Journal of Geological Research
http://ojs.bilpublishing.com/index.php/jgr-a

ARTICLE

# Structural Exploration of Aeromagnetic Data over Part of Gwagwalada, Abuja for Potential Mineral Targets Using Derivatives Filters

**Priscillia Egbelehulu[1*] Abu Mallam[1] Abel U. Osagie[1] Adewumi taiwo[2]**

1. Department of Physics, University of Abuja, Abuja, Nigeria
2. Department of Physics, Federal University lafia, Nasarawa, Nigeria

ARTICLE INFO

*Article history*
Received: 10 August 2021
Accepted: 23 August 2021
Published Online: 25 August 2021

*Keywords*:
Aeromagnetic
Derivative filters
Faults
Mineralization

ABSTRACT

Aeromagnetic data are consistently used for economic interest targeting and geological mapping. Besides solving problems that are concerned with the basement, the method has become a useful tool in exploring minerals, hydrocarbons occurrence, groundwater investigations, and geothermal potentials. This study analyses aeromagnetic data from the Nigerian Geological Survey Agency acquired at 100 m terrain clearance over a section of Gwagwalada in Abuja. The study area spans longitudes 7.0875° E to 7.1458° E and latitude 8.9625° N to 9.0° N (about 27 km$^2$). After a reduction to the equator (RTE) transformation, the data is downward continued by 50 m. Different filters are applied to outline area of alteration associated to mineral deposit. Regional geologic structures trend NE - SW. The application of vertical derivatives (FVD and SVD) to the RTE grid enhanced shallow structures which trend NE - SW. Horizontal gradients along the X- and Y- directions enhance geological contacts attributable to blind faults. The Tilt derivative (TD) accentuated fault lines which trend NE - SW.

## 1. Introduction

Aeromagnetic exploration is often times carried out to investigate the distributions of bedrock lithologies and structures. Magnetic method is one of the oldest of all geophysical exploration techniques. With several innovation and improvements in the designs of field equipment's, it has become feasible to map the crustal sections at different scales. From a high magnetic basement to a weak sedimentary contact either at regional or at local scale [1]. Magnetic method plays an important role in mineral investigation which ranges from structure delineations to detect possible areas of ore deposits, since minerals are structurally controlled. Thus, delineating them plays a key role in the localization of mineralization [6].

Magnetic method responds to ferromagnetic materials and detects metallic objects composed of iron and steel [15]. It is concerned with the estimation of the earth's magnetic field intensity. Despite varieties of rock types available on the Earth crust, majority of them exhibit magnetic properties, either as a result of the present geomagnetic field, or as a result of remnant magnetization obtained in geological past, or combination of them [2]. Aeromagnetic data are consistently used for economic interest targeting and geological mapping [9]. Besides solving problems that are concerned with the basement, the method has become a useful tool in exploring minerals, hydrocarbons occur-

**Corresponding Author:*
*Priscillia Egbelehulu,*
*Department of Physics, University of Abuja, Abuja, Nigeria;*
*Email: priscilliaegbelehulu@gmail.com*



DOI: https://doi.org/10.30564/jgr.v3i3.3540

rence, groundwater investigations, and geothermal potentials [17].

Interpretation of magnetic anomaly pattern leads to geological map productions which gives guidance to exploration procedures [14]. They are also used as tools for reconnaissance survey. Its role has continued to gain relevance in assessing prospective area in recent times as a result of its distinctiveness [4].

Nigeria is furnished with several mineral resources. If duly explored could lead to its industrialization. Countries that are graced with abundant mineral become developed nations [10]. However, a country's greatness is usually the reflection of how her resources are managed [7]. Owing to the fact that Nigeria is endowed with both minerals and manpower competent of harnessing these minerals for industrialization, what is experienced in most cases is that the mineral exploration is usually done by unskilled and unauthorized miners and artesian who uses very crude techniques, lacks the technological know-how and insufficient finance to conduct exploration in a suitable manner. Consequently, they ruin the landscape which in turn affects the environment and its resources such as water, soil and food crops and the health of humans and animals [8]. The scenario is not different from what is obtainable in the study area, as illegal miner and artesian continuously exploits the area Figure 1. Thus the need arises for a research to be carried out to delineate the subsurface structure of the area for proper exploration of mineral. This research work presents the analysis of aeromagnetic data for the intension of recognizing major faults over the study area which is vital in it exploration. Geological information obtained from the data will be a useful guide in the future prospecting.

