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RESEARCH ARTICLE

GEOPHYSICAL INVESTIGATION OF IWO AND ILESHA, OSUN STATE USING HIGH RESOLUTION AEROMAGNETIC DATA

John Akor Yakubu[a]*, Friday Egbunu[b], Ngozi Agatha Okwesili[a], Igwe Emmanuel Awucha[a], Ngozi MariamRita Ossai[a]

[a] Department of Physics and Astronomy, University of Nigeria, Nsukka, Enugu State, Nigeria.
[b] Department of Physics Kogi State University Anyigba
**Corresponding Author Email: john.yakubu@unn.edu.ng*

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ABSTRACT

The study deals with the Geophysical investigation of Iwo and Ilesha, Osun State, using aeromagnetic data. Qualitative as well as quantitative interpretation of the aeromagnetic data were carried out to obtain more information about the thickness of sedimentary basins. Two methods were used in the interpretation; there are Euler deconvolution method and source parameter imaging (SPI). Oasis Montaj software was employed in the analysis, the Magnetic intensity ranges from a minimum value of -22.7 nT to a maximum value of 110.4 nT, this indicate that the area is characterised with low and high magnetic signature and could be as a result of difference in magnetic susceptibility, depth and the nature of the magnetic anomalous bodies present. The depth for magnetic source ranges from 187.6 to 1005.5 m using parameter imaging (SPI).Using Euler deconvolution method, the depth estimation for structural index (SI = 0.5, 1.0, 1.5) ranges from 300 m to 25481m, 262.9m to 1826.2m and 391.0m to 3243.6m respectively. The results obtained indicate shallow depths to magnetic anomalies which may not be suitable for hydrocarbon accumulation.

KEYWORDS

Euler deconvolution, SPI, Iwo and Ilesha

1. INTRODUCTION

The aeromagnetic geophysical method has been widely used since its inception. The most unique feature of this method, compared with other geophysical methods, is the speedy rate of coverage and low cost per unit area explored (Reford and Sumner, 1964). The use of this method makes it possible for geophysicists to acquire data regardless of ownership or accessibility of remote lands of interest. This inherent advantage has made it possible for large scale airborne magnetometer survey to be carried out around the globe. The subsurface of the earth can be investigated using magnetic method depending on the magnetic characteristics of principal rocks and sediments resulting in the differences in the magnetic field of the earth that is been measured by the magnetometer. The key purpose of magnetic surveying is to identify mineral and rocks having uncommon magnetic properties that reveal themselves in producing anomalies or disorders in the magnetic field intensity of the earth (Sunmonu and Alagbe, 2014). The aeromagnetic data is utilize for different purposes; detection of some deposits of certain iron ores, delineation and identification of post tectonic intrusive, interpretation and recognition of different fractures and faults for variety of minerals, description of volcano-sedimentary belts, prospecting for water and oil, etc.

This study seeks to estimate the sedimentary thickness of Iwo and Ilesha and possibly depict the possible mineralization prevalent in the area using Euler deconvolution method and SPI. Some researchers have worked in the study area using different methods of data analysis. A group researchers interpreted aeromagnetic data of Ilesha Southwestern, Nigeria using forward and inverse modeling techniques (Adetunji et al., 2010). The results obtained indicate shallow depths to magnetic anomalies, as expected in most areas of the basement complex of Nigeria. Some researchers carried out geophysical ground magnetic survey in eastern part of Ilesa town located in the southwestern part of Nigeria (Kayode et al., 2013). They concentrated on delineation of subsurface geological structures that are suitable for mineral potential. The depth to the magnetic source were estimated using Peters half slope method which gave a maximum depth to basement of about 160m. The lateral extent of interpreted lithologies was estimated using the analytical signal. The results generated were used to delineate geological structures and to target areas with mineral potential.

