Journal of the Nigerian Association of Mathematical Physics
***Volume27*, (*July, 2014*), pp335 – 340**
© J. of NAMP

Determination of Depth to the Top of Magnetic Sources beneath Zaria Area, North Western Part of Nigeria

[1]Usman, N. and[2]Lawal,K.M

[1]Department of Physics, Umaru Musa Yar'adua University Katsina, Nigeria
[2]Department of Physics, Ahmadu Bello University Zaria, Nigeria

Abstract

In this research, the aeromagnetic data of Zaria area is used, to determine depth to the top of magnetic sources, along the three selected profiles (AA', BB' and CC') in order to produce depth map of the study area. The data was obtained by digitizing the aeromagnetic contour map (sheet 102); within the area of approximately 3025km2 in the north western part of Nigeria. The magnetic source values obtained from the data of Zaria area using Werner deconvolution method vary from 0.01 to 1.41km for the sources on the surface of the earth and 0.01 to 3.17km below the earth surface while the magnetic field intensity along the three profiles analyzed varies from -150 to 70nT. It is observed that the anomalies in the residual aeromagnetic map are caused by the intruded and shallow rocks, while some are due to the presence of faults and fractures as in the north eastern part of the study area. The result indicated that magnetic properties and broadness nature of a given magnetic profile determine the number of the sources to be obtained. The filtered result of the quantitative interpretation was used to prepare the depth map which indicated that the depth points of the causative bodies are mostly shallower with the highest value of about 2.5 km and this is one of the factors that hinder the prospect of petroleum exploration in the area.

Keywords: Aeromagnetic data, residual anomaly, depth to the top, depth map and Zaria

1.0 Introduction

The main purpose of the aeromagnetic survey is to detect minerals or rocks that have unusual magnetic properties which reveal them by causing anomalies in the intensity of the earth's magnetic field. The aeromagnetic survey is applied in mapping these anomalies in the intensity of the earth's magnetic field and this is correlated with underground geological structure [1]. The aeromagnetic survey is cheap for investigating large area, it is less time consuming which decreases diurnal changes, the measuring instruments in the airborne are more sensitive than those use in the ground work, altitude may be chosen to favor structures of certain type and depth [2].

A ground Magnetic investigation in the Kubani River Basin, Zaria was conducted [3]. A quantitative interpretation of the residual anomaly map shows a maximum depth to basement value of 52.5m around UnguwanMaigamo village. Reduction to the pole technique was applied to the aeromagnetic data of Zaria area and estimated the depth to the top of 1.8km and 4.3km [4]. A gravity survey was carried out in order to investigate the batholiths in the Zaria area. A three dimensional modelling of the residual anomalies reveals the existence of three distinct batholiths located at depths of two to three kilometers with magmatic mode of emplacement [5].

This research is carried out in order to produce depth map of the study area. The objectives of this research work are to obtain the depth (to the top) estimates of the causative bodies, to interpret the residual anomaly, and to show the relationship between the depth estimate and the total field intensity (graphically).

2.0 Materials and Methods

The aeromagnetic map of Zaria area (sheet 102), on a scale of 1:100,000, was obtained from Geological Survey of Nigeria [6] and digitized. The total magnetic field intensity consists of two components; regional and residual field. Polynomial fitting of the first order is employed in this research in order to separate the two components. The residual field is the component of the magnetic field which represents the effect of near surface bodies. The values of the residual field together with the respective geographical coordinates were then map as shown in Figure 1.