This work aims at interpreting aeromagnetic data of the study area to delineate the subsurface structures using derivative filters.

Objectives of the study are:

- To identify geologic features such as contact zones, fractures and faults, etc.
- To delineate boundaries of anomalies using derivatives filters.
- To delineate geological structures that might host possible minerals using derivatives filters.

## 1.1 Location of the Study

The research area is within Abuja, Gwagwalada area council. Bounded by longitude 7°5'15"E and 7°8'45"E and Latitude 8°57'45"N and 9°00'00"N was extracted from aeromagnetic map of sheet 281. The area consists of two broad landforms. These are the medium hill which ranges between 200- 450 m above sea level [11]. Figure 2 and 3 show the location map and topography map respectively. The hills present within the study area are formed by outcropping basement rocks. It has a relatively high temperature with sunshine of the area ranging between 8 - 10 hours daily during the period of January to May. The area records its highest temperature during the dry season at 38 °C. The rain starts by March and ends October [5].

**Figure 1.** Devastating land scape as a result of artesian mining activities

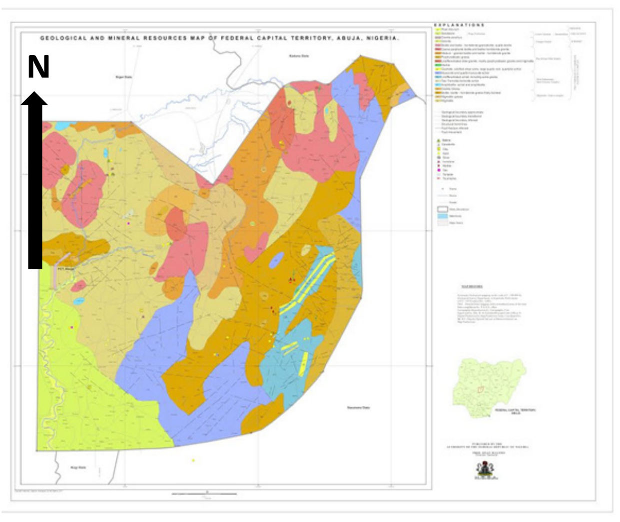


**Figure 2.** Updated Geological and Mineral Resources Map of FCT (After NGSA, 2017)

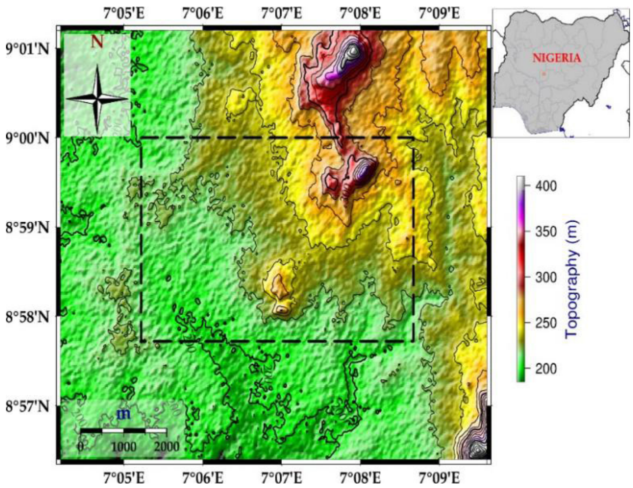


**Figure 3.** Topography map of study area

## 2. Geology of the Study Area

Gwagwalada is underlain by the undifferentiated Nigerian basement complex. The region lies within the Precambrian Paleozoic crystalline basement which spans over 50% of the land surface of Nigeria. The basement complex represents the end of two major orogenic cycles [12]. The later of these end products extended from the late Precambrian to lower Paleozoic. They were involved in the extensive remetamorphism and partial mobilization of the underlying basement leading to the development of high grade gnesis, migmatites and older granites. The dominant rock within the study area is banded gneisses. The outcrops are well foliated showing prominent gneissosity with the alternation of bands of mafic and felsic minerals. They are medium-to coarse-grained with large quartz intrusions exploiting joints and weak zones within the rock.

## 3. Methodology

Aeromagnetic dataset is obtained from Nigerian Geological Survey Agency (NGSA). The surveys were flown having a 100 m flight line spacing and a 500 m tie - line spacing and terrain clearance of 100 m in direction NE-SW, which is perpendicular to the major trend of the geology in the area. The data of the survey were obtained as a total magnetic intensity map.

