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RESEARCH ARTICLE

AEROMAGNETIC STUDY OF KALTUNGO-173, GUYOK-174, LAU-194 AND DONG-195 IN UPPER BENUE TROUGH NIGERIA FOR MINERALIZATION POTENTIALS

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ABSTRACT

This study focuses on the exploration of mineralization potentials in Kaltungo-173, Guyok-174, Lau-194 and Dong-195 in the Upper Benue Trough, Nigeria, using high-resolution aeromagnetic data obtained at an altitude of 100m along a flight line spacing of 500m oriented in NW-SE and a tie line spacing of 2000m. The maps generated are on a scale of 1:100,000 and half-degree sheets contoured mostly at 10nT intervals. The data was then processed and analyzed using Geosoft Oasis Montaj software to identify areas of high magnetic anomalies. The results show the structural trends of rocks in the area are in the E-W, NE-SW, and N-S respectively which represent the various episodes of deformation from the youngest to the oldest, several positive signals from several places in the analytical signal map which is an indication of an intense igneous activity occurring as a near surface intrusion or very shallow basement from Basement outcrop in the south region. Pwana, Bajama, Pupule, Gorra, Bille, Jambutu, Didngo, Lau, and Tau, and the basement occurrences as intrusion within the sedimentary section covering the north, north-eastern, north-western in regions such as Kwya, Kashere, Lamumgu, Polapindi, Kaltungo Tula Wange, Kulani, Dunma Guyuk and Sabon Layi Jessu in most part of the study area. Sediment thickness between -2200m to -83m was established over the area. The findings show that this area has a high potential for mineralization, making it a prime location for future mining or extraction operations. This information can be used by researchers and companies looking to invest in the mineral resources of Nigeria. The abundance of intrusive bodies in the study area renders this part of the Northern Benue trough where our study area falls in within the Nigerian sedimentary basins unattractive for petroleum exploration but the area possesses high potential for large accumulation of base metal mineralization.

KEYWORDS

Aeromagnetic Study, Upper Benue Trough, Nigeria, Structural Trends, Mineralization Potentials

1. INTRODUCTION

One of the key functions of aeromagnetic survey and interpretation is to quantitatively map the magnetic basement depth beneath sedimentary cover. Depth to magnetic source is based on the principle that a magnetic field measured at the surface can be considered an integral of magnetic signatures from all depths. The power spectrum of the surface field can be used to identify average depths of source ensembled (Spector and Grant, 1970). This is essential to estimate depths (sedimentary thicknesses) to basement across geological area. The Benue Trough in Nigeria possesses a geological complex that can be assessed using aeromagnetic survey to estimate the depth to magnetic source.

Ofoegbu reported that roughly about 60% of magnetic surveys are carried out for regional geological mapping and mineral exploration purposes while the remainder being mainly for petroleum exploration (Ofoegbu, 1985). A group researcher equally pointed out that the main purpose of magnetic survey is to detect rocks or minerals possessing unusual magnetic properties that reveal themselves by causing disturbances or anomalies in the intensity of the earth magnetic field (Onuba et al., 2008). Aeromagnetic survey is like magnetic method used to detect magnetic anomalies within the earth's magnetic field which are caused by the magnetic properties of the underlying rocks. The aim of aeromagnetic survey is to investigate the subsurface geology based on magnetic anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks (Onuba et al., 2008). Its operating physical property is the magnetic susceptibility and remanence which determine magnetizability. Depth to source interpretation of magnetic field data provides important information on basin architecture for petroleum exploration and for mapping areas where basement is shallow enough for mineral exploration.

Methods such as spectral analysis, analytical signal method, 3D Euler method, forward and inverse modeling method and graphical interpretation methods are quantitative methods for estimating magnetic source location, depth, and mineralization zones. These methods have been used in the interpretation of magnetic anomalies. However, the north-east region of Nigeria has been of concern because of the minerals deposit in some parts of the region. Since the oil boom of the early 1980s, Nigeria has continued to rely on the revenue from the proceeds of crude oil export to the detriment of other sectors like the solid mineral and agricultural sectors that has sustained the economy prior to the oil boom. The economy recession has re-echoed the need to diversify the sources of

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revenue generation of the country; with the solid mineral sector well placed to produce solution to the problem because of the vast potential it offers.

