Zimbabwe Journal of Science & Technology pp 66-75 Vol.11 [2016]
e-ISSN 2409-0360
Zimbabwej.sci.technol

Application of 3-D Euler Deconvolution Technique to Aeromagnetic Data of Ilorin and Osi, Northcentral Nigeria

***Lawal, T. O., Salawu, N. B., Orosun, M. M., Ekpumoh, J. I. and Nwankwo, L, I.**

Department of Physics, University of Ilorin, Ilorin Nigeria

Corresponding email: *taofeeqlawal4u@gmail.com*

Abstract

Euler deconvolution of the Aeromagnetic Data of Ilorin and Osi in the North central part of Nigeria was carried out to identify, determine the depths to various magnetic sources and the geometry of the magnetic sources with prescribed values of the structural indices that ranges from 1.0 to 3.0 in the study area. Analytic signal grid was obtained from the Aeromagnetic map of the study area. Furthermore, the Euler solutions for structural index of 1.0 have their depths values ranging from 106 to 360 m for Ilorin and 71 to 389 m for Osi, while for structural index of 2.0 have their depth values ranging from 185 to 571 m for Ilorin and 167 to 523 m for Osi and structural index of 3.0 have their depths values ranging from 276 to 750 m for Ilorin and 280 to 743 m for Osi. The result from the interpretation of the obtained different structural indices has enabled a rapid determination of the locations and depths of magnetic sources such as sills and dykes which could be attributed to occurrence of feldspar in the study area.

Keywords: Euler deconvolution, Aeromagnetic map, Magnetic sources, Structural Indices, Depths to magnetic sources.

Received: 10.09.2016. Accepted: 11.11.2016

1. INTRODUCTION

Aeromagnetic survey is a type of geophysical survey carried out using a magnetometer aboard or towed behind an aircraft. The survey has developed to a sizeable extent over the past few years such that it has seen a revolution in the interpretation of solely basement structures to detailed examination of structures and lithologic variation in the sedimentary section (Emudjaporue and Ofoha, 2015). The data obtained from aeromagnetic survey are normally presented in form of maps which allows the use of mathematical techniques (quantitative interpretation) to obtain positions and depth to magnetic sources (Salawu, 2016).The quantitative interpretation of huge amounts of data obtained from the survey can be aided by automatic interpretation techniques such as Euler deconvolution (Cooper and Derrheim 1997). The Euler deconvolution technique is an interpretation tool in potential field for locating anomalous sources and the determination of their depths by deconvolution using Euler's homogeneity relation (Reid et al., 1990). The technique 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. Application of Euler deconvolution on total magnetic field data has been defined by many researchers (Nwankwo et al., 2016; Nabighian et al., 2005; Aboud et al., 2003; Dawi, 2004; Durrheim and Cooper, 1997; Thompson, 1982). Its application begins with the work of Thompson (1982) that proposed a scheme for analyzing magnetic profiles based on Euler's relation for homogeneous functions. The procedure uses first-order *x*, *y* and *z* derivatives to determine location and depth for various idealized targets (sphere, cylinder, thin dike, contact), each characterized by a specific structural index (Nwankwo et al., 2016).

1.1 Location and Geologic Setting of Study Area

The study area is found in Kwara State, North central Nigeria which lies between Longitude 5.00°E to 5.30°E and Latitude 8.00°N to 8.30°N respectively. The area has a typical guinea savannah type with shrubs and undergrowth. It has a distinct climate condition of wet and dry seasons: a dry season which usually last from October to February and a rainy season which last from March to September. Temperature variation is between 25^{o}C around November/December and 35^{o}C in February/March. The elevation of the study area is between 320 - 335 meters and the average ambient pressure is 975.11 mb (millibars).

The area lies within the crystalline basement rocks of eastern part of Northcentral Nigeria. (Figure.1). The rocks types found Nigeria mainly the migmatite-gneiss complex, which are the oldest basement rocks believed to have been of sedimentary origin but which have profoundly undergone many processes of metamorphism and magmatic intrusions. The rocks comprises of mainly sedimentary rocks. It also contains both primary and secondary laterites, and alluvial. The study area falls within the category of hard rock terrain where aquifers possess distinct features from the porous and permeability are product of secondary processes. This type of rock deposits are weak and therefore readily yield to agents of erosion (Olawepo et al., 2013). The rocks that dominate the study area can be grossly divided into gneiss, granite, gabbro, migmatite, amphibolite and pegmatite (Bamigboye and Adekeye 2011).