### 3.1 Data Processing

Horizontal, vertical, tilt derivative and total horizontal tilt derivative plug was applied over aeromagnetic data of a part of Gwagwalada Abuja to outline area of alteration associated to mineral deposit.

### 3.2 First and Second Vertical Derivatives

First vertical derivative as well as the second highlight near surface anomalies and is calculated either in the space or frequency domain. They also intensify high-frequency noise. To control this problem, special "tapering" of the frequency response is usually applied. Calculation of the first derivative was initiated by Nabighian in1984, the second derivative filter was used majorly for delineating and estimating depths to the basement which formed the basis of aeromagnetic interpretation [18,3].

### 3.3 Horizontal Derivatives

Horizontal gradient is usually taken in a particular direction which helps to enhance lateral variation in the magnetic field and diminish its regional trend. This derivate reaches its maximum or minimum value in an area where exhibit a high and contrasting magnetic susceptibility, accentuating discontinuities that are perpendicular to the direction of deviation and revealing clearly faults and edges of the structure. Horizontal gradient is the easiest and simplest way to detect contract location of bodies at depth, having the advantage of minimal sensitivity to noise in the data [13]. M is given as the magnetic field, and the horizontal gradient magnitude (HGM) is thus:

$$HGM = \sqrt{\left(\frac{\partial M}{\partial x}\right)^2 + \left(\frac{\partial M}{\partial y}\right)^2}$$

### 3.4 Tilt Derivatives

The Tilt derivative is used to determine the boundary of source anomaly. It is used to determine shallow depth as well as deeper depth because of its less sensitivity to



DOI: https://doi.org/10.30564/jgr.v3i3.3540

source depth. Tilt is a function of the ratio of vertical and horizontal derivative of the field's magnetic intensity. However, it does not contain any information of the geomagnetic field strength nor the causative bodies' susceptibility. The peak is located over the center and the zero over the edges of the source.

The total horizontal tilt derivative equalizes signal from near surface and deep seated sources. Its notable feature is it produces amplitude maxima over source edges, gives suitable resolution also is less dependent on the depth of the structures. This application is done basically to reduce the data to a simpler form such that the edges and center of the causative bodies are easily determined. Edge detection of a magnetic structure is one of the most important task in the interpretation of magnetic data [16].

## 4. Results and Discussion

To delineate the lineaments and structures, the total magnetic intensity (TMI) grid is reduced to the equator (Figure 4) (Figure 5). This ensures that the magnetic anomaly is directly positioned on the body causing them since the direction of magnetization varies. On the RTE map, the magnetic signature is enhanced and trends NE - SW.

