Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2016, 3(2):1-7

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Assessment of the Reliability of Magnetic Method to Delineate Geologic Features in a Basement Complex: A Case Study of Phase 1, Federal University Oye

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Abstract A geophysical survey using magnetic method was carried out to map the bedrock topography, delineate region of potential stress amplification and to map structures such as faults and contact zones in Oye Ekiti, Ekiti state, south western Nigeria. Nine traverses were laid in the east-west direction of the surveyed area for the investigation. The station separation was ten metres interval and records of total magnetic field were made from the proton precision magnetometer system. The data obtained were subjected to drift correction and filtered. Softwares such as Grapher, Magmap 2000, Magpick and Sulpher-8 were employed for the processing and data reduction. The magnetic data are presented in form of magnetic profiles and maps. Total magnetic field plot of the entire survey profile describes a noted trend that agrees with known geology or suspected feature areas of high/positive and low/negative magnetic anomalies. The map shows the areas of high magnetic gradient (closely packed contour lines) which coincide with the part of the surveyed area with outcrops and areas of low magnetic gradient (sparse distribution of contour lines) which is the area of the plain land with no physical features. The depth to the top of the bedrock ranges between 0 m and 6.6 m. From the result of the magnetic survey, it is obvious that there is assuring ability of the method to actually delineate interesting features in the basement complex terrain.

Keywords bedrock, magnetometer, drift-correction, basement complex

Introduction

Geophysics is a branch of earth science which involves the application of physical principles and mathematical procedures to delineate the sub-surface. Geophysicists examine physical phenomena and their relationships within the earth; such phenomena include the earth's magnetic field, heat flow, the propagation of seismic (earthquake) waves, and the force of gravity.

To achieve this, various geophysical methods were invented using various earth principles. The application of these methods has gone a long way to solve various problems ranging from ground water, environmental, engineering and exploration.

This paper focuses on the application of magnetic geophysical method in basement complex terrain to investigate subsurface geology on the basis of anomalies in the earth's magnetic resulting from magnetic properties of the underlying rock forming minerals and non-magnetic minerals.

Scope

The study is a reconnaissance study to have preliminary information about the area. In doing this, both geological and geophysical surveys were carried out. The surface geophysical investigation includes the use of:

- Magnetic prospecting method

And the scope of the study includes:

- Laying of traverses in the East – West direction at regular interval, taking the GPS position and the elevation.
- Data acquisition and analysis.
- Data processing
- Data interpretation.

Aims and Objectives

- To map the bedrock topography.
- To delineate region of potential stress amplification.
- To delineate zones of weakness
- To determine the depth estimation to the top of the causative body.

Site Location and Description

The area under investigation is situated in Northern part of Oye Ekiti, Ekiti state, Nigeria. The survey covers an approximate area of 18000 m^2.

Accessibility

The study area is easily accessible due to its proximity to farmland and residential areas as it enjoys good number of minor roads connecting them. Cutlasses were used to clear bushes so as to make way for the traverse. Most of the areas were easily accessed.

Principle of Magnetic Method

This method in applied geophysics depends on measuring accurately the anomalies of local magnetic field produced by the variations in the intensity of magnetization in rock formation. The magnetization of rock is partly due to the induction of magnetizing forces associated with the earth fields and partly by their permanent (remanent) magnetization. The induced intensity depends primarily on the magnetic susceptibility as well as magnetizing force and the permanent (remanent), intensity depends on the geological history of the rock. The method is the measurement of direction of gradient or intensity of the earth's magnetic field and interpretation of variation in quantities over the area of investigation. The most significant magnetic property of rocks is their susceptibility K which is defined as a measure of the magnetic mineral content in a rock [1-2]. It is the fundamental parameter in magnetic prospecting. In case of homogenous external field H, for a field normal to the surface of a material, capable of being magnetized, the induced pole strength per unit area is:

$$J = KH \qquad 1.1$$

Where, J = Magnetization

K = Susceptibility (proportional constant)

H = Magnetic field for an external field which makes an angle, θ with the normal to the surface of material

$$J = KH \cos\theta \qquad 1.2$$

For low magnetic concentration, there is an approximately linear relationship between the percentage of magnetic and susceptibility, K, which is expressed as K=0.3 P, where P is the percentage (by volume) of dissemination magnetic [3-4].