Corresponding author: Usman, N.E-mail:uk_nuraddeen@yahoo.com,Tel.: +2348032155545

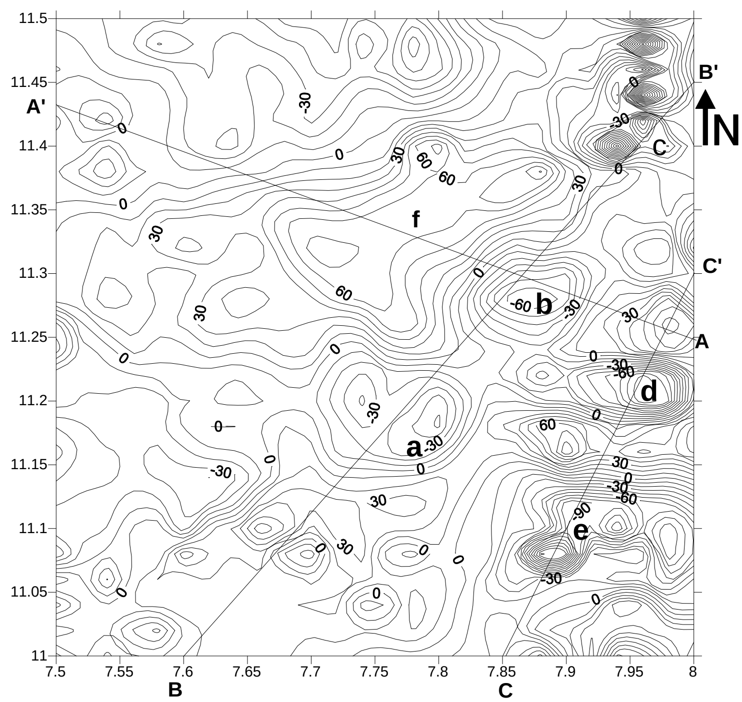
Theory of the computational method: The basic equation for the computation of depth to the top is given as:

$$x^2F(x) = a_0 + a_1x + b_0F(x) + b_1xF(x) \quad (1)$$

$$X_0 = \frac{1}{2}b_1 \;\; and \;\; Z = \pm\sqrt[\frac{1}{2}]{-4b_0 - b_1^2} \quad (2)$$

The depth (z) and the surface point directly above the center of the top of the dike () can be determined from the solution of equation (1) using the relation: (2)

Where X_0 is the surface point directly above the center of the top of the dike, x is the point of measurement and x axis is normal to the strike, and z is the depth to the top [2].



Scale. 1:360,000

Legend: **30** a contour line showing magnetic field intensity, 30nT

Figure 1: Residual aeromagnetic anomaly map

3.0 Results and Discussion

Figure 1 shows the residual aeromagnetic map of Zaria area [7] where three profiles were selected for the quantitative interpretation in order to estimate the distance along the profile to the center on the top of the dike and depth of the causative body using Werner deconvolution technique mentioned above when the sources are assume to be dike and contact. The profiles are AA', BB' and CC' were used for detailed interpretation (Figure 1).

The program used to analyze the data of the three profiles mentioned above, interpret evenly spaced profile data in accordance with the equations given in the theory of the method. The results are: distance along the profile to the centre on the top of the body, magnetic susceptibility, dip and depth when the sources are assumed to be contact and dike. The result obtained is then filtered using the parameter of 2. There is the provision of filter in the program in order to remove noise.

The depths along each profile obtained were plotted against the distance along the profile in order to produce 'Werner profiles. When the depths were plotted against the distance, intrusions were observed. These are shown in the figure 2, 3 and 4. The origin (0) of the graphs (2,3,4,5,6 and 7) indicates the surface of the Earth, negative values represent the depth points below the ground surface and positive values along the depth (km) axis shows the intrusions on the ground surface. A particular body can be defined by observing the clustering of depth points.

Profile AA': There are about four bodies below the earth surface and two major intrusions (Figure 2) which are responsible for causing anomaly b and f in Figure 1. The depth value of 3.2km below the surface along this profile is not consistent with the rest of the values and therefore can be discarded so that depth values obtained vary from 0.07 to 0.87km on the earth surface and 0.01 to 3.17km for the sources below the earth surface (Figure 3).

