

Structural Complexity and Mineral Potential of Central Benue Trough, Using High Resolution Aeromagnetic Dataset.

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ABSTRACT

Mineral mining is an important resource for economic development, and its mineralization is controlled by geology, structures and hydrothermal alteration within rock formations. For this reason, high resolution magnetic dataset covering parts of the Central Benue Trough was processed and filtered/enhanced using analytic signal, first vertical derivative and tilt derivative algorithms. Qualitative interpretation of the total magnetic intensity maps reveals numerous magnetic depletion zones defined as hydrothermal active areas within Dampar, Wuro Jam, Kishr, Yamere, Shnye, Jibu, Adi, Amafan, Akwana, Akahana, Ayere, Awe and Tunga. There is a major NE-SW trending low magnetic amplitude stretching from Ugba to Kwarata, which is interpreted as active zones at the contact between the Central Benue Trough and Eastern Nigerian Basement Complex, the zone is interpreted as a major area of interest, especially around intense structurally active areas at Wukari, Chonku, Ngbebe, Bayawai, Gidan Idi, Wamgbe, Gusawa, Anzwa and Gada Mayo. Derivative filters revealed majorly NE-SW trending structures within the Central Benue Trough, with minor NW-SE trends observed at the contact between the Central Benue Trough and Eastern Nigerian Basement Complex with the longest fault having a length of about 42 km, stretching from Sankara to Apar, Hundu area. Major folds are mapped at Dampar, Wuro Jam and Kishr area. Long stretched fault systems within the Central Benue trough is observed at Bangalala, Gwinwan, Amar, Yamere and Rufai, Uzam, Sojo area. The dominating series of high angle NE-SW trending faults and folds structure was defined to have resulted from two major regional series of deformation stages. Integration of geological information and geophysical interpretation defined Wukari, Chonku, Bayawai, Wamgbe, Gusawa, Anzwa, Dampar, Yamere, Akwana, Akahana, Bangalala, Gwinwan, and Tunga as area of highest potential of mineral deposits occurrences based on the geology, extensive alteration and structural complexity.

Keywords: Akwana, Wukari, aeromagnetic, first vertical derivative, analytic signal, exploration.

1 Introduction

Airborne surveys such as aeromagnetic surveys provide fast coverage of large and inaccessible areas for subsurface reconnaissance, which makes magnetic data analysis an essential tool of geophysical exploration. This past decade has witnessed a paradigm shift from the interpretation of structures to detailed studies with respect to both lithologic and morphologic variations. Its application ranges from mineral exploration (Murphy, 2007), structure mapping and rock characterization (Telford et al., 1998). Recent advances in technology have substantially increased the accuracy and resolution of

these techniques so that they can be used to provide useful enhanced information on lithology and geological structures. Additionally, advances in data analysis, processing and image enhancement techniques have improved the resolution of geophysical datasets further so that very subtle variations in the geophysical responses can be identified (Armstrong and Rodeghiero, 2006).

Magnetic anomalies are major precursor of mineralization, especially along fault planes. The magnetic anomaly signature characteristics are results of one or more physical parameters such as the configuration of the anomalous zone, magnetic susceptibility contrasts as well as the depth to the anomalous body. The variation of magnetic mineral composition in rocks due to the distinction in lithological set up and mineralization processes such as hydrothermal mineralization make the use of these methods in the mapping rock lithology, structures and mineral zones an important technique. The efficiency of the method depends mainly on the presence of magnetic minerals in the subsurface rocks that underlie the survey area (Abo-Ezz and Essa 2016; Essa and Elhussein 2017; Essa et al. 2018; Ugbor et al. 2020). The use of aeromagnetic data has been applied world over in lineament identification, magnetic mineral identification and estimation of depth to underlying basement rock (Connard et al. 1983; Thurston and Smith 1997; Selim and Aboud 2014; Oha et al. 2016; Effiong et al. 2017; Ngama and Akanbi 2017)

In this paper, airborne magnetic was used to map the delineated possible mineralized hosting structure within the study area. The mineral potential of most part of the study area has not been properly explored, hence the importance of the study. This research seeks to review the geology and to aid the delineation of regional and local geological structures (shear zones and faults) that have the potential of hosting lead mineralization within the study area. The work allows the prediction of target areas for detailed exploration work in search for ore mineralization within the Central Benue Trough that has not been extensively explored as compared to the other parts of the Benue Trough.

