and vector map showed that magnetic anomalies are as a result of rocks present in the region. The major rocks and minerals suspected to be found in this studied area and its environs are slate, gneiss, serpentenite, rhyolite, pegmatite, gabbro, basalts, oceanic basalts and hematite.

Key words: Magnetic field, magnetic anomaly, magnetometer, Sumaje village.

INTRODUCTION

Ground magnetic survey has not been given much attention in the past; especially in developing country like Nigeria. Aeromagnetic data cannot give details of magnetic structures of small dimension. Hence, the use of ground magnetic survey method to delineate the subsurface structure is important.

Magnetic survey sets out to investigate subsurface geology on the basis of anomalies causing magnetic field to result from magnetic properties of the underlying rocks (Philip et al., 2002). It is also used in mapping geological boundaries between magnetically contrasting lithologies including faults (Telford et al., 2001). A magnetic anomaly originates as a result of the magnetization contrast between rocks with different magnetic properties. Most rocks contain some magnetite, hematite or other magnetic material and will produce disturbances in the local magnetic field. Because of this, most soils and much man - made objects that contain nickel or iron have magnetic properties detectable by a sensitive magnetometer because they create local or regional anomalies in the earth's main field. Anomalies are revealed by systematic measurement of the variation in magnetic field strength with position. Folami and Ojo (1991) are of opinion that magnetic methods are sensitive to the susceptibility within the subsurface geology and so are ideal for exploring in the basement complex regions which make this method suitable for this research work. Total magnetic intensity which traverses over an area can aid understanding of the underlying geology and, in the case of iron ore deposits, can indicate very clearly their locations.

Reynold (1997) discussed that magnetic method can

Figure 1. Map of the Oyo State, Nigeria.

be used in locating pipes, cables, and metallic objects, buried metal drums of contaminated or toxic waste, archaeological remains, concealed basic igneous dykes, metalliferous mineral lodes, geological boundaries between magnetically contrasting lithologies including faults, and large-scale geological structures. Gunn and Dentith (1997) discussed that magnetic data can be used to identify the extent of the favourable host stratigraphy, folds in the stratigraphy, the location of cross-cutting shears that may control the emplacement of the deposits, and the magnetic anomalies caused by magnetite associated with the economic minerals.

Some ground magnetic surveys carried out in Nigeria recently include the following: Nwankwo et al. (2005) carried out a ground magnetic survey using a digital fluxgate magnetometer, and gradient analysis of the residual magnetic data found that the basement thickness varies between 2.14 and 19.73 m along the profile. Fasunwon et al. (2007) delineate undifferentiated older granite, gnesiss and charnockite. Kayode et al. (2010) delineated major subsurface structures that include major and minor faults in Ilesa town in Osun State, Nigeria using proton magnetometer. This research work aimed to delineate the subsurface geological structure of Sumaje Village, Oyo State,

Study area

The studied area (Sumaje village) is located in the Ogo Oluwa area of Oyo State, Nigeria and lie between latitudes 7.42 and 7.98° and longitudes 3.86 and 4.10° (Figure 1).

MATERIALS AND METHODS

The most commonly used magnetometer for magnetic survey work is proton precession magnetometer. This instrument is commonly used because it combines high accuracy and is easy to operate. Proton precession magnetometers have different models. The model used in this work is G-856AX which is portable. Global positioning system (GPS) was used for taking the longitude and latitude of the survey area and elevations of certain points. The G-856AX sensor may be mounted on the sensor staff either vertically or horizontally to the staff. In this work, the sensor was mounted vertically so that its cylindrical axis is vertical to the staff. In this configuration, the sensor has a north arrow on its top surface which