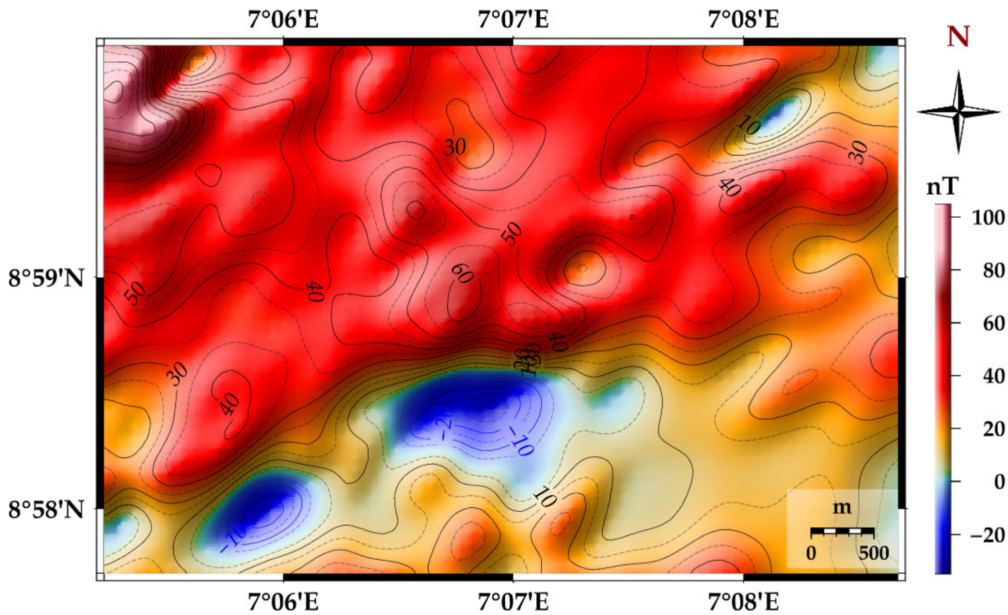


**Figure 4.** TMI of the study area

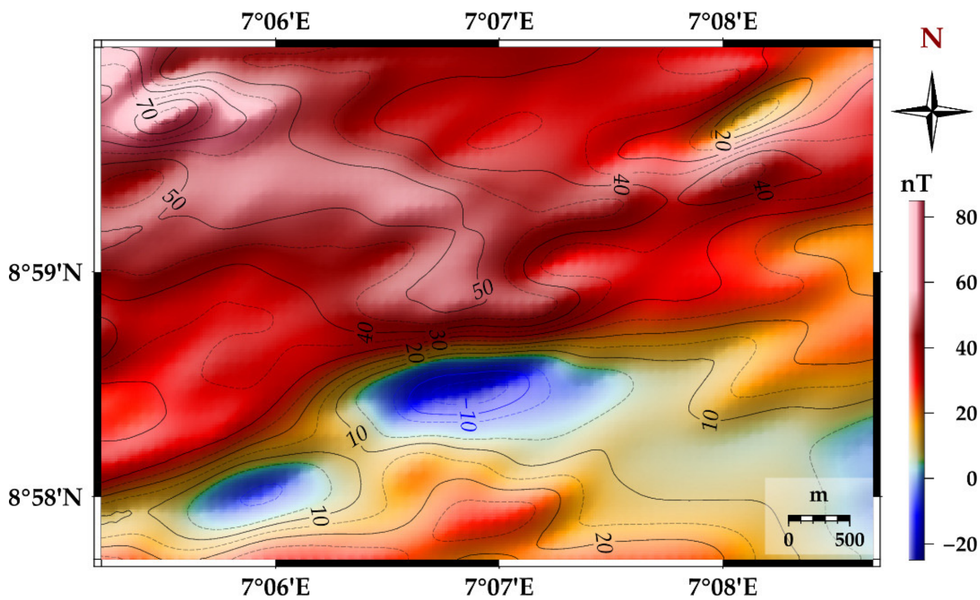


**Figure 5.** TMI Reduced to Equator

 DOI: https://doi.org/10.30564/jgr.v3i3.3540

**Application of the first and second Vertical Derivative for Structural Analysis**

The first vertical derivative (FVD) in Figure 6 enhances shallow structures and suppresses the effect of deep-seated geologic bodies. This enhances anomalies over bodies proving a clearer image of the causative structures. The area is marked with magnetic anomaly highs and lows which is attributed to slight variation in depth. High frequency signature noticed at the NE region of the area reveal a near surface depth to magnetic source. This is expected owing to the extrusive landform in the area and typical to Basement complex terrain. The major or predominant structure trend NE-SW. The rock type at the northeastern region is identified as granite gneiss.

The second vertical derivative (SVD) Figure 7 accentuated the structure observed on the FVD. Dominant structures are delineated on the SVD. It accentuates local features and emoves the influence of large anomalies.

The essence of this enhancement is for the zero value to be closely followed by sub-vertical edges of intra-basement blocks of the magnetic data or the edges of basement disturbances or faults. It is particularly helpful in highlighting line noise. The trend of these structures (lineament) correlate with the Pan- Africa structure (lineament) that trends NE - SW.

**Interpretation of Structures identified from Horizontal Gradient**

Horizontal Gradient (HGRAD) derivative enhances discontinuities such as fault and contact features in the