1.1 Location of the Study Area

The study area falls within the Central Benue Trough. The study area is located in the North-Central part of Nigeria (Fig.1). It is bounded in the north and south by Latitudes 7.50 °N and 9.00 °N and east and west by Longitudes 9.00 °E and 10.50 °E respectively, it covers a total surface area of about 27,225 km². The study area cut across parts of four (4) states within the country including Plateau, Taraba, Nasarawa and Benue State.

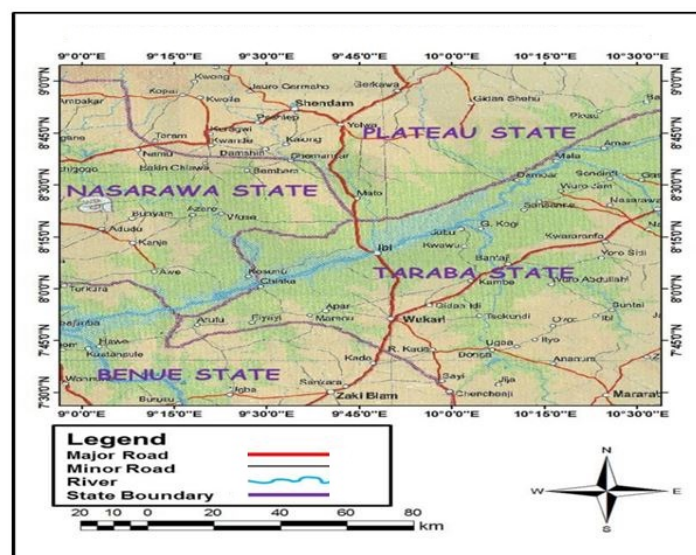


Figure. 1 : Location / Accessibility map of the study area. (Modified after NGSA, 2006)

1.2 Regional Geologic Setting

The Benue Trough was formed as a result of pull-apart of sub-basins generated by sinistral strike-slip displacements inherited from pre-existing transcurrent fault zones in the Pan African mobile belt (Benkhelil, 1989; Nwajide, 2013). It is part of the much larger West and Central African Rift System (Fairhead, 1991; Genik, 1993) which originated during the breakup of the Gondwana supercontinent and the opening up of the southern Atlantic and Indian Oceans in the Jurassic (Burke et al., 1972; Benkhelil, 1983, 1989; Fairhead, 1991). The geologic map of the Central Benue Trough is presented in Fig. 2. The trough contains up to 6,000 m of Cretaceous – Tertiary sediments of which those predating the mid-Santonian have been compressively folded, faulted, and uplifted in several places (Obaje, 2009). Compressional folding during the mid-Santonian tectonic episode affected the whole of the Benue Trough and was quite intense, producing over 100 anticlines and synclines (Benkhelil, 1989).

Previous geophysical work done within the study area (Cratchley and Jones, 1965; Ofoegbu, 1984; Charles, 2007; Obaje, 2009; Nwosu, 2014; Ugwu, et al, 2018; Rowland and Nur, 2018; Onyishi and Ugwu, 2019) dwelt more on the depth to basement and sediment thickness within the basin using source parameter imaging and Euler deconvolution technique of aeromagnetic method and trend of structures. This work interpreted high-resolution aeromagnetic data with the aim of evaluating the complexity of sediments within the Central Benue Trough which has defined sediment thickness suitable for hydrocarbon generating by Obaje, 2009, Nwajide, 2013, Rowland and Nur, 2018 and Onyishi and Ugwu, 2019).

