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# Geophysical Assessment of Geologic Structures Associated With Gold Mineralization along Garin Hausawa (Izga) Using Aeromagnetic Data

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## ABSTRACT

This paper is aimed to assess the geophysical structural associated with gold mineralization in the study area. This was achieved by determining depth to basement complex of the study area, producing a magnetization map showing magnetic susceptibility range across the entire study area, and produces a geological map of the study area. The study area falls within the basement complex of northwestern Nigeria and covers four adjacent quarter degree sheets of Danko, Fokku, Shanga and Wudil. Artisanal miners often suffer a lot in finding the gold occurrence in the area which results to the destruction in landforms and the environmental setup. The artisanal miners are exposed to digging with hardship for them to determine the structures associated with gold mineralization. Previous works have shown that primary gold mineralization within the Nigerian basement complex is controlled by geologic structures where they act as conduits for fluids flow and as loci for mineralization. The anomalies on the aeromagnetic map were defined by fitting a first order polynomial to the total fields, by the method of least squares to obtain the residual field data. First vertical derivative and analytic signal computed, defined distinct pattern of the magnetic signatures. Depths to the surface of the geologic structures were obtained from Euler deconvolution solutions which give an average depths range of 167.9 m (0.1679 km) to 2526.7 m (2.5267 km).With very few solutions having depths so Izga fault can be used for gold mining.

**KEYWORDS/WORKWORDS:** Analytical Signal, Euler Deconvolution, Source Parameter Imaging and Vertical Derivatives.

## I. INTRODUCTION

Geophysical methods including different methods such as magnetic, gravity and electrical resistivity methods are important methods in mineral exploration for gold located in basement rocks. Nigeria has been known to have a long history of mining and the country was a prominent exporter of minerals such as tin, coal, and kaolin. Gold is generally found in Nigeria as alluvial and eluvia placers and primary veins from several parts of supra crustal (schist) belts, in the northwest and southwest of the country (Usman et al., 2019). Several authors have studied the gold mineralization in Nigeria and the host rocks. The most occurrences of such gold mineralization are found in the Maru, Anka, Malele, Tsohon Birnin Gwari-Kwaga, Gurmana, BirninYauri and Okolom-Dogondaji areas, all associated with schist belts of northwest and southwest Nigeria. The economic importance of these minerals paved a way for researches in the related areas, all associated with the schist belts of northwest and southwest Nigeria (Aliyu et al., 2016). All these areas are spatially related to the two fault systems in the region, the gold bearing veins, reefs and stringers are often localized by brittle and ductile fault structures or planes of schistosity that traverse phyllites, schist, quartzite and gneisses. (Talaat et. al., 2010).The role of aeromagnetic method in mineral exploration varies from delineating structures like faults, folds, contacts, shear zones and intrusions to automated detection of porphyry and favorable areas of gold deposits. There are various enhancements techniques that can help achieved objectives.

**Location and Geology of the study area**

The Location and Geology of the Study Area is situated in Garin Hausawa (IZGA) Village of Danko Local Government Area of Kebbi State, Nigeria. It lies within the Northern Nigerian Basement complex between Latitude 11$^{0}$4’ N - 11$^{0}$6’ N and longitude 5.1$^{0}$00’ E – 5.4$^{0}$00’ E. Different techniques were taken of photo-geological interpretation and chosen field route were used to construct four geological maps. It lies within the Northern Nigerian Basement Complex between Latitude 11$^{0}$00’ N - 12$^{0}$00’ N. and longitude 4.5$^{0}$00’ E – 5.5$^{0}$00’ E. The Garin Hausawa (IZGA) mining is located in Danko Local Government Area of Kebbi State. The study area consists of the Precambrian rocks which include igneous rock and sedimentary rocks. The study area contains internal rocks of granite, granodiorite, diorite, tonalite, and syenites. The rocks in the study area are gold deposits, which result to mining in the area.

