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Aeromagnetic Assessment for Hydrocarbon Prospectivity in the Mid-Benue Trough

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Abstract

This study aimed at assessment for favourable subsurface structural traps for hydrocarbon prospectivity of some parts of The Central Benue Trough, Nigeria, using aeromagnetic data sourced from the Nigerian Geological Survey Agency. The data, acquired through a 2008 airborne geomagnetic survey, involved a flight altitude of 80 meters, flight line spacing of 500 meters, and tie lines at 2 kilometres. Data processing included the removal of long-wavelength components via the 2020 International Geomagnetic Reference Field (IGRF) values and gridding using Oasis montaj™ 6.2 software. Given the study area's proximity to the equator, Reduction to the Equator (RTE) processing was applied to the Total Magnetic Intensity (TMI) map to reposition magnetic anomalies directly over their sources. Regional-residual separation, first vertical and horizontal derivatives, and analytic signal processing were employed to enhance the identification of geological structures. The TMI values ranged from -132.8 to 227.2 nT, indicating magnetic heterogeneity. High-intensity anomalies in the northern region suggest shallow basement rocks or high magnetic susceptibility formations, while low-intensity anomalies in the southern region imply deeper basement rocks indicating low susceptibility formations. As shown by the Analytical Signal method, the largest concentration in the northwestern part of the study area is due to a shallow basement with values ranging from 0.03469 to 0.6464 nT/m, which implies the existence of lineaments, which are evenly distributed across the area. The probable depth to distance ranges from 741.2 to 1688.7 m, tilting towards basement formations, while the yellowish greenish with values from 108.4 to 348.9 m suggesting the presence of near-surface structures, then the blue patches with distances ranging from 495.6 to 1502.3 m indicating a highly elevated portion of the earth revealed lineaments and significant structural features and sedimentary thickness variations, this validates the existence of structural traps within the study area and makes further prospectivity a promising venture.

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Introduction

Between 1990 and 2025, the cost of hydrocarbon exploration and production in Nigeria's onshore areas has experienced significant fluctuations due to various factors, including infrastructure challenges, security issues, and regulatory changes. In the early 1990s, production costs were relatively low, estimated at around $4 to $5 per barrel. However, over the years, these costs have escalated. The cost of hydrocarbon exploration and production cost surges to $40/barrel as reported by the **Nigerian Upstream Petroleum Regulatory Commission (NUPRC) report (2023/2024) and** Malik (2025) Some of the listed responsible factors for the rising cost are: exploration and production cost, infrastructure challenges, security issues, and regulatory changes. In comparison, countries like Saudi Arabia maintain production costs as low as $10 per barrel, highlighting Nigeria's competitiveness challenges in the global oil market. Efforts are underway to reduce these costs to $20 per barrel through modernization initiatives and regulatory reforms. The factor that has not been given adequate attention is the exploration cost challenges and the Aeromagnetic method is perhaps the most affordable of all the geophysical methods that can serve as a useful tool because the data is readily available, Chifu *et al* (2019) and Joel *et al* (2016). It can also be used for both deep and shallow targets assessment. Such applications include mapping of geological structures and the estimation of sedimentary basin thickness. Much of the shallow subsurface investigations are directed toward characterizing the sediments above the bedrock, defining the bedrock topography and delineation, Keary *et al* (2002).Several authors have reported on the use of aeromagnetic data and hydrocarbon prospectivity in the study area and elsewhere such as Elawadi *et al* (2024), Osinowo *et al* (2023) and Osinowo *et al* (2023), Nwaobodo *et al* (2023), Okoro *et al* (2021), Osinowo and Taiwo, (2020) and Simon and

Solomon.(2019) highlighted the potential of aeromagnetic techniques in revealing sedimentary thickness variations and mapping structural highs and lows crucial for hydrocarbon entrapment. Adeola et al., (2022) reviewed the crude oil exploration in Africa and highlighted socio-economic and environmental challenges, whereas the study on the Central Benue Trough utilizes high-resolution aeromagnetic data to identify hydrocarbon potential, revealing sedimentary thicknesses up to 3.68 km and significant fault systems. While the scholars address broader continental issues, efforts to focus on cost-effective, geophysical methods to pinpoint promising exploration areas in Nigeria will go a long way toward energy security, Dhali *et al* (2023). This study aims to leverage aeromagnetic data assessment to evaluate hydrocarbon prospectivity, focusing on structural traps delineation and infer the depth estimation to guide future exploration efforts.

They demonstrated the efficacy of aeromagnetic data in identifying promising hydrocarbon zones. Techniques such as Total Magnetic Intensity (TMI) mapping, Reduction to Equator (RTE), Analytical Signal, and Total Horizontal Derivative (THD) have been employed to enhance boundary definition, detect fault structures, and estimate basement depths exceeding 3 km conditions favourable for hydrocarbon accumulation.

