International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Assessment of Aeromagnetic Data to Determine the Structural Trends and Basement Depth in Lower Benue Trough, Nigeria.

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A B S T R A C T

High resolution aeromagnetic data acquired between 2005 and 2009 were analyzed to delineate the structural trends and determine the basement depth of the study area. Enhancement techniques and depth estimating methods were applied. The lineament exhibited two distinct sets of linear structures in the NW-SE and NE-SW, having the NE-SW direction as the dominant structural trend. These structures displayed cross-cutting relationships with each other majorly around the NE, central and southern part of the study area indicating phases of generic events. The SPI depth result ranges from 13242.3 to 83.1154m. The results of the study reveal evidence of the presence of the essential factors for mineral prospecting in the study area.

Keywords: Analytic signal, Aeromagnetic data, Lineaments, Source parameter imaging,

1. Introduction

Magnetic method is one of the useful tools deployed for investigating and acquiring information about the surface and subsurface geology of an area as a result of the irregularities in the earth's magnetic field produced by changes in magnetic properties of the rocks (Ejiga et al., 2022). Airborne magnetic survey has been of tremendous importance in the delineation of structural discontinuities within the basin (Nwokocha *et al.*, 2016). Several studies have documented that basement structure and depths can be accurately delineated using magnetic data (Omenikolo et al., 2022; Nwokocha *et al.*, 2016; Opara et al., 2015; Ghazala, 1993; Ofoegbu & Onuoha, 1991). Aeromagnetic data are acquired by flying an aircraft with a magnetometer attached, over the desired location. The survey has proved essential in displaying the spatial distribution and relative abundance of magnetic minerals and non-magnetic minerals in the upper levels of the crust which can help in the visualization of the geology and geological structures of the upper crust of the earth (Graham *et al*., 2014). The essence of the magnetic survey is to investigate subsurface geology on the basis of the anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks. Common causes of magnetic anomaly include dykes, faults and lava flows. This study attempts to reassess the mineral potentials of the study area by using high resolution aeromagnetic data. Delineation of subsurface structural features and depth estimates were achieved by employing enhancement filters.

2. Location and Geology of the study area

The study area covers an aerial extent of approximately 13,128 km^2. It is bounded by Latitude 7° 00^{1}N - 8° 00^{1}N and Longitude 7° 00^1 E - 8° 00^{1}E and occupies part of Lower Benue Trough. Four (4) aeromagnetic datasets were used for this study and are numbered (248, 249, 268, 269). The Benue Trough is one of the sedimentary basins in Nigeria that trends north – easterly for about 800 km in length and about 150 km in width (Cratchely and Jones, 1965). The origin of the Benue trough was from the early cretaceous rift system of the central West African uplift of the basement. It is made up of the lower Benue trough located at the southern part, the middle Benue trough at the centre and the upper Benue trough found at the Northern part. The first depositional cycle started with the origination of sedimentation which lasted till the late Albian from the middle, the second sedimentary cycle started by way of transgression of middle Albian that led to the deposition of shales of Asu river assemblage and the reversion that led to the deposition of the Keana and Bima sandstones at the end of cenomanian, and the third cycle started from the late Turanian.

3. Materials and Method

The aeromagnetic data set of the study comprising Sheet 248 (Dekina), 249 (Loko), 268 (Angba) and 269 (Ankpa) were obtained from the Nigeria Geological Survey Agency (NGSA). This was acquired by Fugro Airborne Surveys. The data, are part of the digital airborne data acquired between the period of 2005 and 2009. The maps were digitized along flight lines with a spacing of 500m and 80m terrain clearance and was flown along the NW – SE direction. The geomagnetic gradient was removed from the data using the International Geomagnetic Reference Field (IGRF) formula for 2005. Processing of the aeromagnetic data was done using the Oasis Montaj, Surfer 13, and potent software package. Production of total magnetic intensity

(TMI) grid of the study area using Oasis montaj software was done by merging the four (4) aeromagnetic data sheets. For this study, enhancement filters were applied to analyze, enhance the signature of hidden faults and estimate the depth to magnetic sources.

4. Source parameter imaging

The Source Parameter Imaging (SPI) is a technique developed by (Thurston et al. 1997) also referred to as local wavenumber technique. It is based on the principle of complex analytic signal and estimates source parameters from gridded magnetic data. The method utilizes the relationship between source depth and the local wavenumber (k) of the observed field, which can be calculated for any point within a grid of data via horizontal and vertical gradients.