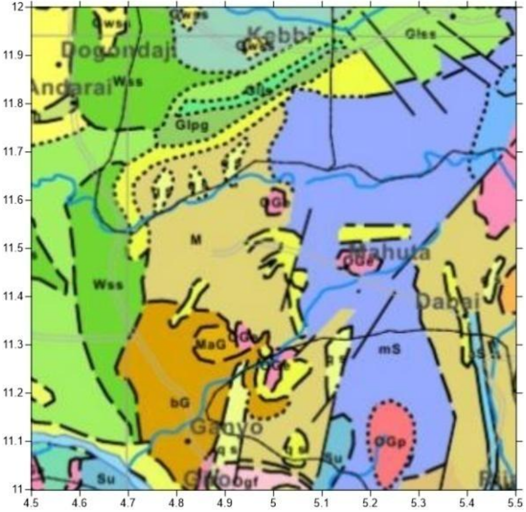

Figure (1) Geology of the study area (modified after NGSA 2021)

Data procurement

Four High degree sheet of Aeromagnetic data of Danko (sheet 74), Shanga (sheet 96), Fokku (sheet 73) and Wudil (sheet 97), which lies from latitude 011$^{0}$00’E-012$^{0}$00’E to longitude 4.5$^{0}$00’N-5.5$^{0}$00’N.

