

# Pseudo-Gravity Interpretation Of High-Resolution Aeromagnetic Data Over Part Of The Nigerian Central Benue Trough To Isolate Prospective Areas For Pb-Zn-Ba Mineralization

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## Abstract

The global demand for lead, zinc and barite is projected to have risen and this can be tie to the wide range of their industrial applications. Considering this high global demand, there is need to appraise and to also explore more areas that are economically viable and can permit large scale mining of these commodities in the central Benue Trough. In this study, the total magnetic intensity (TMI) data covering part of the central Benue Trough was subjected to reduction to the equator (RTE), regional residual separation, pseudo-gravity transformation and CET analysis using Oasis Montaj version 8.4 software. Results of the analysis revealed a residual magnetic anomaly range of -102.59 nT to 82.69 nT, with residual magnetic anomaly high observed in areas around Awe, Tunga, Arufu, Akwana, Abede southwest of Ikpayongo, southeast of Wunnune, east of Rafin Kada and the southern part of Bantaji towns. Coincidentally, the pseudo-gravity anomaly data revealed high density anomaly (0.155 mGal to 0.274 mGal ) to moderately high density anomaly (0.1 mGal to 0.131 mGal) around the aforementioned towns. Areas that have shown good correlation between the residual magnetic and pseudo-gravity anomaly highs were interpreted to indicate present of mineralized zones. The structural analysis revealed high density structures trending dominantly in the N-S to NNE-SSW direction over the mineralized zones. This direction is in conformity with the trend of lead, zinc and barite mineralization in the study area implying that, the mineralization is structurally controlled. Therefore, from this study areas that have indicated good prospect for lead, zinc mineralization because of the anomaly similarities are: Tunga, southwest of Ikpayongo, southeast of Wunnune, east of Rafin Kada and the southern part of Bantaji towns.

**Keywords:** Central Benue Trough, High Resolution Aeromagnetic, Pseudo-gravity, Structures, Mineralization.

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## I. Introduction

Intra-continental rifting is developed as a result of divergent plate motion, in this case the landmass may split into two or more smaller segments as a result of tensile forces that pull and stretch the lithosphere (Tarbuck et al., 2017). This stretching in turn promotes mantle upwelling and up-warping of the overlying lithosphere resulting to lithospheric thinning and brittle deformation of the crustal rocks. As the tectonic forces continued to pull apart the crust, the broken crustal fragments sinks to generate and elongated depression refers to as continental rift which can widen to form narrow sea (Tarbuck et al., 2017). This tectonic process is mostly associated with mineralization such as Pb-Zn-Ba-Ag deposits.

The Nigerian Benue Trough which extends for about 800 km in length and about 130 to 150 km in width trending in the NNE-SSW direction is believed to evolve from rifting process (Carter et al., 1963; Cratchley and Jones, 1965; Christ, 1979; Ofoegbu, 1984; Ajakaiye, et al., 1986; Okereke, 1988; Ekwueme, 1994). Though, some authors believed that the origin of the Benue Trough is strike-slip related (Benkhelil et al., 1989; Wilson and Guiraud, 1992; Onyedim et al., 2005).

Attributing the origin of the Benue Trough to continental rifting process, there were reported occurrences of Pb-Zn-Ba  $\pm$  Ag  $\pm$  Cu mineralization distributed continuously in a well-defined metallogenic belt running the length of the Trough from Isiagu in the southern part to Gombe in the northern segment of the

Benue Trough (Akande et al., 1988; Akande et al., 1989; Nwajide, 2013; Ogundipe, 2017; Bute et al., 2024). Contribution from these authors indicated that the mineralization occurs in lodes or veins infilling open spaces.

Considering the importance of the lead zinc mineralization as it is the major global resources accounting for about 52 % and 48 % of lead and zinc respectively (Singer, 1995; Wilkinson, 2014). It is imperative to explore more areas of this mineralization within the Benue Trough now that, there is clamor by the Federal Government of Nigeria to boost its economy by diversify from fossil fuel to mineral sector.

To appraise the occurrence of this mineralization in parts of the central Benue Trough and also isolate new areas with good prospect, this research work utilizes high resolution aeromagnetic data over the study area transformed to pseudo-gravity anomaly using Fourier transformation. Similar work was carried out by Barka, 2020 to isolate mineralized areas in parts of the Bida Basin and environments.

The pseudo-gravity interpretation of high-resolution aeromagnetic data is pivotal for understanding subsurface geological structures. This approach reveals the distribution of dense igneous bodies and potential mineral deposits, particularly lead (Pb), zinc (Zn), and barite (Ba). Fluid circulation, which is often metal-rich and enhanced by hydrothermal activities that occurs during tectonic events plays a crucial role in the deposition of Pb, Zn, and Ba, particularly in areas influenced by magmatic activity and structural features. Therefore, by integrating aeromagnetic and pseudo-gravity data researchers can better target prospective areas for mineral occurrence since this analysis highlights tectonic features, such as rift zones and block faulting, which can influence mineralization patterns.

