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ARTICLE

The Use of Euler Deconvolution Technique in the Estimation of Depth to Magnetic Source Bodies around the Schist Belt Parts of Kano State, Nigeria

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Abstract: Depth estimation of magnetic source bodies in parts of the Schist Belt of Kano, using Euler Deconvolution is presented in this paper. Detail ground magnetic survey was carried out using SCINTREX proton precession magnetometer to produce the Total Magnetic Intensity (TMI) map and consequently the residual map. The TMI ranges from 34,261 nT to 34,365 nT, while the residual field ranges from -160 nT to 115 nT. The depth estimate for contacts ranges from 6.5 m to 39.8 m, while that of dyke ranges from 8.9 m to 51.3 m. The depth estimation presented in this work is compared with the results of aeromagnetic study carried out in the same area and found to agree fairly well. Further, this also ensures the validity of aeromagnetic investigation in such applications.

Keywords: Contacts, Dykes, Euler Deconvolution, Schist Belt.

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Introduction

Nigeria has over forty (40) minerals distributed unevenly across the country [1]. The location of prime targets of mineral deposits is one major concern of geophysicists. Use of geophysical methods to determine the targets have helped over the years in saving time and cost.

The depth of source bodies is of great importance in geophysics. It is worthy of mentioning that there is no one technique that gives a 100% depth determination and hence the use of the clause ‘depth estimation’. So, there is a need to use other depth estimation methods to build confidence on our depth results.

The study area is around western parts of Kano State (Fig. 1); it is an extension of Kazaure Schist belt (other Schist belts in Nigeria are Zuru, Anka, Maru, Wonaka, Karaukarau, Kushaka, Zungeru-Birnin Gwari, Iseyin-Oyan, Ilesha and Igara belts) [2].

Attention paid to the study area can be said to be very little as obvious in the number of reported geophysical works available on it. This may be because Kano State, having generally Migmatite-Gneiss Complex geology, is hardly believed to form part of the Schist belt. A resistivity study was carried out by [3] around Alajawa in Shanono and obtained a maximum depth to mineralization zone of 184m. In addition to the fact that the area covered in his work is small compared to the entire schist belt part of Kano, resistivity survey is also always subjective in terms of depth (the surveyor has to

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choose the depth (s)he is prospecting to) and so, using other methods, e.g. potential field method, was necessary. Airborne magnetic data was used by [4] to delineate the potential mineral zones in the schist belt part of Kano and found the mineral favourabilty regions to be bounded between longitudes 7^{o} 51' E to 8^{o} 12' E and latitudes 11^{o} 46' N to 12^{o} 30' N in the NE – SW trend. The depth to the mineralization zones in the region was estimated, using Source Parameter Imaging technique, in the work of [5] and found to range from 14.62 m to 261.4 m.

In this work, we estimated the depth of causative body using Euler Deconvolution technique on acquired ground magnetic data in the study area. However, the work is limited to a particular anomalous zone due to the strenuous nature of acquiring ground magnetic data. The area covered is bounded within longitudes 7^{o} 58' 23'' E to 7^{o} 59' 10'' E and latitudes 12^{o} 6' 26'' N to 12^{o} 7' 3'' N, covering approximately 1.3 by 1 km^2.