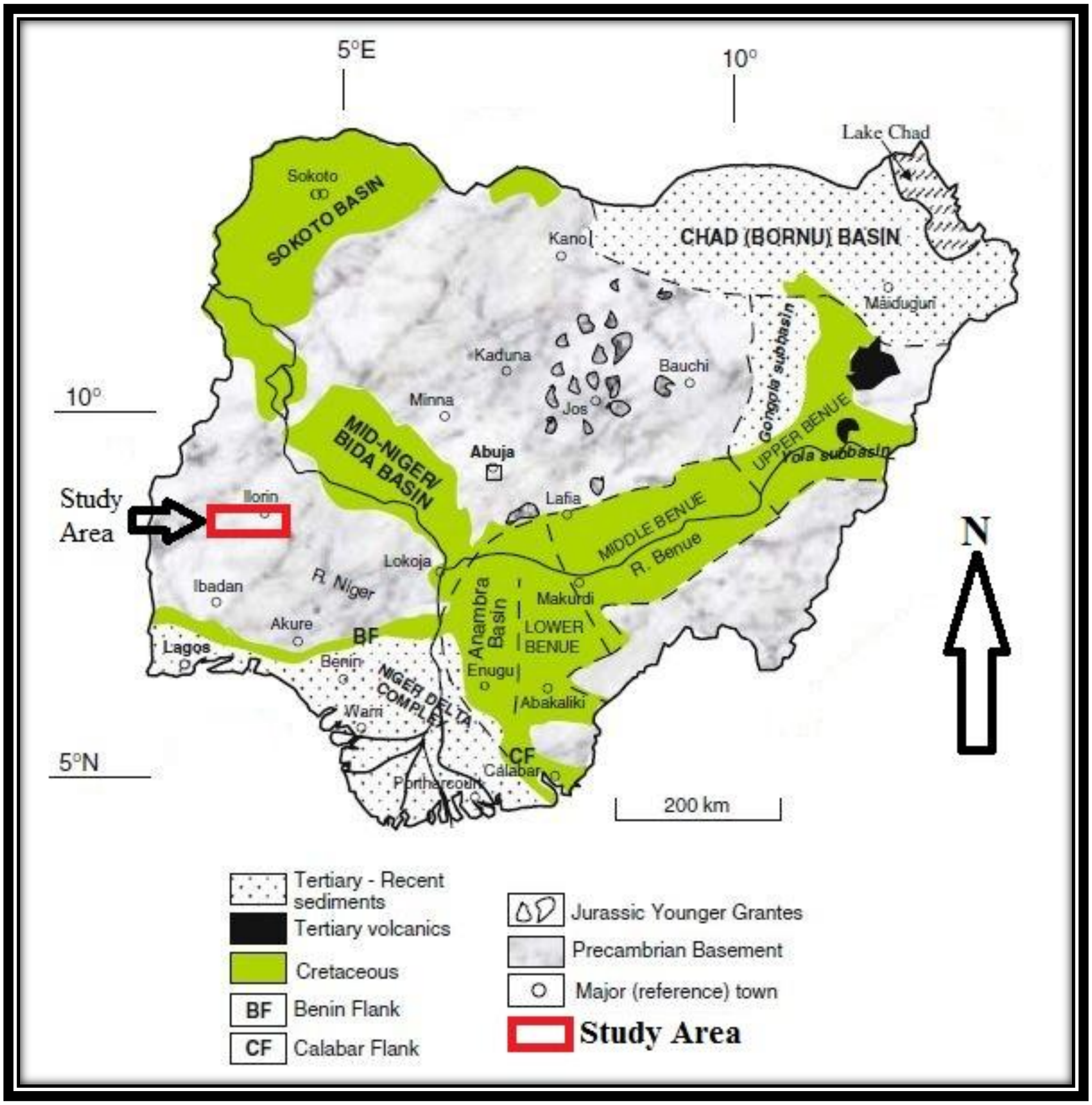

Figure 1. Map of Nigeria indicating the Study Area (modified after Nwankwo et al., 2016).

2. MATERIALS AND METHODS

Two aeromagnetic maps (sheet numbers 223 and 224) (Figure 2) with a total area of 6,050 km^2 were acquired from Nigerian Geological Survey Agency (NGSA). The survey was carried out by NGSA along a series of NW – SE flight lines with a spacing interval of 500 m and an elevation of about 80 m while tie lines occur at about 2 km interval. The Regional field was removed from the data by NGSA using the International Geomagnetic Reference Field (IGRF).