Field Layout of the Survey

A total of nine profiles were established of varying lengths (the second traverse was of length 180 metres but other traverse has a length of 170 metres). Traverses 1,3,5,7 and 9 were established from west to east to cover some paths of the study area. Traverse 2, 4, 6 and 8 were established from east to west of the survey area. The station separation is of 10 m interval.

Data Processing of Magnetic Survey

A magnetic survey involved data reduction technique because of instrumental drift amongst others. Softwares such as Grapher, Magmap 2000, Magpick and Sulpher 8 were employed for the processing. Therefore, the data obtained in the study area were subjected to drift correction after which a three point running average filter was used to smoothen the data. The relative magnetic values obtained are the difference in the filtered corrected magnetic reading and the base station reading.

Data Presentation

The magnetic data are presented in form of magnetic profiles. This is achieved by drawing the drift corrected relative magnetic intensity on the vertical axis and station position on the horizontal axis. Also, by residualizing the regional and observed magnetic readings. The Profiles were subjected to both qualitative and quantitative interpretation.

Qualitative Interpretation of Traverse 1

Figure 2 is the ground magnetic profile of traverse 1. This traverse covers a total length of 170 m and trends west-east direction. Its magnetic amplitude ranges from -571 to 12 gammas. The anomaly signature showed various peak along the profile, this may be due to presence of structures that is associated with this area (bearing in mind that this area is a basement complex environment). After various processing, it was discovered that the depth to the top of the bedrock is 4.3 m using half slope method. Between 0 and 60 m, and from 60 m distance to the end of the traverse, the depth varied between 2.6 and 4.3 m. The contrasting magnetic intensities vary from -710 to -150 gammas at distance 0-180 m that is indicative of varying magnetic mineral content. Areas of magnetic lows were observed between 60 and110 m and between 120 and 170 m. In the geomagnetic section figure 2, one kind of depression is noticed this could be due to the effect of a fault or basement depression and this area could serve as an area of good aquifer.

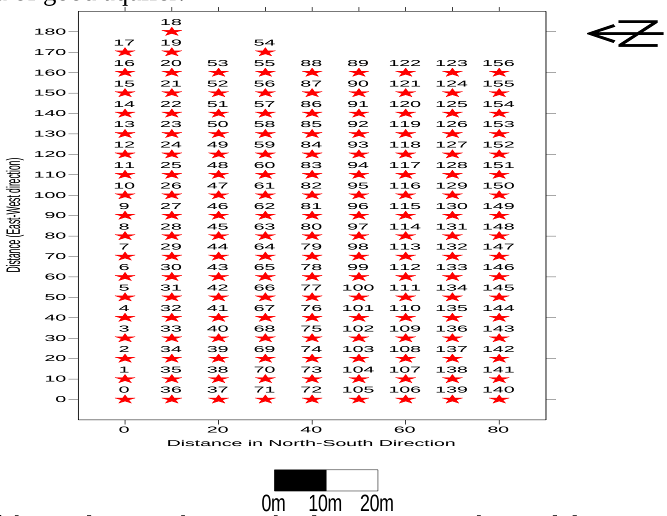

Figure 1: Base Map of the Study Area showing the data points number and direction of movement