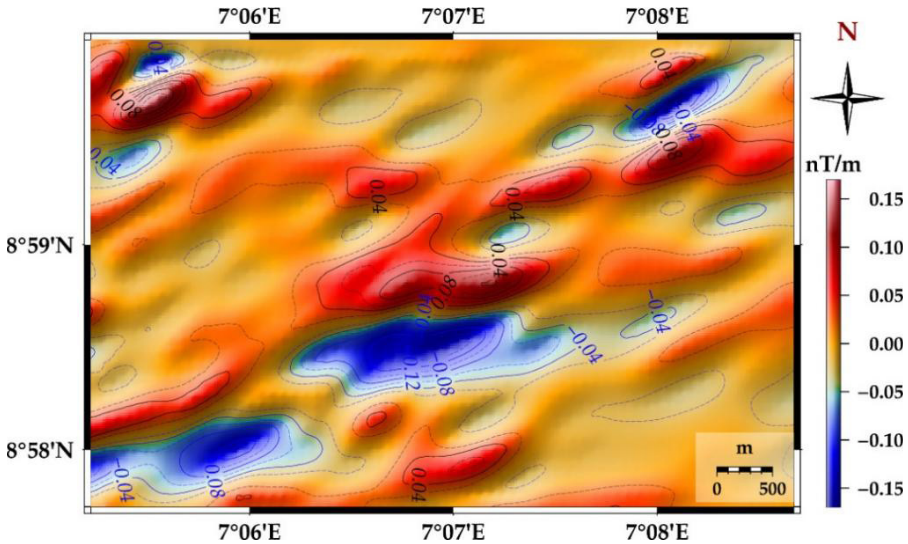


**Figure 6.** First Vertical Derivative Map

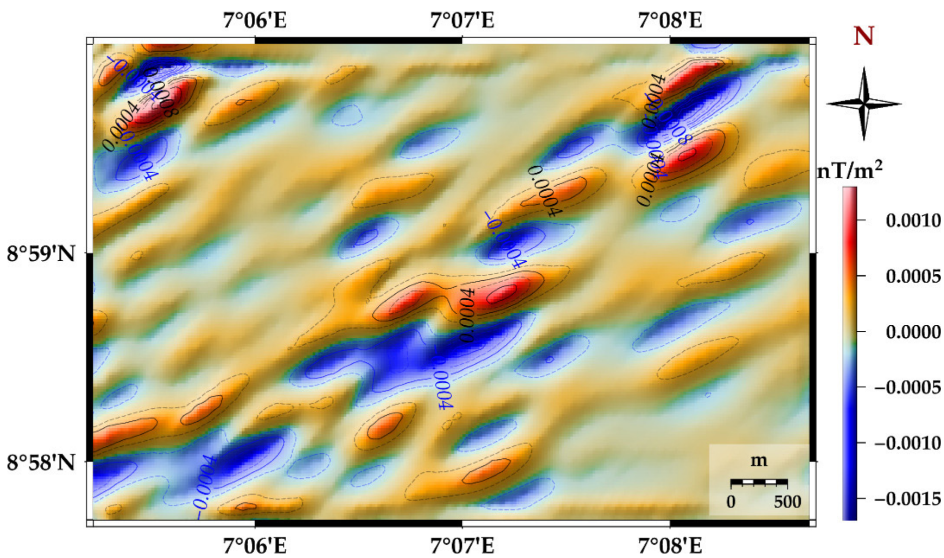


**Figure 7.** Second Vertical Derivative



DOI: https://doi.org/10.30564/jgr.v3i3.3540

data. It complement to the vertical derivative enhancements. It gives a more exact location for faults than the FVD.

To consider the main fault direction, two maps of horizontal gradient were generated each processed on the RTE map. The first along WE ($H_x$) direction which highlight the system of faults in the direction of almost NS (Figure 8) with its magnetic intensity. The other enhances the structures in the direction of almost WE (Figure 9) along the direction NS ($H_y$).

## Application of Tilt Derivative and Horizontal Tilt Derivative (TAHG) Analysis and Result

The tilt derivative filter was applied to RTE map to determine the boundary of the source anomaly. Since it is less sensitive to the depth of the source, it was applied to resolve shallow and deep source and to look at faults and contact features Figure 10. The peak of the tilt angle amplitude is located over the center and its zeros over the edges of the source body. Tilt derivatives usually produce

