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PRELIMINARY INTERPRETATION OF MAGNETIC SURVEY UNDERTAKEN IN MICHAEL OKPARA UNIVERSITY OF AGRICULTURE (MOUAU), UMUDIKE, ABIA STATE.

Igboekwe M. U.[1]***, Ohakwere-Eze M. C.***[2]***, Anyadiegwu, F. C.***[3]***, Ahamefule C. Y.***[4]***, Eme U. K.***[5]

[1,3,4,&5]**Department of Physics, College of Physical & Applied Sciences, Michael Okpara University of Agriculture, Umudike, Abia State.**
[2]**Department of Physics, Faculty of Science, Federal University of Kashere, Gombe State.**

Abstract

This presents the results of a magnetic survey conducted in the campus environment of the University. The magnetic data was collected by a 3 AxiS MCL6 Magnetometer. The data were collected from a 1km by 500m area along four profile line measuring about 1000m each. The separation between each profile is approximately 250m respectively. The magnetic survey was designed in such a way that deep insight into the depth to magnetic sources in the area was delineated. The data acquisition technique used requires measurements of the magnetic intensities at discrete points along traverses regularly distributed within the area of interest so as to cover enough segment used to determine the structure and the structural history of the study area. Coordinates were recorded using the WGS84 datum in the UTM zone 31N. The line orientation was approximately parallel to the regional geological strike. The Earth's magnetic field is a composite of anomalies of varying frequencies. The highest frequency events of interest are those created by geological conditions in the shallow subsurface and the lowest frequency events are caused by magnetic property contrasts at or beneath the basement surface. Intermediate frequency events are created within a sedimentary section. The result is minor but measurable anomalies. Important lateral variations and contrasts in magnetic properties of the shallow formations are brought about singularly or by some combination of faulting, deposition and mineralization associated with structural displacement.

***Keywords*: **magnetometer, magnetic intensities, regional, frequency, anomalies.

1.0 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]. It is this induction current that generate the earth's magnetic field [2].

A mathematical model for the earth's magnetic field have been develop by geophysicist to study and understand the intensity across the surface of the earth. Magnetometer surveys indicate that there are many unexpected variations in this model, called "magnetic anomalies". A magnetic high anomaly is where the measured field strength is higher than the value predicted by the global model, and a magnetic low is where the measured field strength is lower than the value predicted by the global model [3].

Variations or otherwise called anomalies in the earth's magnetic field are caused by induced or remanent magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferrous body by the earth's magnetic field. Possible causes for magnetic highs include the presence of magnetically charged rocks in the subsurface. Magnetic prospecting looks for variations in the magnetic field of the earth that are caused by changes in the subsurface geologic structure or by differences in the magnetic properties of near-surface rocks. The inherent magnetism of rocks is called the magnetic susceptibility.

Corresponding Author**:** Igboekwe M.U., Email: fzinoz@gmail.com, Tel: +2348036446870

Susceptibility values are important for the quantitative interpretation of magnetic data and can be used for 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 [4]. Where the rocks have high magnetic susceptibility, the local magnetic field will be strong; where they have low magnetic susceptibility, it will be weaker. Rock units with higher susceptibility will show up as areas of high magnetic field strength.

Equation 1 and 2 are known as the magnetic potential and Poisson's relation respectively, equation 2 is particularly useful in predicting the magnetic effects of buried bodies, where V is gravitational potential, G is Universal gravitational constant, ρ is density of the body, I is intensity of magnetization and i is direction of magnetic polarization.

$$U = \frac{1}{\mu}\frac{P}{r} \qquad (1)$$

Where r is the distance from source and P is the magnetic pole strength, this implies that the magnetic field is the spatial derivative of the potential.

$$U = -\frac{I}{G\rho}\frac{dV}{di} \qquad (2)$$

In studying magnetic anomalies from shallow features having economic interest, there is need to subtract larger-scale variations in the geomagnetic field from the magnetic intensities observed. We must be conversant with the earth's magnetism on a general scale to be able to determine what to subtract.

Sedimentary rocks generally have a very small magnetic susceptibility compared with igneous or metamorphic rocks, which tend to have much higher magnetite (a common magnetic mineral) content. Most magnetic surveys are designed to map the geologic structure on or inside the basement rocks (the crystalline rocks that lie beneath the sedimentary layers) or to detect magnetic minerals directly.

The aim of a magnetic survey is to investigate subsurface geology on the basis of the anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks. In general, the magnetic content (susceptibility) of rocks is extremely variable depending on the type of rock and the environment it is in. Common causes of magnetic anomalies include dykes, faults and lava flows. Magnetic gradient anomalies generally give a better definition of shallow buried features such as buried tanks and drums, but are less useful for investigating large geological features. Magnetic survey methoddetermines the sub-surface spatial distribution of rock magnetisation properties, (or susceptibility and remanence) which cause small changes in the earth's magnetic (Geomagnetic) field strength and direction.