Therefore, this work is aimed at using the aeromagnetic data of in Kaltungo-173, Guyok-174, Lau-194 and Dong-195 in the Upper Benue Trough, Nigeria for the identification of magmatic intrusions, locating depths of magnetic sources, and possibly identify zones with high mineralization potential within the study area.

2. The Area Of Study And Its Geology

The area of study covers part of the Upper Benue Trough covering latitudes 9°0'0''N to 10°0'0'' and longitudes 11°0'0''E to12°0'0''E (Figure 1) with a total area of 12,100km^2 which corresponds to parts of upper Benue Trough (Kaltungo, Guyok, Lau and Dong) which covers three of the thirty-six States in Nigeria which are Adamawa, Gombe, and Taraba Northeast, Nigeria. The Benue Trough is a NE-SW folded rift basin that runs diagonally across Nigeria. It formed simultaneously with the opening of the Gulf of Guinea and the Equatorial Atlantic in Aptian-Albian times, when the Equatorial part of Africa and South America began to separate (Benkhelil, 1987). The Trough is an elongate rifted depression in which the sediments reach well over 5000m thickness in places and have been strongly folded, probably by later adjustments along faults in the underlying basement.

It is geographically sub-divided into lower, middle, and upper portion. The upper Benue trough is Y shaped made up of three arms, namely: The EW trending Yola arm, NS trending Gongola arm or Gongola basin and the NE SW trending main arm of Muri Lau basin (Shettima et al., 2016). The outcrops of various lithologic units of the upper Benue trough are inliers of the prominent Bima sandstones and deposited as extrusive lithographic units during the Albian transgressive phase (Onuba et al., 2008; Ukaegbu and Akpabio, 2009). This transgressive episode led to the deposition of the various formations that made up the sedimentary basin which outcrops or occurs as shallow marine deposit of limestone, shale, and mudstone. Ogungbesan and Akaegbobi however observed that the outcrop units of the formation consist of Sandstone, Shale and Basaltic rocks lying unconformably on the Basement rocks (Ogungbesan and Akaegbobi, 2011).

These Aptian-Albian pyroclastics sediments were described as the earliest sedimentation of the entire Benue trough. The Bida Basin is a shallow upfaulted arm of the Benue Trough. The Benue Trough probably provided the major link between the Mediterranean Ocean and Gulf of Guinea via the lullmedden and Chad Basins, during Upper Cretaceous times. The basal lithic fill in the Benue trough (best exposed in the upper part) are the lower Cretaceous alluvial fan, braided river, laustrine and deltaic clastic of Bima Sandstone which also extends into the central Benue Trough (Allix and Popoff, 1983; Nwajide, 1990). Volcanic and minor intrusive rocks are widespread and there are deposits of lead ores and coal. The trough bifurcates near its north-eastern end, and the northern branch continues beneath the Chad Formation as an elongate depression that extends well beyond Lake Chad.