In 2013, Adelusi et al., interpreted aeromagnetic anomalies and electrical resistivity mapping around Iwajara area Southwestern Nigeria. They utilized aeromagnetic, ground magnetic and vertical electrical sounding (VES) to delineate the basement structure around the study area. They estimated depth to fracture to be between 6 to 36 m using half slope and automated Euler deconvolution and VES results assisted in delineation of four subsurface geologic layers, the top soil layer resistivity, the weathered layer, the fractured basement resistivity and the fresh basement resistivity ranges from 50 to 2359 Ωm, 35 to 4935 Ωm, 152 to 981 Ωm and 1132 to 22821 Ωm respectively. Several authors (Yakubu et al., 2023; Yakubu et al 2020; Obiora et al., 2016; Obiora et al., 2021; Ekwueme et al., 2017; Okorie et al., 2019; Oguama, et al., 2021, etc.) have worked in other regions for different purposes, in this research we utilized SPI and Euler deconvolution with the aim of estimating the sedimentary thickness of the study area.

2. LOCATION AND GEOLOGY OF THE STUDY AREA

The study area covers Iwo and Ilesha areas, Osun state, Southwest Nigeria. The areas lie approximately between latitudes 7°30′N to 8°00′N and longitude 4°00′E to 5°00′E, it lies within the tropical climate marked by wet and dry seasons. The basic geological structure of South-Western Nigeria is a complementary enticliriorium and synclinorium with northwards plunging axes (Ajayi and Adegoke-Anthony, 1988). The geomorphological division of Ilesha and its environs are two major segments of fractured zones, namely: The Iwaraja faults in the eastern region and the Ifewara faults in the western parts (Layade et al., 2021;

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Rahaman, 1976; Elueze, 1988). The structural features exhibited by rock of the area include foliation in the gneisses; lineation; folds; faults and joints. Rocks of the basement complex have been subjected to deformation during several orogeny cycles and it is difficult to differentiate between structures belonging to the separate periods of deformation (Ajeigbe et al., 2014; De Swardt, 1953). Geology of Ilesha and Iwo consists of Precambrain rocks which forms the basement complex. The major rocks associated with the area form part of the proterozoic schist belts in Nigeria. Quartz-schist, quartzite, amphibolites, granite-gneiss, amphibolites schist and migmatite-gneiss complex are the major rocks in Ilesha (Rahaman, 1976). Other minor rocks according to some study, are garnet, quartz chlorite bodies and dolorites., (*Bassey and Odong., 2017; Kayode* et al., 2010; Rahaman, 1976). *The geological map of the study area is shown in Figure 1.*