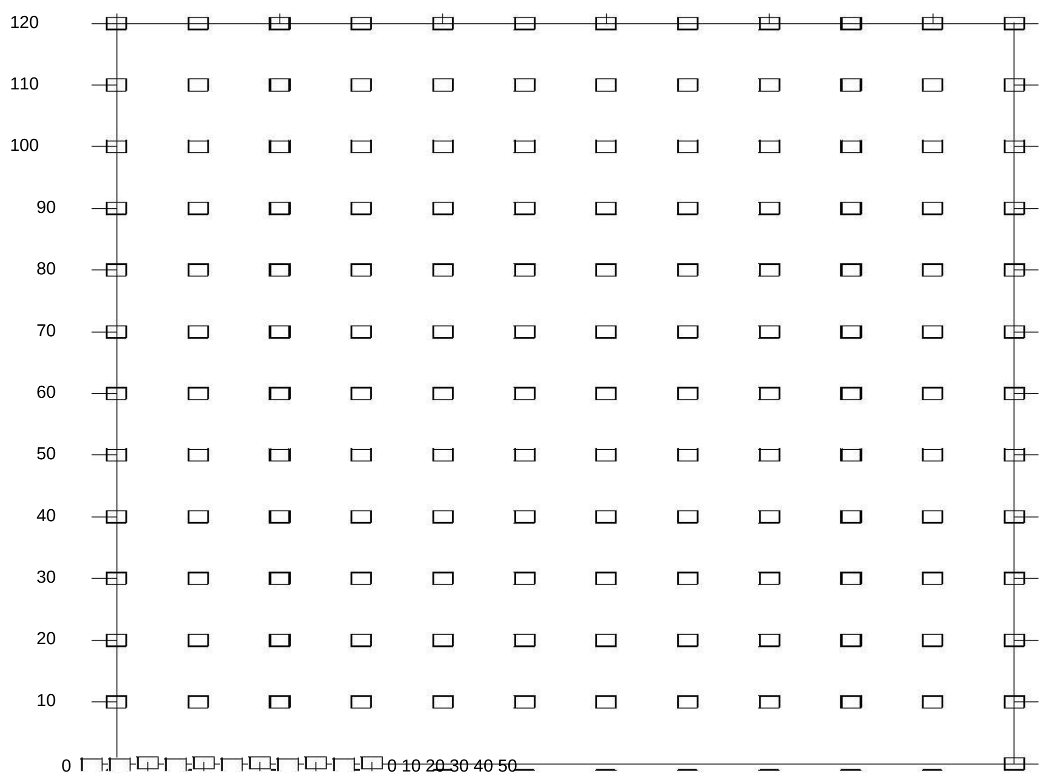

Figure 2. Grid points of the location at Sumaje Village, Oyo State, Nigeria.

was always directed toward magnetic north when taking a measurement.

Twelve traverses of 155 points along east-west and west-east profiles were acquired. The station interval is 10 m while the distance between lines is 5 m. The total area of the survey location is 6600 m^2. For greatest measurement accuracy, it is best to orient the sensor in the same direction at each station when acquiring the measurement. The grid points of the location are shown in Figure 2. In order to prepare the data for interpretation, the data was plotted traverse by traverse and the line of best fit was drawn in each profile to obtain the residual using Microsoft Excel. The value on the line was subtracted from the original (raw data) value to obtain either positive or negative values which represent the anomaly in the data. On each profile, a tangent was drawn to the point of maximum slope and using a right-angled triangle construction, a second line with half the same slope was drawn. The horizontal distance (d), between these two tangents is a measure of the depth to the magnetic body. The above method of obtaining the horizontal distance (d) is known as Peter's half slope method. The estimate depth (Z) to the top of the magnetized body can be calculated using Equation 1.

$$Z = \frac{d}{n} \qquad 1 \quad (1)$$

where (d) is the horizontal distance between half-slope tangents and (n) is constant ($1.2 \leq n \leq 2$), but usually n = 1.6 (Peters, 1949).

The contour map (Figure 3) of the data was plotted using the Surfer software by importing the data to the Surfer software. The 3D magnetic map (Figure 4) and vector map (Figure 5) were also plotted by clicking the surface map and vector map icon respectively on Surfer software after the data have been gridded.

RESULTS AND DISCUSSION

In Figure 3, where the contour lines are closed together represent steep gradient or change in value which is the zone with higher magnetic susceptibility. Where contour lines are widely spaced represent shallow gradient or slow change in value which is zone with lower magnetic susceptibility. The prominence of sudden changes in the contour over an apprpreciable distance, that trends mostly in the south-west direction of the map suggests discontinuity in depth, possibly subsurface major faults.

The absence of any magnetic expression inbetween horizontal distance 30-50 m may be explained as the extension of deep source bodies or non-magnetic source rocks near the surface. Area with high magnetic intensities are good for engineering purpose while areas with low magnetic intensities are the suspected area for hydrogeologic purposes.