The expression for SPI depth is in the form (Thurston and Smith,1997)

$$Depth = \frac{1}{K_{max}} \quad (1)$$

where Kmax is the peak value of the local wave number. It can be shown that

$$K_{max} = \sqrt{\left[\left(\frac{\partial Tilt}{\partial x}\right)^2 + \left(\frac{\partial Tilt}{\partial y}\right)^2\right]} \quad (2)$$

4. Results and Discussion

The techniques utilized in this study, provided details for the structural trend and depth to magnetic source. Figure 1 is the total magnetic intensity (TMI) map. It shows variation of highs and lows in magnetic signature and the intensity ranges from −171.016 to 319.851 nT. The high and low magnetic signature could be attributed to several factors which include, depth variation, degree of strike, difference in lithology and magnetic susceptibility. The elliptical contour closures seen in the study is an indication of the presence of magnetic bodies. The circular contours are areas of basic intrusives with ore bodies. Magnetic highs are observed around Ejule, Alomo, Ogba, Ankpa, Abejukolo and Magnetic lows are observed around Okwoga, Igabada, akpanya,Angba, Ogugu, Adausu.

Figure 2 is the Source Parameter Imaging (SPI) map. It displays the depth to magnetic sources in the study area and characterized by significant shallow and deeper depth variations. The SPI depth value ranges from -13242.3 to 83.1154m. The red colour shown in the SPI legend signifies thick sedimentation (deep magnetic bodies), which might be as a result of basement or near surface intrusive. It is observed around Angba**,** Ankpanya, Alomo, Ejule, Ankpa, Ogugu and Ado while the blue coloured region indicate areas occupied by shallow magnetic bodies, observed around Adausu, Ogba, Okpakiri, Okwoga, Igabada,Abejukolo.

Structural Trend

The lineament map (Figure 3) shows the structural lineaments having different orientations and varied lengths. A total of 329 lineaments were identified and delineated to generate a lineament map for the study area using the ArcGis software of Oasis Montaj. The lineament exhibited two distinct sets of linear structures in the NW-SE and NE-SW, having the NE-SW direction as the dominant structural trend. This is in agreement with previous studies carried out in the Benue Trough (Ananaba et al. 1987; Guiraud, 1990; Opara et al. 2015;). The lineaments are observed to cut cross each other majorly around the NE, central and southern part of the study area. This is typical of conjugate system associated with wrench tectonics and it implies that the fracture and fault are evidence of transpressional, trans-tensional, and extensional movements along oceanic fracture zones as African and South American Plates separated rift (Fairhead et al. 2013; Mustapha et al. 2019). The high concentration of lineament in the area portrays intense tectonic activities.

5. Conclusion

Interpretations of high-resolution aeromagnetic data over parts of lower Benue trough were carried out to delineate the subsurface structural lineaments, understand the structural trend and to estimate the depths to magnetic sources. The enhancement filters were applied to the Total Magnetic Intensity (TMI) map. The process provided proper distinction of the lithological boundaries and structures such as lineaments, faults, etc. The magnetic depth was determined using source parameter imaging technique. The SPI depth value ranges from -13242.3 to 83.1154m. The lineament exhibited two distinct sets of linear structures in the NW-SE and NE-SW, having the NE-SW direction as the dominant structural trend. The lineaments also cut cross each other majorly around the NE, central and southern part of the study area. The results from the study revealed shallow basement depth, presence of intrusive and cross-cutting relationships of the lineament structures which predict favorable areas as potential hosts for minerals exploration.

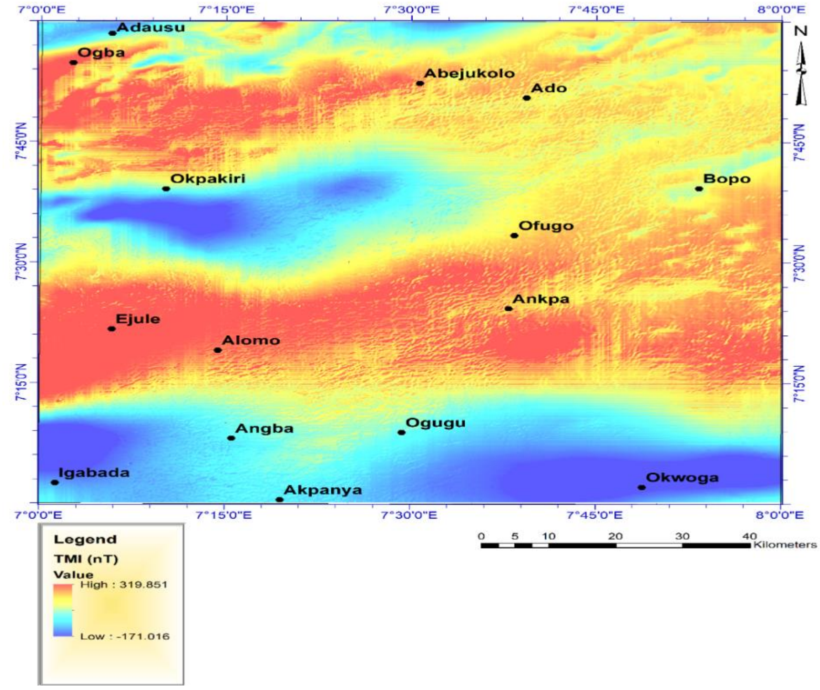

Figure 1: Total Magnetic Intensity (TMI) Image of the study area.