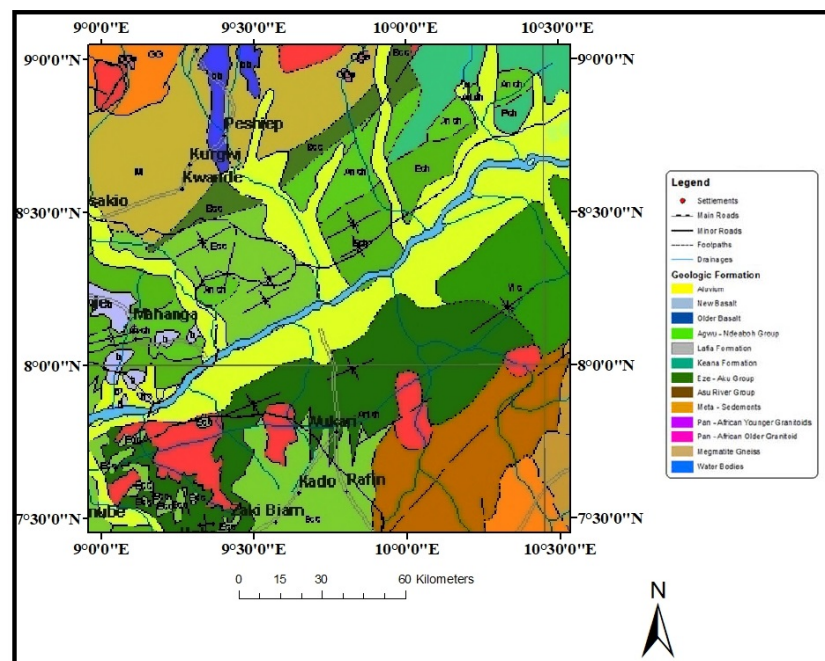


Figure 2: Geologic map of Central Benue Trough (Adapted after NGSA, 2006).

2 Materials and Method

2.1 Data Acquisition

The aeromagnetic dataset used for this study is from the high-resolution airborne survey coverage in Nigeria carried out by Fugro Airborne Survey at 826,000 along a series of NW – SE flight lines of magnetic surveys flown at 500 m line spacing and 80 m terrain clearance in 2009 and was obtained

from the Nigerian Geological Survey Agency. The parameter measured was the total magnetic field. It consists of nine (9) square blocks of map sheets (211, 212, 213, 232, 233, 234, 252, 253 and 253) of square block which represents a map on the scale of 1:600,000. The total magnetic intensity grid was generated using a minimum curvature algorithm. The digitized data were filtered using a low pass Fourier domain sub-routine filter to eliminate unwanted wavelengths and to pass longer wavelengths. Reduction-to-pole (RTP) transformation was applied to the aeromagnetic data to minimize polarity effects. These effects are manifested as a shift of the main anomaly from the center of the magnetic source and are due to the vector nature of the measured magnetic field. The RTP transformation usually involves an assumption that the total magnetizations of most rocks align parallel or anti-parallel to the Earth's main field.

2.2 Data Processing and Enhancement

2.2.1 Regional - residual separation

Separation of regional and residual anomaly was done using Trend analysis in which a linear trend surface was fitted into the total aeromagnetic field data by a multiple regression technique for the purpose of removing the regional magnetic field. The linear surface fitted was removed from the regional component to obtain the residual magnetic anomaly map that was interpreted.

$$\text{Total field} = \text{Regional field} + \text{Residual field} \quad (1)$$

$$\text{Residual field} = \text{Total field} - \text{fitted Surface/Regional} \quad (2)$$

The Regional Field can be represented using the trend surface equation. Davies, (1973) expressed the regional field as;

$$\text{Regional Field} = a + bx_i + cy_j \quad (3)$$

Where, a, b and c are constants, x_i and y_j are coordinates in x and y directions.

Let Z_{ij} = the observed Total Field at ij^{th} data point.

Therefore,

$$\text{Total Field } (Z_{ij}) = (a + bx_i + cy_j) + \text{Residual Field} \quad (4)$$

Hence,

$$\text{Residual Field} = Z_{ij} - (a + bx_i + cy_j) \quad (5)$$

For a given magnetic data, the best fitting surface has the least square error,

$$\text{fitting error} = t - a - bx - cy \quad (6)$$

Where t is the magnetic value at x and y coordinate point.

Note that a, b and c are unknown coefficients while t, x and y are given. To obtain the least square error, the unknown coefficients a, b and c must yield zero first partial derivative.