The vector map (Figure 4) suggests appreciable magnetic minerals that causes special changes in the direction of magnetic field. Between traverse 1 to 5, Figure 4 clearly shows different changes in the direction of the magnetic field which suggests that the target

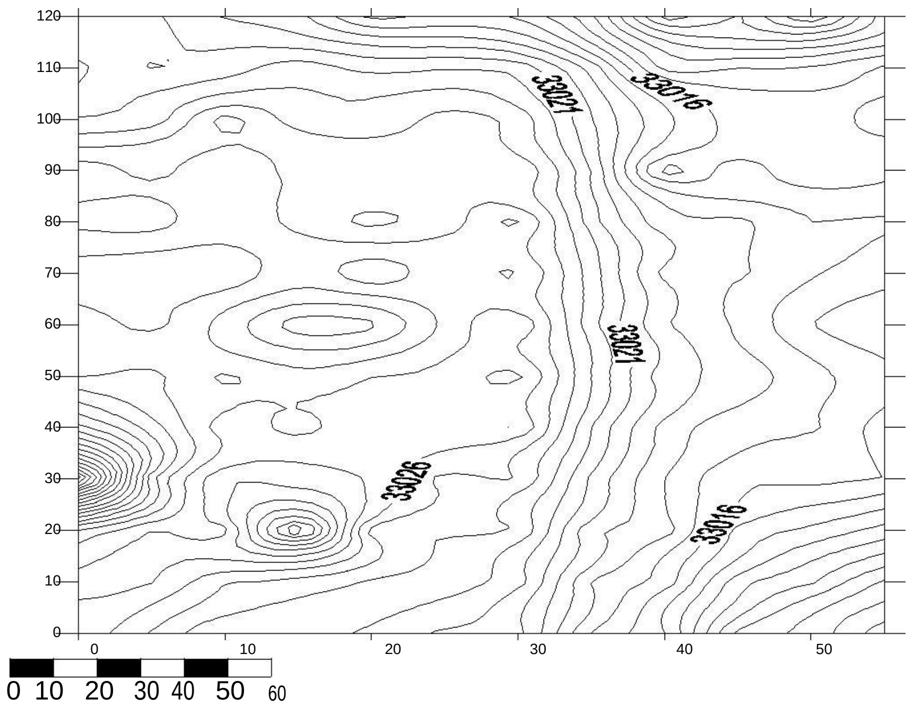

Figure 3. Contour map of the study area at Sumaje Village, Oyo State, Nigeria.

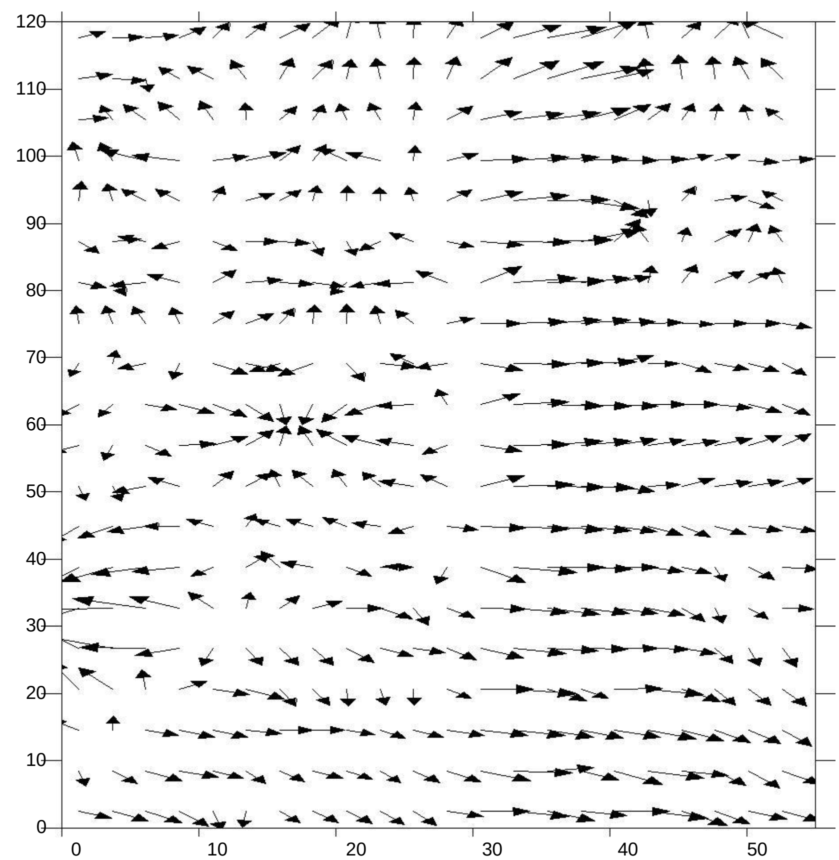

Figure 4. Vector map of the study area at Sumaje Village, Oyo State, Nigeria.