The Euler's 3D homogeneity relation as related to magnetic field data is of the form (Reid et al 1990; Reid 1997)

$$(x-x_0)\frac{\partial T}{\partial x}+(y-y_0)\frac{\partial T}{\partial y}+(z-z_0)\frac{\partial T}{\partial z}=N(B-T) \tag{1}$$

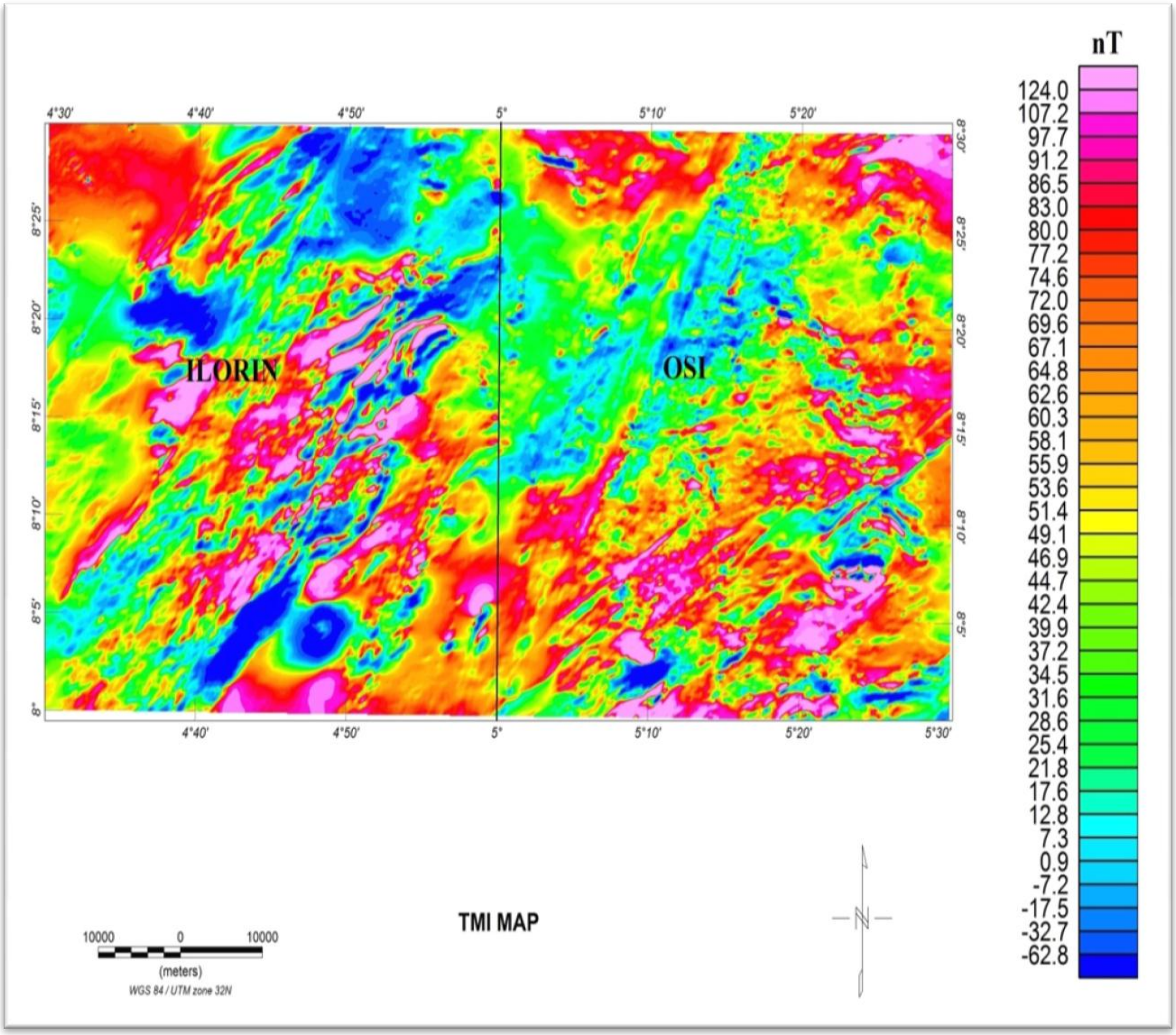

Figure 2. Total Magnetic Intensity (TMI) map of the study area.

where (x_0, y_0, z_0) is the location of a magnetic source, whose total field magnetic anomaly at the point (x, y, z) is T and B is the regional field. N is a measure of the rate of change of a field with distance and assumes different values for different types of magnetic source (called structural index). Equation (1) is solved by calculating or measuring the anomaly gradients for various areas of the anomaly and selecting a value for N (Philip et al., 2002). For a homogeneous point source N = 3, a linear source (line of dipoles or poles, and for a homogeneous cylinder, rod, etc.) N = 2, for extrusive bodies (thin layer, dike, etc.) N = 1, for a contact, vertex of a block and a pyramid with a big height N = 0 (Amigun et al., 2012). Also, Hsu (2002) provided the overall formula for Euler's equation as:

$$\frac{\partial}{\partial x}\left(\frac{\partial^n T}{\partial z^n}\right)(x - x_0) + \frac{\partial}{\partial y}\left(\frac{\partial^n T}{\partial z^n}\right)(y - y_0) + \frac{\partial}{\partial z}\left(\frac{\partial^n T}{\partial z^n}\right)(z - z_0) = -N\left(\frac{\partial^n T}{\partial z^n}\right) \qquad (2)$$

where n is the order of the gradient used and for n = 1 to the first vertical gradient of the magnetic field, equation. (2) gives a solution:

$$\left(x-x_0\right)\frac{\partial^2 T}{\partial x \partial z}+\left(y-y_0\right)\left(\frac{\partial^2 T}{\partial y \partial z}\right)+\left(z-z_0\right)\frac{\partial^2 T}{\partial z^2}=-N\frac{\partial T}{\partial z} \quad (3)$$