Hence, the sum of the square of the fitting error becomes;

$$\sum_{i=1}^N \sum_{j=1}^N (\text{fitting error})^2 = \sum_{i=1}^N \sum_{j=1}^N (t_{ij} - a - bx_i - cy_j)^2 \quad (7)$$

where x_i, y_j and t_{ij} are vectors and i and j are unit vector while t, x and y are Coefficient of the unit vector.

$$M = \sum_{i=1}^N \sum_{j=1}^N (t_{ij} - a - bx_i - cy_j)^2 \quad (8)$$

Taking the partial derivative of equation (9) with respect to a and equate it to zero,

$$\sum_{i=1}^N \sum_{j=1}^N t_{ij} - \sum_{i=1}^N \sum_{j=1}^N a - b \sum_{i=1}^N \sum_{j=1}^N x_i - c \sum_{i=1}^N \sum_{j=1}^N y_j = 0 \quad (9)$$

Partial derivative of the second constant b and equating it to zero;

$$\sum_{i=1}^N \sum_{j=1}^N t_{ij} x_i - a \sum_{i=1}^N \sum_{j=1}^N x_i - b \sum_{i=1}^N \sum_{j=1}^N x_i^2 - c \sum_{i=1}^N \sum_{j=1}^N x_i y_j = 0 \quad (10)$$

Taking the partial derivative of the third constant c;

$$\sum_{i=1}^N \sum_{j=1}^N t_{ij} y_j - a \sum_{i=1}^N \sum_{j=1}^N y_j - b \sum_{i=1}^N \sum_{j=1}^N x_i y_j - c \sum_{i=1}^N \sum_{j=1}^N y_j^2 = 0 \quad (11)$$

Solving this series of simultaneous equations will give the coefficients of the best fitting linear trend surface, being defined by the least-square criterion. The above equation can be written into matrix form as:

$$\begin{bmatrix} N & \sum_{i=1}^N \sum_{j=1}^N x_i & \sum_{i=1}^N \sum_{j=1}^N y_j \\ \sum_{i=1}^N \sum_{j=1}^N x_i & \sum_{i=1}^N \sum_{j=1}^N x_i^2 & \sum_{i=1}^N \sum_{j=1}^N x_i y_j \\ \sum_{i=1}^N \sum_{j=1}^N y_j & \sum_{i=1}^N \sum_{j=1}^N x_i y_j & \sum_{i=1}^N \sum_{j=1}^N y_j^2 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^N \sum_{j=1}^N t_{ij} \\ \sum_{i=1}^N \sum_{j=1}^N t_{ij} x_i \\ \sum_{i=1}^N \sum_{j=1}^N t_{ij} y_j \end{bmatrix} \quad (12)$$

The values of a, b, and c were obtained as follows;

$$\left. \begin{array}{lcl} a & = & 33293.2 \\ b & = & 3.5429 \\ c & = & -3.6132 \end{array} \right\} \quad (13)$$

The trend surface equation (regional gradient) becomes:

$$T(x, y) = 33213.2 + 3.472x - 3.5232 y \quad (14)$$

Furthermore, the trend surface equation was then subtracted from the aeromagnetic (observed) data and the resultant residual anomaly was digitized.

2.2.2 Analytic signal filter

Nabighian et al. 2005 suggested the concept of analytic signal (AS) and proposed that in the 2-D case, the horizontal and vertical derivatives of magnetic fields satisfy the Hilbert transform, thus can be regarded as analytic signals. The amplitude of the analytic signal is the same as the total gradient, independent of the direction of magnetization, and represents the envelope of both the vertical and horizontal derivatives over all possible directions of the earth's field and source magnetization (Luo et al. 2011).

$$\frac{\partial T}{\partial z} = H \left[\frac{\partial T}{\partial x} \right] \quad (15)$$

Where;

T = Magnetic anomaly data

H = Hilbert transform

The analytical signal of a real signal f is defined as;

$$AS\left(\frac{\partial T}{\partial x}\right) = \frac{\partial T}{\partial x} - iH\left[\frac{\partial T}{\partial x}\right] \quad (16)$$

Where:

$$i = -1 \text{ (Luo et al. 2011)}$$

According to the definition, the analytical signal of the potential field obtained by combining these two quantities into a two-dimensional quantity known as the analytic signal is given as;

$$AS(x, z) = \frac{\partial T}{\partial x} + i \frac{\partial T}{\partial z} \quad (17)$$

Where:

$$\frac{\partial T}{\partial x} \text{ and } \frac{\partial T}{\partial z} = \text{Horizontal and vertical component of the total field respectively,}$$

$T(x, z)$ = Magnitude of the total magnetic field

z and x = Cartesian coordinates for the vertical direction and the direction perpendicular to strike respectively