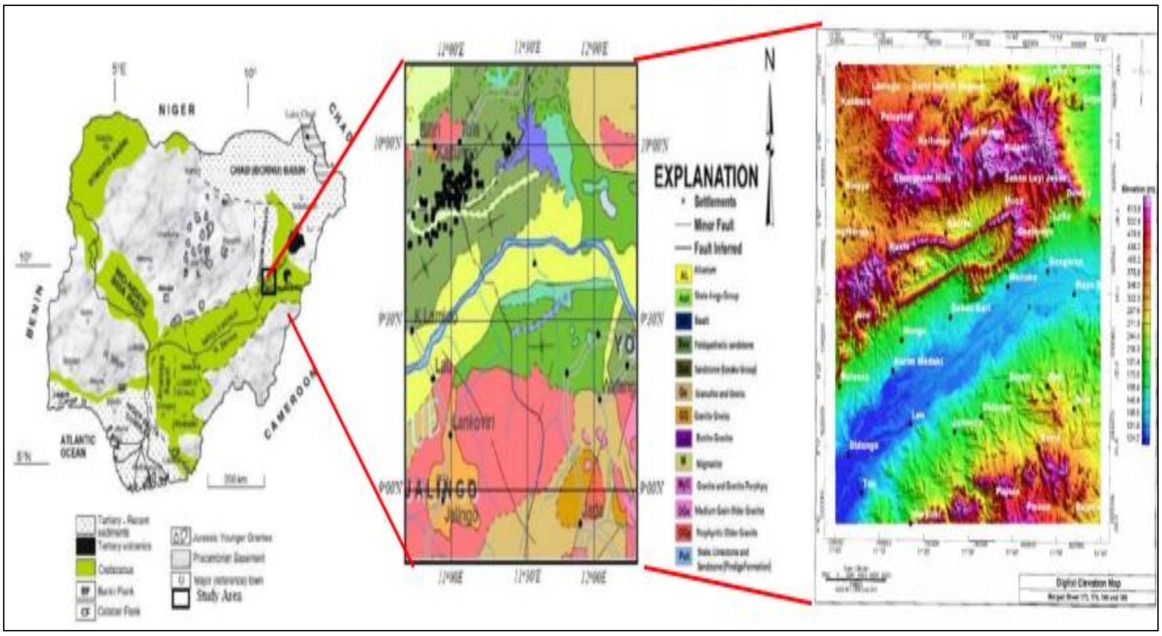

Figure 1: General geology map of Nigeria showing the location of the study area (Obaje, 2009).

The Benue Trough is a major geological structure underlying a large part of Nigeria and extending about 1,000 km northeast from the Bight of Benin to Lake Chad. It is part of the broader West and Central African Rift System. The trough has its southern limit at the northern boundary of the Niger Delta, where it dips down and is overlaid with Tertiary and more recent sediments. It extends in a north-easterly direction to the Chad Basin, and is about 150 km wide. The trough is arbitrarily divided into lower, middle, and upper regions, and the upper region is further divided into the Gongola and Yola arms. The Anambra Basin in the west of the lower region is more recent than the rest of the trough, being formed during a later period of compression, but is considered part of the formation (Obaje, 2009).

The Benue Trough was formed by rifting of the central West African basement, beginning at the start of the Cretaceous period. At first, the trough accumulated sediments deposited by rivers and lakes. During the Late Early to Middle Cretaceous, the basin subsided rapidly and was covered by the sea. Sea floor sediment accumulated, especially in the southern Abakaliki Rift, under oxygen-deficient bottom conditions. In the Upper Cretaceous, the Benue Trough probably formed the main link between the Gulf of Guinea and the Tethys Ocean (predecessor of the Mediterranean sea) via the Chad and Iullemmeden Basins (Wright, 1985). Towards the end of this period the basin rose above sea level, and extensive coal forming swamps developed, particularly in the Anambra Basin. The trough is estimated to contain 5,000m of Cretaceous sediments and volcanic rocks.

A common explanation of the trough's formation is that it is an aulacogen, an abandoned arm of a three-armed radial rift system. The other two arms continued to spread during the break-up of Gondwana, as South America separated from Africa (Peters, 1978). The two continents seem to have started to split apart at what are now their southern tips, with the rift extending up the modern coastlines to the Benue Trough, then later split along what is now the southern coast of West Africa and the north eastern coast of South America. As the continents were wedged apart, the trough opened. When separation was complete, the southern part of Africa swung back to some extent, with the sediments in the Benue Trough compressed and folded (Wright, 1968).

During the Santonian age, around 84 million years ago, the basin underwent intense compression and folding, forming over 100 anticlines and synclines. The deposits in the Benue Trough were displaced westwards at this time, causing subsidence of the Anambra Basin (Obaje, 2009). A refinement to the model involves the rise of a mantle plume, where abnormal heat leads to melting of the upper mantle, thinning and stretching the crust, followed by rifting of the weakened crust. This may have been repeated several times, with the Benue Trough deformed between rifting episodes (Ofoegbu 1984). The same plume may be responsible for the line of volcanoes in Cameroon along the Central African Shear Zone and for the volcanic island of St. Helena in the Atlantic ocean (Coulon et al., 1996).