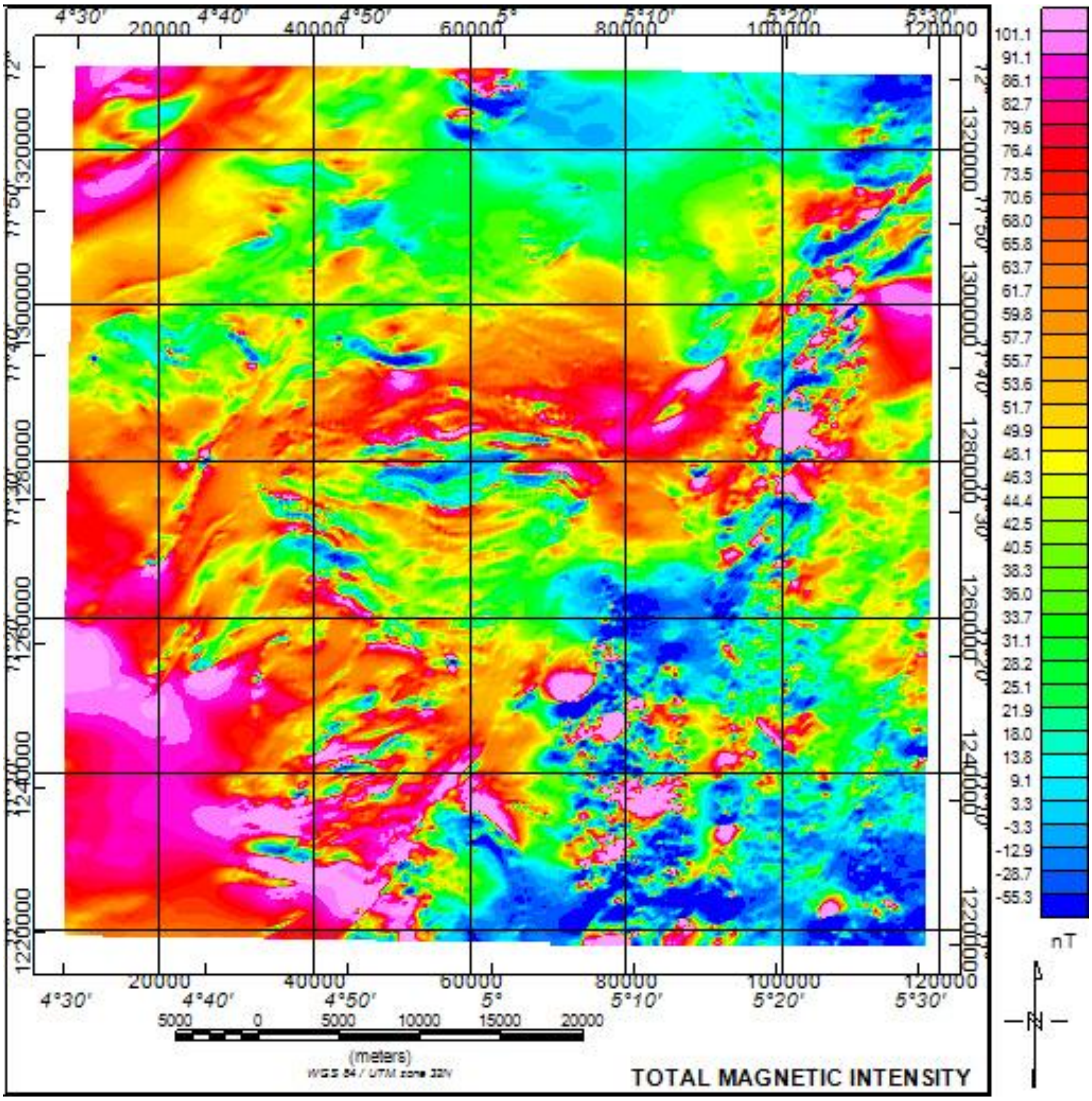

Figure (2) Total Magnetic Intensity Map of the study area

This data are on a scale of 1:100, 00 which covers the entire study area were purchased from Nigerian Geologic Survey Agency. This data was obtained at a flight altitude of 80 m, along NE-SW flight lines spaced approximately 500 m apart.

## II. MATERIALS AND METHODS

Data Enhancement**:** Data enhancement of magnetic data is relevant in the study of structural features because it improve the edges of anomalies. To achieve this, the first vertical derivative (FVD) is applied as given in equation 1

$$\mathrm{FVD} = \frac{\partial M}{\partial z} \quad (1)$$

Where M is the potential field anomaly. This is relevant to this research because it brings out the lineaments of interest clearly.

First Vertical Derivative**:** Is used to delineate high frequency features more clearly where they are shadowed by large amplitude low frequency anomalies in the study area. This is done using the Laplace transformation expression shown below:

$$\nabla^2 f = 0 \quad (2)$$

where $\nabla^2 f$ is the Laplace transform which can be expressed in full as:

$$\frac{\partial x}{\partial z} = -\boldsymbol{\partial}^2 f \partial x^2 + \boldsymbol{\partial}^2 f \partial y^2 \quad (3)$$

$\partial x, \partial y$ and $\partial z$ are the differentials in x ,y and z coordinates The nth vertical derivative can be computed using: $F\left[\frac{\partial^n f}{\partial z^n}\right] = k^n F(f\ )$ (4)

Analytical Signal: Analytic Signal has been applied for establishing the edges of magnetic anomalies in the study area. To achieve this, the aeromagnetic data in the study area have been simplified by creating a function which is independent of body magnetization direction and ambient geomagnetic parameters in the study area. The analytic signal filter possesses the property which was used for edge detection and depth estimation of magnetic bodies in the study area. The analytic signal filter possesses this property and has been used for edge detection and depth estimation of magnetic bodies by several authors. Roest et al.(1992), applied it for detecting causative body location used it for geologic boundary edge detection in the study area.

$$(x,y) = \left(\frac{\partial M}{\partial X}\right) X + \left(\frac{\partial M}{\partial Y}\right) Y + \left(\frac{\partial M}{\partial Z}\right) Z \quad (5)$$

With M= magnetic field. The analytical signal amplitude is applied as in equation 6:

$$(x\ ,y,z) = \sqrt{\frac{\partial M^2}{\partial x}} + \sqrt{\frac{\partial M^2}{\partial Y}} + \sqrt{\frac{\partial M^2}{\partial Z}} \quad (6)$$

Source Parameter Imaging (SPI)

The Source Parameter Imaging (SPI) has been applied to calculate the depth of potential magnetic field body in the study area. The aeromagnetic data in the study area was subjected to a profile for estimating potential magnetic field, magnetic source and depths in the study area. The aeromagnetic data used for magnetic source, susceptibility and density contrast in the study area. The Source Parameter Imaging (SPI) function is a method for calculating the depth of potential field sources. Thurston and Smith (1997) defined Source Parameter Imaging as a profile or grid-based method used for estimating potential field source depths, and for some source geometries the dip and susceptibility and density contrast. The Source Parameter Imaging (SPI) function is also a quick, easy, and powerful method for calculating the depth of magnetic sources (Kamba and Ahmed, 2017). Its accuracy has been shown to be +/- 20% in tests on real data sets with drill whole control. This accuracy is similar to that of Euler deconvolution; however SPI has the advantage of producing a more complete set of coherent solution points and it is easier to use. A stated goal of the SPI method (Thurston and Smith, 1997) is that the resulting images can be easily interpreted by someone who is an expert in the local geology. This method utilizes the relationship between source depth and the local wave number (k) of the observed field, which can be calculated for any point within a grid of data through horizontal and vertical gradients.