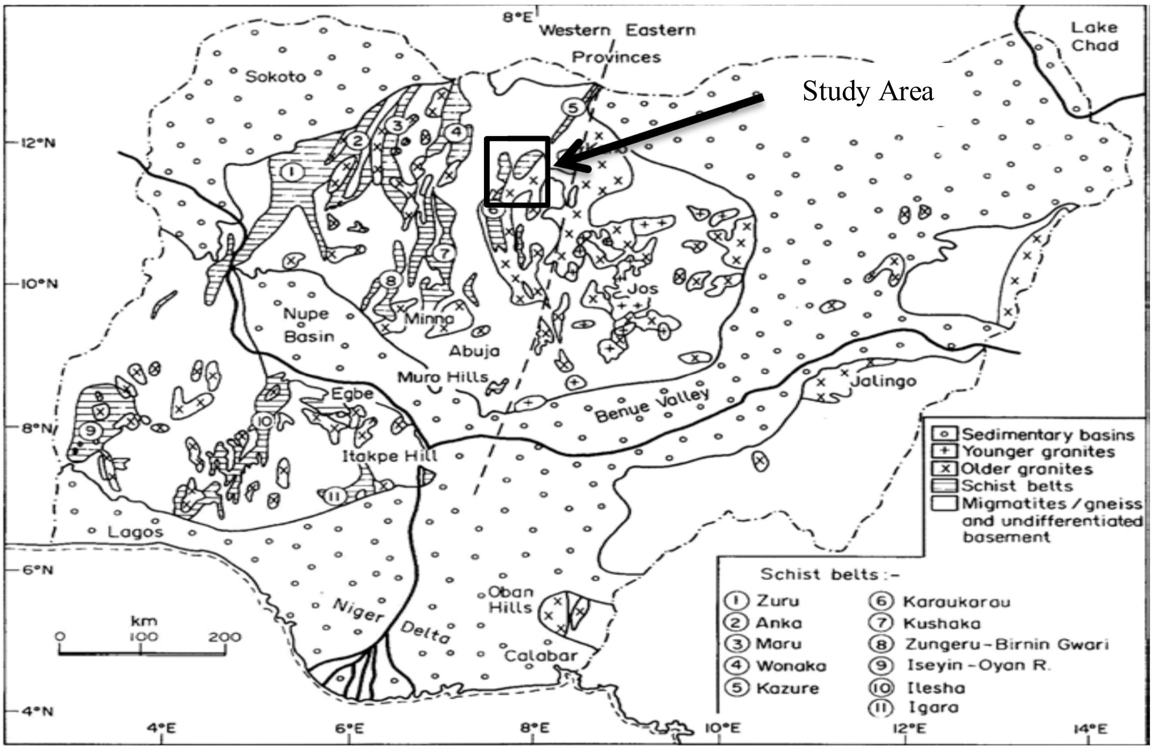

FIG. 1. The Geologic Map of Nigeria Showing the Study Area [2].

Method

In this section, the ground magnetic data acquisition, data correction, production of the Total Magnetic Intensity and the residual maps are discussed. Lastly, depth estimation using Euler Deconvolution technique is also presented.

Data Acquisition

Detailed ground magnetic survey was carried out in the study area using SCINTREX proton precession magnetometer; the same magnetometer was used for base station reading for diurnal variation correction. The survey was conducted along 45 profiles covering the study area. A total of 9,360 measurement points of observation were recorded with station interval of 5m and inter-profile spacing of 30m. Readings taken include position coordinates, time and total magnetic field. Furthermore, diurnal correction was applied to the acquired data.

Residualization

Because our interest is shallow features, residualization was carried out to separate long wavelength anomalies of regional field from shorter wavelength features consisting the residual field. This was done following the polynomial fitting method [6], where a best fit is made to the observed data according to:

$$Z(x,y) = Ax + By + C \quad (1)$$

where Z is the computed value of regional field for coordinates x and y. A, B and C are constants found to be -1.997 x 10^{-5} nT/m, 4.81 x 10^{-4} nT/m and 422.91 nT, respectively.

The residual field R is:

$$R = B - Z \tag{2}$$

where B is the observed field.

Depth Estimation Using Euler Deconvolution (ED)

Here, we did a general estimation of depth to the causative bodies using ED technique.

ED uses gradients to locate magnetic edges and bodies and estimate their depths. Its major advantage is in its ability to locate variety of shapes including irregular bodies.

ED is based on Euler's homogeneity relation [7] given by:

$$(x - x_o)\frac{\partial R}{\partial x} + (y - y_o)\frac{\partial R}{\partial y} + (z - z_o)\frac{\partial R}{\partial z} = NR \tag{3}$$

where (x_o, y_o, z_o) is the position of a source whose field R is detected at (x, y, z). N is the degree of homogeneity, interpreted geo-physically as Structural Index (SI). For contact and dyke, the SI [8] is 0.5 and 1, respectively.

Eq. (3) was solved for all data points with SI 0.5 and 1 and the results were plotted using Oasis Montaj.

Results and Discussion

Here, the results of the analyses carried out and discussions are presented.

Fig. 2 shows the Total Magnetic Intensity map of the study area. The magnetic field ranges from 34,262 nT to 34,365 nT. The field values are high due to the contribution of deep and large-scale sources of regional field. The N-S trend observed is because the survey was done along the NE-SW trend observed in [4].

The residual map is shown in Fig. 3. Here, the magnetic field has reduced greatly because of the removal of regional contribution. It ranges from -160 nT to 115 nT. This variation could be attributed to factors, such as variation in depth, difference in lithology or difference in magnetic susceptibility.