Three periods of magmatic activity (volcanic action) have been identified, 147-106Ma, 97-81Ma and 68-49 Ma. The first is prominent in the north of the trough, and contemporary with magmatism in Brazil, probably occurring during a period of crustal extension before the Atlantic started to open. The second is found only in the south of the trough and may belong to a period when the extension of the Atlantic had slowed, ending with a period of compression. The third and last period is also found only in the south of the trough, and may be related to an isostatic response to the earlier crustal thinning (Maluski et al., 1995). The mantle plume activity was probably limited in its effect, with most of the basins in the trough being created from a combination of extension and strike-slip faults. The faults extend into the ocean with the Chain and Charcot fault zones and have their counterparts in north-eastern Brazil (Christian, 2009).

3. Materials And Methods

3.1 Data Acquisition and Processing

Four high-resolution aeromagnetic maps (HRAM) with sheet numbers Kaltungo-173, Guyok-174, Lau-194 and Dong-195 were acquired, assembled, and interpreted. These maps were obtained as part of the nationwide airborne survey carried out by Fugro and sponsored by the Nigerian Geological Survey Agency in 2009. Equipments that was employed during the data acquisition included a fixed-wing aircraft, three sintres, CS3 Celsium Vapour Magnetometers, FASDAS magnetic counter, king KR 405/KING KR 405B radar altimeter and Envirobaro/Digiquartz barometric altimeter. The data was obtained at an altitude of 100m along a flight line spacing of 500m oriented in NW-SE and a tie line spacing of 2000m. The maps are on a scale of 1:100,000 and half-degree sheets contoured mostly at 10nT intervals. The elevation ranges from 124m to 613.8m with a mean value of 297m. Aeromagnetic data reduction and preprocessing was also carried out by Fugro Airborne survey, south Africa. The reduction and pre-processing that was applied to the data include: lag correction, diurnal variation removal, geomagnetic field gradient removal, stripping micro leveling, background correction, etc. The data was plotted using Universal Transverse Mercator (UTM) projection method.

4. Results And Discussions

Visual analysis was used to outline geological formations and identify the various lithologies in these photos. Delineation were high radiometric element patterns, anomalous high magnetic zones, and low magnetic regions thought to be the result of rocks beneath. The bedrocks were qualitatively interpreted using the available geophysical datasets to improve the existing geological map and lessen its subjectivity. Making inferences about structure and geology entailed comparing the existing geology map with one produced by a GIS environment.

4.1 Reduced to Magnetic Equator (RTE)

The raw TMI map (Figure 2a) have a magnetic intensity map from -19nT and 136.8nT, the raw TMI as displayed in Figure 2b. TMI of the study area was reduced to the Equator to produce a RTE map of the area, the RTE map the inverse relationship between the observed intensity and the Magnetism, the RTE displayed in Figure 2b showing variation in magnetic intensities/susceptibility in different areas of the map, the RTE ranges in intensity from -2.5 to 138nT, the RTE show very less variation from the raw Total magnetic intensity map as the survey area is nearer to the Magnetic equator.