Study Area

Regionally, the Benue Trough is an elongated sedimentary basin extending approximately 800 km in length and 150 km in width, filled with Cretaceous to Cenozoic sediments. The Central Benue Trough features a lowland relief with elevations ranging from 100 to 300 meters above sea level, characterized by flat or gently undulating terrain interspersed with occasional low hills. Geologically, it comprises limestone, sandstone and shale, and is underlain by basement complex rocks, younger granites, sedimentary formations, and other magmatic rocks. The Benue River, originating from the Adamawa Plateau in northern Cameroon, traverses this region, following NE-SW lineaments and exhibiting significant seasonal flow variations, with its banks exposing shale units during the dry season, Offodile (1976), (1989); Ajayi and Ajakaiye (1981), (1986); Benkhelil (1989); Obaje (2009); Nwajide (2013); Anudu *et al* (2014) and Anudu (2017). The drainage of the Central Benue Trough traversed by the Benue River, which is the largest in the study area as seen in Figure.2. The map of the study area lies within Latitudes 90°00'00'' - 11°30'00'' N and Longitudes 11°00'00'' -12°30'00''E in the Central Benue Trough of Nigeria which straddles the Northern Nigerian basement Complex to the north and the Eastern Nigerian basement complex in the Southeast. From the northeastern flank, It is having Kerri Kerri Formation lays beside Gombe Sandstone, beneath it is the Pindiga Formation, Bima Sandstone and Yolde Formation, then the basement complex and some spike of Tertiary to recent volcanics , while the Basement Complex dominate from the southern flank (Figure. 1). The hydrocarbon prospectivity of the area which lies majorly on when it possesses mature source rock rich in organic material, porous and permeable reservoir rocks, effective traps and seals to contain hydrocarbons, and favourable conditions for hydrocarbon generation, migration, and accumulation. The study aims to highlight the structural framework that supports the hydrocarbon prospectivity of the area. Table 1, having the stratigraphic column showing the formations in the Central Benue Trough as modified by Obaje and Liguois (1996), showed that the minor unconformity occurred between Cenomanian to Albian age having various Formation from Keana, Gboko and Asu River Group, lithologies ranging from limestones and clastic sediments in shallow marine and fluvio deltaic environment and the major unconformity occurred between Maastrichian and Tertiary - Quaternary, Santonian and Campanian with the Formation occupied with good hydrocarbon prospectivity sedimentary rocks within fluvial and shallow marine deltaic environment, whereas, the last major unconformity between pre-Albian and Albian with shales, limestones and sandstones with marine environment underlying the basement complex with igneous and metamorphic rocks. Anudu *et al* (2020) in Table 2, summarized the stratigraphy, tectonic and magmatic events in the central Benue Trough, it highlighted the Geological time from PreCambrian – late Palaeozoic to Eocene age; the tectonic events showing the compressional movements, tensional movements and tensional movements with a transcurrent component, unconformity, magmatism, tectonic phase and Thermo-tectonic sag phase; the various Formation from Lafia Formation as the youngest to the crystalline Basement complex. Also, various lithologies were highlighted, from sandstone, siltstone, claystone, shale, coal, limestone, migmatite, gneiss, schist and granite and the paleoenvironment from fluvial, shallow marine, deltaic and marine environments and metamorphic and igneous rock.

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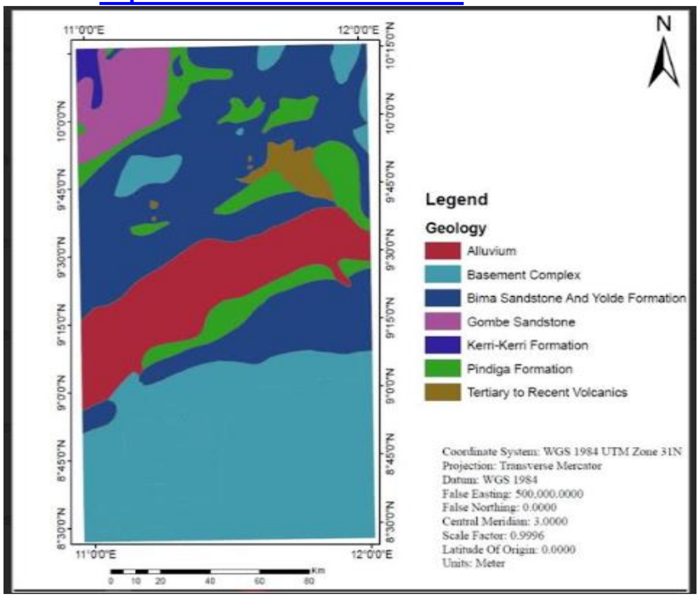