## III. RESULT AND DISCUSSION

The Magnetic data interpretation start with some particular method such that to separates smooth, presumable deep-seated regional effects from the observed field so as to show the residual effects, which are the anomalies of geological interest. The residual magnetic fields are large structures which generally show up as trends (inclination in a particular direction) and proceed smoothly over very significant areas, and they are caused by deeper homogeneity of the earth's crust. The residual magnetic field map figure (3). The magnetic field intensity values show the trend from NW-SE direction, the residual magnetic intensity map is illustrated in Figure (3); this was done using SURFER 12 and Oasis Montaj software. Total Magnetic Intensity (TMI) Map of the study area Figure (2) has a magnetic intensity values from -55.3 nT to 101.1 nT and is shaded by red magnetic signatures (high) and blue magnetic signatures (low) magnetic signatures. These changes may be due to several influences such as difference in magnetic susceptibility, change in degree of strike and depth in the study area. These show that the structures associated with gold minerals increases from south to north part of the study area.

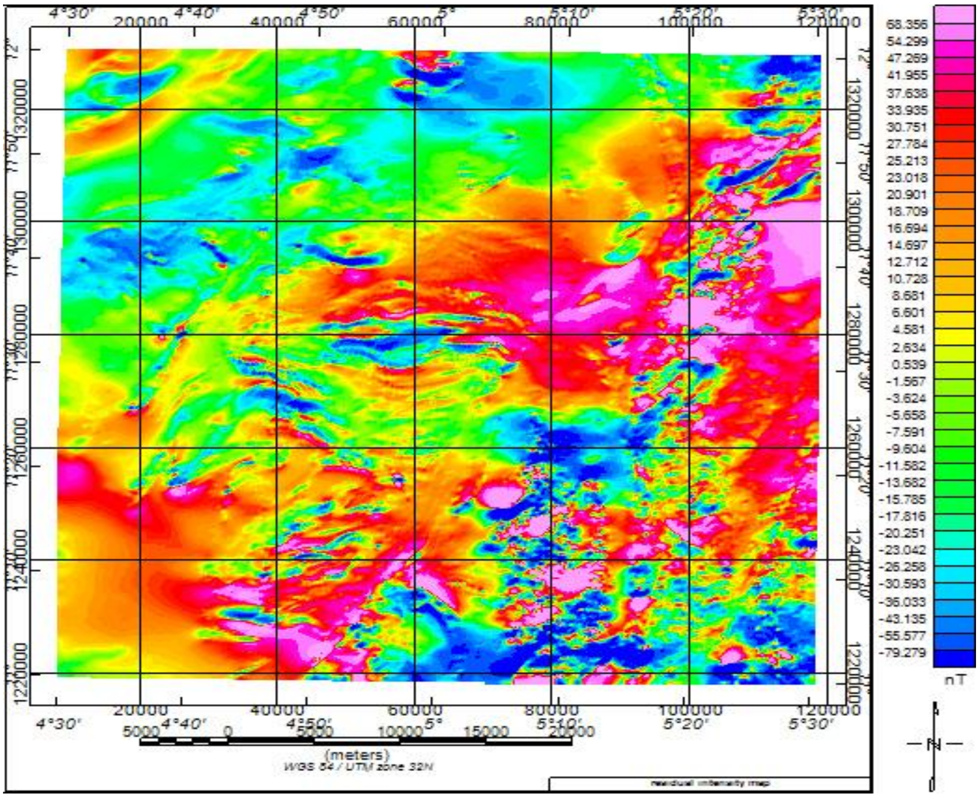

Figure (3) Residual Magnetic Intensity Map of the study area

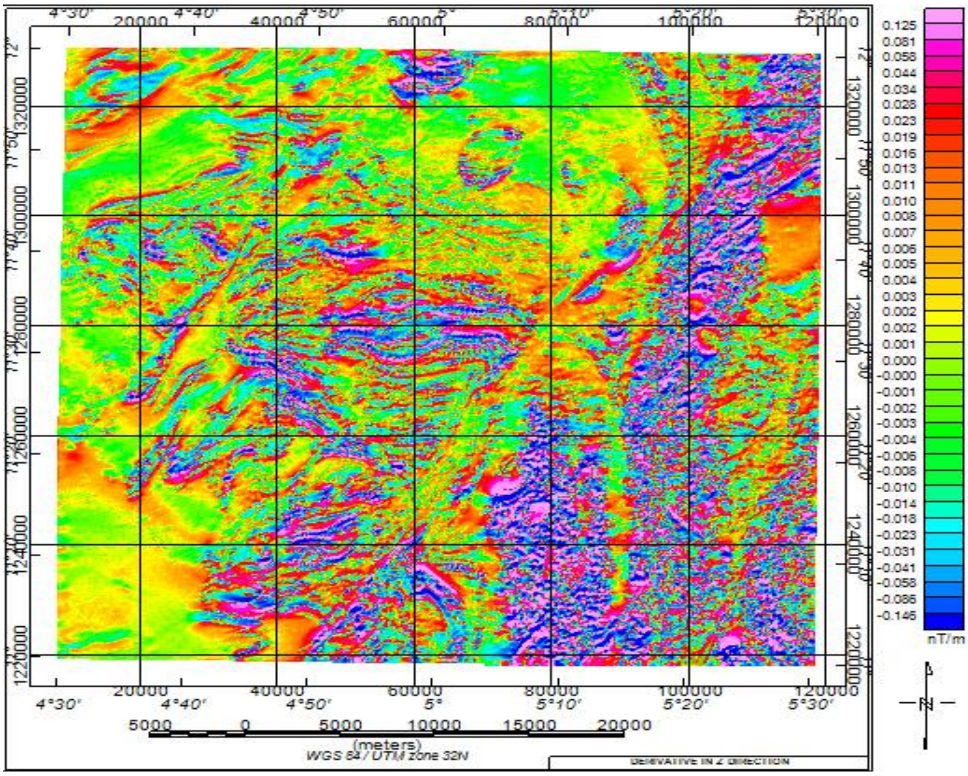

Figure (4) First Vertical Derivative map of the study area

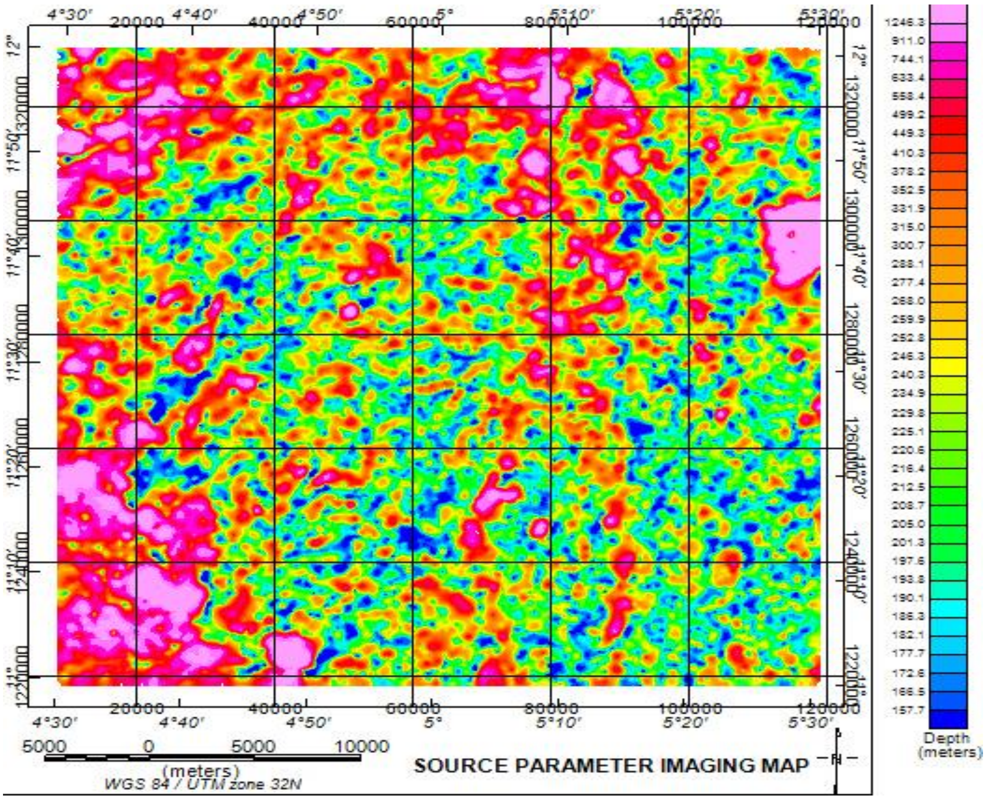

