Aeromagnetic Data Interpretation for Geostructural Analysis of Ibadan, Southwestern Nigeria

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ABSTRACT

The digitized aeromagnetic data of Ibadan obtained from the Nigeria Geological Survey Agency NGSA has been analysed for the purpose of delineating the geostructural settings of the area. Ibadan is located in present Oyo State, South Western Nigeria underlain by basement complex rocks of the Precambrian age and bounded within longitude 3^0 30'E to 4^0 00'E and latitude 7^0 00' to 7^0 30' N. The aeromagnetic anomaly map, its analytic signal amplitude, its vertical gradient magnitude, the Euler solutions and residual magnetic intensity map helped in identifying the nature and depth of the magnetic sources in the study region. The residual magnetic intensity map shows areas of magnetic highs and magnetic lows. The North-Western part shows prominent magnetic clusters trend, relatively prominent along the South East and the North central trending North, which signify areas of magnetic conductive materials which could be higher magnetite (a common magnetic rock) intrusion, buried metallic materials or areas of thin overburden. The depth estimate from analytic signal amplitude revealed magnetic depth range from 0.26-4.28 km while the results from the vertical gradient revealed minimum and maximum limit on source depth to be 0.16 km and 2.87 km respectively. The Euler Deconvolution overestimated the shallow depth to top of the magnetic source and the magnetic basement depth ranging from 0.02 km to 6.78 km respectively. The result obtained from the enhancement techniques used shows the shallow magnetic source depth values in the range 0.263 km to 0.881 km while the magnetic basement depth values are in the range 0.02 km to 6.78 km.

KEYWORDS: Geostructural settings, Euler Deconvolution, enhancement, Magnetic anomaly, Magnetite

1. Introduction

The essential need to always study the geostructural setting of an area for proper allocation of the right site for various activities and corrective measure on the existing failed ones can not be overemphasised. The aeromagnetic survey present the comprehensive magnetic contour map of an area and the magnetic data can also be obtained from such map by digitization method in the analytical interpretation. Such type of digitized aeromagnetic data is that presented on sheet 261 obtained from the Nigeria Geological Survey Agency which has been interpreted in this work. Ibadan, the study area hosts high rise buildings, industries, factories and roads which heavy duty vehicles ply. This activities prompted researchers to use series of enhancement techniques to analyse the aeromagnetic data of the area [1] and [2], who interpreted the aeromagnetic data of Ibadan using horizontal gradient magnitude (HGM), Analytic signal amplitude (ASA), spectral analysis and local wavenumber (LWN) functions to observe shallow depth to magnetic sources as well as source locations.

The Euler deconvolution has become a popular choice because the method assumes no particular geological model and has quick means of turning magnetic field measurements into estimates of magnetic source body location and depth [3] . It is the method of depth estimation which is best suited for anomalies caused by isolating and multiple anomalous sources. It could be applied to a long profile of measurements for estimating the location of a simple body, by dividing the profile into the windows of consecutive measurements, each window providing a single estimate of depth and source location. Acceptable solutions for features of interest may involve some trial and error by adjusting the structural index and the window size. When all such measurements are plotted they tend to cluster around magnetization of geologic interest. Some indication of the source type can be gained by varying the structural index for any particular feature. Shallow features can be deconvolved well by using small window to reduce source interference [4] . Analytic signal method is very useful for delineating magnetic source location [5], the amplitude (ASA) of the simple analytic signal peaks over magnetic contacts. Therefore it can also be used to find horizontal locations and depths of magnetic contacts. However, if more than one source is present, then the shallow sources are well resolved but the deeper sources may not be well resolved. The vertical gradient magnitude (VGM) allows a further increase in resolution of the local anomalies due to a higher signal decay with distance. These filters are considered most useful for defining the edges of bodies and for amplifying fault trends.

The aim of this of this work is to model prominent magnetic anomalies and depth to the magnetic sources. This research covers Ibadan metropolis whose digitized total aeromagnetic data has been analysed using ASA, VGM and Euler Deconvolution enhancement techniques. The combination of the methods yielded better estimate of the geostructural settings of the area.

2. Geology and Location of the Study Area

Ibadan is located in present Oyo State, South Western Nigeria within longitude 3^0 30'E to 4^0 00'E and latitude 7^0 00' to 7^0 30' N. Ibadan falls within the basement complex of Nigeria, characterized by the basement complex rocks of the Precambrian age which consists of various granites and the metasedimentary rocks [6]. The area is composed of biotite granitic gnesis; migmatite biotite gneiss; biotite muscovite granite; hornblende granite and Schists.