## Geology Of The Study Area

Figure 1 is the regional geologic map of Africa showing the location of Nigeria and the study area whereas figure 2 is the geologic map of the study area. The study area is part of the central Benue Trough and it is bounded by Longitudes  $8^{\circ}30' 00''$  E to  $10^{\circ}00'00''$  E and Latitudes  $7^{\circ}30'00''$  N to  $8^{\circ}30'00''$  N (Fig. 2)

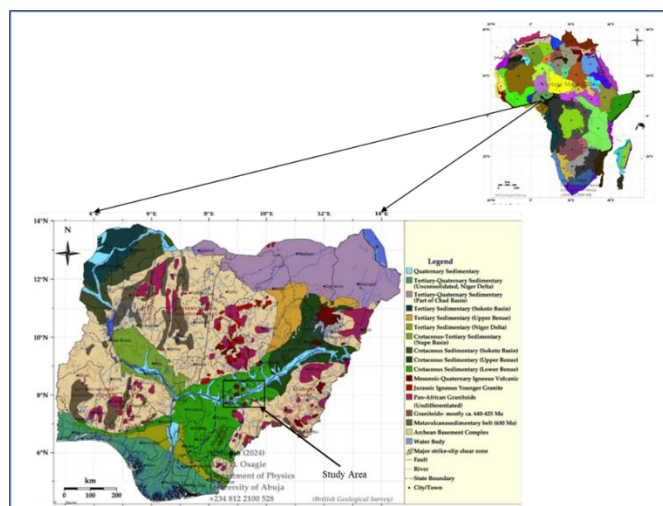


Fig. 1: Regional Geologic map of Africa showing location of Nigeria and the Study Area

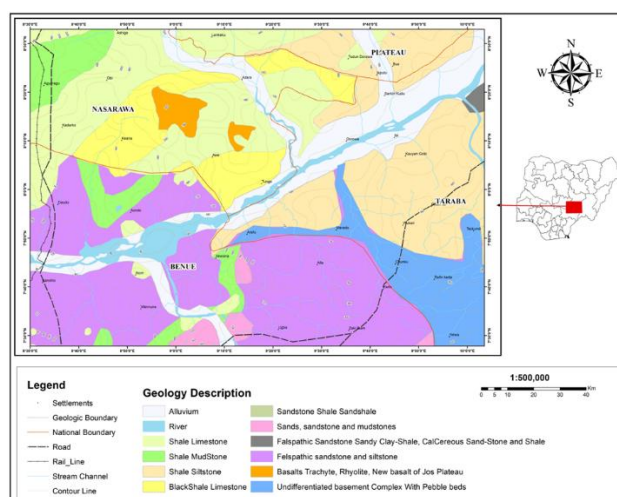


Fig. 2: Geologic map of part of the Central Benue Trough (Modified from NGSA 2023)

The stratigraphic succession in the central Benue Trough comprises of oldest lithostratigraphic unit the Bima Formation which interfingers with the facies of the Asu River group at the northern fringe of the area demarcated as the central Benue Trough (Nwajide, 2013).

The Asu River group consists of four units namely; the Arufu Limestone, the Uomba Formation, the Gboko Limestone and the Awe Formation (Nwajide, 2013). The Arufu Limestone as the name implies comprises dominantly of limestone and is associated with the lead zinc mineralization. The Uomba Formation consists of sandstone, sandy shale and shales (Reyment, 1965). The Gboko Limestone comprises of limestone other units contain are thick fissile and carbonate shale with beds and lenses of limestone (Nwajide, 2013). This formation is observed to directly overlies the Basement Complex rocks around Gboko. The Awe formation which is considered the southernmost component of the Asu River group and is composed of flaggy, medium to coarse grained sandstone interbedded with carbonaceous shales (Nwajide, 2013). The Asu River group in the central Benue Trough has an age span of late Albian to earliest Cenomanian (Offodile, 1976).

The Aze Aku Group found in the central Benue Trough includes the Keana, the Zurak, the Makurdi and the Wukari Formations and are broadly dated Pre-Santonian to Upper Cretaceous largely the Turonian (Nwajide, 2013).

The Keana Formation of the Aze Aku Group consist of poorly sorted fine to coarse and pebbly, feldspathic, micaceous, planar cross-bedded sandstone with subordinate siltstone and shale and is aged Late Cenomanian to Early Turonian (Nwajide, 2013). The Zurak Formation is stratigraphically equivalent to both the Yolde and Pindiga Formations in the Northern Benue Trough. The Makurdi Formation is stratigraphically related to the Keana Formation as described by Offodile (1976). Stratigraphically succeeding the Makurdi Formation is the Wukari Formation and is aged Turonian (Wright et al. 1985). The formation comprises mainly of continental and marine shales, sandstones and limestones (Nwajide, 2013).

Succeeding the Aze Aku Group is the Awgu Formation and it covers an extensive territory within the central and the southern Benue Trough. In the central Benue Trough, this formation has a paralic mode of succession being an alternation of coal, Shelly limestone and marine shales (Nwajide, 2013).

The youngest formation in this part of the basin is the Lafia Formation which was deposited under continental condition (fluvatile), Maastrichtian in age and it overlies unconformable the Awgu Formation (Obaje, 2009). The formation is characterized by ferruginous sandstone, loose sands, flaggy mudstone, clays and claystone (Obaje, 2009).

The central Benue Trough has documented evidence of magmatic activities and the Albian to Turonian deposits have been the most affected, this is evident by the presence of both intrusive and extrusive magmatism in the area. A good example is the succession of interbedded lavas, tuffs, tuffaceous breccias observed on Bima sandstone (Nwajide, 2013). The basalts and dolerite forming topographic prominences within part of the Turonian sandstone of the Keana and Makurdi Formations are all additional evidences.