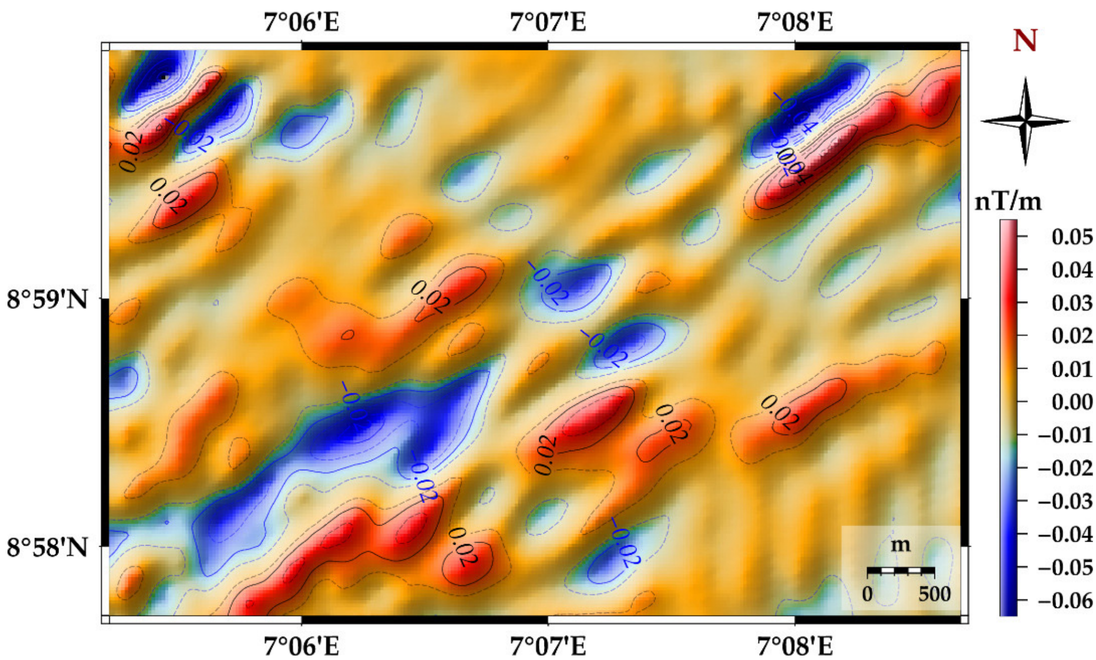


**Figure 8.** Horizontal Derivative in X-Direction

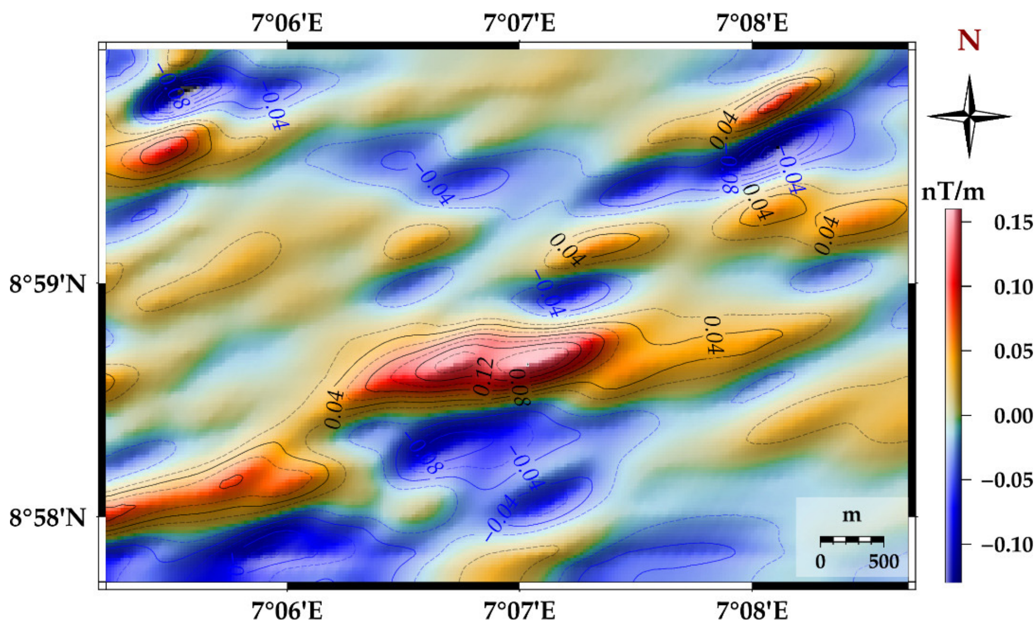


**Figure 9.** Horizontal Gradient in Y-direction

more accurate location for faults than the FVD. The major causative bodies trends from NE- SW. This maximum value of the tilt angle enhances location of the body edges to form a sharp and delicate peak.