Figure 1: Geologic map of the study location

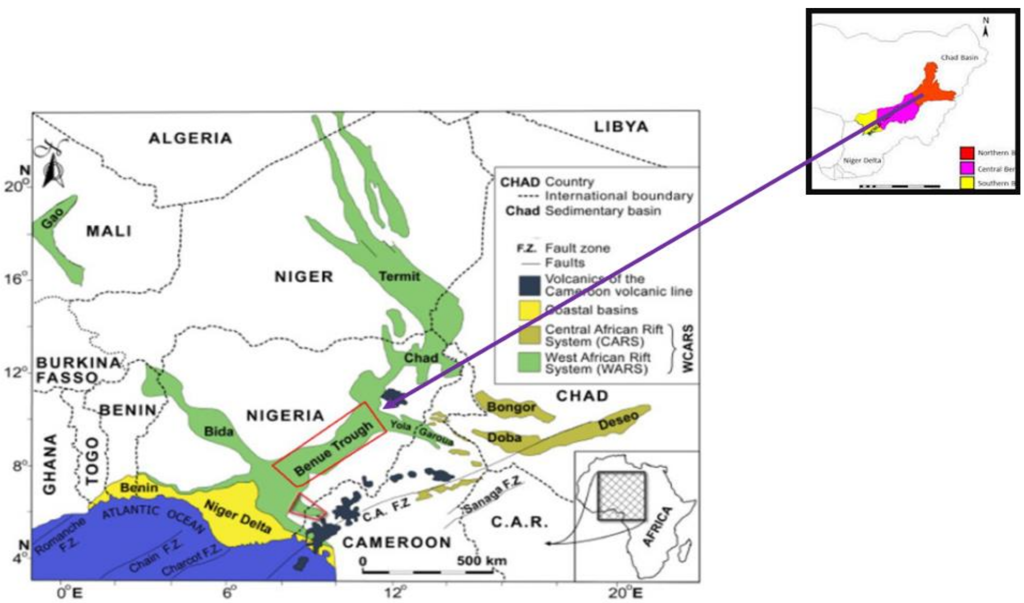

Figure 2: Map of Benue Trough within the West and Central African Rift System (WCARS) with Central Benue Trough indication (modified after Genik, 1983)

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CHRONO-STRATIGRAPHY	FORMATION (Approx. thickness	LITHOLOGY	PALAEO-ENVIRONMENT
Tertiary-Quaternary	Alluvium Volcanics	Sands Volcanics	Alluvial Volcanics
Maastrichtian	Lafia Formation (800 m)	Sandstones, Siltstones, Claystones	Fluvial
Campanian			
Santonian			
Coniacian	Awgu Formation (1000 m)	Shales, Coals, Limestones, Sandstones, Siltstones	Shallow marine, deltaic
Turonian			
	Ezeaku Formation (500 m)	Shales, Limestones	Shallow marine
Cenomanian	Keana Fm (500 m) / Awe Fm (400 m)	Sandstones, Siltstones, Claystones	Fluviodeltaic
Albian	Arufu, Uomba, Gboko Fms (Asu River Group (1800 m)	Shales, Limestones, Sandstones	Marine
Pre-Albian	Basement Complex	Granites, Gneisses, Schist, Migmatites	Igneous, metamorphic

.... Minor Unconformity
▨▨▨▨▨▨▨ Major Unconformity

Table 1: Stratigraphic column showing the formations in the Central Benue Trough (modified from Obaje and Liguois, 1996)

GEOLOGICAL TIME (Ma)				TECTONIC EVENTS	MAGMATIC EVENTS	FORMATION	LITHOLOGY	PALEO-ENVIRONMENT
PALAEOGENE	Eocene	Priabonian	33.9					
		Bartonian						
		Lutetian						
		Ypresian	56.0					
	Palaeocene	Thanetian						
		Selandian						
		Danian	66.0					
CRETACEOUS	Late	Maastrichtian	72.1			Lafia Fm	Sandstone, siltstone, claystone	Fluvial
		Campanian	83.6					
		Santonian	86.3			Agwu Fm	Shale, siltstone, coal, sandstone, limestone	Shallow marine, deltaic
		Coniacian	89.8					
		Turonian	93.9			Ezeaku Fm	Shale, sandstone, limestone, siltstone	Shallow marine, deltaic
		Cenomanian	100			Awe Fm / Keana Fm	Sandstone, siltstone, claystone	Fluvio-deltaic
	Early	Albian	113			Asu River Group (Arufu,Uomba, Gboko Fms.)	Shale, limestone, sandstone, siltstone	Marine
		Aptian	125					
Precambrian - Late Palaeozoic						Crystalline Basement Complex	Migmatite, gneiss, schist, granite	Metamorphic, igneous

→ ← Compressional movements; ◁— —▷ Tensional movements; ◁— —▷ Tensional movements with a transcurrent component
Unconformity; Magmatism; Tectonic phase; Thermo-tectonic sag phase

Table 2: Summary of the stratigraphy, tectonic and magmatic events in the central Benue Trough, (From Anudu *et al* 2020)

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Materials and Methods

The study adopted the workflow in Figure. 3 showing the data source, processing and interpretation.