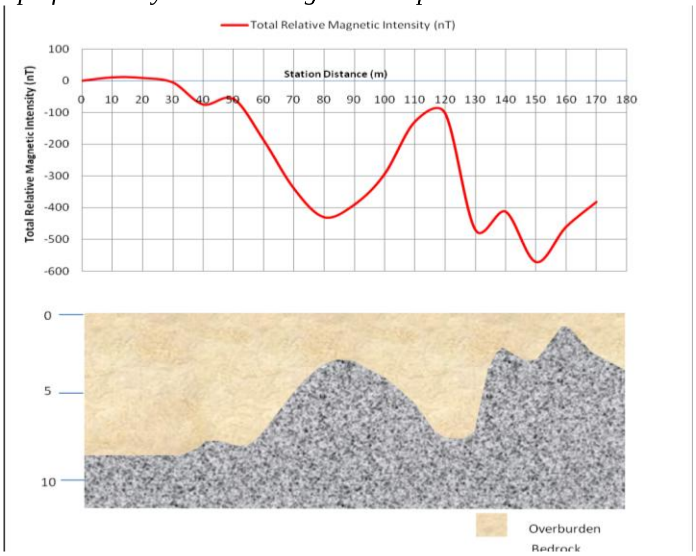

Figure 2a: Magnetic profile and section of Traverse 1

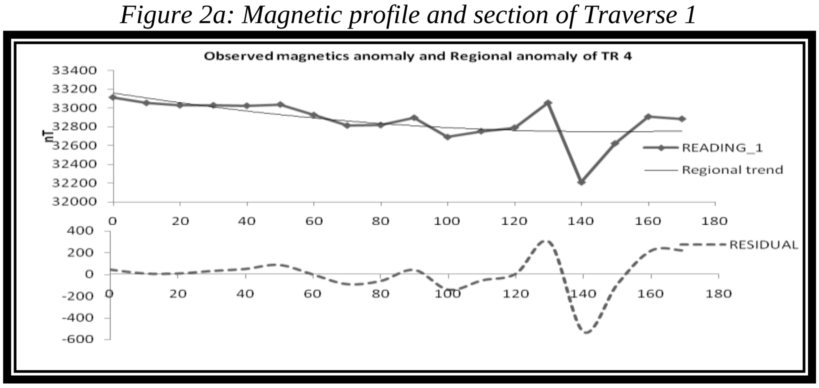

Figure 2b: Ground magnetic profile of Traverse 4

Residual Anomaly Profile

Residualizing is done so as to separate a curve or a surface into its long wavelength _or low-frequency parts, called the regional, and its short-wavelength _or high-frequency parts, called the residual. Residualizing attempts to predict the regional effects and find local anomalies by subtracting the regional effects. This separation is not unique. Residualizing methods used in this project include:

(a) Graphical methods, in which a smooth regional is drawn on a profile and contours are smoothed and spaced more uniformly.
(b) Polynomial method, in which the regional is represented by a polynomial fit to the observed data.
(c) Spectral-domain filtering, in which certain wave numbers are attenuated by filtering.
(d) Stripping method, in which the field of a model that represents certain parts of the geology is calculated and subtracted from the observed field
(e) Upward continuation, which attenuates the effects of shallow sources.

These methods can be thought of as 2D convolution operations _map convolution_ and some of them produce halo effects about local anomalies of the studied area as presented in profiles below and maps.

Discussion of the Result from the Maps

Figure 3 is a map showing the Total magnetic isoanomaly map as distributed across all the nine traverses. From the map it was observed that there is a presence of low magnetic susceptibility from traverse 1 to 6 and in traverse 7 we have high magnetic susceptibility which is a good indicator that traverses 1 to 6 may likely contain the presence of a magnetic rock or mineral deposits.

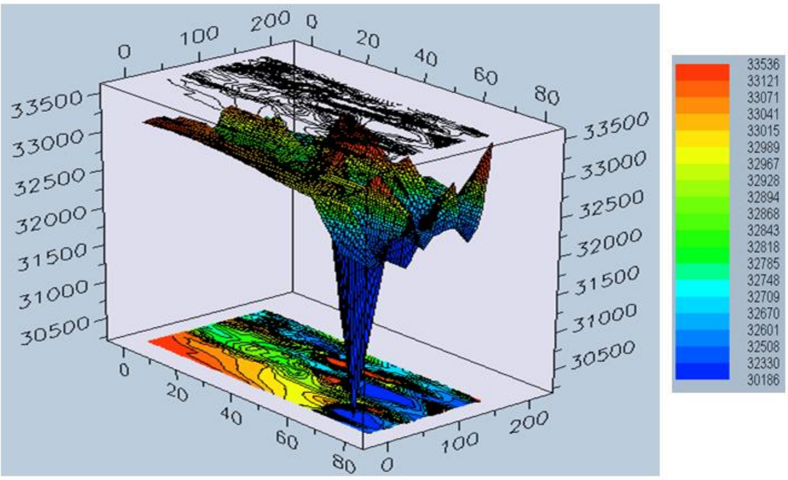

Figure 3: 3D surface for sensor 1 of the magnetic isoanomaly map of the study area