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 remanent which formed during geologic history [5]. The ground magnetic technique requires measurements of the amplitude of magnetic components at discrete points along traverses distributed regularly throughout the survey area of interest. In ground magnetic study, three components are measured which are Horizontal, Vertical and Total components.

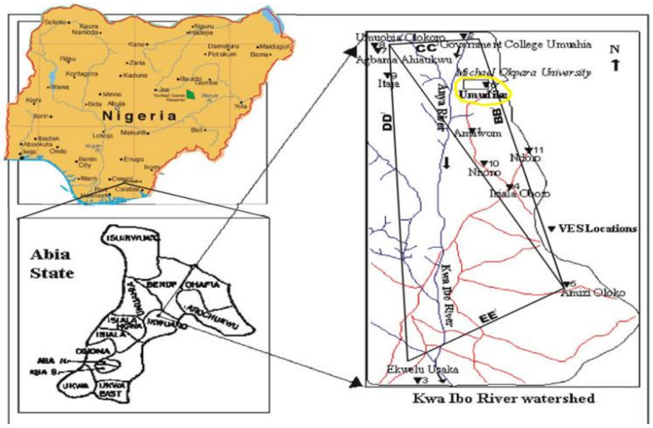

Figure 1a. Location of the field study area showing the study area circled.

2.0 Geology of Umudike

The geologic formation of Umudike is that of coastal plain sands, also known as the Benin formation. It belongs to the later tertiary to early quaternary. The formation is about 200m thick at Umudike. The lithology is unconsolidated fine-medium-coarse grained cross-bedded sands occasionally pebbly with localized clay and shale that favors aquifer formation[6].

Location/Geological setting

The survey area was located on the campus environment of MOUAU. The major link road to the university is the Umuahia-IkotEkpene Federal road, a direct route to the State capitals of Abia, Akwa-Ibom and Cross River States. Also MOUAU can be located at the latitude $5^{o}28.658^{1}$N – $5^{o}29.176^{1}$N and longitude of $7^{o}32.256^{1}$E – $7^{o}32.803^{1}$E. It is within the Kwa Ibo River watershed which has Anya River as the major tributary. The latter is found within the premises of Michael Okpara University of Agriculture, Umudike and flows across the National Root Crops Research Institute, Umudike.

3.0 METHODOLOGY

Field procedures

The magnetic data was collected by a 3 AxiS MCL6 Magnetometer. This instrument measures total field intensity, the accuracy of each measurement is independent of sensor leveling. The inherent simplicity of the MCL-6 Proton magnetometer allows rapid, accurate, high resolution measurements of the field to be obtained from a rugged, compact fieldinstrument. The data were collected from a 1km by 500m area along four profile line measuring about 1000m each. The separation between each profile is approximately 250m respectively. The magnetic survey was designed in such a way that deep insight into the depth to magnetic sources in the area was delineated. The data acquisition technique used requires measurements of the magnetic intensities at discrete points along traverses regularly distributed within the area of interest so as to cover enough segment used to determine the structure and the structural history of the study area.

Data Acquisition

Intense fields from man-made electromagnetic sources such are cars, metallic disposal tanks etc were not necessarily avoided as survey area is the ever busy campus environment. However large belt buckles, etc., were removed when operating the unit. A compass should be more than 3m away from the magnetometer when measuring the field. The magnetometer was immobilized to ensure that it has attained stability after while base station readings were collected over a period of 24 hours. Reading from the base station tends to show stability in the morning than in the afternoon hence the acquisition of magnetic data was done in the morning.

Total field magnetic readings were recorded using the magnetometer. The survey direction and station locations were determined using Garmin GPS model. Coordinates were recorded using the WGS84 datum in the UTM zone 31N. The line orientation was approximately parallel to the regional geological strike.

Data presentation & processing

To make accurate magnetic anomaly maps, temporal changes in the earth's field during the period of the survey must be considered. Normal changes during a day, sometimes called diurnal drift, are a few tens of nT but changes of hundreds or thousands of nT may occur over a few hours during magnetic storms. During severe magnetic storms, which occur infrequently, magnetic surveys should not be made. The correction for diurnal drift was made by repeat measurements of a base station at frequent intervals. The measurements at field stations are then corrected for temporal variations by assuming a linear change of the field between repeat base station readings. After correcting for drift variation, the total magnetic fields were then filter to remove excess noise using the first order polynomial analysis and then plotted as contour (Figure 1b). This was done using the interactive Sulpher 11 software on a work station.

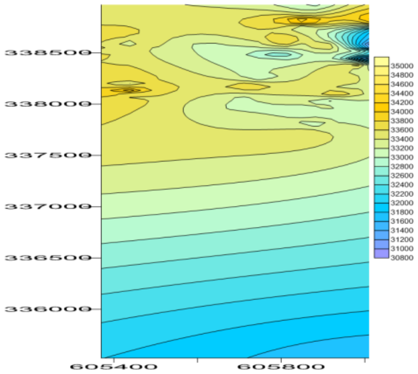

Fig 1b: Total magnetic field collected directly from the field

The total magnetic field is seen to be distorted towards the right hand end of the map. This indicated that a magnetic anomaly exit.