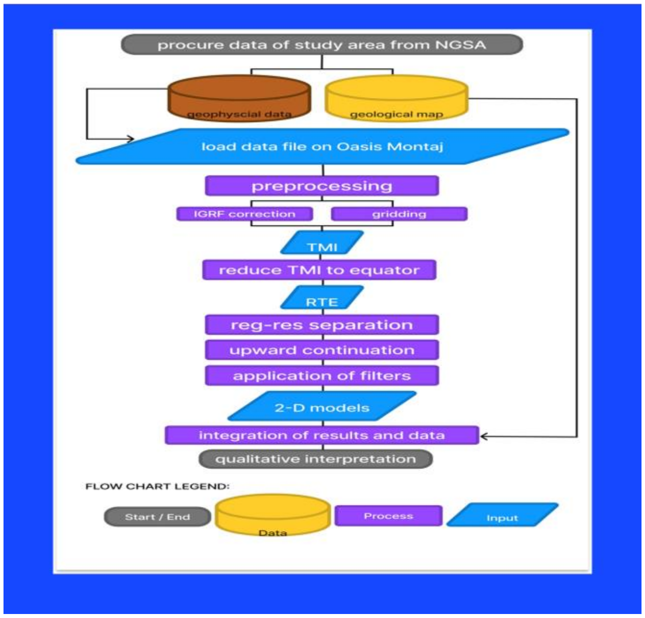

Figure 3: Study workflow adopted

Data source: The aeromagnetic data utilized in this study were sourced from the Nigerian Geological Survey Agency (NGSA) and acquired in 2008 through an airborne geomagnetic survey conducted by Fugro Surveys Limited as part of Nigeria's nationwide aeromagnetic survey. The survey specifications included a flight altitude of 80 meters, flight line spacing of 500 meters, and tie lines spaced at 2 kilometers. Data were digitized along flight lines and contoured at 2.5 nT intervals. The average magnetic inclination and declination across the survey area were approximately -10.812° and -0.874°, respectively.

Data processing: To enhance the interpretability of the magnetic data, long-wavelength components were eliminated by subtracting the 2020 International Geomagnetic Reference Field (IGRF) values. The data were then gridded using Oasis montaj™ 6.2 software, a platform known for its advanced geophysical data processing and visualization capabilities. Given the study area's proximity to the equator, the Total Magnetic Intensity (TMI) map was subjected to Reduction to the Equator (RTE) processing. This technique repositions magnetic anomalies directly over their sources, thereby enhancing their spatial accuracy. To further isolate and enhance shallow subsurface anomalies, regional-residual separation was performed on the RTE data. Subsequent application of first vertical and horizontal derivatives, along with analytic signal processing, facilitated the identification of geological structures that could serve as pathways for hydrocarbon movement and storage. Also, the probable depth to the top of the basement within the study area was estimated using the analytic signal method, which are effective in determining depths to magnetic source bodies and delineating subsurface structures.

Data Interpretation: Aeromagnetic data interpretation in this study involved both quantitative and qualitative approaches to analyze subsurface geological features. Quantitative methods, such as Source Parameter Imaging (SPI), Analytical Signal (AS), and forward modeling, provide numerical estimates of source parameters like location, depth, and geometry. For instance, SPI detects edge locations, depths, dips, and susceptibility contrasts of magnetic sources, aiding in preliminary interpretations. Qualitative interpretation includes visual analysis of Total Magnetic Intensity (TMI) maps, which revealed variations in magnetic intensity corresponding to different lithologies and structural features. Applying filters like Reduction to Equator (RTE) enhances anomaly positioning over causative bodies, while derivative filters such as Analytical Signal and Total Horizontal Derivative (THD) improve boundary definition and highlight subtle geological structures. These combined techniques facilitated a comprehensive understanding of subsurface geology, essential for resource exploration and assessments.