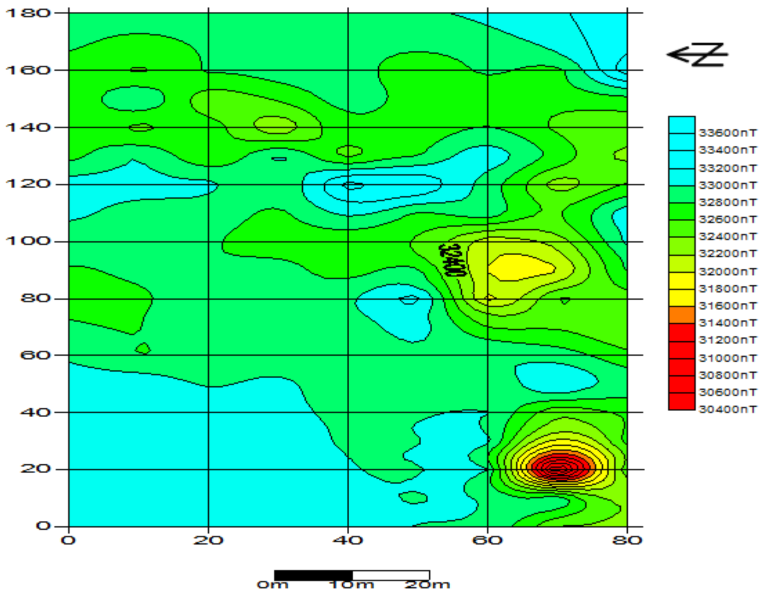

Figure 4: Drift corrected total magnetic intensity anomaly map

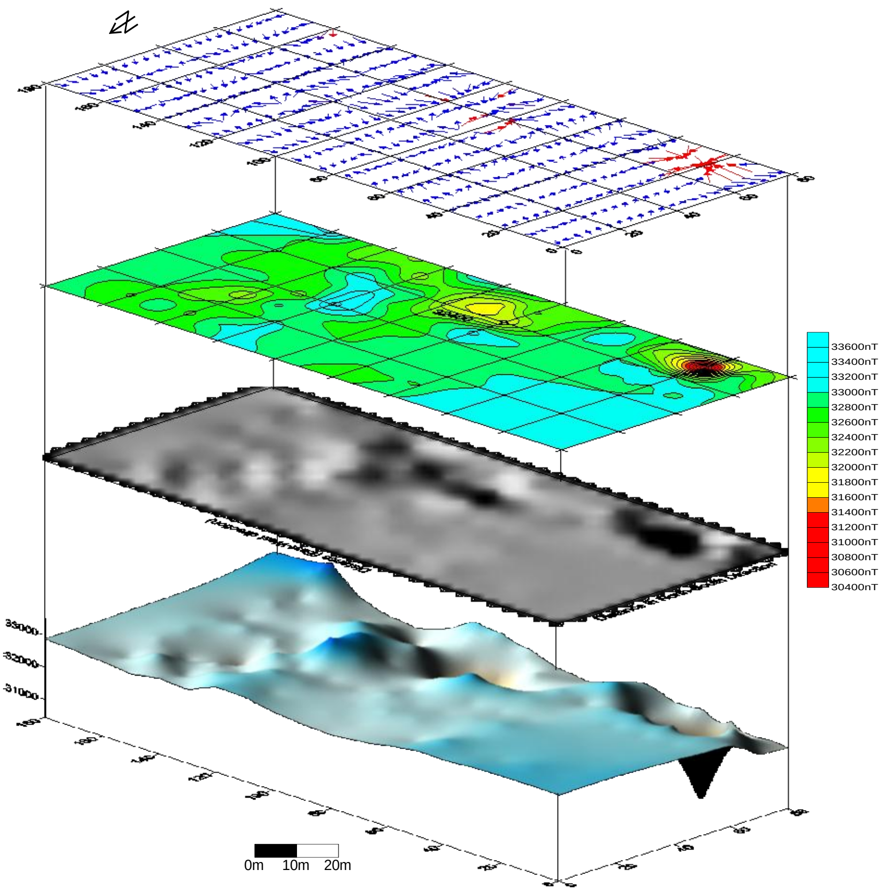

Figure 5: 3-D view of the surveyed area

Figure 6a is a despiked stack profile of sensor 1 showing some interesting anomalous signals on the traverses. These anomalous signals follows a trend on the stack profile with more pronounced effect on trasverse 7,8 and 9 which actually agrees and denotes the known geologic feature on the surveyed site which is the outcrop on the surveyed area. For some surveys, it is useful to view the magnetometer data of different lines at the same time in order to look for trends that occur between different lines. Since an anomaly usually can be seen from adjacent lines, anomalies can be distinguished from noise by looking at several lines. We can also locate presence of objects that extend over many lines. Magmap's stack profile presents a way of looking at the magnetometer data of several lines at the same time. It scales the magnetometer data over each individual mapped survey line. Another importance of this is that it makes the anomaly of interest to be identified and discriminate against the obscuring effects of others. Recognition of the anomaly itself is usually the most difficult aspect of depth determination because of the composite effects of multiple sources, sources at various depths and at various distances in any direction from the magnetometer. Only the net effects of all anomalies are measured by the magnetometer since it has no inherent discrimination ability at the disposal of the operator. The anomaly will be further inspected by production of filtered maps and upward continuation maps to ascertain the probable source and, if complex, the possible combination of sources as regards the geology of the area and the physical features in the field. The regional gradient or background is subtracted from the anomaly and the remaining, residual anomaly, re-plotted. It is this anomaly which is then interpreted for both depth, for amplitude and general configuration of sources

The pseudo Gradient map of the area which is the difference between magnetic field responses of the sensor 2 and 1 of the area was generated after removing 3-degree trend surface from sensor 1. The trend- surface analysis and the digital filters have accentuated the effect of the anomalous sources of the field geology that have been computed using standard methods based upon a geomagnetic field that has an intensity of 32,000nT and is oriented 70^0 degrees below the horizontal. The map shows the areas of high magnetic gradient (closely packed contour lines) which coincide with the part of the surveyed area with outcrops and areas of low magnetic gradient (sparse distribution of contour lines) which is the area of the plain land with no physical features.