The depth ranges for contact (SI = 0.5) and dyke (SI = 1.0) are shown in Figures 4 and 5, respectively. For contact, it ranges from 6.5 m to 39.8 m with an average of 23.15 m. Similarly, for dyke, the depth ranges from 8.9 m to 51.3 m with an average of 30.1 m. The average of both averages is 26.6 m. These depth results agree well with that of [5] who got a range of 14.62 m to 261.4 m for the mineralized zones in the Schist belt area of Kano. This agreement further gives us confidence on the reliability of the aeromagnetic data used in their work.

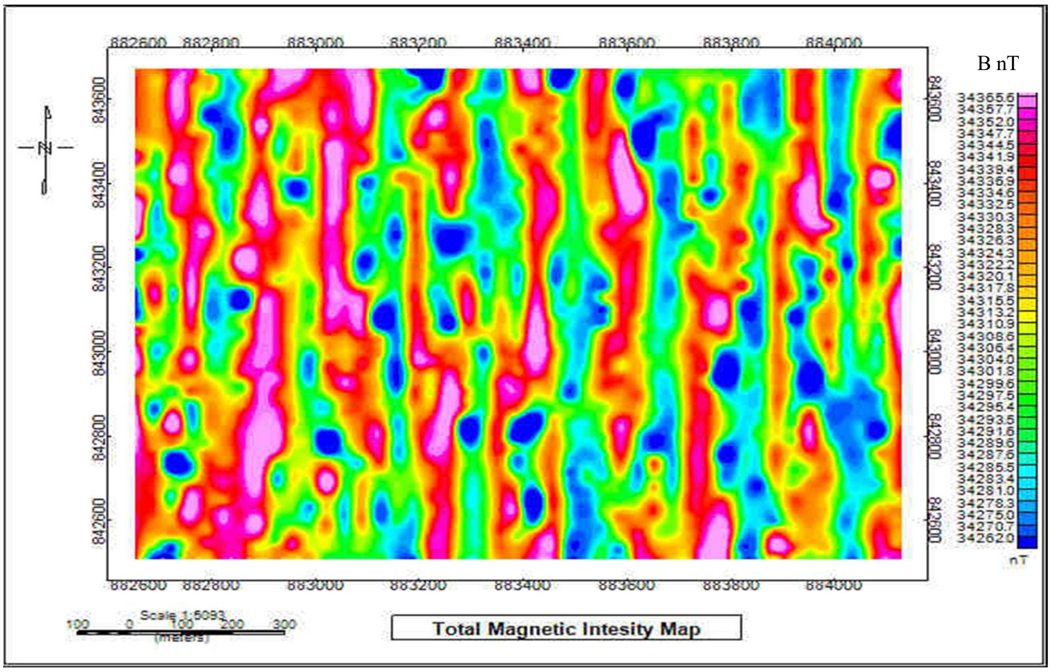

FIG. 2. The total magnetic intensity (TMI) map of the study area.

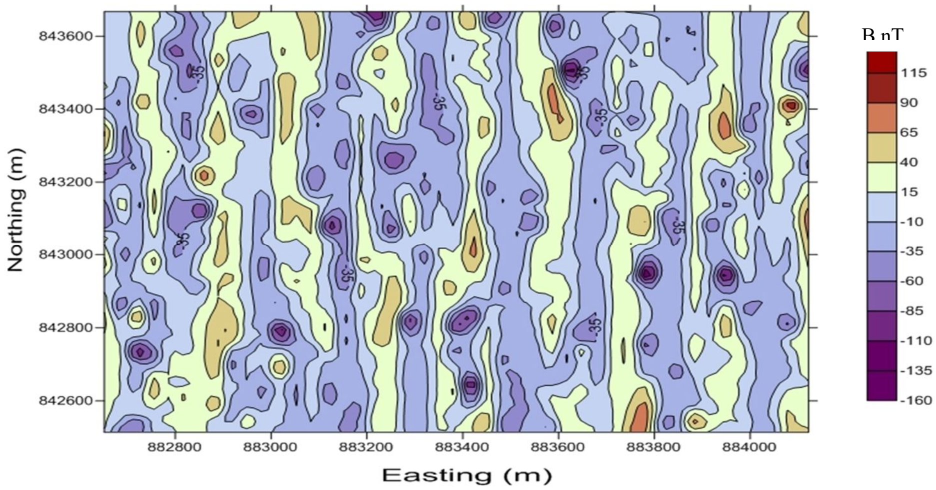

FIG. 3. The residual map of total magnetic field contoured at an interval of 25 nT.