The horizontal gradient of tilt (TAHG) applied to the RTE enormalize signals obtained from the shallow and deep seated sources Figure 11. It produces mavxima over the source edges, gives suitable resolution also it is less dependent on the depth of the structures.

## 5. Conclusions

Analysis from the first vertical derivation (FVD) and second vertical derivative (SVD) showed the enhancement of dominant structure. It enhances shallow structures and suppresses deep-seated geologic bodies. Structures were seen to trend NE- SW. Horizontal gradient were taken at X-direction and Y-direction. This enhanced discontinuities such as faults and contact feature, it compliments results obtained from the vertical derivatives. The Tilt derivative (TD) was used to attain the exact position of fault. TD and TAHG were applied to resolve shallow and deep source and to look at faults and contact feature. The main fault in the study area had the peak of the tilt angle amplitude and could be located within longitude 7°05’00”N, 7°08’30”N and latitude 8°58’00”, 8°59’00”. These faults are possible host for mineralization. TAHG showed the edges of the main fault having its peak at the edges.

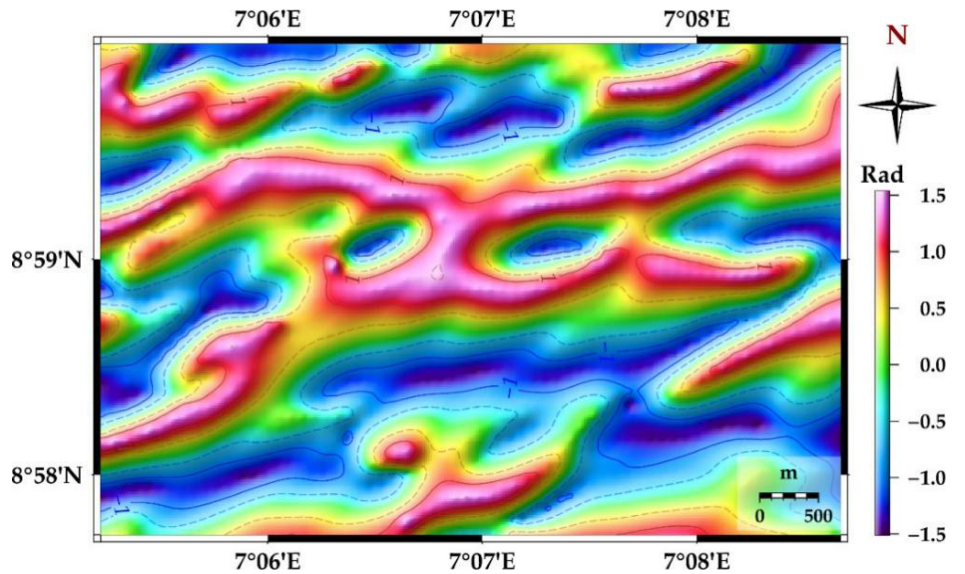


**Figure 10.** Tilt Derivative of the Study Area

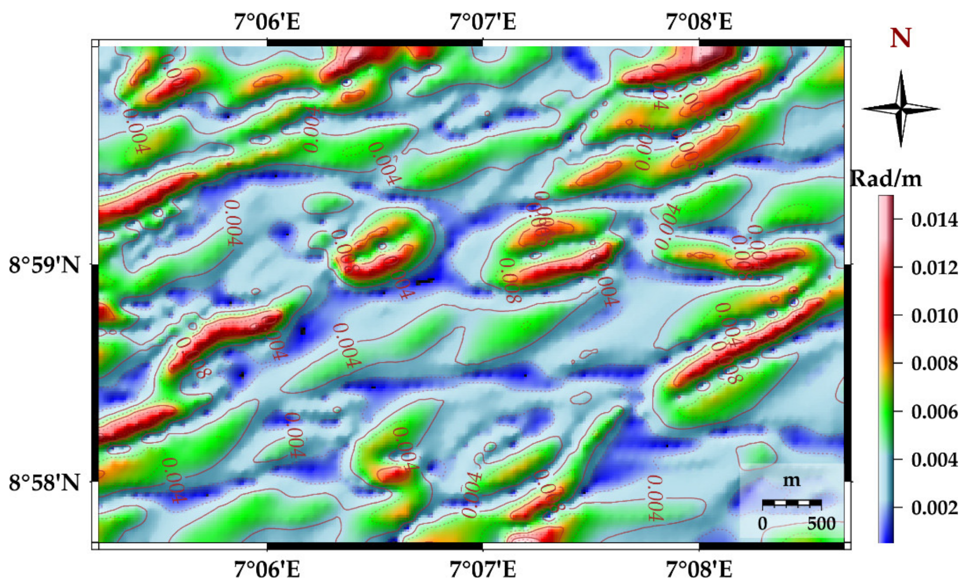


**Figure 11.** Horizontal Gradient of Tilt Derivative



DOI: https://doi.org/10.30564/jgr.v3i3.3540

## References

[1] Adagunodo, T.A., Sunmonu, L.A & Adeniji, A.A. an Overview of Magnetic Method in Mineral Exploration [J]. *Journal of Global Ecology and Environment* (2015), 3(1): 13 - 28.

[2] Adetona, A.A. and Mallam. A. Investigating the Structures within the lower and upper Anambra Basins, Nigeria, Using First Vertical Derivative, Analytical Signal and (CET) Center for Exploration Targeting Plug - in [J]. *Earth Science* (2013), 2(5): 104 - 112.

[3] Andreasen, G.E., and Zietz, I. Magnetic Fields for A 4 X 6 Prismatic Model [J] U. S. Geological Survey Professional Paper 666, (1969).

[4] Barbosa V.C, Silva J.B, Medeiros W.E. Stability analysis and improvement of structural index estimation in Euler deconvolution. Geophysics (1999), 64(1):48-60.

[5] Dawam, P. D. The geography of Abuja federal capital territory (2000). Famous.

[6] Elkhateeb, O.S. Delineation Potential Gold Mineralization Zone in a Part of Central Eastern Desert, Egypt Using Airborne Magnetic and Radiometric data [J]. *NRIAG Journal of Astronomy and Geophysics* (2018), 55 - 70.