In the central Benue Trough, sulphides of lead zinc mineralization occasionally associated with silver and copper are found in Arufu, Akwana, Wase and Zurak (Nwajide, 2013; Fatoye, 2014; Bute et al, 2024). The mineralization occurs in lodes and veins infilling fractures in the host rocks striking in the north-south and northwestern to southeastern directions (Nwajide, 2013). Other economic minerals in the central Benue Trough are barites which are confined to Keana Formation in areas around Keana, Ibi and Azara and according to Ford (1981), the greatest concentrations of the veins are in Azara and Akiri areas. The veins have considerable amount of associated quartz, carbonaceous iron, calcium and magnesium and occasional sulphides of lead zinc in anastomosing system filling fissures in early brecciated fractures (Nwajide, 2013). Additional economic minerals in the area are coal in Lafia-Obi (Offodile, 1976) and brine water in areas around Keana (Obaje, 2009).

## **II. Materials And Methods**

### **Materials**

Six half degree high resolution aeromagnetic data in a block grid format purchased from the Nigerian Geological Survey Agency (NGSA) Abuja comprising of sheets 231(Lafia), 232(Awe), 233(Ibi), 251 (Makurdi), 252 (Akwana), and 253 (Wukari) were utilized for this research. The high resolution aeromagnetic data was acquired between years 2006 to 2007 using 3X Scintrex CS3 Cesium Vapour Magnetometer adopting the following magnetic survey specifications: sensor mean terrain clearance was 80 meters, flight line spacing was 500 meters, tie line spacing was 5000 meters, flight trend was 135<sup>0</sup> and tie line trend was 45<sup>0</sup>. Softwares used for data analysis include: Oasis Montaj version 8.4, Google Earth Pro. version 1.3.36.352, ArcGIS version 10.7.1, QGIS version 3.34.3, Surfer 13 and RockWorks version 17.

### **Methods**

#### **Reduction to the Equator**

In magnetic equatorial regions where inclination is less than 15°, reduction to pole (RTP) operator becomes unbounded along the direction of magnetic declination and therefore amplifies the noise in this

direction to the extent that the resultant RTP field is dominated by linear features aligned with the direction of declination (Ndougsa-Mbarga et al., 2012). Because the study area is located within low magnetic latitude there is need to reduce the data to the equator. This method assumes that measurements are conducted in the region where the inclination is zero degree (Rusman et al., 2023), therefore; this transformation centered the peak of magnetic anomalies over their sources. The total magnetic intensity (TMI) grid was reduced to the equator (RTE) using RTE application filter in the Oasis Montaj version 8.4. Reduction to the equator (RTE) has an amplitude component of  $\sin^2(I_a)$  and a phase component of  $\cos^2(I_a) \cdot \cos^2(D - \theta)$  and assuming that all magnetization is parallel to the Earth's magnetic field then (eq.1):

$$L(\theta) = \frac{[\sin(I) - i \cdot \cos(I) \cdot \cos(D - \theta)]^2 x (-\cos^2(D - \theta))}{[\sin^2(I_a) + \cos^2(I_a) \cdot \cos^2(D - \theta)] x [\sin^2(I) + \cos^2(I) \cdot \cos^2(D - \theta)]} \quad (1)$$

Where I is the geomagnetic inclination,  $I_a$  inclination for amplitude correction ( $\geq I$ ), D is geomagnetic declination and  $L(\theta)$  is the direction of wave number vector in degree of azimuth.

The total magnetic intensity (TMI) data over parts of the Central Benue Trough was reduced to the equator by assuming a magnetic inclination (I) =  $-8.51^\circ$  and magnetic declination (D) =  $-1.7^\circ$  according to the International Geomagnetic Reference Field (IGRF) as at 31<sup>st</sup> May, 2007 (year when the survey was completed)

### Regional – Residual Separation

The residual data used for this research was isolated from the Total Magnetic Intensity data Reduced to the Equator (TMI\_RTE) using the first order polynomial fitting. This was done by calculating the least square fittings to all the values in the TMI-RTE grid using the trend filter available in the Oasis Montaj version 8.4 software, where the regional trend was removed leaving out the residual data.

### Pseudo-gravity Transformation

The pseudo-gravity transformation is based on the Poisson relation between magnetic potential and gravity field. This transformation is useful in interpreting magnetic anomalies, not because a mass distribution actually corresponds to the magnetic distribution beneath the magnetic survey, but because gravity anomalies are in some ways more instructive and easier to interpret and quantify than magnetic anomalies (Blakely, 1995). The method which was first applied by Baronov, (1957), is a Poisson's relation between the magnetic potential and the gravitational field considered as a body with uniform magnetization and density occupying a volume v then (eq.2) gives the magnetic scalar potential as:

$$V(p) = -M \nabla \rho \iiint_v \frac{1}{d} dv \quad (2)$$

Where p is the observed point, d is the distance from p.

The gravitational potential is then given as in (eq.3).

$$U(p) = G \rho \iiint_v \frac{1}{d} dv \quad (3)$$

Where G is the gravitational constant and  $\rho$  the density

Combining equation (2) and (3) then:

$$V(p) = -\frac{1}{G\rho} M \nabla \rho U = -\frac{1}{G\rho} M g_M \quad (4)$$

$g_M$  is the component of gravity in the direction of magnetization and equation (4) is the equation for the poisson's relationship.

The apparent susceptibility filter was first applied to the TMI data to calculate the apparent magnetic susceptibility of the source parameter before subjecting it to the pseudo-gravity transformation using the Fast Fourier Transform (FFT) available in the Oasis Montaj version 8.4 software. The idea behind this method was borrowed from Hinze et al., (2013). The filter has the advantage of performing a reduction to the pole but most importantly it performs a downward continuation to the source depth, correct for geomagnetic effects and division by the total magnetic field to yield susceptibility (eq.5).

$$k(\theta) = [\sin(I_a) + i \cos(I) - \cos(D - \theta)]^2 \quad (5)$$

Where I is the geomagnetic inclination,  $I_a$  inclination for amplitude correction ( $\geq I$ ), a is  $\frac{1}{2}$  cell size, D is geomagnetic declination and  $k(\theta)$  is the apparent susceptibility in degree of azimuth.