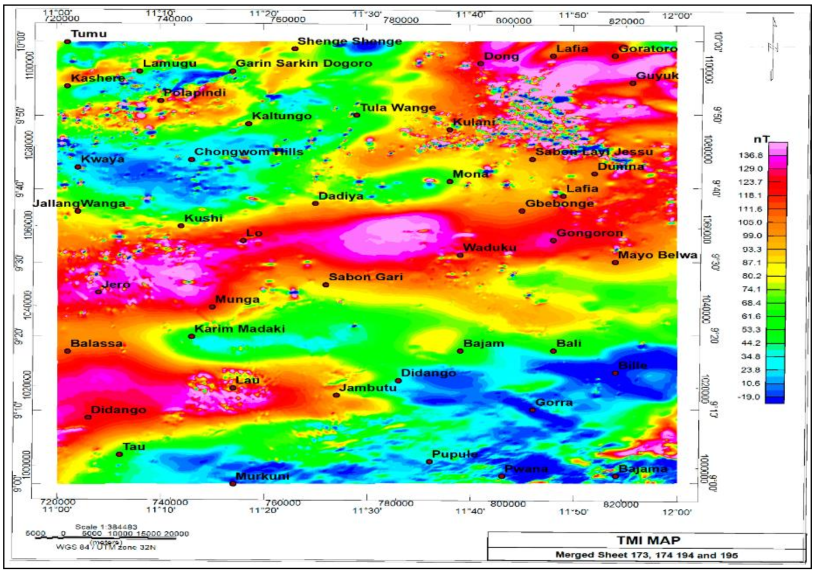

Figure 2a: The Total Magnetic Intensity map over the study area.

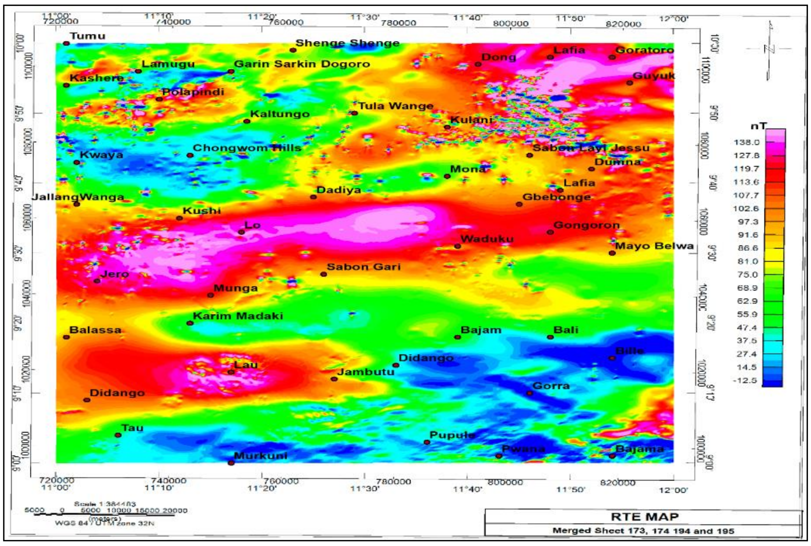

Figure 2b: The Total Magnetic Intensity map over the area Reduced to the Magnetic Equator (RTE MAP).

4.2 Residual and Regional Anomaly Map

The residual map of the study area, which is also referred to as a localized anomaly inside the region, is shown in Figure 3 and was created by the regional-residual separation. The first order residual map of the research area shows variations in the magnetic susceptibility/intensity, which are shown in pink for low magnetic susceptibility but high intensity and blue for low magnetic intensity and high magnetic susceptibility, these variations can be seen in the residual map of the study area from lithology to lithology as different rock units gives have different magnetic susceptibility , and even there are possible variation of magnetic response from the same rock units which has undergone differential natural geological processes and surface activities such as weathering, fracture and faulting or geothermal heating, the magnetic intensity values ranging from -42.2 to 21.8, these anomalies also show variation in wavelength, which indicates whether they are of deep or shallow origin. Long wavelength anomalies are of deep origin, and short wavelength anomalies are of shallow origin, and both can be found in the across the study area.

The occurrence of this short wavelength are prominent within the Northern and the southern region of the study area, these areas include Kulani, Kwaya, Wanga, Chongworm Hill, Lamugu, Garin Srkin Dogoro, Sabon Layi Jessu, Lafia, jero and others within the Northern part of our study area and the Lau, Pupule, Gorra, Bajama and ohers in the southern part of the study area, the other predominantly areas within the study area, other short wavelength signals can be found in some other section as seen in Figure 3. As we know that most sedimentary rocks show lows to no response to magnetism, however the area of study falls largely under a sedimentary-basement contact zone and hence this is what account for the predominant widespread short wavelength magnetic anomaly signature which are localized which are produced from the near surface basement rock intrusion or basement exposure within the sedimentary region of the area.