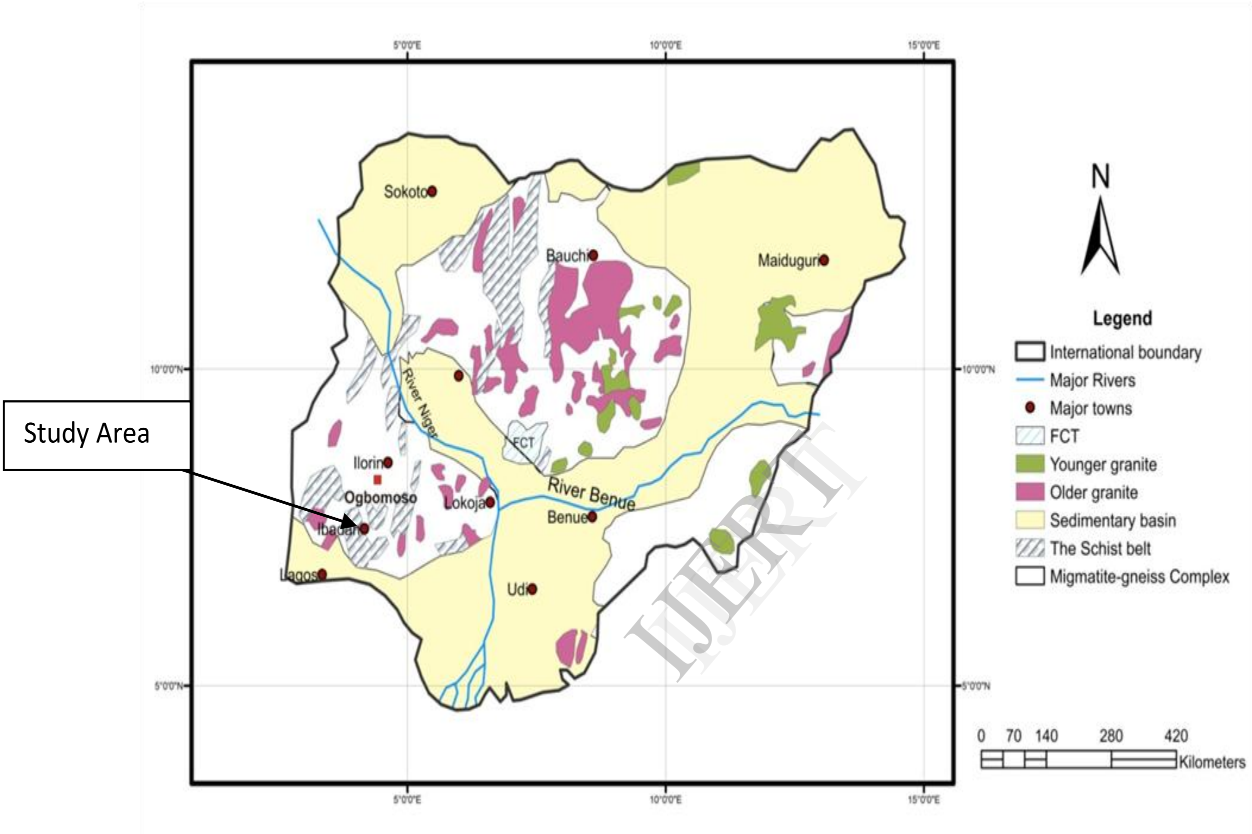

Figure 1. Geological Map of the study area [7]

3. Materials and Method

The digitized total aeromagnetic data obtained from the Nigerian Geological Survey Agency NGSA on sheet 261 as part of the Nigeria wide geological survey data carried out in 2009 has been used. The map was presented on Oasis Montaj Geosoft and the data was extracted using the Excel package. A total of fifty-six gridded profiles were established at interval of 1 km interspacing with the use of Golden Surfer 8 software.