The apparent susceptibility was calculated at a depth of 80 m which is relative to the height at which the data was acquired and was used as a low pass filter that is necessary to smooth out any potential high frequency noise resulting from intensified surface anomaly.

Outcome of the apparent susceptibility on the TMI was then subjected to pseudo-gravity transformation for pseudo-gravity effect in milligal while assuming the following parameters: geomagnetic field strength of 33412.7 nT, Inclination of  $-8.51^\circ$ , Declination of  $-1.7^\circ$ , magnetization value of 0.5 gauss and a density contrast of 1.0 g/cm<sup>3</sup>.

### CET Data Analysis

CET is an acronym for Centre for Exploration Targeting and is a plugin extension in the Oasis Montaj version 8.4 software developed by the University of Western Australia for extracting lineaments. The CET Grid Analysis plugins is an algorithm useful for grid texture analysis, lineation detection, lineation vectorization and identifying areas of structural complexity in a geophysical data sensitive to geologic structures. The residual was used as an input in the CET grid analysis to generate the lineament map of the study area where lineaments that are less than 250 m in lengths were masked to reduce structural complexity on the map. The lineaments were further analyzed using the RockWorks version 17 software to delineate the trends of structures.

## III. Results And Discussion

### Qualitative Analysis

The total magnetic intensity (TMI) data (Fig.3) ranges from 32,361.35 nT to 33,598.88 nT. This range of magnetic intensities implies that the study area is characterized by high to low frequency of magnetic intensities.

The Total Magnetic Intensity data Reduced to Equator (TMI-RTE) grid anomaly (Fig.4) tends to portray a central shift of anomaly from 32,932.70 nT to 33,116.53 nT when compares to the Total Magnetic Intensity (TMI) grid of 32,361.35 nT to 33,598.88 nT. This has demonstrated that, the peak of magnetic anomalies was centered over their sources.

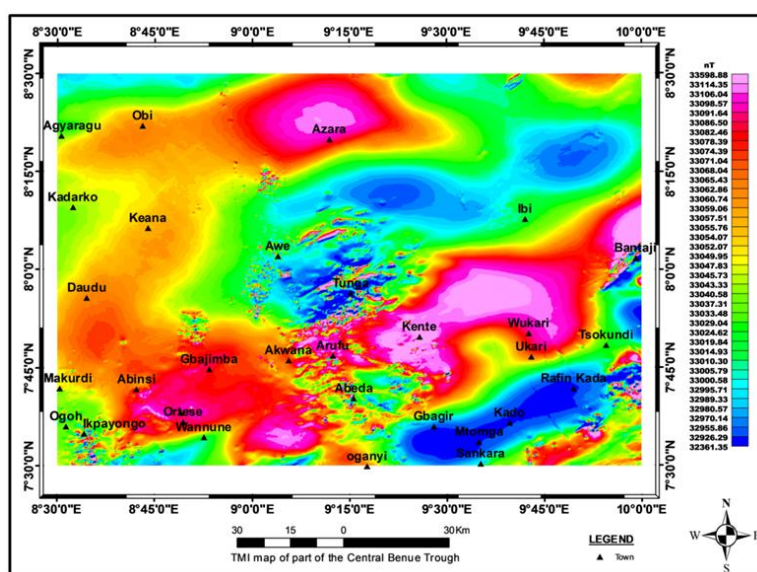


Fig. 3: Total Magnetic Intensity (TMI) map of part of the Central Benue Trough

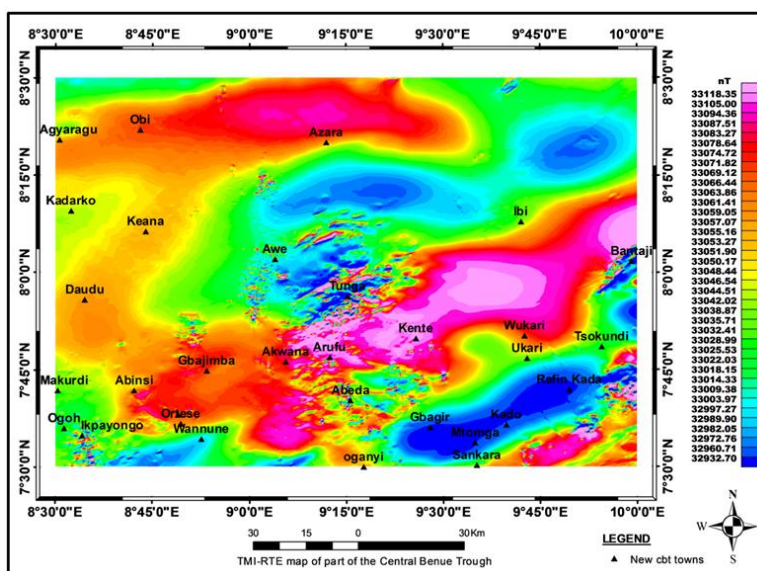


Fig. 4: TMI-RTE map of part of the Central Benue Trough



The residual magnetic anomaly data over the study area (Fig.5) shows an anomaly range of -102.59 nT (magnetic low) to 82.69 nT (magnetic high). From this grid (Fig.5) it will be tasking to identify areas of high and low relief magnetic anomalies. Therefore to isolate these anomalies the residual magnetic anomaly data was transformed to its contour representation (Fig.6). From figure 6, magnetic anomaly highs were represented by successive closed circular and long narrowed pattern of contours. These magnetic anomaly high areas were observed in the central part of the study area around Awe, Tunga, Arufu, Akwana and Abeda towns. To the southwestern part of the study area, similar anomalies were observed around the southwestern part Ikpayongo and the southeastern part of Wunnune towns. Around the eastern part of Rafin Kada and to the southern part of Bantaji towns at the eastern part of the study area, magnetic high anomalies represented by closed magnetic contours were also observed.