Results and Interpretation

Total magnetic intensity: From the data, the two-dimensional (2D) Total Magnetic Intensity (TMI) map, using a colour-shaded grid for enhanced interpretability (Figure 4)**.** The use of colour shading improves the visibility of anomalies within the magnetic data, with their intensity ranges indicated on the accompanying scale bar. Positive anomaly areas could be interpreted to be underlain by high magnetic susceptibility rocks or shallow magnetic rock bodies or areas of exposed basement rock. Also, negative anomalies could be interpreted to be underlain by low magnetic susceptibility rocks or deep subsurface basement rocks. The TMI values of the area range from -132.8 to 227.2 nT. after IGRF correction, which shows that the area is magnetically heterogenous. high-intensity anomalies while low- intensity anomalies are concentrated in the southern part of the area which implies shallow subsurface or high susceptibility rocks in the northern part of the area. it revealed variations in the Earth's magnetic field caused by subsurface geology, and this analysis identify magnetic anomalies associated with structural features, and lithological contacts, and may likely be potential hydrocarbon traps. The TMI response lacks distinct geological zoning, while the study area exhibits a dendritic drainage pattern as shown in Figure. 2, a common formation in regions with uniform subsurface geology. The observed magnetic heterogeneity may be attributed to variations in sediment thickness or the configuration of basement rocks.

Reduction to the Equator : Applying the Reduction to the Equator (RTE) filter to the Total Magnetic Intensity (TMI) data enhances interpretability without compromising geophysical integrity. As depicted in Figure 5, the RTE map

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preserves the trends observed in the TMI map but offers improved image clarity and boundary definition. The RTE filter centers magnetic anomalies over their causative geological sources, facilitating accurate anomaly positioning. The magnetically subdued areas are the magnetic lows of the study area and is typical of the sedimentary environment which is concentrated in the northern to northwestern part while the magnetic responsive areas are the magnetic highs, as shown in Figure 5 host a shallow basements of crystalline rocks or deep-seated volcanic rocks in contrast to the northern area. As shown in the Figure 5 for TMI, the trend remains the same in the (RTE) map but the image was enhanced and boundary definition was improved. The rock body is likely to be shallow in the northern part of the study area compared to the southern part of the study area. The TMI values of the area range after IGRF correction, which from observing this mapped section due to its gentle transition between three magnetic moderately homogenous signatures. The 3 major regions with their varying magnetic intensities show that the northernmost region seems to be dominated by low to very low magnetic intensity signatures. The central region seems to be dominated by very high magnetic intensity and the southern extent displays moderately to high magnetic intensity signatures. This points out that fairly shallow basement or very highly susceptible rocks are present in the central portion of the study area. Consequently, the basement appears shallower in the northern part of the study area compared to the southern region.

Residual Anomaly: Residual anomalies which is the wavenumber, indicated that of high wavenumber, low wavelength component of the total magnetic field intensity, varies from -63 nT to 86 nT across the study area. It implied that the causative objects originated from near the surface. The existence of high amplitude anomaly in the northern part of the study area and low amplitude anomaly in the southern part of the study area are reflected in the TMI and RTE maps, isolate local geological features by removing regional trends, and highlight subsurface structures and potential traps.

First Vertical Derivative: The first vertical derivative was applied to the total magnetic field, it filtered magnetic data and emphasizes near thereby sharpening magnetic anomalies to emphasize near-surface geological features and analysed by computing the vertical rate of change in magnetic intensity to identify faults, contacts and shallow structures. The values in the study area range from -0.18 to 0.23 nT/m. These peaks of the first vertical derivative were enhance in the northern part of the study area because of the shallow rock body than southern part of the study area which has higher sedimentary cover.

Analytical Signal: Figure 6 shows the magnetic signature impact assessment been investigated, the RTE map in Figure 6 exhibits sharply distinctive geological zoning. The moderate magnetic heterogeneity observed across the study area was attributed to fluctuations in sediment thickness or the configuration of the underlying basement rocks. Attempts to identify the structures on the Figure 6 indicated linear structures scantly distributed across the area but with the largest concentration in the northwestern part of the study area due to shallow basement with values ranging from 0.03469 to 0.6464 nT/m, indicating the existence of lineaments. The analytic signal aided in locating the edges of magnetic source bodies subsurfaces and potential reservoirs. Geological linear structures are evenly distributed across the study area but they are more visible in the northern part of the study area due to the shallow basement. Michael and Stephen (2014) noted that the top of the geological structure coincides with the peak of the analytical signal, particularly where remanence and/or low magnetic latitude complicates interpretation, however, the existence of lineament could serve as conduit pathway and storage rock unit. Also, MacLeod *et al* (1993) in their work stated that in analysing data from equatorial regions, where total magnetic intensity provides limited spatial resolution and where the source carries strong remanent magnetization, also reflect on assessment, as the study area is in a magnetic equatorial region with the magnetic inclination of -10.8120 and declination of -0.8740, and the magnetic analytic signal depends upon the strength and not the direction of body magnetism and it enhances the identification of magnetic source boundaries and depths.