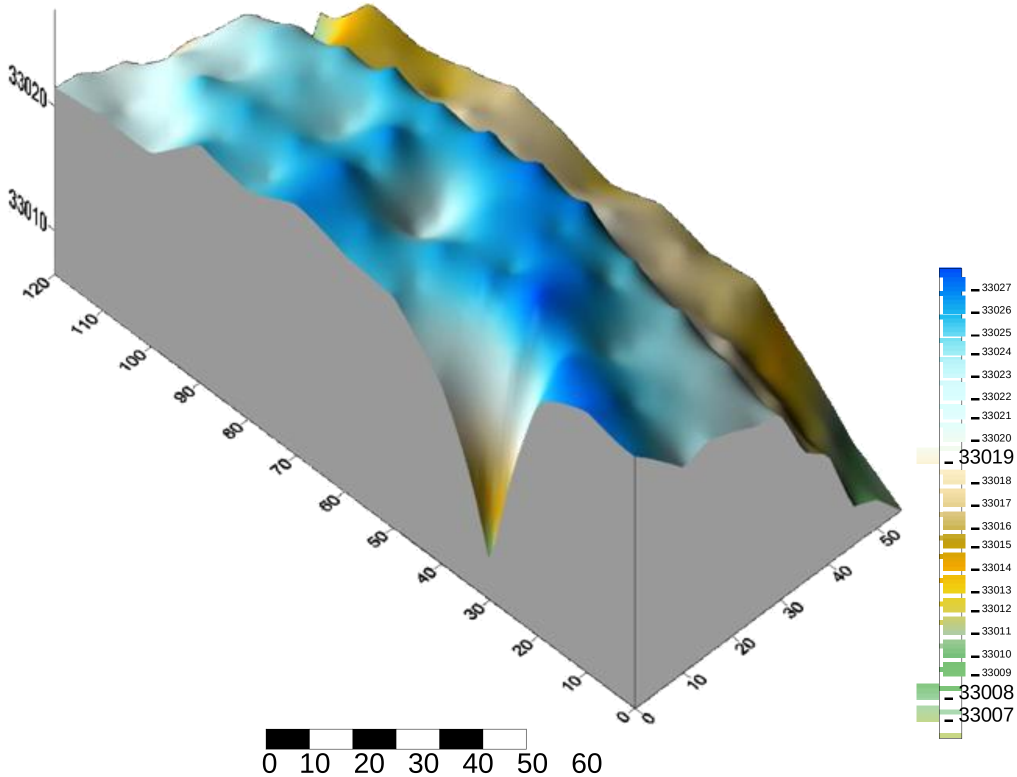

Figure 5. 3D map of the study area at Sumaje Village, Oyo State, Nigeria.

location where the magnetic mineral is of more significant is within that region of the map. That area of the map is good for engineering purpose. The other part of the map where the directions point towards the estern part of the map shows low magnetic signature and that area is good for hydrogeologic purpose.

Four of the graphs (Figure 6a to d) are presented in this paper. The four graphs are presented because they clearly have distinct magnetic signatures. The estimated basement depths were determined and presented in Table 1. Profile 1 has the highest amplitude of 18.2 nT followed by profile 9 and profile 2 with 3.2 and 3.1 nT, respectively. It was also observed that the minimum depth is 6.25 m which indicate near-surface feature.

The major rocks and minerals suspected to be found in this studied area and its environs are slate, gneiss, serpentenite, rhyolite, pegmatite, gabbro, basalts, oceanic basalts and hematite. This was achieved using susceptibility data by Parasnis (1986), Sharma (1986); Reynolds (1997) and Telford et al. (1990).

Figure 6a shows high residual values at points A, B, C and D and low residual values at points W, X, Y and Z. Point W has the minimum residual value which is the best point for hydrogeologic purpose at the studied area of Sumaje Village. Figure 6b shows high residual values at points A, B and C and low residual values at points X, Y and Z. Figure 6c shows high residual values at points A, B, C and D and low residual values at points X, Y and Z. Figure 6d shows high residual values at points A, B and C and low residual values at points X, Y and Z.