The regional magnetic map, which varies the magnetic intensity (I) value from 28.8 to 108.5nT, illustrates the regional magnetic anomaly in the region. It also demonstrates regional magnetic trends and is replete with long-wavelength anomalies, which are signs of deep magnetic sources and a variety of magnetic responses on the site. Understanding regional anomaly trends that potentially regulate regional mineralization is made easier by the regional magnetic map, a main regional anomaly can be seen trending in the NE-SW direction from Balassa to Jero, to Dadiya up to the North-Eastern part of the study are which is Lafia, Guyuk and Gotatoro. Figure 4 represents the deeply-seated basement rock within this region overlaid by sediments.

4.3 Vertical and Horizontal Derivatives

The vertical derivative, which can be calculated in the space or frequency domains, accentuates shallower anomalies. These operators also enhance high-frequency noise, and to address this issue, a particular frequency response tapering is typically used. First vertical derivative is a type of edge detection method that maps the edge of these bodies and emphasizes the structures within the rocks, and from the first vertical derivatives map of the study area, we can see the shallow anomaly sources within the area. These shallow anomaly magnetic sources may be the result of near surface intrusions or because of the basement depth being shallow, the first vertical derivatives map of the study is displayed in Figure 5 and it shows the region with high structural activities within the study area which are because of remanent magnetization.