In the past, various geophysical methods have been carried out within the basement complex (Olasehinde 1984, Olasehinde et al. 1986; Adelana 1988, Olasehinde 1999, Nwankwo 2002, 2011; Raji and Bale 2008; Bamigboye and Adekeye 2011). Olawepo et al., (2013) reported the contributions of some of the aforementioned researchers to fracture pattern and the geology of the area. From their report and many others, it was observed that information about the identification of various magnetic sources and depth to the basement structures within study area is inadequate and lacking in this regard. Therefore, a comprehensive location, identification and depth determination of isolated magnetic causative anomalous sources in the study area has been carried out with a view of contributing to the geophysical information of the Basement complex of Nigeria.

In order to determine the location and depth estimate of causative anomalous bodies for various magnetic sources in the study area, Euler deconvolution technique was employed on the Total Magnetic Intensity data (Figure 2) of the study area using the Oasis Montaj Software. In achieving these objectives, we start by calculating the analytic signal grid and later determine the peaks in the grid whose locations were used by Euler deconvolution. The Euler deconvolution applied involves setting an appropriate structural index, SI value and using least – squares inversion to solve equation (1) for an optimum X_0, Y_0, Z_0, and total magnetic field intensity (B) (Amigun et al., 2012). The TMI map shown in (Figure 2), was used for the calculation and subsequent display of the analytical signal map shown in (Figure 3) which was used for the Euler deconvolution method. The analytical signal map (Figure. 3) is also useful in the location of edges of magnetic source bodies particularly where remanence and / or low magnetic latitude complicates interpretation (Amingun et al., 2012).

3. RESULTS AND DISCUSSION

The Total magnetic intensity map (Figure 2) shows that the study area is divided in to regions of positive (> 0.9 nT) and negative magnetic values (< - 32.8 nT). These regions of positive values are characterized as high magnetic anomalies while regions of negative values are characterized as low magnetic anomalies. These high magnetic anomalies are more prominent in the central part of the Maps trending NE-SW and NW-SE of the study area. Few of these anomalies are also noticeable in the N-W and S-E part of the area. The low magnetic anomalies are prominent in the southern part while few of them were noticed in the northern part of the area and they all trends in NE-SW direction. The high magnetic anomalies found in the area are felsic igneous intrusive rocks because of their high magnetite content and they may have resulted from several tectonic activities events which occurred in the formation of the basement complex, while the low anomalies in the area are mafic sedimentary rock because of their low magnetite content. These anomalies are reflections of the down-faulted blocks of the Precambrian basement complex which controls the sediments above it. Also, the result of the Analytic signal map (Figure 3) shows that the map has maxima which are used to locate the outlines of magnetic sources, and some of these maxima are noticeable in the north central portion of Ilorin and few of them in southern portion of Osi. All these maxima are trending NE – SW. Also, networks of magnetic discontinuities are observed on the map trending NE- SW. These represents fracture zones which can be a target zones for minerals prospectivity.