Profile BB': It passes through three major closures (a, b and c in Figure 1). It is clearly seen in Figure 3 that, by observing the clustering of depth points, there are about two or three bodies along this profile. Up to about 14.5km there were no results obtained along this profile (Figure 3). Also, about 4km to the extreme end of this profile (toward B') there was no result obtained (Figure 1) despite the fact that the area is characterized with high total magnetic field intensity. Therefore, the high magnetic field intensity in the area is due to the presence of faults, fractures or the variation may be due to noise which is taking care by the polynomial in the Werner interpretation equation. Along this profile, there are large vertical scatter of the depth points, this is simply because a particular feature may yield both the total field and horizontal gradient result. The depth values obtained vary from 0.01 to 1.41km on the earth surface and 0.02 to 2.34km for the sources below the earth surface (Figure 3).

Profile CC': The contours d indicate dike body. The result obtained along this profile is not much because of its broadness nature and low magnetic properties compared to the rest. The depth values obtained vary from 1.37 to 1.01km on the earth surface and 0.1 to 2.34km for the sources below the earth surface (Figure 4).

The depth values were filtered using the parameter of three and then plotted against the distance along the profile together with the magnetic field intensity and the distances along the profile are also plotted, these are shown in the Figure 5, 6, and 7. Only the depth values below the ground surface remained. The graphs in these figures indicate that the higher the depth of the magnetic source the lower the magnetic field intensity the body produces. In effect, the shallow sources produce more magnetic field than the deeper once.

Depth Map:

The depth points obtained from each profile shown in Figures 5, 6 and 7 were then compared with the data file containing geographical coordinates and the distance along the profiles obtained from Figure 1 in order to establish depth map for the study area. The geographical coordinates with their corresponding depth points are then taken and used as the data basis for the depth map. The data for each profile were then merged together and interpolated using the software Surfer V.7.0. The data is then contoured as shown in Figure 8.