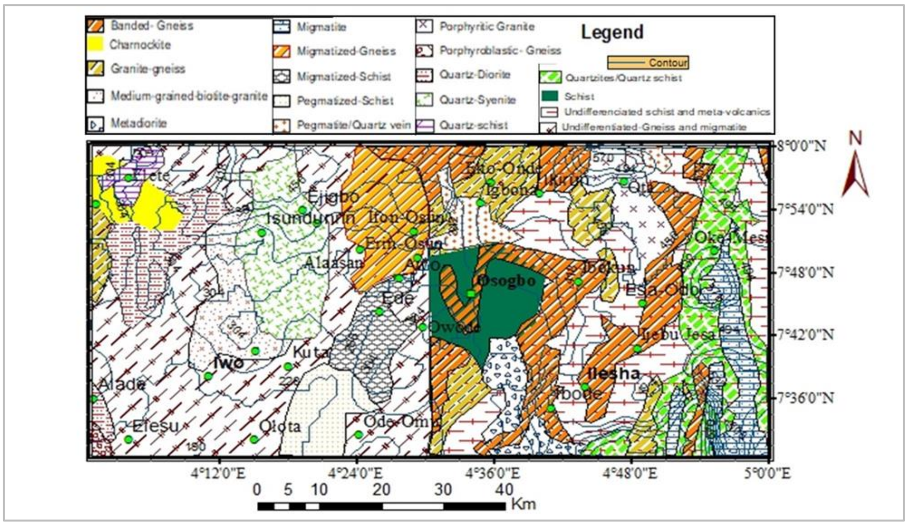

Figure 1: *Geological map of study area*

3. Source of Data and Methodology

The aeromagnetic survey data of Iwo (sheet 242) and Ilesha (sheet 243) in Osun State, used for this study were obtained from Nigeria Geological survey Agency (NGSA) abuja. The aeromagnetic data were obtained using a 3x Scintrex CS3 Cesium Vapour Magnetometer by Fugro airborne survey. In order to draw the TMI map, grid file was created. This grid file consists of cells, each grid cell has a calculated z value associated with it and they are evenly spaced in the x, y, z direction. The obtained digitized data from the NGSA were imputed into Oasis Montaj software and gridded using minimum curvature with a grid size of 320 to avoid over or under sampling of data and the TMI map was produced. Oasis Montaj software was used to fit the different orders of polynomial on the TMI data (regional-residual separation) until the best order (1st order) was obtained, which reflects the geologic information of the area (i.e. the residual map). Other data enhancement techniques (first vertical and horizontal derivative) were carried out on the magnetic data which were used in calculating the SPI.

3.1 Source Parameter Imaging (SPI)

The quantitative SPI technique was developed by Thurston and Smith, it is sometimes called the local wave number method (Thurston and Smith, 1997). The technique is used to estimate magnetic depths with the extension of complex analytical signal. It make use of the correlation between the source depth of the observed field and the local wave number that can be calculated at any point within the grid of the data via horizontal and vertical gradient. The fundamentals are that the peaks of the local wave number describe the inverse of depth for vertical contact. That is:

$$\text{Depth} = \frac{1}{K_{max}} = \frac{1}{(\sqrt{(\delta Tilt/\delta x)^2} + ((\delta Tilt/\delta y)^2\ )_{max}} \tag{1}$$

$$\text{Tilt} = \arctan\left(\frac{\delta T/\delta z}{(\sqrt{(\delta T/\delta x)^2} + ((\delta T/\delta y)^2\ )}\right) \tag{2}$$

$$\text{Tilt} = \frac{\delta T/\delta z}{HGRAD} \tag{3}$$

where, T is the TMI, HGRAD is the horizontal gradient, $\delta T/\delta x$, $\delta T/\delta y$, $\delta T/\delta z$ are the first order partial derivatives of the TMI in coordinate x, y and z respectively, K_{max} is called the local wave number.

The source parameter imaging of the magnetic data are obtained by putting both the calculated first order vertical derivative and the horizontal gradient into equation (1). These calculated SPI values are then put into Oasis Montaj software to produce 2D SPI map.

3.2 Euler Deconvolution

Euler deconvolution method is an automatic technique used for location of the source of potential field based on both their amplitude and gradients. In computing the Euler depth for aeromagnetic data, Oasis Montaj software was employed. The Euler depths were estimated using vertical derivatives in three dimensions (x, y, and z). These Vertical derivatives enhance shallow magnetic bodies. Hence, depths of shallow magnetic anomalies for different structural index were generated by applying Euler deconvolution method. The filter was applied for structural index 0.5, 1, and 1.5. The Euler method satisfies the Euler's homogeneity equation given by (4):

$$(x-x_o)\frac{\partial M}{\partial x} + (y-y_o)\frac{\partial M}{\partial y} + (z-z_o)\frac{\partial M}{\partial z} = -NM \tag{4}$$

where $\frac{\partial M}{\partial x}, \frac{\partial M}{\partial y}$ *and* $\frac{\partial M}{\partial z}$ represent first-order derivative of the potential field along x, y and z directions, respectively. N is the structural index which is related to the geometry of the magnetic and source. Putting into consideration the base level of the regional potential field (D), equation (4) becomes:

$$x_o\frac{\partial M}{\partial x} + y_o\frac{\partial M}{\partial y} + z_o\frac{\partial M}{\partial z} + ND = x\frac{\partial M}{\partial x} + y\frac{\partial M}{\partial y} + z\frac{\partial M}{\partial z} + NM \tag{5}$$

The structural index (N) assigned to equations (4) and (5) helps in obtaining a system of linear equations and used in estimating the location and depth of the magnetic bodies.