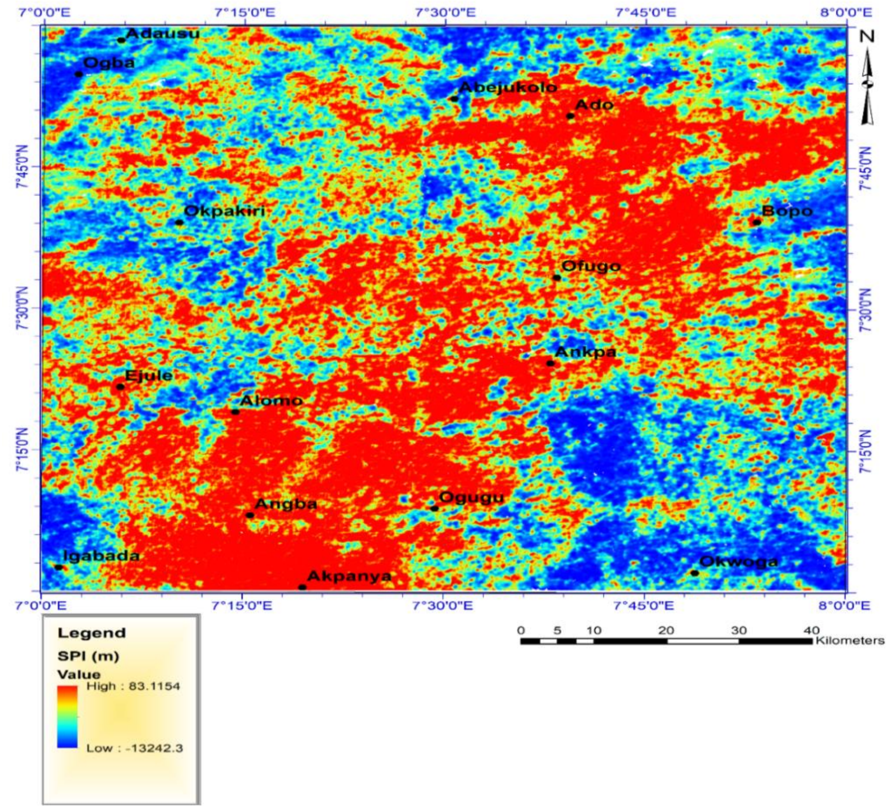

Figure 2: Source parameter imaging map

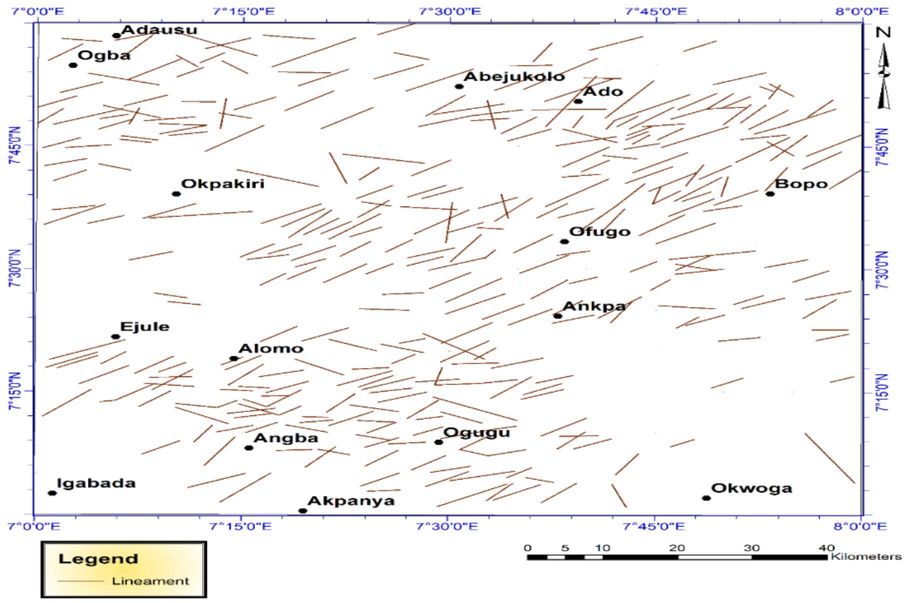

Figure 3: Lineament map

Acknowledgements

The authors are grateful to the Management of Tertiary Education Trust Fund (TETFund) Nigeria, for sponsoring this research work, through Federal Polytechnic Nekede Owerri, Nigeria. We are also grateful to Nigerian Geological Survey Agency (NGSA,) for the technical and data support.

Conflict of interest

There is no conflict of interest.

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