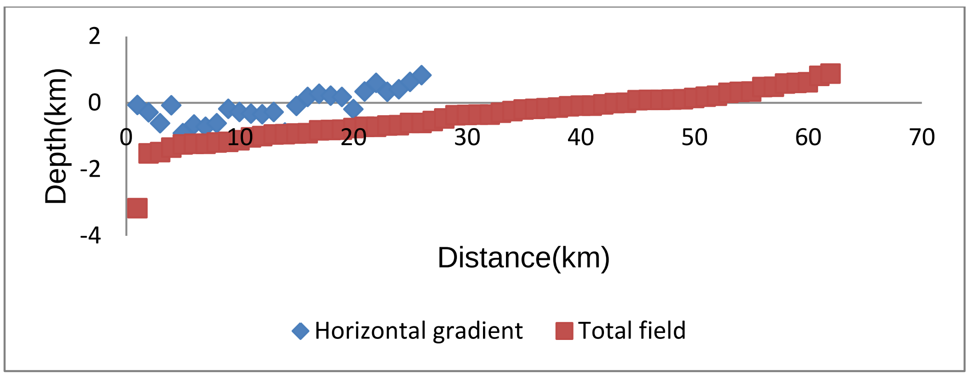


Figure 2: Profile AA' magnetic source bodies

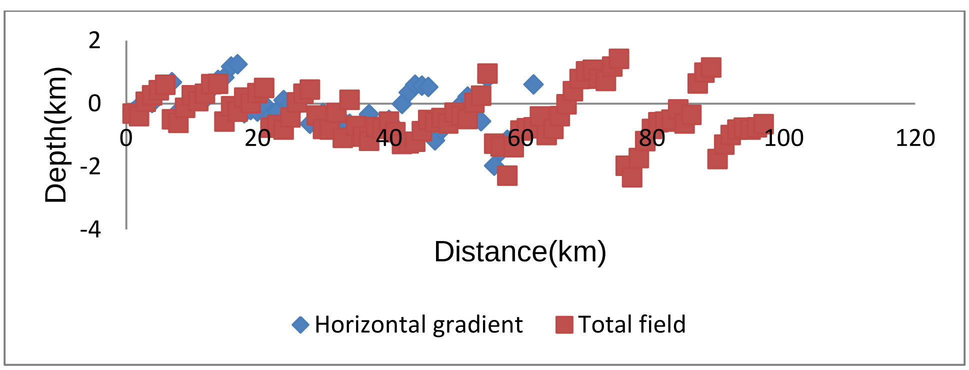


Figure 3: Profile BB' magnetic source bodies

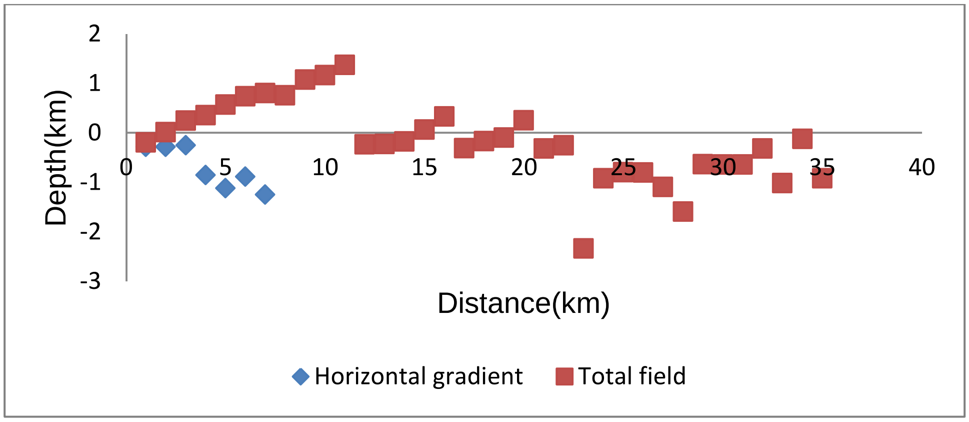


Figure 4: Profile CC' magnetic source bodies

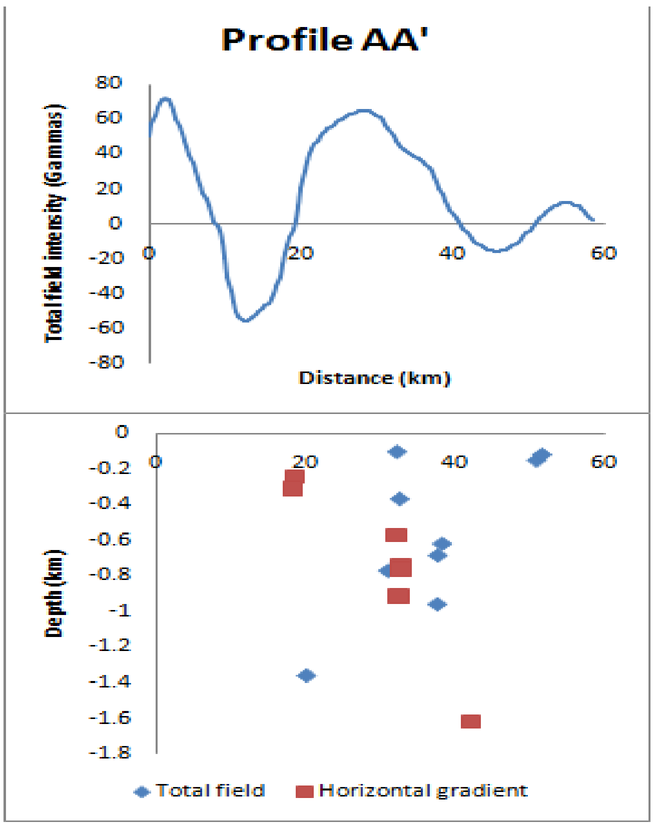


Figure 5: Werner profile processed to define magnetic basement beneath the major anomalies AA'.