The amplitude of the analytic signal is defined as;

$$|AS(z)| = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2} \quad (18)$$

The amplitude of the analytic signal is a symmetric bell-shaped function. By examining its profile across a magnetic source, the analytic signal can be used in interpretation to provide an indication of the edges of the causative body. Similarly, for the three dimensional case, the analytic signal is given by;

$$AS(x, y) = \left(\frac{\partial T}{\partial x}\right) + \left(\frac{\partial T}{\partial y}\right) + \left(i \frac{\partial T}{\partial z}\right) \quad (19)$$

Where its amplitude is defined as;

$$|AS(x, y)| = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2} \quad (20)$$

The maximum value of the analytic signal determines the edges of a magnetic body.

2.2.3 First Vertical derivative

Derivatives (vertical) are based on the principle that the rates of change of magnetic field are sensitive to rock susceptibilities near the ground surface than at depth. First vertical derivative is physically equivalent to measuring the magnetic field simultaneously at two points vertically above each other, subtracting the data and dividing the result by the vertical spatial separation of the measurement points. The first vertical derivative was obtained from Laplace equation which is used to describe the magnetic potential field (U) thus,

$$\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} + \frac{\partial^2 U}{\partial z^2} = 0 \quad (24)$$

$$\text{but, } -\text{grad } U = T \quad (25)$$

Hence,

$$-\frac{\partial T}{\partial x} - \frac{\partial T}{\partial y} - \frac{\partial T}{\partial z} = 0 \quad (26)$$

Therefore,

$$\frac{\partial T}{\partial z} = -\left(\frac{\partial T}{\partial x} + \frac{\partial T}{\partial y}\right) \quad (27)$$

Where, $U = \text{magnetic potential field}$, $T = \text{total magnetic field vector}$

Rewriting equation (10) in numerical form we have,

$$-\frac{\partial T}{\partial x} = \left[\frac{T(x+\Delta x) - T(x)}{\Delta x} + 0(\Delta x) \right] \quad (28)$$

$$0(\Delta x) = \text{error terms} \quad (29)$$

$$-\frac{\partial T}{\partial x} = \left[\frac{T(x+\Delta x) - T(x)}{\Delta x} \right] \quad (30)$$

Similarly,

$$-\frac{\partial T}{\partial y} = \left[\frac{T(y+\Delta y) - T(y)}{\Delta y} \right] \quad (31)$$

Therefore,

$$\frac{\partial T}{\partial z} = -\left[\frac{T(x+\Delta x) - T(x)}{\Delta x} \right] - \left[\frac{T(y+\Delta y) - T(y)}{\Delta y} \right] \quad (32)$$

Equation (15) was applied on TMI grid to produce the first derivative map of Figure 7.

$\Delta x = \text{grid interval in } x - \text{direction}$

$\Delta y = \text{grid interval in } y - \text{direction}$

3 Result and Discussion

The residual magnetic intensity (RMI) map (Fig.3) emphasizes the intensity and the wavelengths of local anomalies. The rock formations at low magnetic latitude are magnetized parallel to the Earth's magnetic field; the area around Kopar, Jauro Garmaho, Peshiep, Kopbepand, Kurgwi, Shandam, Yalwa, Kwande and Namu is characterized by high magnetic susceptibility and short wavelength anomalies, this signature is commonly associated with basement rocks. Anzwa, Ugba, Zaki Biam, Sankara, Chonku, Ngbebe, Toskundi, Tunari, Bayawal and Nwarara is characterized by low magnetic susceptibility and both long and short wavelength anomalies. Donga, Mbusa, Abako Avermum, Sankara, Dooga, Norjjo Gankoi, and Zaga is characterized moderate magnetic susceptibility and short wavelength anomalies. Akwana and Fiyayi is also characterized by high magnetic susceptibility bodies and short wavelength anomalies, while nearby Hawe, Hundu, Apar, Wukari and Chonku is characterized by high magnetic susceptibility and long wavelength anomalies. A NE-SW trending low magnetic susceptibility is overserved at Akahana, Tunga, Keffin, Awe, Adawa, Amafan through Ibi, Shinye, Yamere to Dampar, Kishr, Wuro Jam; Gassol. Bangalala and Giden Shehu is characterized by both long and short wavelength with high magnetic susceptibility, while Gidan Tata, Bakin Chiawa, Bembem, Shamanajar and Ajikemai is characterized by moderate to low magnetic susceptibility.