4.0 RESULTS

Interpretation: anomaly types

In this study, we adopted the two most convenient methods of interpreting residual magnetic field data. These are profile lines and contour maps.

Profile Lines Interpretation:

Three types of geomagnetic anomaly have been distinguished in the data:

Positive magnetic regions of anomalously high or positive magnetic field gradient, which may be associated with high magnetic susceptibility soil-filled structures such as pits and ditches.

Negative magnetic regions of anomalously low or negative magnetic field gradient, which may correspond to features of low magnetic susceptibility such as wall footings and other concentrations of sedimentary rock or voids.

Dipolar magnetic paired positive-negative magnetic anomalies, which typically reflect ferrous or fired materials (including fences and service pipes) and/or fired structures such as kilns or hearths.

In profile lines interpretation, residual magnetic field are plotted along distance. The variation in the field is presented as both positive and negative. It is important that you examine the magnetic data and note the range of frequencies. This will give you an appreciation of the likely depth range of the magnetic bodies. As a rule of thumb, for a well-defined peak, the depth of the corresponding source is approximately equal to the width of the peak at half of its amplitude.

Figure 2: Magnetic profile along profile 1.

Profile 1: From profile 1 (figure 2), magnetic data were collected from 20 sampling point at a distance of 50m each. Magnetic high were observed from the beginning of the profile to a distance of about 110.0m. This indicate a reasonable thickness of the over burden within the section. However, there is a sharp drop afterwards and rise at about 460m showing a magnetically quiet zone at the rest of the profile.

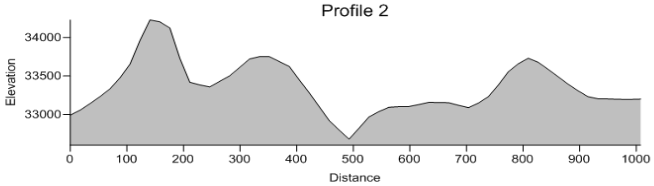

Figure 3: Magnetic profile along profile 2

Profile 2: From profile 2 (figure 3), magnetic data were collected from 20 sampling point at a distance of 50m each. At a distance of about 490.0m, fall in the magnetic signal may be as a result of a fault within the basement. However, sharp decreases noticed along the profile are an indication of a magnetic anomaly within the section.

Figure 4: Magnetic profile along profile 3

Profile 3: From profile 3 (Figure 4), magnetic data were collected from 16 sampling point at a distance of 50m each and shows an undulating basement. However, between 620-700m, magnetic high peak was observed indicating an intrusive body of high magnetic susceptibility.

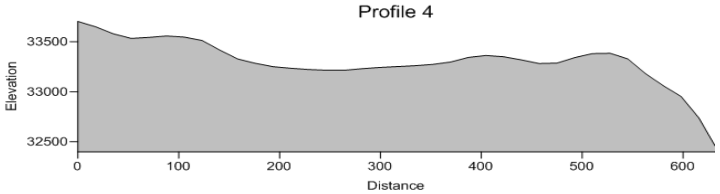

Figure 5: Magnetic profile along profile 4

Profile 4: From profile 4 (Figure 5), magnetic data were collected from 20 sampling point at a distance of 50m each. At a distance of about 550.0m, fall in the magnetic signal may be as a result of a fault within the basement.

Contour Map Interpretation:

A colour-coded contour map of the residual magnetic field was used in the presentation of the magnetic data of this area (Figure 6). From the contour map, a striking anomaly can be seen at the top right side of the map which is the beginning of the first profile.

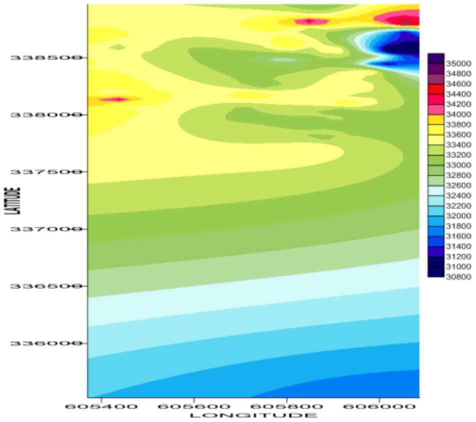

Figure 6: Residual magnetic field within the study area

Conclusions

The Earth's magnetic field is a composite of anomalies of varying frequencies. The highest frequency events of interest are those created by geological conditions in the shallow subsurface and the lowest frequency events are caused by magnetic property contrasts at or beneath the basement surface. Intermediate frequency events are created within a sedimentary section.

There are a number of geological causes for local distortions in the Earth's magnetic field. Causes especially important to an explorationist are those that put near-surface formations with contrasting magnetic properties in contact with one another. The result is minor but measurable anomalies. Important lateral variations and contrasts in magnetic properties of the shallow formations are brought about singularly or by some combination of faulting, deposition and mineralization associated with structural displacement.

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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