The voluminous magnetic datasets demand automatic interpretation techniques like Naudy, Euler and Werner deconvolution. Of these techniques, the Euler deconvolution has become a popular choice because the method assumes no particular geological model. Euler's homogeneity relation has attracted sporadic interest from geophysicists over the years. It may be stated succinctly in the form

$$(x - x_o)\frac{dT}{dx} + (y - y_o)\frac{dT}{dy} + (z - z_o)\frac{dT}{dz} = N(B - T) \qquad 1$$

where (x_o, y_o , z_o) is the position of a source whose total field T is detected at (x, y,z). The total field has a regional or background value B. N is the degree of homogeneity, interpreted physically as the fall-off rate with distance and geophysically as a structural index [4]. The vertical gradient allows a further increase in resolution of the local anomalies due to a higher signal decay with distance and the Analytic signal method is very useful for delineating magnetic source location [5] the amplitude of the simple analytic signal peaks over magnetic contacts. Therefore it can also be used to find horizontal locations and depths of magnetic contacts. The vertical gradient and analytic signal has been incorporated into the Euler Deconvolution [8] used for this work.

4. Results and Discussion

The results obtained from the aeromagnetic data of Ibadan were presented in a qualitative and quantitative interpretation which involves the estimation of the depth to the top of the magnetic basement and magnetic profiles, contour map and the magnetic surface map respectively.

4.1. Qualitative Interpretation

The 2D base map of total magnetic variation of Ibadan with color separation code ranging from deep to pale red and deep to pale blue respectively, is presented on figure 3 from which the strong influence of the earth's main magnetic field on the survey data was removed by subtracting a model of the main field from the survey data through the use of the standard International Geomagnetic reference field (IGRF). The 2D residual magnetic plot was obtained shows areas of magnetic lows and magnetic highs analysed with color code ranging from -260 nT to 20 nT (Blue to violet) and -20 nT tp 280 nT (Purple to Red) respectively. The contour traces North-West shows prominent magnetic clusters trend, relatively prominent along the South East and the North central trending North, which signify areas of magnetic conductive materials which could be higher magnetite (a common magnetic rock) or buried metalic materials. The possible causes for magnetic highs in this area include the presence of magnetically charged rocks in the subsurface and the rocks could serve as a strong foundation bedrock for high rise buildings and industrial location where machines are used. The unmarked areas are regions of relatively magnetic lows which are best for hydrogeological supply and low rise buildings. The 3D residual magnetic intensity plot of the area shows clearly the areas of magnetic highs/ lows with the minor and major magnetic undulation as stated by the 2D plot.