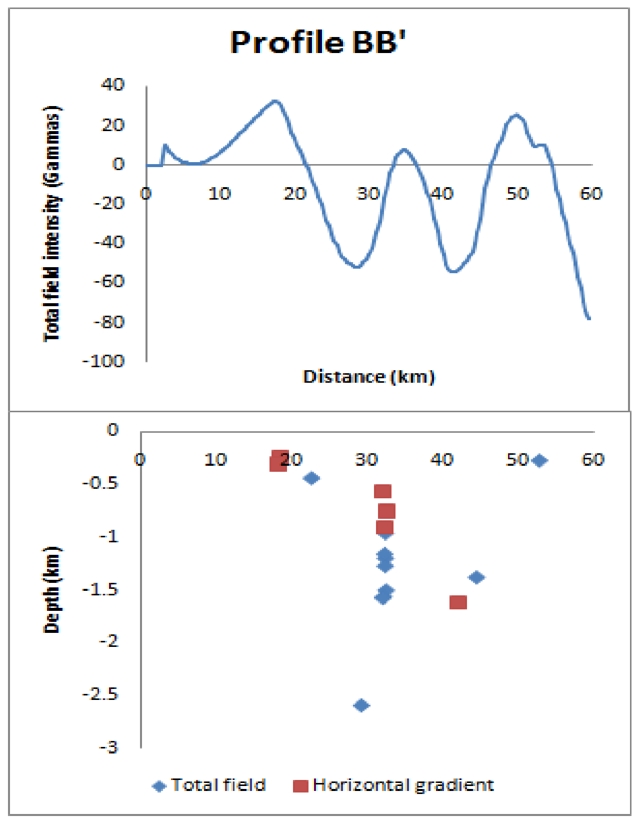


Figure 6: Werner profile processed to define magnetic basement beneath the major anomalies BB'.

The results of the quantitative interpretation of the depth points shown in Figure 8 indicates that the depth points of the causative bodies are generally shallower with the highest value of about 2.5 km along profile BB'.

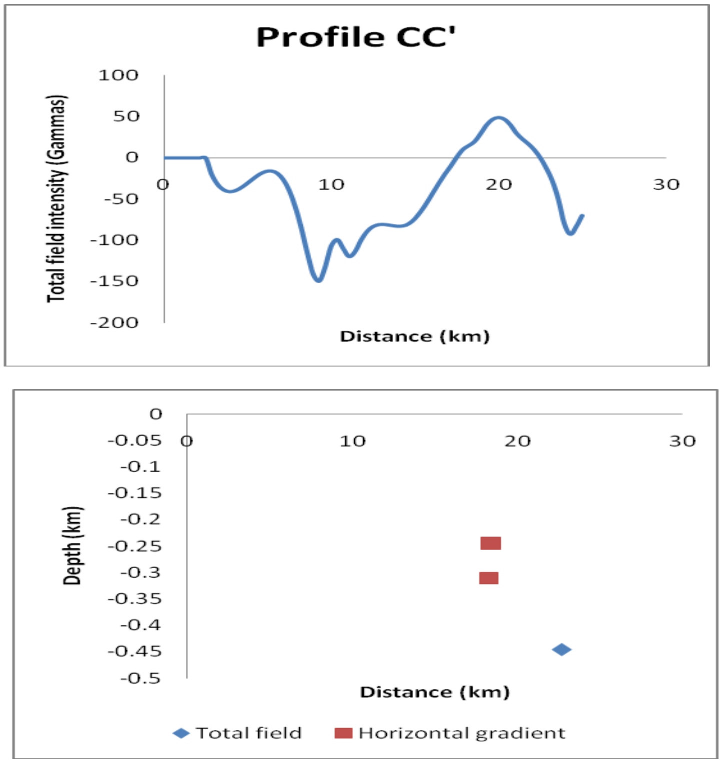
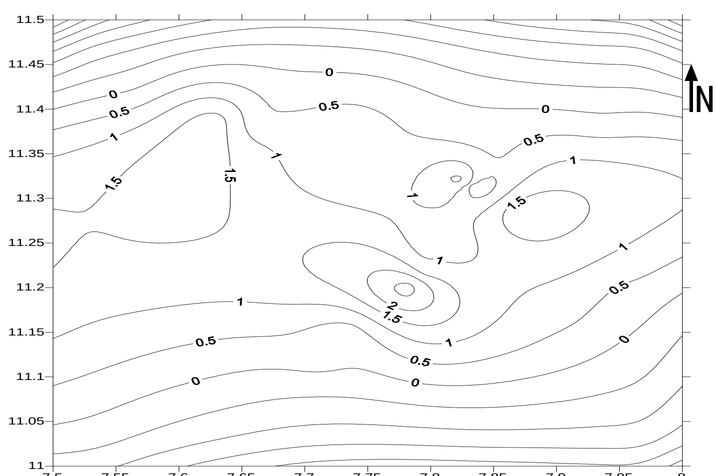


Figure 7: Werner profile processed to define magnetic basement beneath t
he major anomalies CC'.