4. Results and Discussion

4.1 The Total Magnetic Intensity (TMI)

The TMI map of the study area was produced using Oasis Montaj software; it ranges from -22.7 m to 110.4 m. The maps aided the visibility of a wide range of anomalies in the magnetic maps and the ranges of their intensities were also shown in Figure 2. Areas of strong positive anomalies (pink colour) likely indicate a higher concentration of magnetically susceptible minerals while areas with broad magnetic low (blue colour) are likely areas of low magnetic concentration which may be as a result of lower magnetic susceptibility. This indicates that the study area is characterized with low and high magnetic signature and this variation in the intensity could be due to the difference in magnetic susceptibility or depth, faults, etc.

4.2 Residual and Regional Map

Residual map is characterized by the presence of several anomalies with different amplitudes, shapes, and orientations. They are also characterized by possessing different values of gradient indicating the presence of anomalous bodies at different depths. The magnetic intensity of the residual map ranges from -122.8nT to 108.3 nT as shown in Figure 3. The magnetic intensity of the regional map ranges from -124.0nT to 104.8 nT as shown in Figure 4.

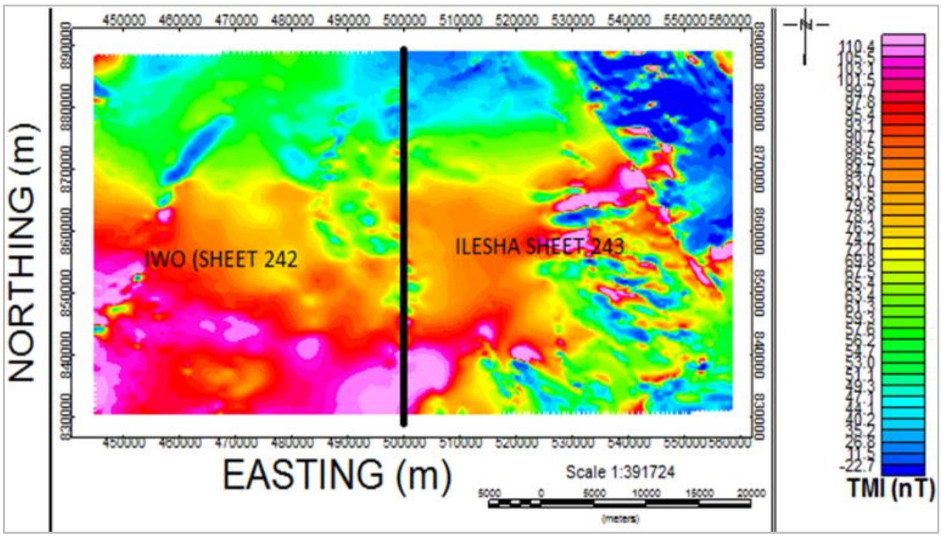

Figure 2: Total magnetic intensity (TMI)