Gidan Tata, Bakin Chiawa, Bembem, Shamanajar and Ajikemai are interpreted to be area sedimentary environment that has undergone mobilization of magnetic minerals such as magnetite and hematite. Akahana, Tunga, Keffin, Awe, Adawa, Amafan through Ibi, Shinye, Yamere to Dampar, Kishr, Wuro Jam and Gassol. Bangalala and Giden Shehu are interpreted to be area of igneous intrusive rocks that has

undergone tectonism leading to the destruction of magnetic minerals and emplacement of intrusive rocks. Akwana, Fiyayi Hawe, Hundu, Apar, Wukari and Chonku is interpreted as areas of intense structural activities with intrusive rocks and occurrence of ferrogitized sandstone; Hawe, Hundu, Apar, Wukari and Chonku has thicker sedimentary cover when compared to Akwana and Fiyayi Hawe. The NE-SW stretching low magnetic amplitude is interpreted as Akahana, Tunga, Keffin, Awe, Adawa, Amafan through Ibi, Shinye, Yamere to Dampar, Kishr, Wuro Jam and Gassol. Bangalala and Giden Shehu is interpreted as zone of thick sediment cover is high faulting and fracturing and thermal activities during the santonian orogeny. Kopar, Jauro Garmaho, Peshiep, Kopbepand, Kurgwi, Shandam, Yalwa, Kwande and Namu is interpreted to be zone of igneous environment (Basement Complex). Jangwa, Agana, Madakin, Azaza, Gidan Shahu and Bangalala and Akiri is interpreted to be areas of thick sediment cover and ferrogitized sandstone, but Gidan Shehu and Bangalala is interpreted to as having shallow magnetic sources and intense fracturing and faulting.

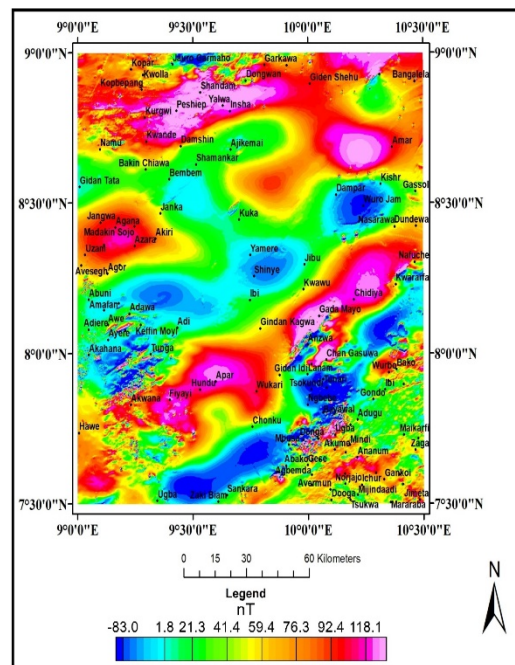


Figure 3: Residual Magnetic Intensity (RMI) Map of the Study Area

The Analytic signal filter was applied to the airborne residual magnetic intensity field data (RMI) to produce Fig.4 sharpen the edge of bodies within the study area. Magnetic bodies are better interpreted within the analytic signal map. Folds and sills are observed around Yamere, Shinye, Dampar, Auro, Nasarawa Dundewa, Kishr and Gassol. Numerous longitudinal bodies trending NE-SW is also observed at Bangalala and Giden Shehu. Akwana and Fiyayi, Chonku Akahana, Tunga, Keffin, Awe, Adiere areas is seen to have numerous magnetic bodies indicative to igneous rocks such as porphyritic granite. NW-SE trending structures is observed at Hawe, Hundu, Apar, Wukari, Chidiya, Chan Gasuwa and Kwararfa; while, Kopar, Jauro Garmaho, Peshiep, Kopbepand, Kurgwi, Shandam, Yalwa, Kwande, Namu, Anzwa, Chan Gasuwa, Wurbo, Bako, Gidan Idi, Tunari, Yerima Baya, Bako, Gbakpo, Ugba, Maikarfi, Zaga, Mindi, Mbusa, Zaki Biam, Avermun, Dooga, Mararaba and Gidan Usumanu is interpreted to be characterized by high amplitude magnetic bodies. High amplitude magnetic body trending NE-SW is also observed stretching from Janka to Bembem.