Total Horizontal Derivative: Structures with a NE-SW trend appear to have occurred at the northwestern portion of the study area, with positive indicators of potential lineament which always supportive towards fluid movement. The boundaries inferring structures ranging from lineaments to faults, which serve as area for prospectivity prospect in the northern part of the study area, are located at the maxima of the horizontal gradient since the rock body is likely to be shallower vis-à-vis thin sedimentary cover is shown in Figure 7. This highlighted edges of geological structures and fault boundaries revealed the identified the likely structural features (traps) for hydrocarbon prospectivity.

Magnetic Basement Depth : The analytic depth map was used to estimate as shown in Figure 8, the magnetic basement depth map, while Table 3 showed **Summarizing depth ranges** and corresponding geological interpretations inferred in the study. The flight height was subtracted from the analytic depth for true depth realization. The depth to the magnetic basement ranges from 352.3 to 1688.7 m (analytic depth). The northern part of the study area is characterized by a shallower basement. The analytic depth map showed varying distances from the flight height with zero surface value, positive values indicating near and subsurface formations or structures and negative values indicating presences of outcrops. The area with 741.2 to 1688.7 m magnitude value are inferred as basement formations, also the area with magnitude values from 108.4 to 348.9 m inferred as the near- surface structures, then the area with distances ranging from 495.6 to 1502.3 m magnitude values indicating the highly elevated portion of the earth were inferred as the sedimentary formation. The northern part of the study area is characterized by a shallower basement while the southern portion is characterized by deeper basement. Giving a well log data on this area can add more validation, which may be located on the linear structure or a deeper basement or both. This infers that major factors controlling reservoir potential within this area for prospectivity are the thickness of the rock body and linear structures.

Table 3: **Summarizing depth ranges** and corresponding geological interpretations inferred in the study.

S/N	Depth ranges (m)	Corresponding geological interpretation	
1	108.4 – 348.9	Near Surface	
2	495.6 – 1502.3	Sedimentary formations	
3	741.2 – 1688.7	Basement formations	