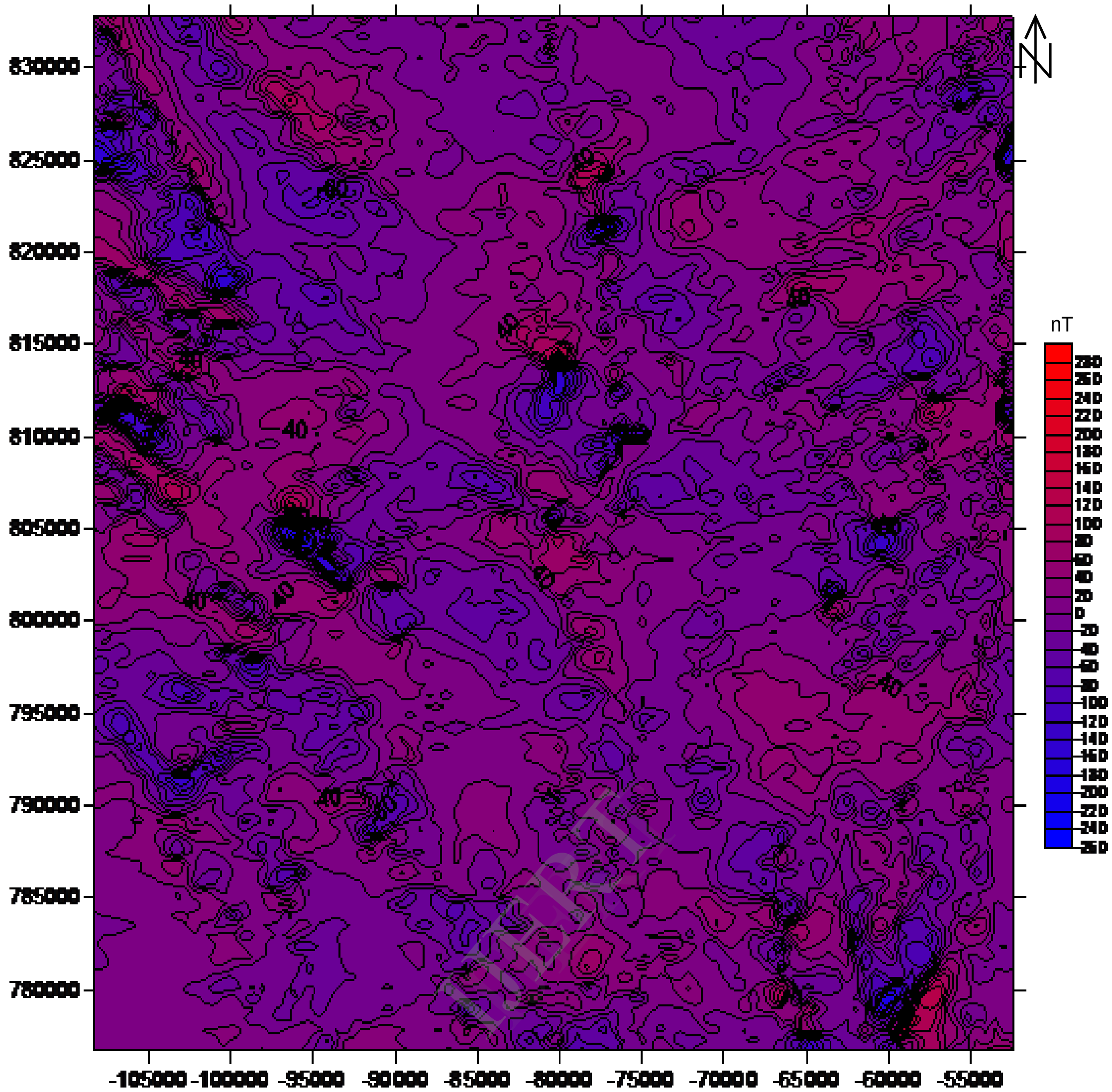

Figure 3. Residual Magnetic Intensity Map of the study area.