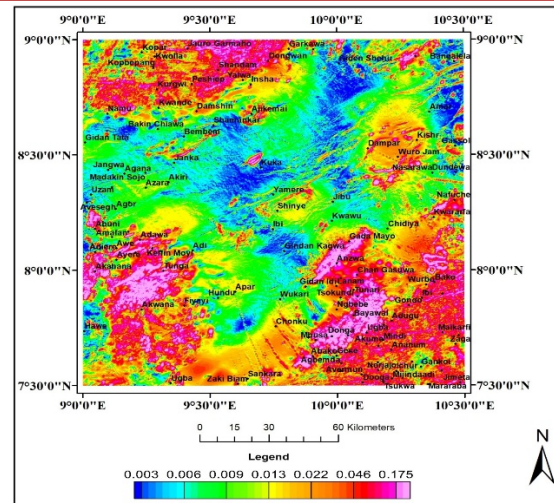


Figure 4: Analytic Signal Map of the Study Area

First vertical derivative filter removed long wavelength features of the magnetic field and significantly improved the resolution of closely spaced and shallow anomalies. Comparison of the first vertical derivative map (Fig.5), with the residual field map (Fig.3), shows an improved visibility of structural features such as faults, fractures and folds, within the first vertical derivative map structures are represented as bi-polar bodies. The folds around Dampar, Kishr, Wuro Jam and Nasarawa Dundewa as better visualized, the structures at Gindan Kagwa, Anzwa and Gadan Mayo with a NE-SW trend is also better enhanced for interpretation and mapping. The faults and fracture at Madakin Sojo, Uzam, Jangwa, Azara and Akiri, that were not visible in the analytic signal and residual map is also better mapped. NW-SE trending structures within Chonku – Wukari axis is also better interpreted and Bangalala, Amar and Ginden Shehu axis faults and fractures are also better visualized. The contact between the basement complex and sedimentary basin (Central Benue Trough) is also better highlighted, trending NE-SW.

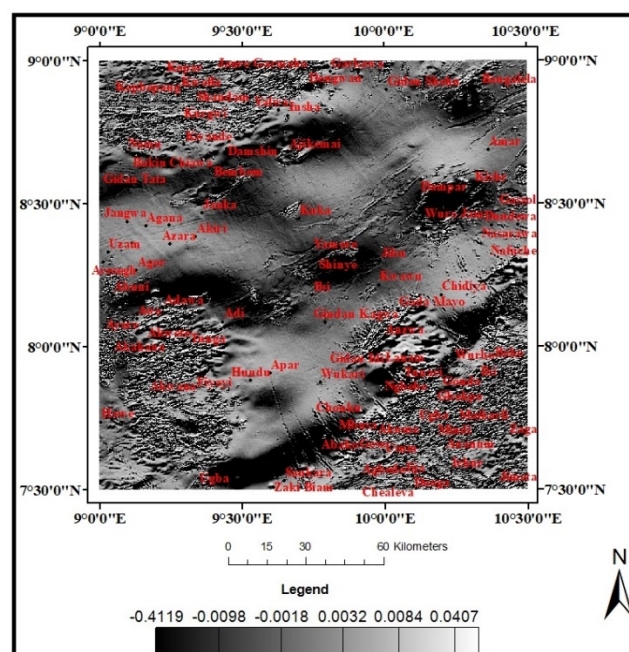


Figure 5: First Vertical Derivative Map of the Study Area

These interpreted structures was used to generate a structural map of the study area (Fig.6). The structural map reflects a general NE-SW structural trend within the study area, with minor NW-SE and EW trending structures. The Central Benue trough is dominated by a series of NE-SW trending fractures and folds which are interpreted as high angle fault and fold structures formed during regional NW-SE compression resulting in a high degree of shearing and faulting at the contact zone, this is in agreement with the works of Cratchley and Jones, 1965; Ofoegbu, 1984; Charles, 2007; Obaje, 2009; Nwosu, 2014; Ugwu, et al, 2018; Rowland and Nur, 2018; Onyishi and Ugwu, 2019. The contact between the Central Benue Trough and Eastern Nigerian Massif is characterized by NW-SE trending structures and the Northern and Eastern Nigerian Massif within the study area is characterized by NE-SW and EW trending structures.