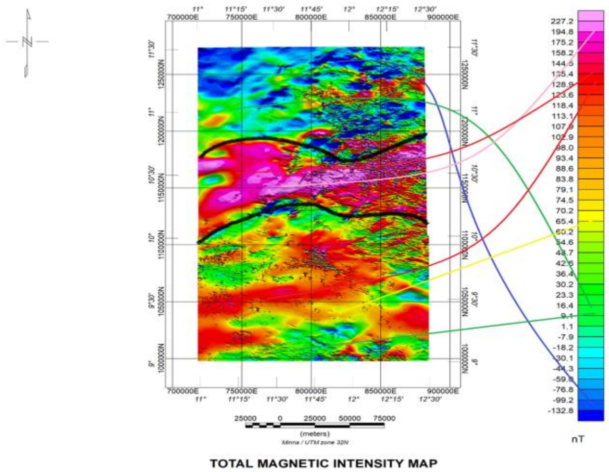

Figure 4: Total Magnetic Intensity Map

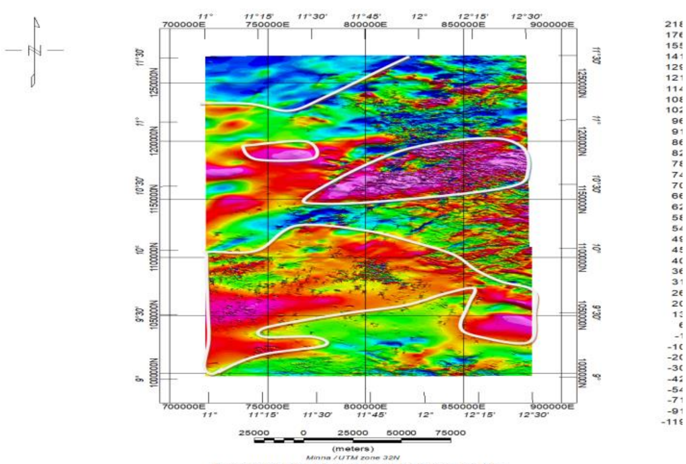

Figure 5: Reduction to equator Map

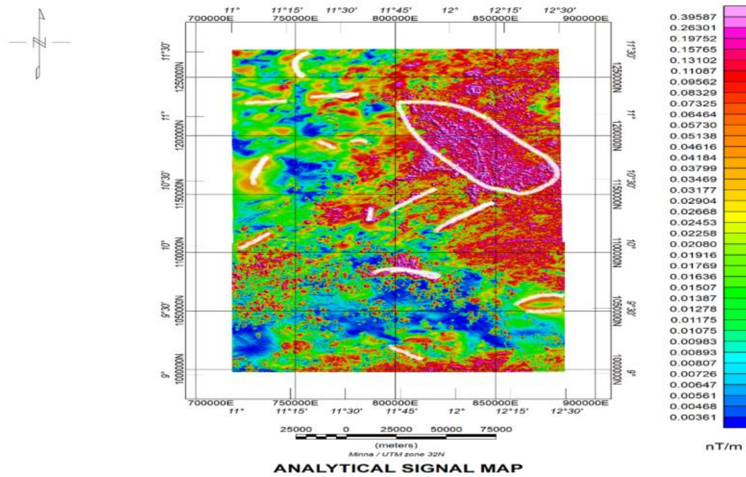

Figure 6: Analytical Signal Map

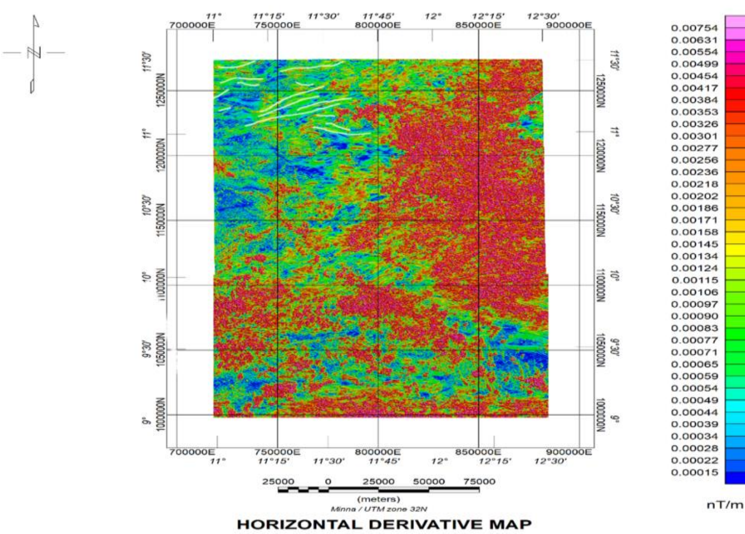

Figure 7: Total Horizontal Derivative Map

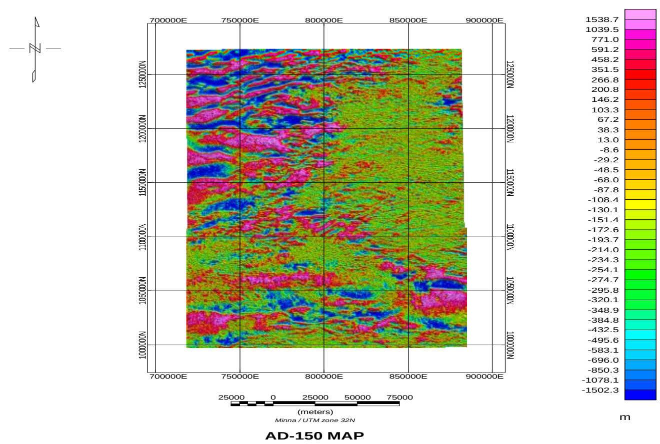

Figure 8: Magnetic Basement Depth Map

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Discussion

This study was carried out at some parts of the Central Benue Trough, to assess the structural features for hydrocarbon exploration prospecting. The primary method for assessing the subsurface and defining favorable zones for hydrocarbon prospecting was aeromagnetic data analysis. The study highlights the relevance of processing and interpretation showing that the Total Magnetic Intensity (TMI) revealed a magnetically heterogeneous region, with TMI values ranging from -132.8 to 227.2 nT after IGRF correction. Positive anomalies suggest areas underlain by high magnetic susceptibility rocks or shallow magnetic bodies, predominantly in the northern part, while negative anomalies indicate regions with low magnetic susceptibility rocks or deeper basement rocks, mainly in the southern part. The observed magnetic heterogeneity is attributed to variations in sediment thickness and basement rock configurations. Upon applying the Reduction to the Equator (RTE), the magnetic lows, indicative of sedimentary environments, are concentrated in the northern to northwestern parts, whereas magnetic highs, associated with shallow crystalline or deep-seated volcanic rocks, are prevalent in the southern region. The RTE map enhances boundary definitions, maintaining the trend observed in the TMI map. The central region exhibits very high magnetic intensity, suggesting the presence of highly susceptible rocks or a fairly shallow basement. The Analytical Signal (AS), highlighted linear structures, particularly concentrated in the northwestern part, indicating potential lineaments. The Total Horizontal Derivative revealed NE-SW trending structures in the northwestern portion, which are supportive of fluid movement. The Magnetic Basement Depth analysis estimates depths showed that the shallower basement depths characterize the northern part, while deeper sections are observed in other areas. The analytic depth map showed varying distances from the flight height with zero surface value, positive values indicating near and subsurface formations or structures and negative values indicating presences of outcrops. The area with 741.2 to 1688.7 m magnitude value are inferred as basement formations, also the area with magnitude values from 108.4 to 348.9 m inferred as the near-surface structures, then the area with distances ranging from 495.6 to 1502.3 m magnitude values indicating the highly elevated portion of the earth were inferred as the sedimentary formation. Okoro *et al* (2021) showed that Structural features such as lineaments, faults, and basement undulations in the Dahomey Basin delineate horst-graben architectures that create favourable conditions for hydrocarbon trapping by forming fault-bounded closures and accommodating thick sedimentary sequences. These tectonic structures, identified through the aeromagnetic data, influence the distribution of petroleum systems by controlling sediment deposition patterns and providing pathways for hydrocarbon migration. Adebiyi *et al* (2023) further collaborate the same outcome in Niger delta basin, Benue trough and crystalline basement. Fichler (2025) clarified that magnetic anomalies are interpreted as indirect indicators of hydrocarbons not because magnetic methods detect hydrocarbons directly, but because hydrocarbons can induce chemical and mineralogical changes in surrounding rocks that alter their magnetic properties. For instance, hydrocarbon seepage can lead to the formation of magnetic minerals like magnetite or pyrrhotite