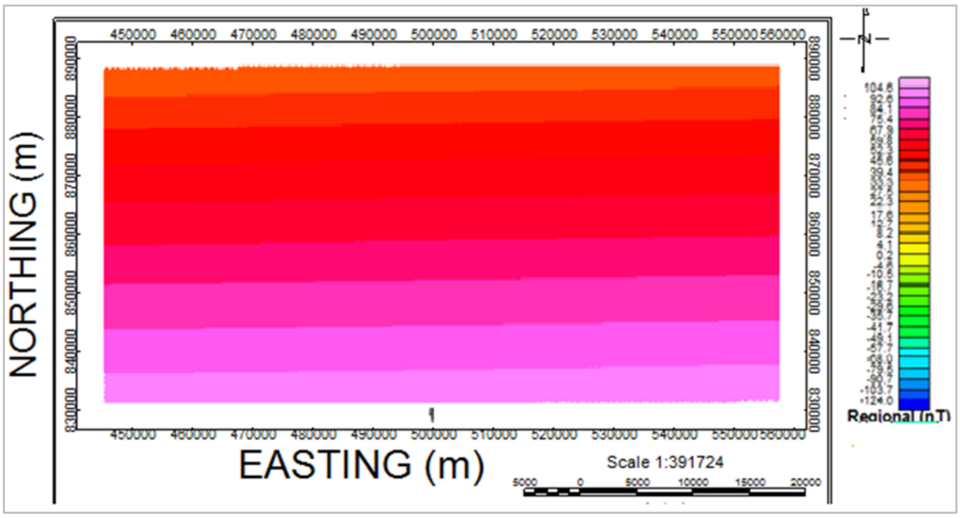

Figure 3: Regional map

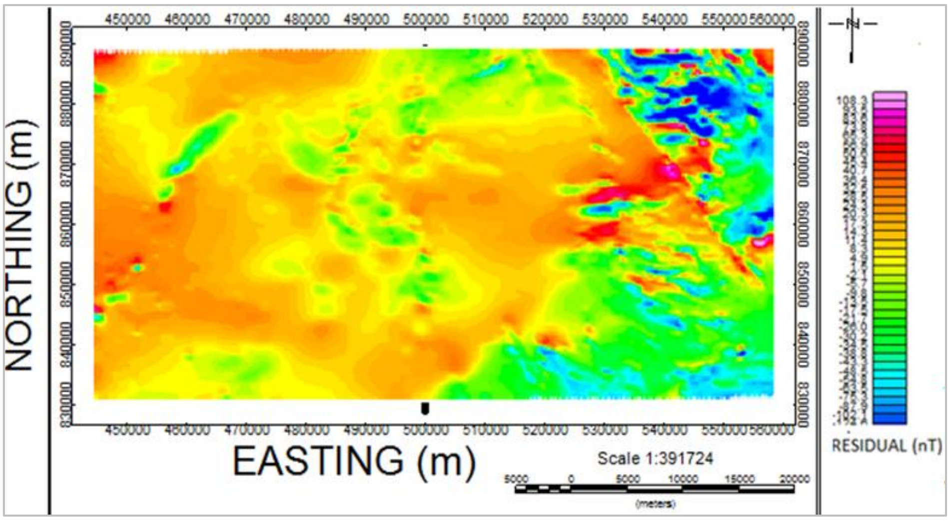

Figure 4: Residual map

4.3 First Vertical Derivative Map

Derivatives tend to sharpen the edges of anomalies and enhance shallow features. The vertical derivative map is much more responsive to local influences than to broad or regional effects and therefore tends to give sharper picture than the map of the total field intensity. The first vertical and horizontal derivative enhanced the shallow sources by suppressing the effects produced by the deeper sources Thus the smaller anomalies are more readily apparent in area of strong regional disturbances. In fact the first vertical and horizontal derivatives are used to delineate high frequency features more clearly where they are shadowed by large amplitude, low frequency anomalies as shown in Figure 5 and 6 respectively.

4.4 Interpretation and Result of Source Parameter Imaging

The SPI and Depth was computed with Oasis Montaj software. The generated SPI grid image and SPI legend show varied colours supposedly indicating different Magnetic susceptibility contracts within the study area, the blue colour at the legend shows areas of thicker sediments or deep lying magnetic bodies, the pink, purple, orange and yellow colour show areas of shallower sediment or near surface lying magnetic bodies, the depth of magnetic source ranges from 187.6m to 1005.5m as shown in

Figure 7. This variation may be as a result of the heterogeneous nature of the earth, intrusive or the different type of bodies within the subsurface.

This sedimentary thickness is not good enough for hydrocarbon accumulation.