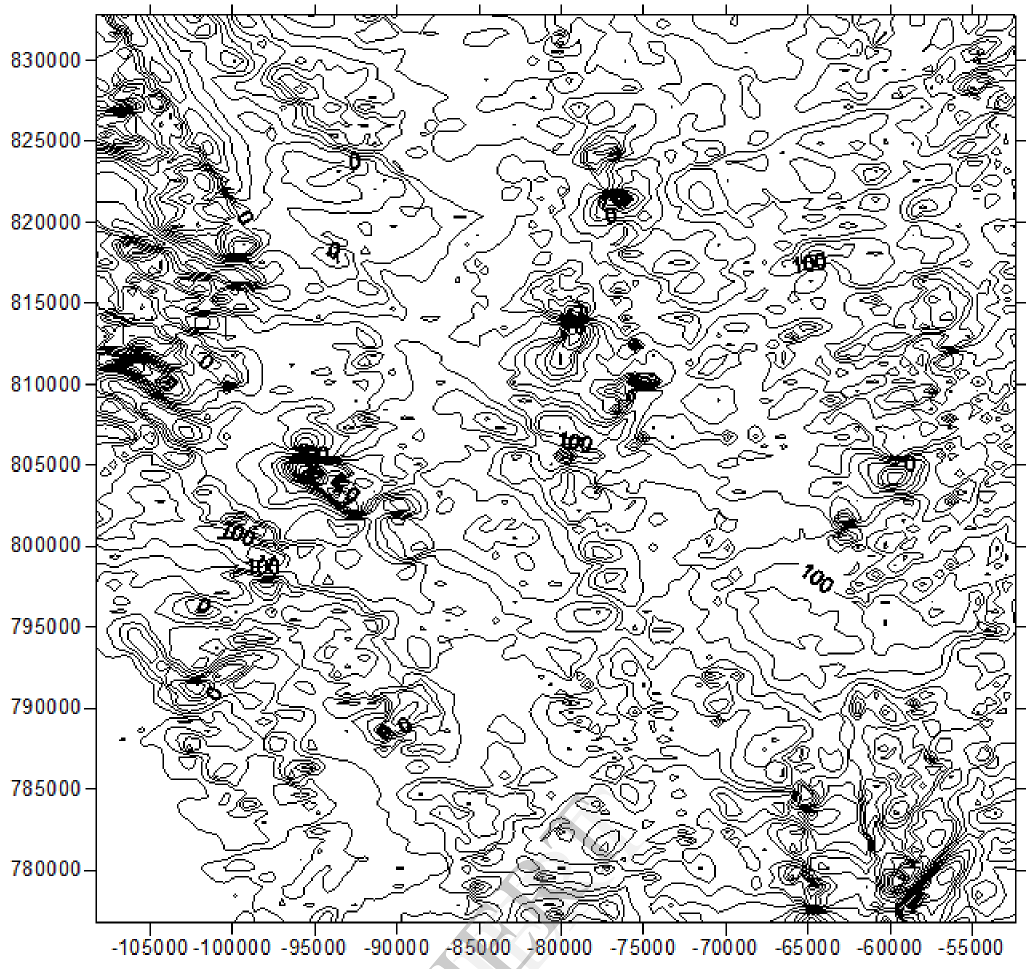

Figure 4. Residual Magnetic Intensity Contour Map of Ibadan

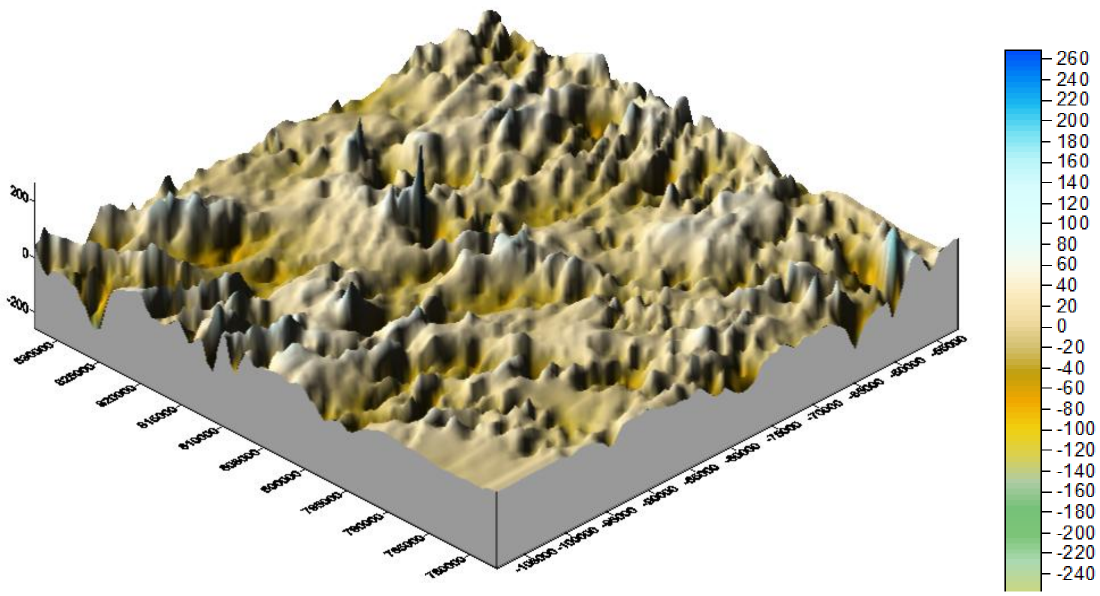

Figure 5. 3D Residual Magnetic Intensity Surface Map of Ibadan

4.2.Quantitative Interpretation

The depth estimate from analytic signal amplitude revealed magnetic depth range from 0.26-4.28 km which shows shallow magnetic source depth to the magnetic basement and agrees with previous literatures while the results from the vertical gradient also revealed Shallow magnetic source depth to the magnetic basement depth at 2.87km within the limit of 0.16 km and 2.87 km. The Euler Deconvolution overestimated the shallow depth to top of the magnetic source and the magnetic basement depth ranging from 0.02 km to 6.78 km respectively but helps to reveal deeper magnetic anomalies sources which may not be well resolved with ASA. The summary is given on table 1.

Techniques	**Min. Depth (km)**	**Max Depth (km)**
VGM	0.16	2.87
ASA	0.26	4.28
Euler Deconvolution	0.02	6.78

5. Conclusion

The analysis of the aeromagnetic data of Ibadan revealed with the aid of the 2D magnetic plots and 3D magnetic map, the North-Western part of the study area to have prominent magnetic clusters trend, relatively prominent along the South East and the North central trending North, which signifies common magnetic conductive materials like metamorphic and igneous rock intrusion; areas with strong bedrock for high rise buildings and industrial location where machines are used while other areas of magnetic lows shows faulted or fractured rock trend which could be analysed for water supply or location of lost buried metallic materials or pipes. This could help the construction engineers in allocating the right structure to the right location.

The depth estimation from ASA and VGM techniques reveals shallow magnetic source depth but the Euler Deconvolution overestimated the shallow sources which help to reveal deeper magnetic anomalies sources which may not be well resolved with ASA.

This shows high advantage in the choice of several methods of enhancement for better resolution. It is recommended that other relevant geophysical methods be used in the study area to confirm the predictions in this works.

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