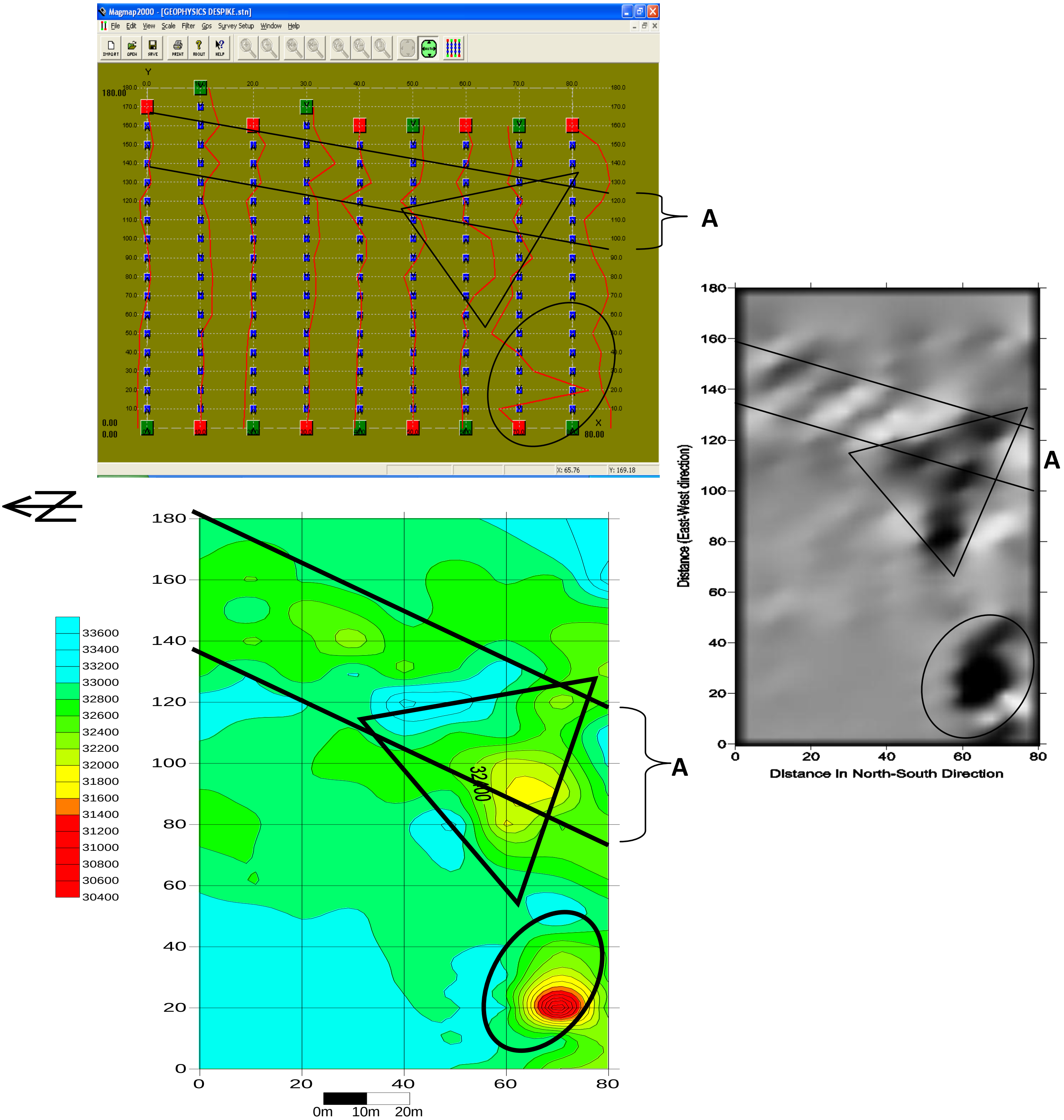

Figure 6(a,b,c): Different shapes showing similar anomaly and signature on different maps

The comparison of the filtered maps with one another and with the actual isoanomaly maps has been helpful in illustrating their relative effectiveness in isolating and enhancing specific anomalies and attributes of the observed field. Seldom is a single filtered map adequate for interpretational purposes; rather comparisons among filtered maps and the original unfiltered data is needed in the effective interpretation process has employed in this project. It is interesting that despite different data processing procedures and filtering processes, all the

maps are showing the same trend i.e attitude/pattern of the contour in same section of the different maps. This confirms the presence of an outcrop in the surveyed area and coincides with the areas of high magnetic gradient.
The Upward-continued magnetic anomaly to 50m and 30m smoothen the magnetic field with increasing elevation permitting the observation of the longer wavelength anomalies free from the distorting effect of the local anomalies related to aerially-restricted sources. The North-South boundary between the surveyed areas actual depicts that the eastern part of the surveyed area is a low lying outcrop close to a bigger outcrop (domal in shape) with the N-S anomaly gradient. This effect is marked on comparing the magnetic anomaly map of upward continued to 50m and 30m with the total magnetic isoanomaly map.
Reduced-to-pole map shows some isolated anomalies that are more symmetric and are shifted by several meters from the comparative anomaly from Low-Pass filtered magnetic anomaly map of the surveyed area. The shift of the anomalies brings the isolated anomalies of the reduced-to-pole map into spatial coincidence with the total magnetic isoanomaly map and the location of the sources (figure 4).