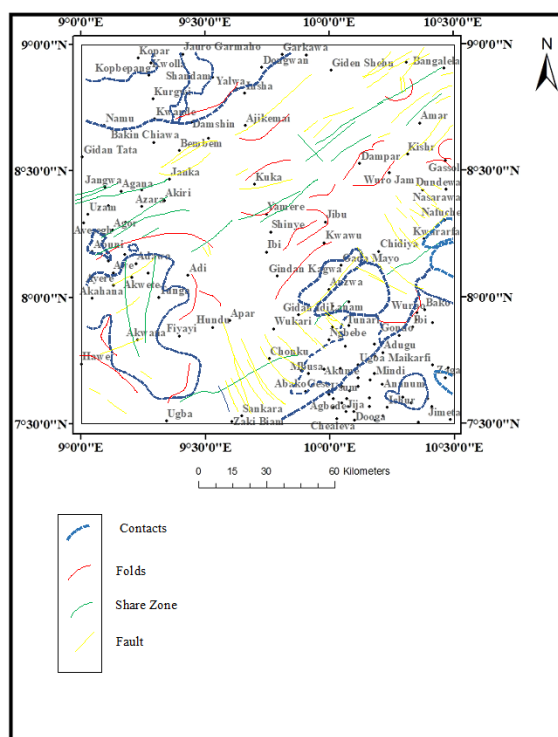


Figure 6: Interpreted Structural Map of the Study Area

In sandstone environment, mineralized areas are characterized by magnetic mineral enrichment in sediments due to ferroginitization, while in shale environment mineralized altered zone are characterized by destruction of magnetic minerals, all having intense structural activities which serves as conduit for mineral forming hydrothermal fluids (KelmaGeodynamics, 2019). Based on these principle, areas of high potential of hosting mineralized deposits in sandstone/shale environment include Wukari, Akwana, Chonku, Fiyayi, Apar, Bangalala, Chindiya, and Nafuche with preference to NW-SE structures, while at Bangalala, GidenShehbu and Amar structural preference is the NE-SW directional structures. The contact between sediment and Basement rock around Adiere, Ae, Adawa, Amafan, Aboni, Hawe and Adi also show good potential. The shale environment of interest is observed around Dampar, Kishr, Wuro Jam, Shinye, Yamere, Ibi, Ajikemai, Bembem, Gidan Tata and Janka. Lead and Zinc mineral deposit is currently been exploited in Akwana, Wukari and Bangalala area, therefore this research has defined other potential mineralized areas within the study area, these areas are highly recommended for ground truthing.

4 Conclusion

Aeromagnetic data covering parts of the Central Benue Trough was processed and filter in other to evaluate the mineral potential zones within the basin. Qualitative interpretation of the residual magnetic intensity was used to map magnetic depleted areas within the shales of the study area. These areas include Dampar, Wuro Jam, Kishr, Yamere and Shinye. The structures within the area shows a major NE-SW trend within the Central Benue Trough and NW-SE structures at the contact between the Trough and Eastern Nigerian Massif, the longest with length of 42 km from Sankara to Apar, Hundu area. A low magnetic amplitude stretching from Ugba to Kwarata, is interpreted as a previously active zones at the contact between the Central Benue Trough and Eastern Nigerian Massief, this zone is interpreted as a major area of interest, especially around intense structurally active areas at Wukari, Chonku, Ngbebe, Bayawai, Gidan Idi, Wamgbe, Gusawa, Anzwa and Gada Mayo. Major folds are mapped at Dampar, Wuro Jam and Kishr area. Long stretched fault systems within the Central Benue trough is observed at Bangalala, Gwinwan, Amar, Yamere and Rufai, Uzam, Sojo area. The dominating series of high angle NE-SW trending faults and folds structure was defined to have resulted from two major regional series of deformation stages. Integration of geological information and geophysical interpretation defined Wukari, Akwana, Chonku, Fiyayi, Apar, Bangalala, Chindiya, Nafuche, Dampar, Kishr, Wuro Jam, Shinye, Yamere, Ibi, Ajikemai, Bembem, Gidan Tata and Jankaas area of highest potential of lead deposits occurrences based on their geology, extensive alteration and structural complexity.

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