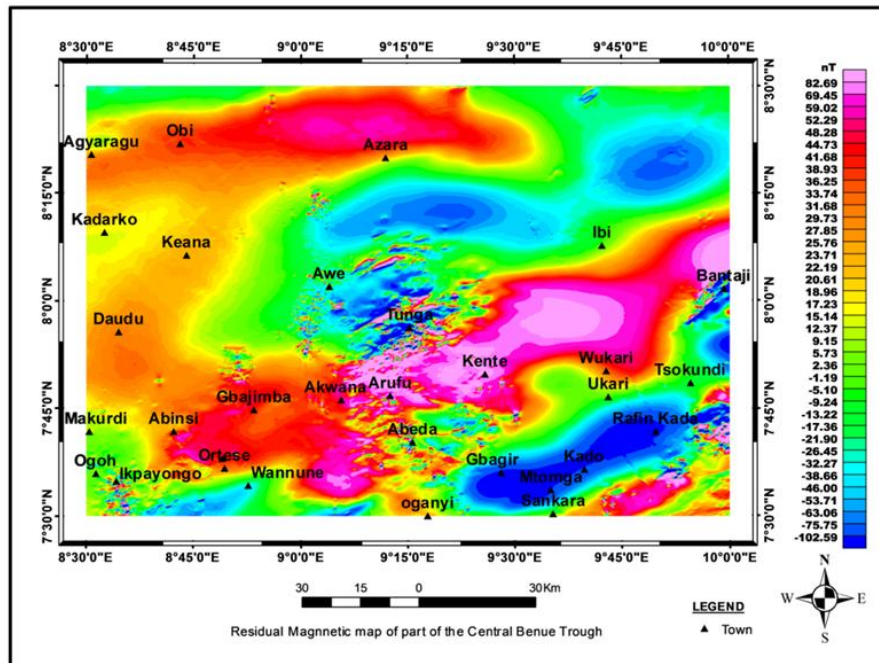


Fig. 5: Residual Magnetic Anomaly map of part of the Central Benue Trough

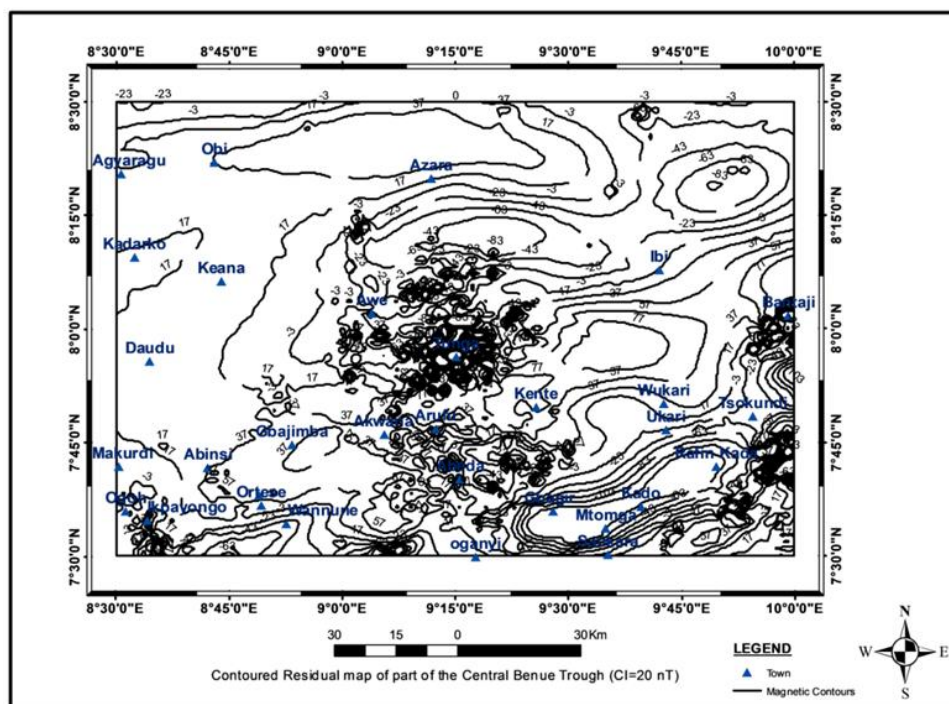


Fig. 6: Contoured Residual Magnetic Anomaly map of part of the Central Benue Trough

The Pseudo-gravity anomaly data (Fig.7) revealed anomalies ranging from -0.344 mGal to 0.274 mGal. The Pseudo-gravity map revealed high density anomalies in the range of 0.155 mGal to 0.274 around Awe, Tunga at the central part of the study area, southwestern part of Wannune and southern Bantaji town. Moderately high anomalies of the range of 0.100 mGal to 0.131 mGal were observed around Azara, Akawana, Arufu and Abeda to the central part of the study area, Ikpayongo to the southwestern part, Bantaji to the eastern part and Tsokundi to the southeastern part of the study area. The study area is also characterized by moderate (0.003 mGal to 0.089 mGal), and very low (-0.344 mGal to -0.003 mGal) anomalies scattered in different parts of the study area (Fig.7)