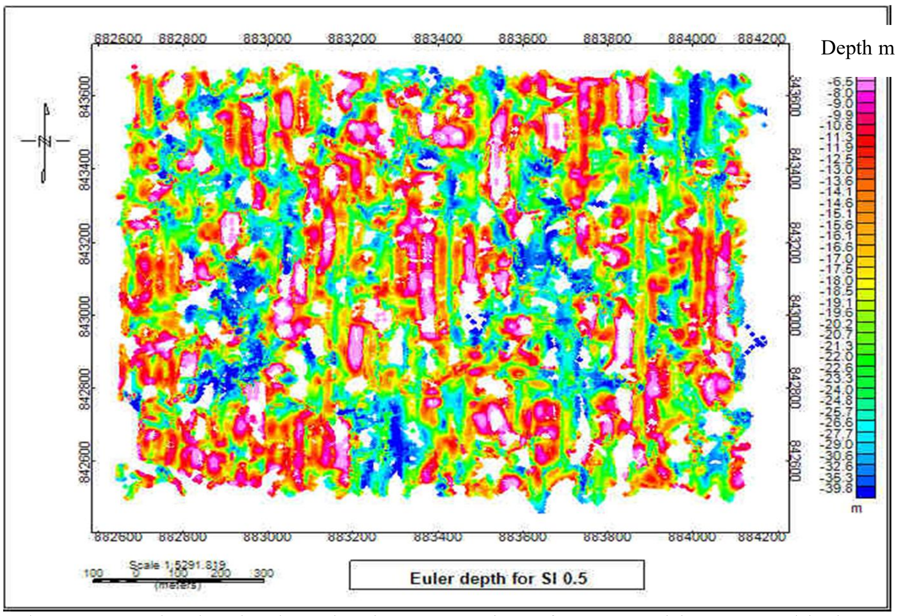

FIG. 4. The computed euler depth under the assumption of contact with structural index SI = 0.5.

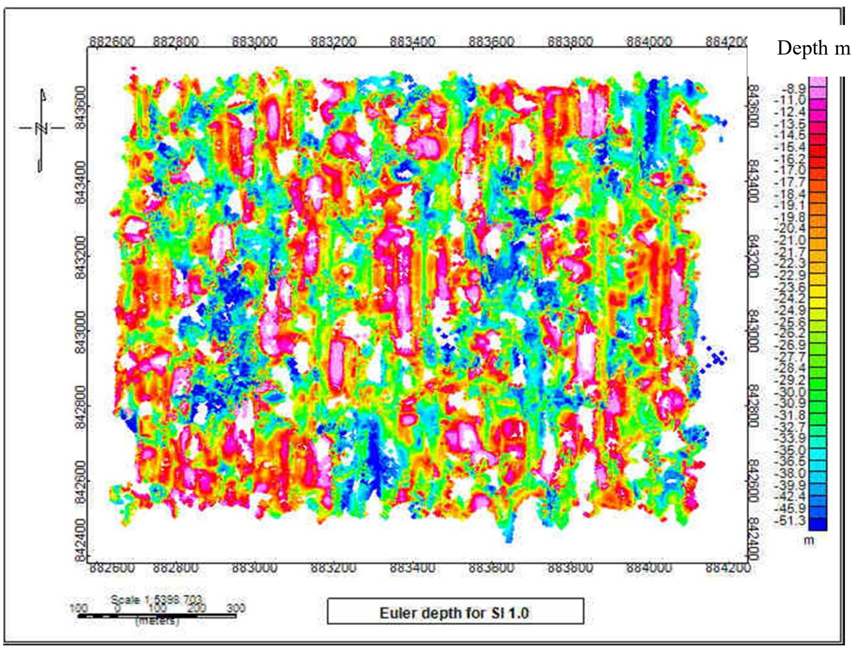

FIG. 5. The computed euler depth under the assumption of dyke with structural index SI = 1.

Conclusion

In this study, we found that the depth ranges for contact (SI = 0.5) and dyke (SI = 1.0) are from 6.5 m to 39.8 m with an average of 23.15 m for contact, while for dyke, the depth ranges from 8.9 m to 51.3 m with an average of 30.1 m.

In conclusions these depth results agree well with that of [5] who got a range of 14.62 m to 261.4 m for the mineralized zones in the entire Schist belt area of Kano. This agreement further gives us confidence on the reliability of the aeromagnetic data used in their work.

Finally, it is suggested that anomalies observed in the residual maps should be studied in detail to determine the causative parameters e.g. body dimension and susceptibily.

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