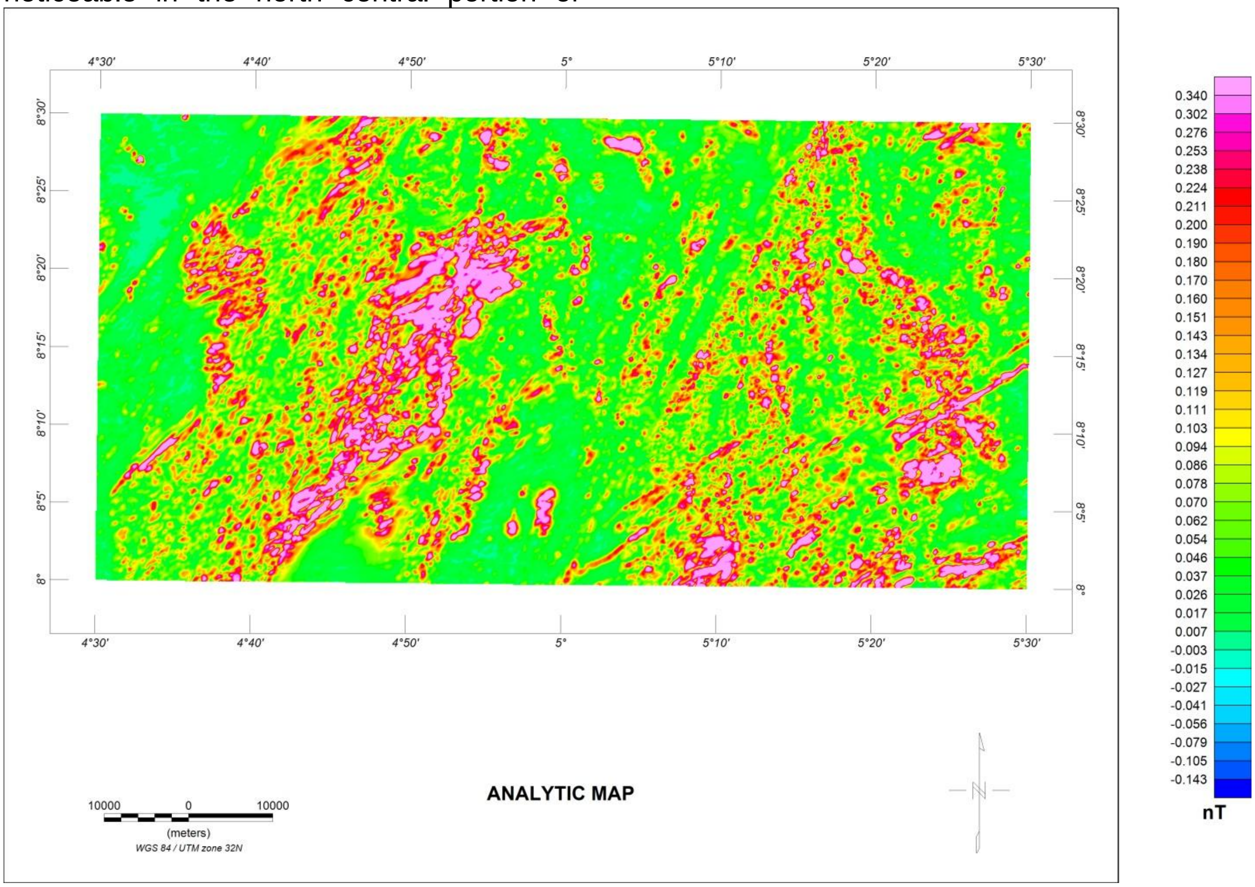

Figure 3. Analytical Signal Map of the Study Area

Figure 4, shows the result of Euler solutions for structural index 1.0 of the magnetic anomalies over the study area, with their depths values ranging from 99 to 361 m. The clusters of solutions (circles) produced over anomalies for S.I = 1.0 as observed are spread out but more concentrated in the western part of them map (Ilorin) and it also has the deepest depth which range from red (241m) to lilac (361m), it coincide with the high magnetic intensity value in Figure 1 and also on the analytic map (Figure 3) located in Ilorin. The value of the structural index, 1.0 is typical for a sill or dyke (Yaghoobian et al., 1992; Adetona, and Abu, 2013) and this could be attributed to feldspar which always crystallize in intrusive igneous rocks that have intrude layers of sedimentary bed and also feldspar are part of the mineral found in this part of the basement complex.

Figure 5, shows the Euler solutions for structural index of 2.0 of the magnetic anomalies having their depths values ranging from 198 to 570m. The cluster of solutions (circles) produced over anomalies for S.I = 2.0 as observed are more concentrated in Ilorin as observed in Figure

4, however few circles is depicted in the southeastern part of Figure 5 (which falls in Osi) and it show similar features with both the TMI map (Figure. 1) and Analytic map (Figure. 3) and the also coincide with Figure 4.

Figure 6, shows the Euler solutions for structural index 3.0 of the magnetic sources, having their depths values ranging from 277 to 746 m. The cluster solutions (circles) produced over anomalies for S.I = 3.0 are more concentrated in Ilorin than Osi which is an indication of more minerals.