The high density pseudo-gravity anomalies (Fig.7) trend majorly in the N-S to NNE-SSW directions, these trends are in conformity with the general trend of structures that hosted the lead zinc mineralization in the Benue Trough (Nwajide, 2013; Ukwuteyinor and Ezeh, 2023; )

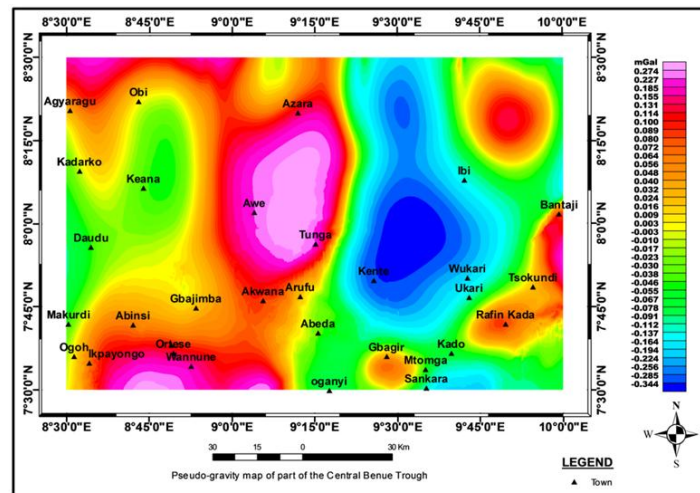


Fig. 7: Pseudo-gravity map of part of the Central Benue Trough

The lineament in the study area as interpreted from (Fig.8) represents presence of fractures, faults, folds and intrusions such as dykes. Figure 8, revealed high density lineaments around the central part of the study area particularly around Awe, Tunga, Akwana and Arufu. Other areas with high density lineaments are: Abeda, south of Kante, south of Ikpayongo and Wannune, northeast of Ibi and east of Rafin Kada. From the structural analysis of lineaments within the study area (Fig.9) the major lineaments trend is in the N-S to NNE-SSW direction, whereas minor directions are in the E-W and NW-SW. The dominant structural trend in the study area is symbolic with the major structural trend of structures hosting the lead zinc mineralization in the Benue Trough. This structural analysis has shaded more light about the practical relationship between geologic structures and deposit of interest in the study area.

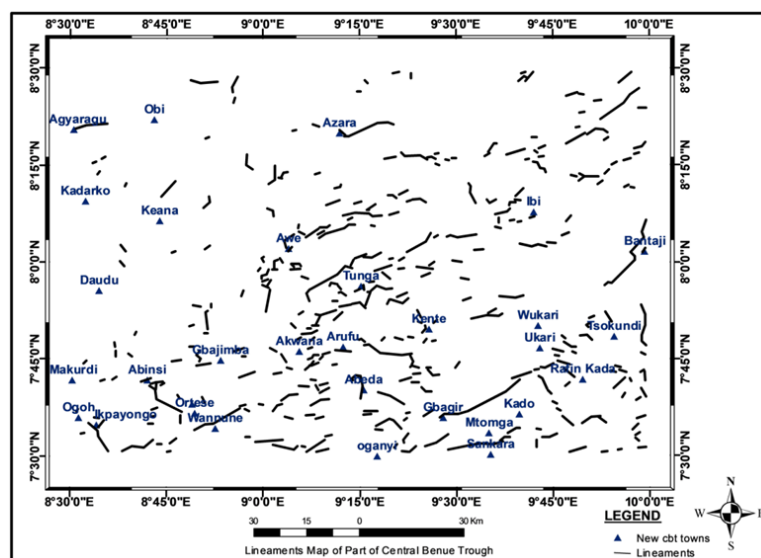


Fig. 8: Lineament map of part of the Central Benue Trough

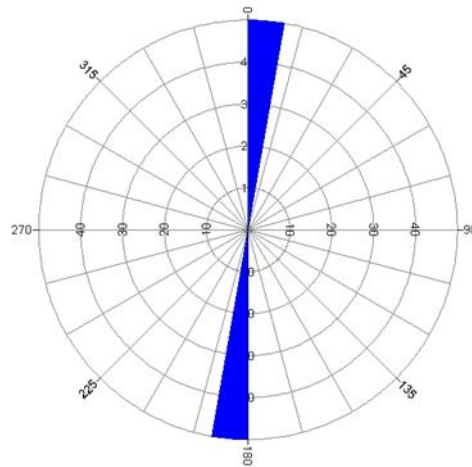


Fig. 9: Rose Plot of Lineaments showing structural directions over part of the Central Benue Trough

### Data Integration

For the purpose of mineral exploration, qualitative interpretation of contoured magnetic map can reveal anomalous conditions in the sub-surface (Parasnis, 1986). Experience has it that each contour pattern has its distinctive geologic counterpart although the exact nature of this may differ from area to area. For instance, successive closed circular patterned contours with anomalous values increasing or decreasing towards the centre are often associated with granitic as well as basic intrusions or with ore bodies (Parasnis, 1986). Also, long narrowed patterns are frequently due to dikes, tectonic shear zones, isoclinal folded strata with magnetic impregnation or long ore bodies (Parasnis, 1986).

The successive circular and the long narrowed patterns with anomalous values increasing towards the centre as interpreted from figure 5 and the magnetic anomaly contours superimposed on the residual map (Fig.10) over Awe, Tunga, Arufu, Akwana and Abeda towns, southwestern and southeast parts of Ikpayongo and Wunnune towns respectively, the eastern and southern parts of Rafin Kada and Bantaji towns respectively can best be associated with ore mineralization.