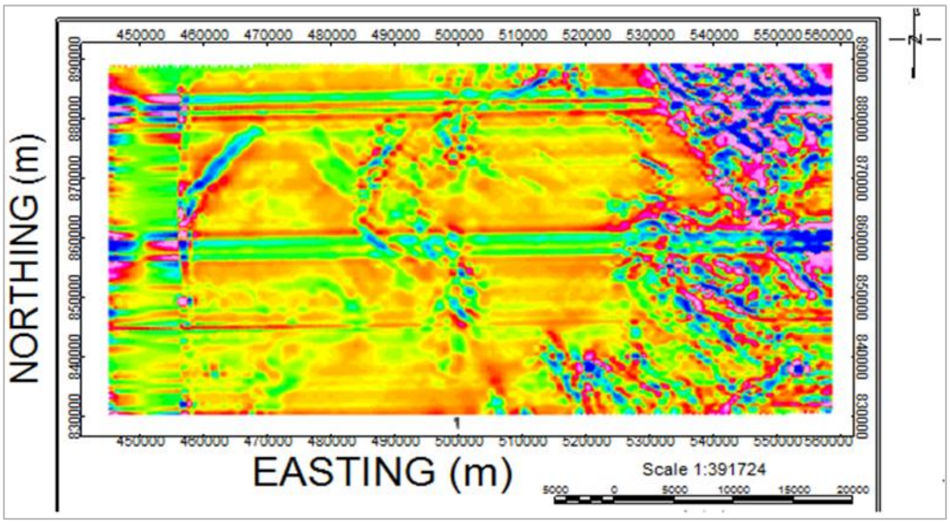

Figure 5: First vertical derivative map

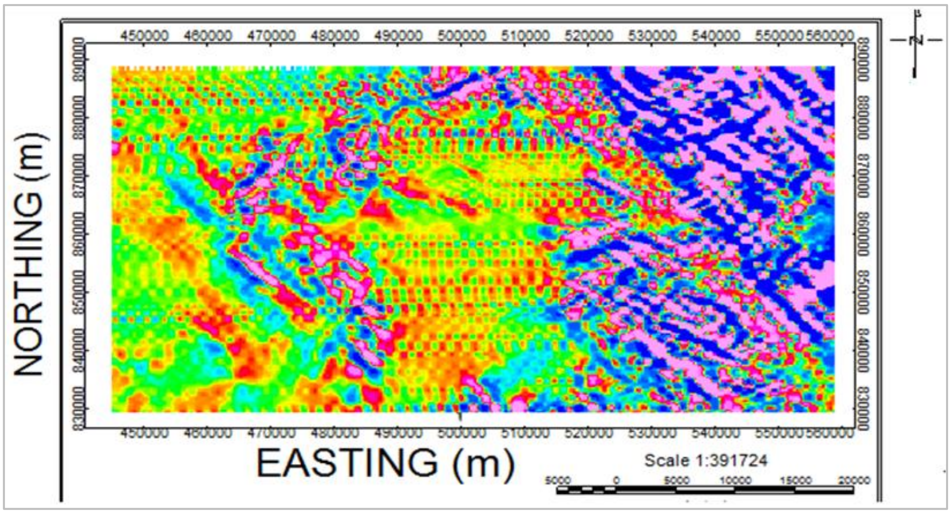

Figure 6: First horizontal derivative map

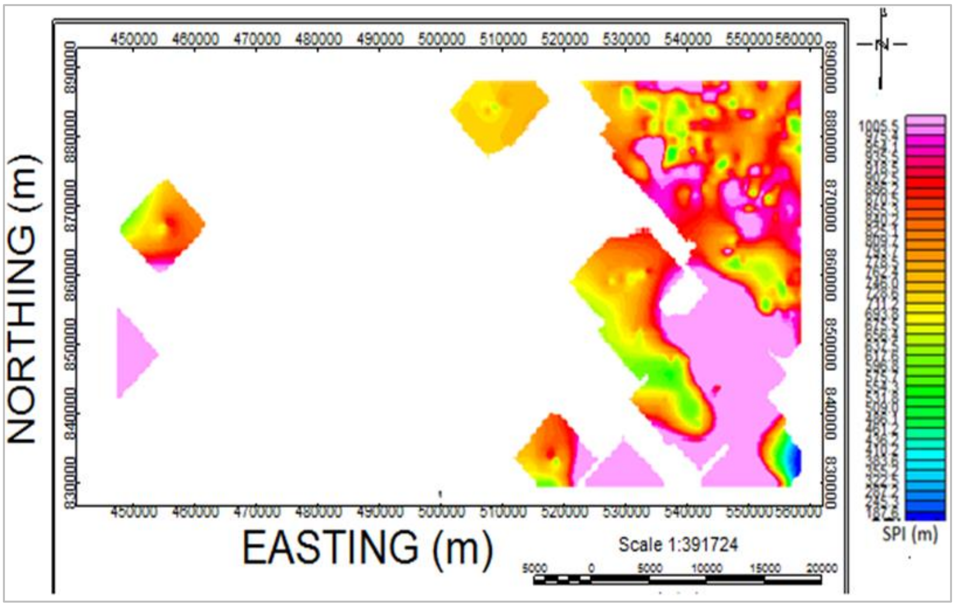

Figure 7: Source parameter imaging (SPI) map

4.5 Interpretation and Result Of 3-D Euler Deconvolution Method

The Oasis Montaj software was employed to compute Euler3D image and depth. the results were achieved using structural indices (SI= 0.5,1.0,1.5), which represent vertical contacts in geological model. This was done to locate depth to the lithologic contacts of the gridded map. Figures 8, 9 and 10 show varied colours of different Magnetic susceptibility contrast within the study area and also portrayed the undulations in the basement surface. The