High residual points on Figure 6a to b are suspected area with near surface rocks with appreciable magnetite content. Point X on traverse 2 (Figure 6b) is suspected to be fractured because of the wide gap between point A and B. Low residual points on Figure 6a to b are suspected area with non-magnetic minerals or contact between rocks which are good points for hydrogeologic purpose.

Conclusion

The ground magnetic study of the studied area has helped in many ways to delineate the geological structures. First, the profiles obtained from the data helped in determining the depth to the magnetic basement of the studied area. Secondly, the study helped in producing contour map for the study area which will serve as a reference for further studies in the region. Profile 1 has the highest amplitude of 18.2 nT and profile 2 has the highest width of 32 m. The depth to the basement rocks ranges between 6.25 to 13.75 m. The highly mineralized region of the study area is between traverse 1 to 5.

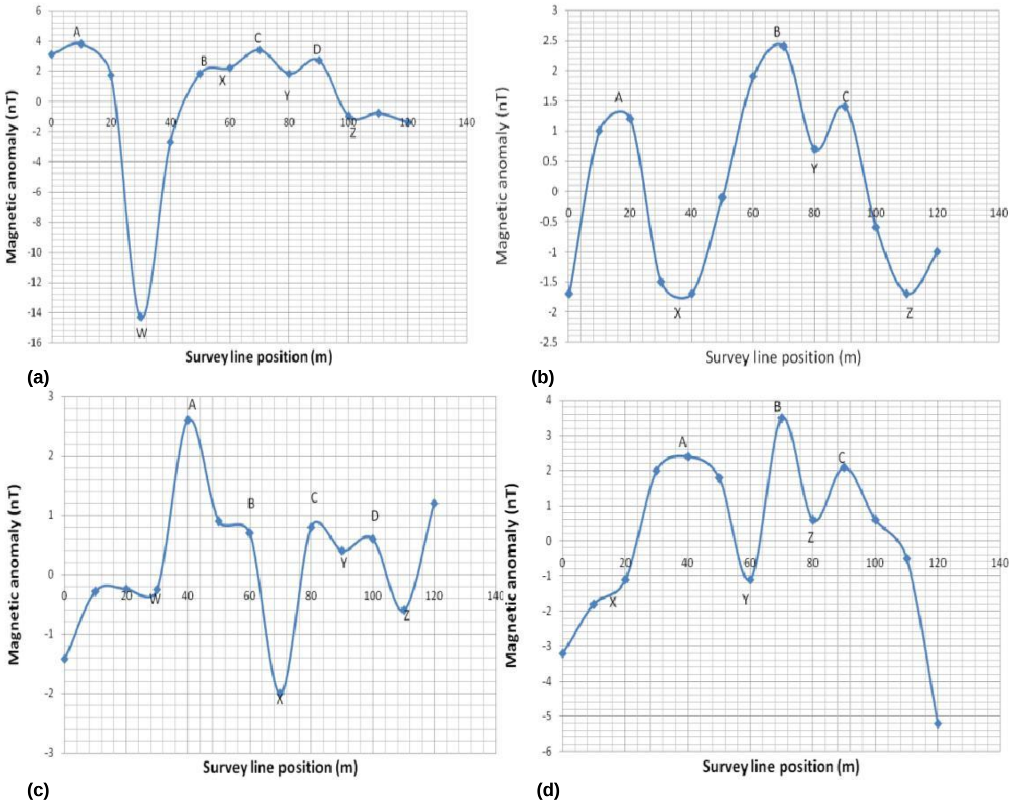

Figure 6. Magnetic anomaly of corrected data on traverses (a) 1, (b) 2, (c) 4, (d) 5.

Table 1. Estimated basement depths.

Profile	Width (m)	Amplitude (nT)	Depth (m)
1	28	18.2	6.25 – 8.75
2	15 – 32	0.7 - 3.1	6.25 – 7.5
3	14	1.2	6.25 - 7.5
4	20	2.8	6.25
5	20	1.2	6.88 – 7.5
6	23	0.4	6.25
7	12	0.6	6.25
8	14	0.4	6.25
9	20	3.2	6.25 – 7.5
10	18	0.4	6.25
11	24	1.6	6.25
12	28	1.4	6.25 – 13.75

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