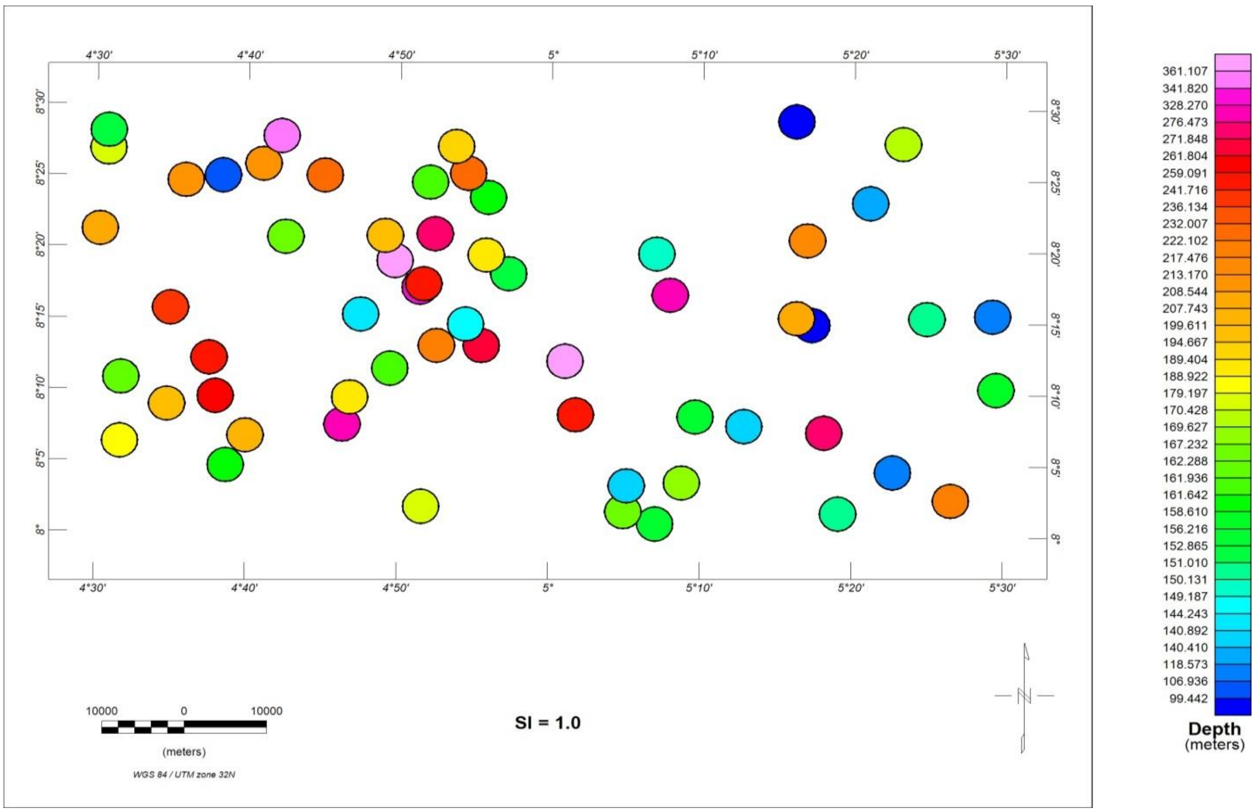

Figure 4. The Euler Deconvolution Depth Plot of the Study Area for S.I = 1.0

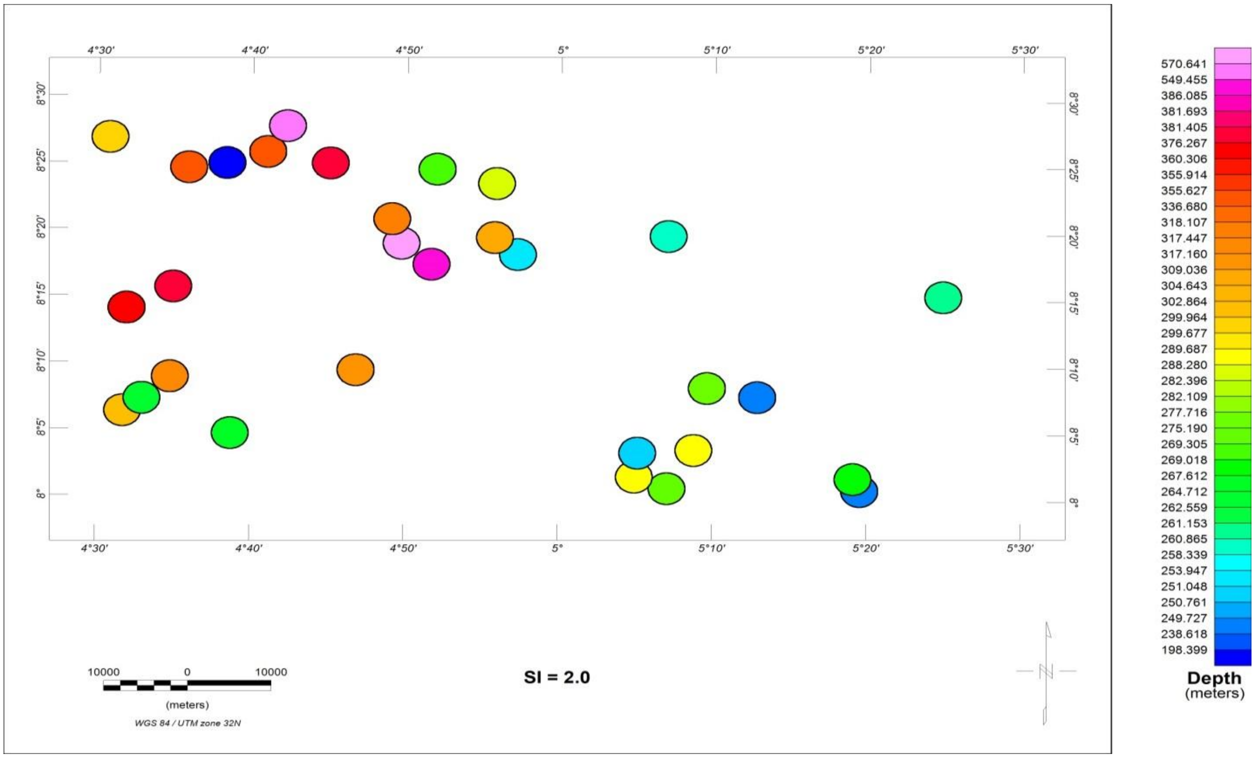

Figure 5. The Euler Deconvolution Depth Plot of the Study Area for S.I = 2.0

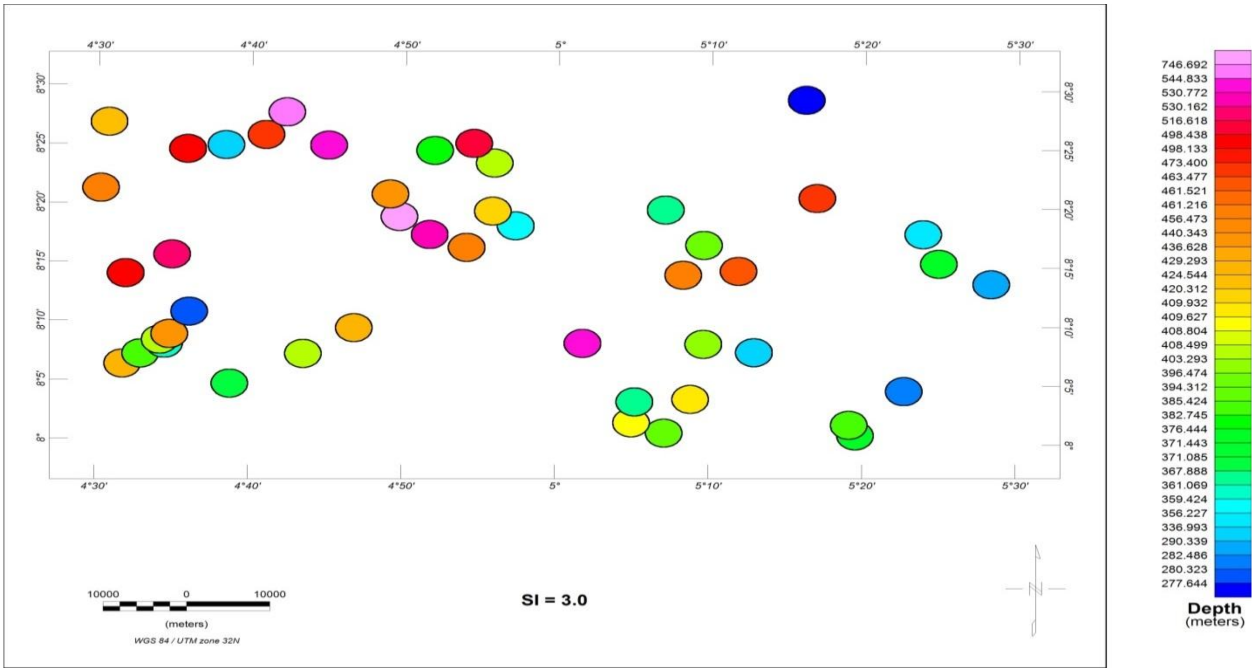

Figure 6. The Euler Deconvolution Depth Plot of the Study Area for S.I = 3.0

4. CONCLUSION

Euler deconvolution has been employed over Ilorin and Osi using different structural indices, and the results have shown similar features. The obtained cluster solutions (circles) coincide with the Total Magnetic Intensity map and the Analytic map of the study area. The result from the interpretation of the obtained different structural indices has enabled a rapid determination of the locations and depths of magnetic contacts such as sills and dykes which could be attributed to feldspar in the study area and the obtained depths could represent the depth to various kinds of minerals. The Euler deconvolution has served as a good magnetic model for estimation of depths and location of minerals which has served as a preliminary reconnaissance survey of the area since information about the magnetic source types and its location is yet to be established.