blue colour at the legend shows areas of deep lying Magnetic bodies, the pink, purple and orange colours at the legend show areas of shallower sediment or near surface lying magnetic bodies. From the result of the 3-D Euler deconvolution method shown in Figure 8, 9, and 10 respectively, the depth for the structure index(SI=0.5) ranges from 300 m to 2548.1 m, for structural index (SI= 1.0) the depth ranges from 262.9 m to 1826.2 m, and structural index (SI =1.5) the depth ranges from 391.0 m to 3243.6 m. The result is in agreement with they asserted that Ilesha is expected to have a shallow depth because it is in the basement complex of Nigeria (Adetunji et al., 2010).

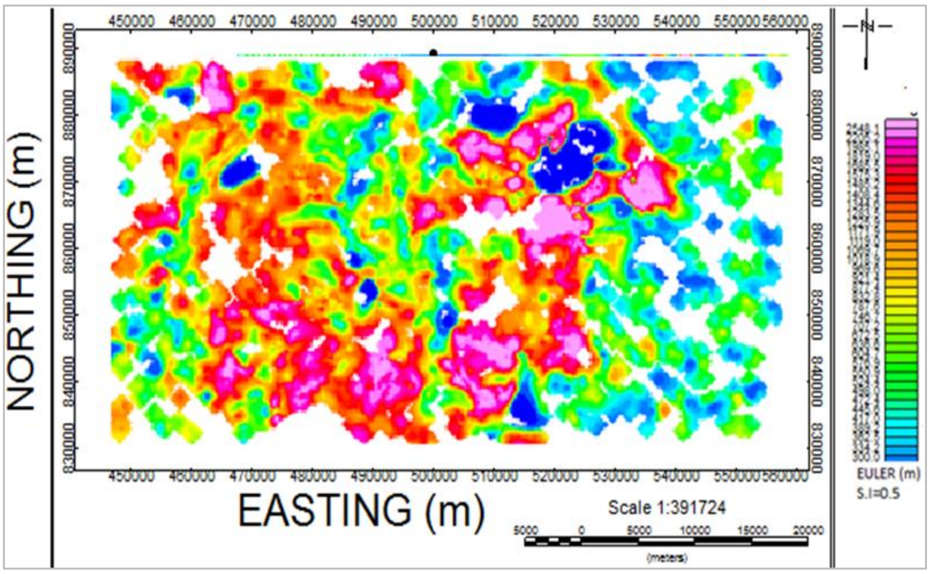

Figure 8: Euler Deconvolution map (SI=0.5)