Three (3) point moving average filtering technique was carried out on the data acquired so as to enhance the anomaly. This technique will accentuate a particular characteristic and increase its perceptibility of which the anomaly characteristics of interest in filtering can be used in an inspection interpretation. The filtered data was used to produce the map (figure 4) which still has the same type of closures on same part of other maps.

Conclusion

The results of the entire magnetic survey carried out in a part of Oye Ekiti, Ekiti state indicate that the closures on maps coincides with areas with outcrops and areas with very thin overburden thickness where the bedrock is very close to the surface. From the magnetic survey it was observed that the area under investigation is characterized by a relative magnetic reading that is low on outcrops except for some areas that the magnetic reading is high. This means that traverse one to six (1-6) actually show the presence of very thin overburden thickness in the eastern part of the area and on traverse seven to nine (7-9) are presence of a low-lying outcrops in the western part of this area. It was also noted that the depth to the top of the bedrock ranges between 0m and 6.6m.
A large peak (very dark spot on the contour graph) can be indicative of a large object, or something near the surface. The width of the anomaly had distinguished this. An object buried close to the surface will tend to have a high peak but narrow width, whereas the same object buried deeper will give a larger width and shorter peak as being observed in the areas with outcrops. From the result of this magnetic survey, it is obvious that there is assuring ability of the method to actually delineate interesting features in a typical basement terrain as the studied area.

Reference

1. Dobrin, M.B. (1976): Introduction to Geophysical prospecting (2nd edition) Mc Graw-Hill book, London.
2. Folami S.L. (1980): Paleomagnetism and rock magnetism of Ice land drill core samples unpublished M.Sc. Thesis, University of Washington, pg. 45.
3. Parasinis, D.S. (1976): Principles of Applied Geophysics (3rd edition) Chagman and hall. London.
4. Telford W.M; Geedart, E.P. Sheriff R.E. and Keys D.A. (1984): Applied Geophysics (9th edition) in pp 671-672 Cambridge University.