REFERENCES

Aboud, E., Salem, A. and Ushijima, K. (2003). Interpretation of Aeromagnetic Data of Gebel El-Zeit, Gulf of Suez, Egypt Using Magnetic Gradient Techniques. Memoirs of the Faculty of Engineering, Kyushu University 3, 63-70.

Adelana, S.M (1988). Seismic refraction survey of Unilorin Main campus Unpub. MSc thesis.

Adetona, A. A. and Abu, M. (2013).Estimating the Thickness of Sedimentation within Lower Benue Basin and Upper Anambra Basin, Nigeria, Using Both Spectral Depth Determination and Source Parameter Imaging. Geophysics 4, 60-70.

Amigun, J. O., Afolabi, O. and Ako, B. D. (2012). Euler 3-D Deconvolution of Analytical Signal of magnetic anomalies over Iron Ore deposit in Okene, Nigeria. Journal of Emerging Trends in Engineering and Applied Sciences 3, 711-717.

Bamigboye, O.S. and Adekeye, J.I.D (2011). Stream sediment survey of Eruku and its environs, Central Nigeria: Implication for Exploration. IJRRAS 7 (2).

Durrheim, R. J and Cooper, G. R. J (1997). Euldep: A Program For the Euler Deconvolution of Magnetic and Gravity Data. Computers and Geosciences 24(6), 545-550.

Emudjaporue, G. and Ofoha, C. C. (2015). Qualitative Interpretation of High Resolution Aeromagnetic (HRAM) Data from some parts of offshore Niger Delta, Nigeria. Scientia Africana 14, 40-54.

Nabighian, M. N., Grauch, V.J.S., Hansen, R.O., Lafehr, T.R., L:,Y., Peirce, J.W., Phyllips, J.D., and Ruder, M. E. (2005). The historical development of the magnetic method in 18 exploration, Geophysics 70, 33-61.

Nwankwo, L. I., Olayinka, L. A., Ige, S.O. and Lawal, T. O. (2016). Euler Deconvolution of Total Magnetic Fields of Gandi, North-West Nigeria. Gashua Journal of Sciences and Humanities.

Nwankwo, L.I. (2002). The use of electrical resistivity pseudo section in elucidating structural disposition in an E-W profile around the University of Ilorin, Nigeria. Unpub. MSc thesis.

Nwankwo, L. I., P. I Olasehinde, Babatunde, E. B. (2004). The use of electrical resistivity pseudo-section in elucidating the geology of the east-west profile in the basement complex terrain of Ilorin, west-central Nigeria. Nigeria Journal of Pure and Applied Science 19,1672-1682.

Nwankwo, L. I. (2011). 2D Resistivity survey for Groundwater Exploration in Hard Rock Terrain: A Case Study of MAGDAS Observatory, Unilorin Nigeria. Asian Journal. of Earth Science 1819-1886.

Olasehinde, P. I. (1999). An integrated geological and geophysical exploration technique for groundwater in the basement complex of west central part of Nigeria. Water Resources 10, 46-49.

Olasehinde P.I. (1984). A Comparison of radial geoelectric sounding and structural lineaments in unilorin main campus, Unpub. MSc. Thesis.

Olasehinde P.I., Annor A.E. and Pal P.C. (1986). A geological evaluation of a prospective site for a weir on river Oyun, Ilorin, Nigeria. 7. Angew Geowiss 8(5), 83-90.

Olawepo, A.O., Fatoyinbo, A.A., Ali, I and Lawal, T.O. (2013). Evaluation of Groundwater Potential and Subsurface Lithologies in Unilorin Quarters using Resistivity Method. The African Review of Physics 8(45), 317-323.

Philip, K., Micheal, B. and Ian, H. (2002). An introduction to geophysical exploration. Blackwell

Raji W.O and Bale R.B (2008). The geology and geophysical studies of a gravel deposit in university of Ilorin, South western Nigeria. Continental Journal of earth Science 3, 40-46.

Reid, A. B.,Allsop, I. M., Grasner, H, Millet, A. J. and Somerton, I. W. (1990). Magnetic interpretation in three dimensions using Euler deconvolution, Geophysics 55, 80-91.

Reid, A. B. (1997). Prospect Scale Interpretation of HRAM Data: Euler Depth Estimates. Canadian Journal of Geosciences 34, 1.

Salawu, N. B. (2016). Estimation of Depth to Magnetic Sources in Southern Nigeria from Spectral Analysis of High Resolution Aeromagnetic Data. An M. SC. Thesis Submitted to the Department Physics, University Of Ilorin.

Thompson D.T. (1982). “EULDPH – A new technique for making computer – assisted depth estimates from magnetic data”, Geophysics 47, 31-37.

Yaghoobian A., Boustead G.A, Dobush T.M (1992): “Object delineation using Euler’s Homogeneity Equation”, Proceedings of SAGEEP ‘92, San Diego, California.