The quite areas over the study (Fig.10) showing no distinctive pattern of contours are areas with low anomaly implying absence or near absence of mineralization that are paramagnetic in nature.

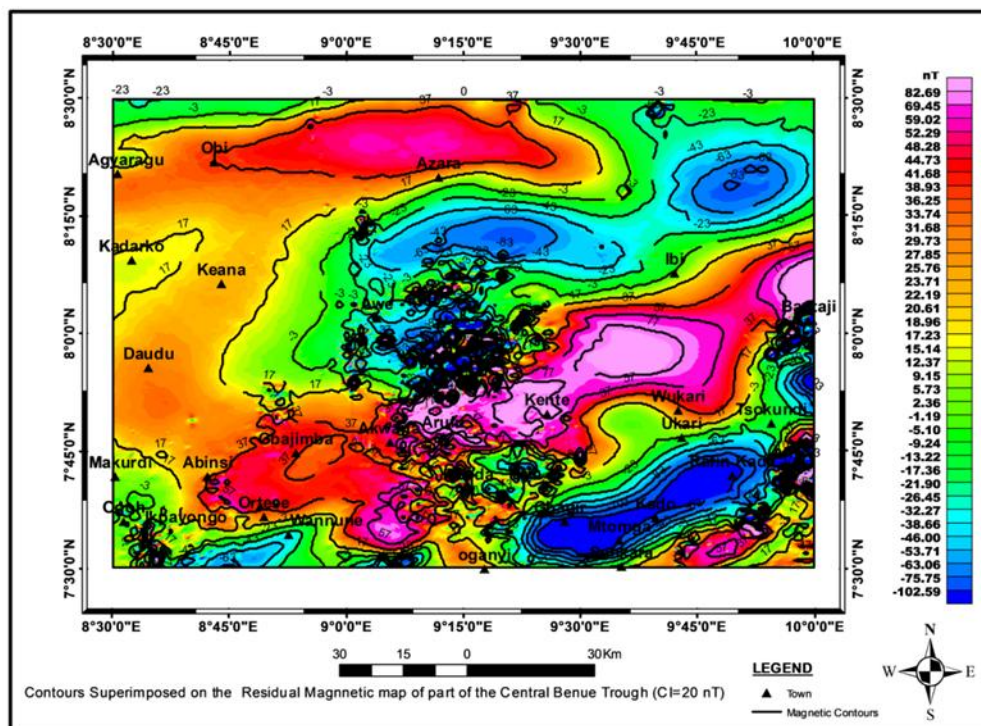


Fig. 10: Magnetic Anomaly Contours superimposed on the Residual map of part of the Central Benue Trough



Superimposing the contoured residual magnetic anomaly map over the pseudo-gravity map (Fig.11), we can notice a good correlation between those areas with high density anomalies high magnetic anomaly. This correlation is not a mere coincidence but are indicative of potential mineralized zones around Awe, Tunga, Arufu, Akwana, southwestern Ikpayongo, southeastern Wunnune, east of Rafin Kada and southern Bantaji towns. These positive and well correlated anomalies from the interpretation of magnetic residual and pseudo-gravity anomalies have buttressed reports by researchers (Akande et al., 1989; Nwajide, 2013; Fatoye, 2014; Bute et al., 2024,) that the fractures within the sedimentary formations (limestone and other carbonates) around Awe, Arufu and Akwana are host to lead Zinc and other associated mineralization.

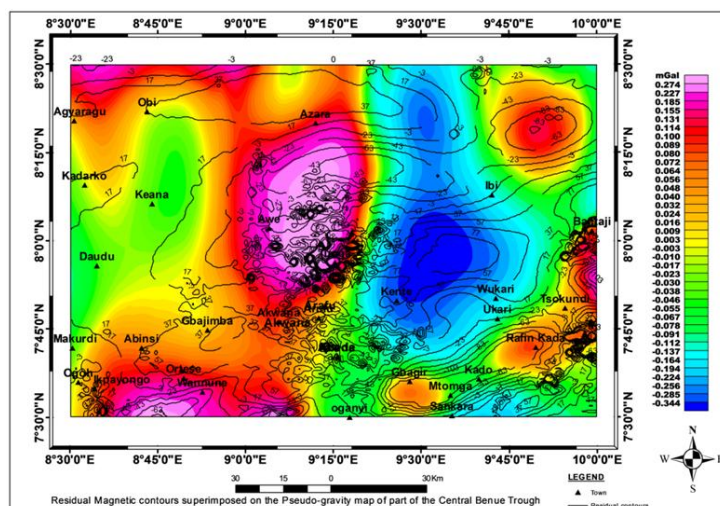


Fig. 11: Magnetic Anomaly Contours superimposed on the Pseudo-gravity map of part of the Central Benue Trough

Overlaying the lineaments over the contoured residual magnetic anomaly map (Fig.12) and the pseudo-gravity map (Fig.13) the outcome revealed that areas with high density lineaments correlates well with areas of high magnetic and high density anomalies respectively. With the preponderance of structures around the central and other parts of the study area is an implication that the mineralization within the study area are structurally controlled. Nwajide (2013) reported that the lineaments related to mineralization in the central Benue Trough trends dominantly in the N-S direction, while minor direction is in the NW-SE. This dominant structural trend of N-S to NNE-SSW (Fig.9) in areas around Awe, Arufu and Akwana established to host lead zinc mineralization were also identified from this present work.

From figure 11 areas around Azara falls within relatively quiet magnetic residual anomaly and moderately high density. This anomaly variance when compared to the central part of the study area around Awe, Arufu and Akwana with high magnetic residual and high density anomalies could be attributed to the preponderance of barite mineralization over lead and galena in Azara area as reported by (Ford, 1981; Akande et al., 1989; Nwajide, 2013; Fatoye et al., 2014).