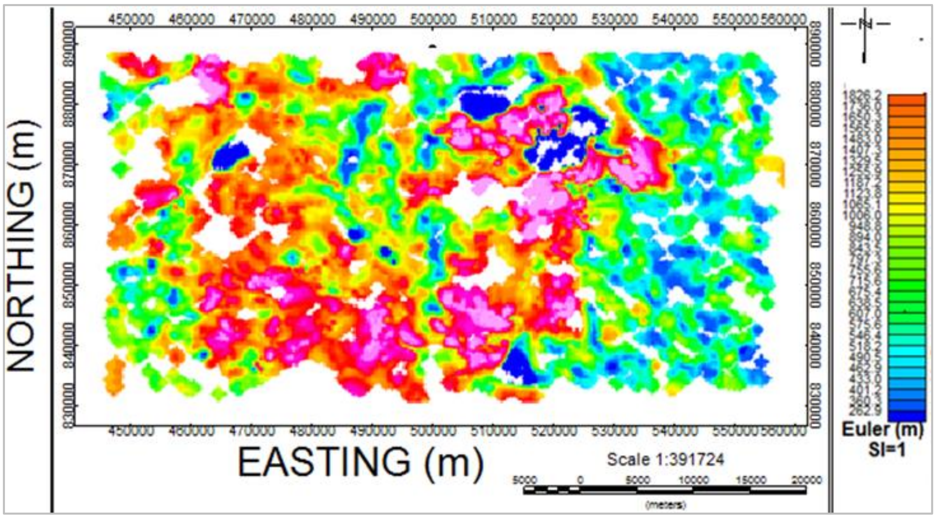

Figure 9: Euler Deconvolution map (SI=1.0)

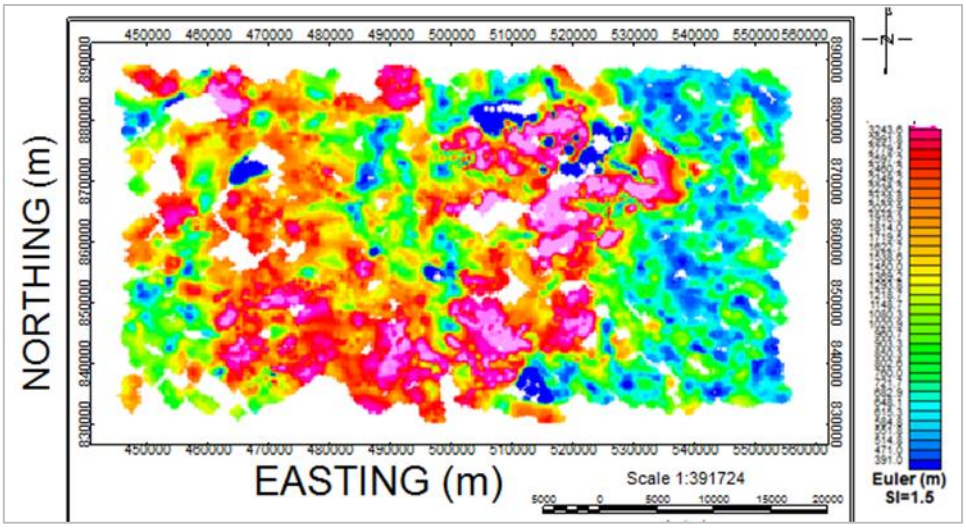

Figure 10: Euler Deconvolution map (SI=1.5)

5. CONCLUSION

Aeromagnetic data of Iwo (sheet 242) and Ilesha (sheet 243) southwest Nigeria has been interpreted by employing qualitative and quantitative interpretation. Source parameter imaging and Euler deconvolution were employed in study of the area, it has helped to delineate the geophysical structure of Iwo and Ilesha with the estimation of the sedimentary thickness, the depths were found to be a near surface rock. The result of the SPI and Euler deconvolution is not favorable for hydrocarbon accumulation but could be favorable for other mineral exploration which is subject to other geophysical investigation. It is clear that Iwo and Ilesha is geologically heterogeneous, as the distribution of both shallow and deeper depths are not uniform.

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