in overlying sediments, creating subtle magnetic anomalies detectable by surveys. The work signified that while direct hydrocarbon indicators are known, indirectly detecting hydrocarbons indicators serve as alternative and complimentary tools in exploration by revealing subsurface geological features such as faults, fractures, and basement undulations that can act as traps for hydrocarbons. Additionally, the diagenetic alterations in surrounding rocks, resulting in the formation of magnetic minerals like siderite, which produce subtle magnetic anomalies detectable through magnetic surveys play key role as a positive signature in revealing structural traps search for hydrocarbon exploration. In further interpretations in these area, Obaje (2009) highlighted the utility of aeromagnetic surveys in delineating structural features and sedimentary thicknesses crucial for hydrocarbon prospectivity in the region. Avbovbo (1980) emphasized the significance of magnetic methods in identifying subsurface structures that influence hydrocarbon accumulation. Similarly, Olade (1975) discussed the role of aeromagnetic data in understanding the tectonic evolution and structural configurations favourable for hydrocarbon entrapment in the Benue Trough. Aeromagnetic studies in the Benue Trough have been substantiated by basin modeling and well log analyses that reveal significant sedimentary thicknesses and structural complexities favourable for hydrocarbon accumulation. For instance, Osinowo *et al* (2023) employed high-resolution aeromagnetic data to delineate NE-SW trending fault systems and sedimentary basins up to 3.68 km thick, indicating potential hydrocarbon generation zones in the Middle Benue Basin. Similarly, Salako and Udensi (2015) utilized two-dimensional modeling over the Upper Benue Trough and Bornu Basin, identifying sedimentary thicknesses reaching approximately 5.4 km, which are conducive to hydrocarbon maturation and entrapment

Conclusion

This study has demonstrated the profound significance of aeromagnetic analysis in structural assessment for hydrocarbon exploration prospecting workflows, particularly in geologically complex regions of some parts of the Central Benue Trough. The techniques used in this study can be used as a model for exploration efforts in other sedimentary basins assessing the structural features like the delineated key subsurface structures and variations in sedimentary thickness that are indicative of potential hydrocarbon traps. The identification of high-intensity magnetic anomalies corresponding to shallow basement rocks in the northern region, contrasted with low-intensity anomalies in the southern region, suggests a heterogeneous subsurface favourable for hydrocarbon accumulation. Depth estimations further support the presence of adequate sedimentary cover necessary for hydrocarbon generation and entrapment. This method adopted aids in more accurately estimating the structural risks and unknowns related to structural existence for hydrocarbon prospecting in this area which will further result in better decision-making for exploration appraisal and development operations. Looking ahead there are intriguing chances to improve these methodologies predictive power even more by incorporating seismic analysis, petrophysical assessment and machine learning algorithms into the workflow it may be possible to more accurately delineate complex geometries and enhance the detection of subtle hydrocarbon indicators. Finally, by showcasing the revolutionary potential of magnetic analysis in hydrocarbon exploration this study has significantly advanced the field of petroleum geoscience. The results offer a solid framework for revealing structure fault enabling geoscientists to make better decisions and eventually improve energy security a cheaper cost for the good of society.

Conflict of Interest: The authors declare no conflict of interest.

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