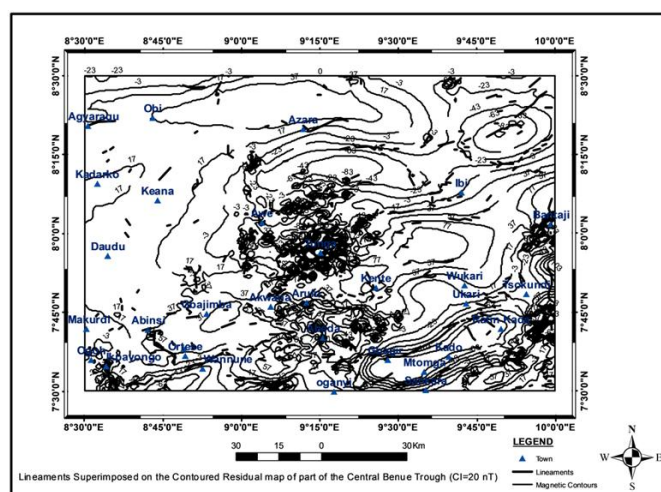


Fig. 12: Residual Magnetic Contours superimposed on the Lineaments map of part of the Central Benue Trough

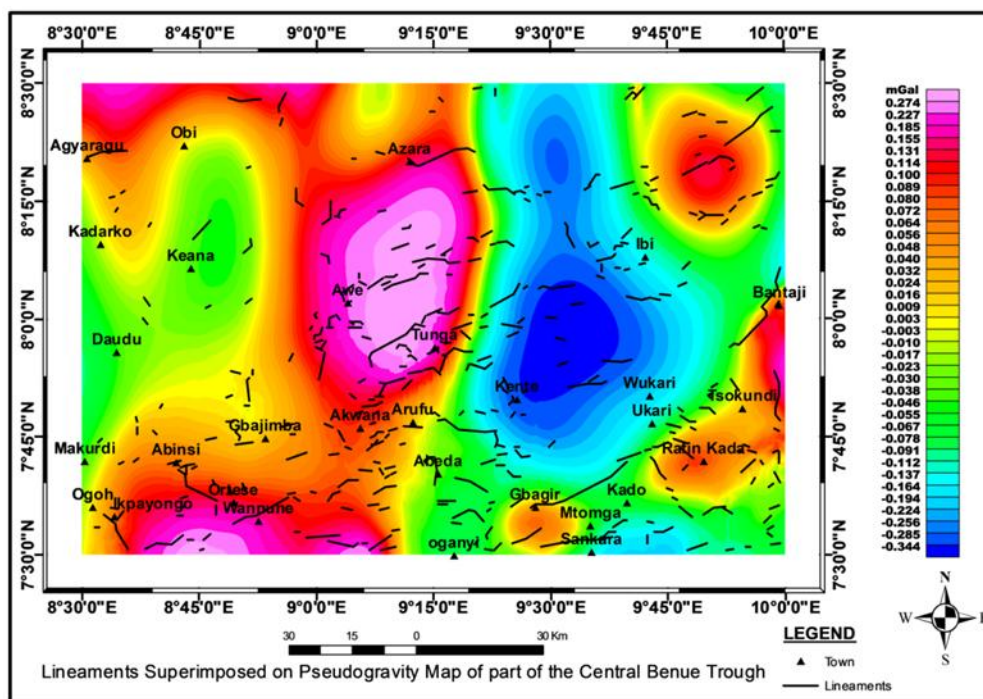


Fig. 13: Lineaments superimposed on the Pseudo-gravity map of part of the Central Benue Trough

Therefore, from this research work areas that have shown good prospect because of the anomaly similarities with areas established to host lead zinc mineralization are areas around Tunga within an approximated enclave of Long.  $9^{\circ}10' - 9^{\circ}20' E$  and Lat.  $7^{\circ}50' - 8^{\circ}10' N$ ; southwest of Ikpayongo, Long.  $8^{\circ}32' - 8^{\circ}40' E$  and Lat.  $7^{\circ}30' - 7^{\circ}40' N$ ; southeast of Wunnune, Long.  $8^{\circ}30' - 8^{\circ}40' E$  and Lat.  $7^{\circ}30' - 7^{\circ}40' N$ ; east of Rafin Kada, Long.  $9^{\circ}50' - 10^{\circ}00' E$  and Lat.  $7^{\circ}42' - 7^{\circ}48' N$  and southern Bantaji, Long.  $9^{\circ}50' - 10^{\circ}00' E$  and Lat.  $7^{\circ}50' - 8^{\circ}05' N$ .

#### IV. Conclusion

In conclusion, the interpretation of magnetic residual and pseudo-gravity anomalies combined with the structural analysis of high resolution aeromagnetic data over part of the central Benue Trough has:

1. Confirmed the present of mineralized bodies in areas around Awe, Arufu and Akwana as reported by previous authors.
2. Also revealed that, the preponderance of structures trending dominantly in the N-S to NNE-SSW direction over areas earlier reported to host lead, zinc and other associated mineralization is an indication that mineralization in the study area is structurally controlled.
3. The observed similarities in terms of anomalies around Tunga, southwest of Ikpayongo, southeast of Wunnune, east of Rafin Kada and southern Bantaji towns are strong indications that these areas have good prospect for lead zinc and other associated mineralization.
4. Further investigation using geophysical methods (gravity, electrical or core drilling) is needed to validate the presence of mineralization within regions delineated as prospective areas.

#### Acknowledment

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