Figure (5) Source Parameter Imaging of the study area

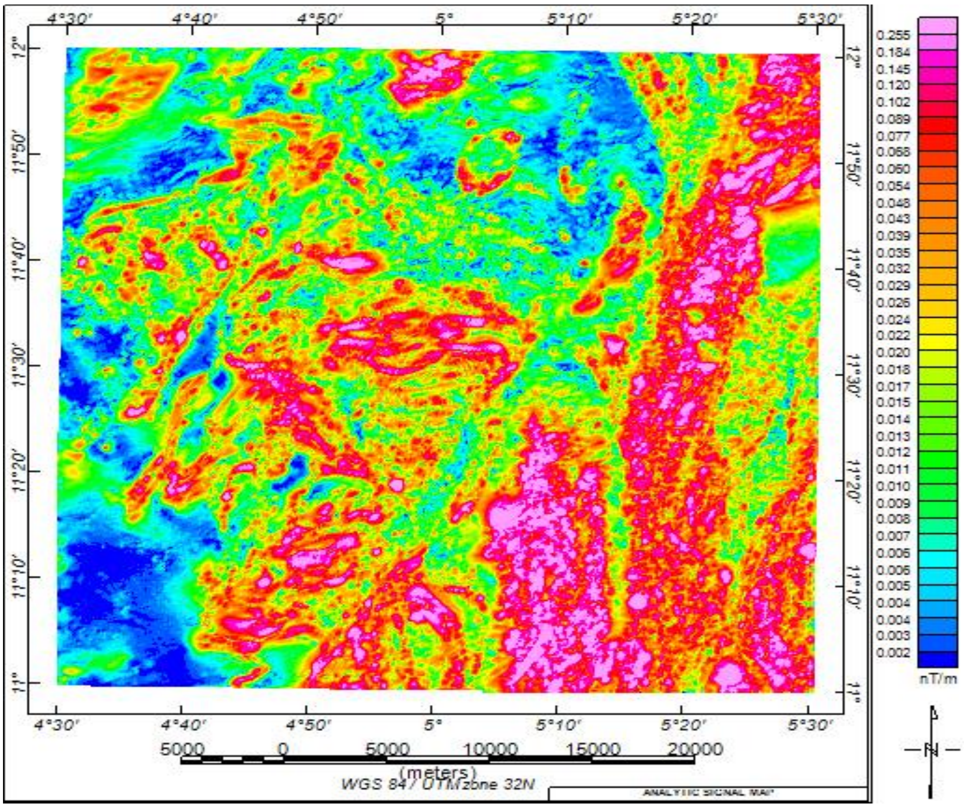

Figure (6) Analytical Signal Map of the study area

## IV. CONCLUSION

The aeromagnetic data showed worthy in the outline of most of the structures in the study area and estimation of the depth to basement of the magnetic body. The depth estimate obtained from the depth estimation analysis is167.9 m (0.1679 km) to 2526.7 m (2.5267 km) and dip of the source body respectively. The total magnetic intensity of map of the study area is – 55.3 nT to 101.1 nT magnetization map of the entire study area showing areas of high and low magnetic intensities indicates with different colors (blue, yellow, green).

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