The result obtained indicated that most of the values obtained are shallow sources as it was revealed by the previous works [3 , 4]. The minimum overburden thickness of sediment required for oil to form ranges from 2 to 4km, while for gas to form the minimum thickness required ranges from 3 to 7km [1], this implies that the sediment is not thick enough to support hydro carbon exploration in the area. The high magnetic intensity in the area is another factor which hinders the prospect of hydroca rbon exploration. The intrusions are responsible for causing anomaly **b** and **f** in figure 1while faults and fractures are responsi ble for causing anomalies in the north eastern part of the map. It is also observed that the higher the magnetic property and the broadness of the rock, the higher the results of the magnetic sources to be obtained.



Scale. 1:360,000

Legend: 0.5 a contour line showing magnetic field intensity, 0.5nT.

Figure 8: Depth map of Zaria area (contour interval ~0.5nT)

4.0 Conclusion

The magnetic source values obtained vary from 0.01 to 1.41km for the sources on the surface of the earth and 0.01 to 3.17km below the earth surface. The depth map of the study area has been produced and it has the highest depth to the top value of 2.5 km along profile BB' signifying shallower sources. This implies that the depths obtained are not thick enough to warrant hydrocarbon exploration. The magnetic field intensity along the three profiles analyzed varies from -150 to 70nT. The high magnetic intensity in the area is another factor which hinders the prospect of hydrocarbon exploration. It is observed that the anomalies in the residual aeromagnetic map are caused by the intruded and shallow rocks, while some are due to the presence of faults and fractures as in the north eastern part of the study area. The result indicated that magnetic properties and broadness nature of a given magnetic profile determine the number of the sources to be obtained.

Acknowledgement

All sources which their materials have been used in the course of this research are hereby acknowledged. The authors wish to appreciate the effort of the staff and students of Umaru Musa Yar'adua University Katsina and Bayero University Kano for their useful suggestions and criticism.

References

[1] Onuba, L.N., Anudu G.K., Chiaghanam O.I. and Anakwuba E.K., (2011). Evaluation of Aeromagnetic Anomalies Over Okigwe Area, Southeastern Nigeria Research Journal of Environmental and Earth Science 3(5): 498 –567, Max well Scientific Organization, 2011.

[2] Telford, W.M., Geldart, L.P., Sheriff, R.E., (2001). Applied Geophysics SecondEdition, University press Cambridge, page: 62-134.

[3] Ibrahim, B., (1992). Ground Magnetic investigation of the Kubani basin, Zaria. Unpublished M.Sc Thesis A.B.U Zaria.

[4] Lawal, K.M. (1998). The application of reduction to the pole technique for the Interpretation of aeromagnetic data Of Zaria area north central Nigeria. Unpublished M.Sc. thesis A.B.U. Zaria.

[5] Osazuwa, I.B., Adeniyi, O.O., Ojo, S.B, (1992). A gravity study of the older granite suite in the Zaria area of Kaduna state Nigeria. Journal of mining and geology, 28(2): 231-236.

[6] Geological Survey of Nigeria, GSN, (1974). Airborne Magnetometer Survey Map of Contours of Total magnetic Field Intensity. Sheet 102, Zaria area.

[7] Usman, N., Lawal K.M. and Aku M.O, (2014). Application of Werner Deconvolution Method in the Direct Interpretation of Residual Aeromagnetic Anomalies. IOSR-Journal of Applied Physics, Vol. 6(1): 18-21.