[7] Gotan, B.J. Solid Minerals Exploration in Plateau State (Legislation, Difficulties and Framework Involved) [C]. A Paper Presented at A Semina by Nigeria Shippers Council, Jos Nigeria (2004).

[8] Gyang, J.D., Nanle, N. and Chollom, S.G. An Overview of Mineral Resources Development in Nigeria: Problems and Prospects [J]. Continental Journal Sustainable Development (2010), 1, 23 - 31.

[9] Jesperson. A. Aeromagnetic Interpretation of Globe-Miami Copper District, Gila and Pinal Counties, Arizona. Geology Survey Research [R], U.S Geological Survey of Canada, Professional Paper D (1964), 70 - 75.

[10] Okpanachi, U.M. Economics of the Solid Minerals Market [c]. Paper Presented at the Nigeria Shippers Council Seminar on "Solid Mineral Exploration and Exploitation", Jos, Nigeria (2004).

[11] Olugboye, M. O. "Report on the Preliminary Hydrogeological Investigation of FCT Abuja [R]." *Federal Department of water Resources* 4 (1977).

[12] Oyawoye M.O. The geology of the Nigerian Basement Complex—a survey of our present knowledge of them. Journal of Mining Geology and Metal. (1964), 1(2pp87-103):80-91.

[13] Philips, J.D. Processing and Interpretation of Aeromagnetic Data for the Santa Crus Basin - Patahonia Mountains Area South - Central Arizona [R]. U.S Geological Survey Open- file (1998). Arizona 02- 98.

[14] Reeves. C. Aeromagnetic Surveys principles, practice and interpretation. Published by Geosoft (2005), 3 - 5.

[15] Robert, J.H. Application of Magnetic and Electromagnetic Methods to Locate Buried Metal [R]. U.S Department of Interior, U.S Geological Survey, Open - File Report (2003), 03 - 317.

[16] Shahverdi M, Czaderski C, Motavalli M. Iron-based shape memory alloys for prestressed near-surface mounted strengthening of reinforced concrete beams [J]. Construction and Building Materials (2016), 112, 28-38.

[17] Ugwu, S.A., Nwankwo, C.N., Umeanoh, D.C. Investigation of Subsurface Structures for the Evaluation of Hydrocarbon Potential Using Aeromagnetic Data from Mmaku and its Envrons, South - East Nigeria [J]. Journal of Scientific and Engineering Research (2017). 4(9), 152 - 164.

[18] Vacquier, V., Steenland, N.C., Henderson, R.G. and Zietz, I. Interpretation of aeromagnetic maps: Geological Society of America, Memoir (1951), 47.