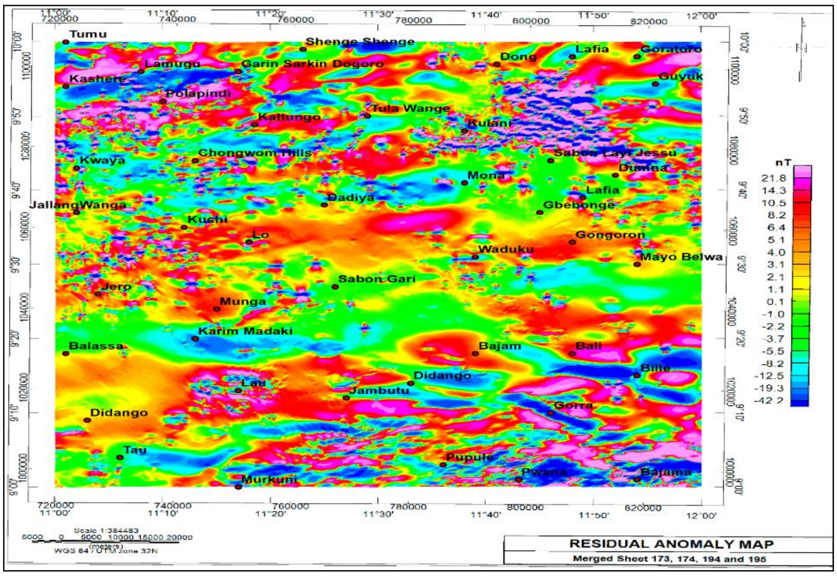

Figure 3: The Residual Anomaly Map of the study area

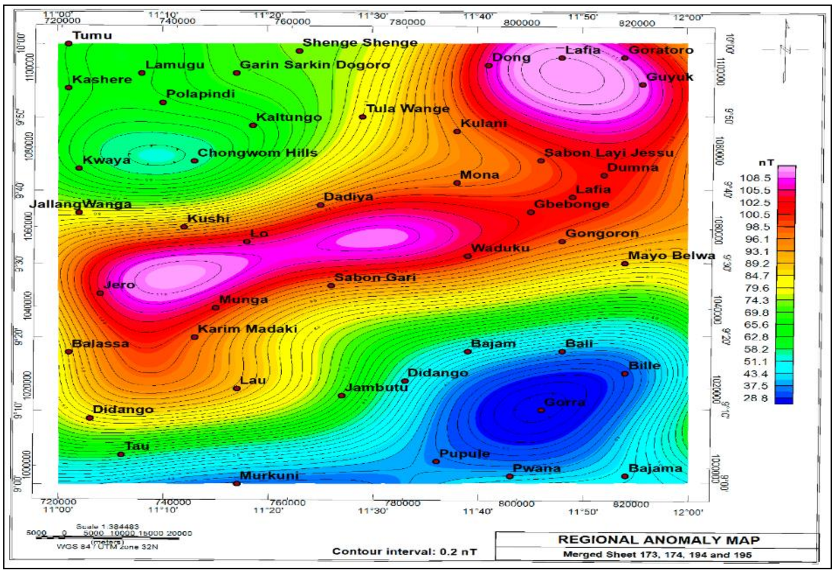

Figure 4: The Regional Anomaly Map of the study area.

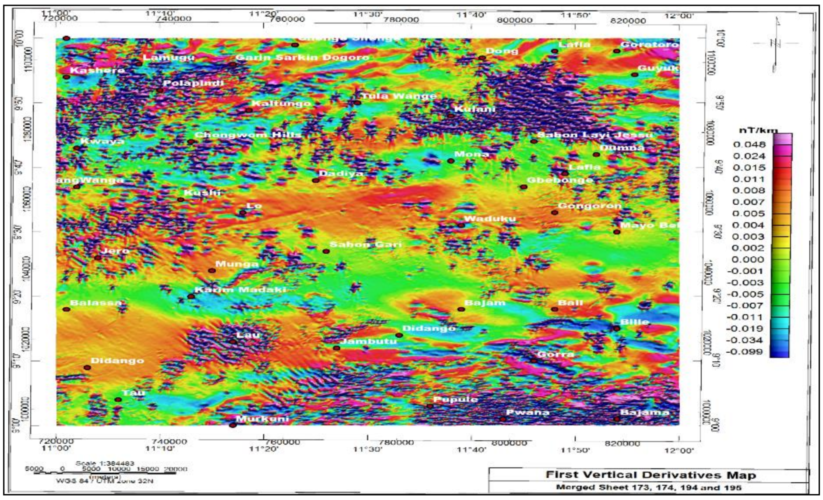

Figure 5: First Vertical Derivatives Map of the the study area.

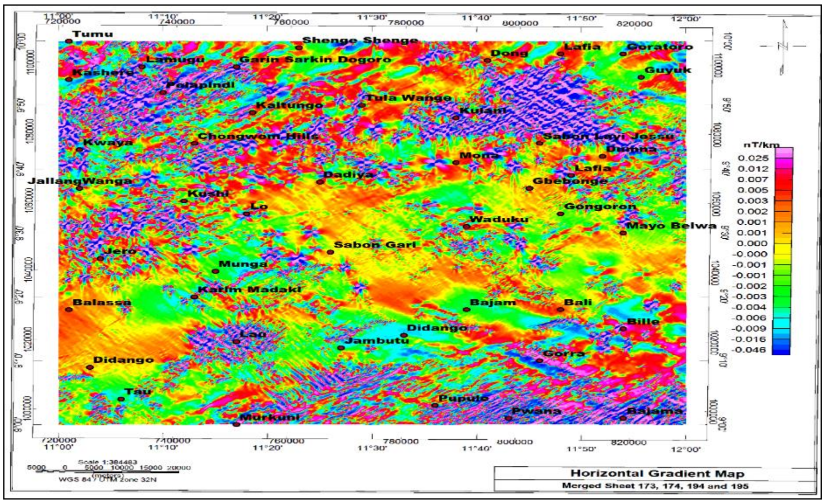

Figure 6: The Horizontal gradient map of study area.

The study area's horizontal gradient map exhibits numerous positive signals at various locations (Figure 6), which can be interpreted as individual or distinct rock types with magnetic signatures. This information can be used to map the boundaries of various rocks with significant magnetic susceptibility and to distinguish different bodies of rocks, most of these signatures can be seen on the area with predominant short wavelength anomaly earlier established in the residual anomaly map. These signals, which account for the distinct signals seen in the Horizontal gradient map and reveal the structural trend of the rock in the study area, are boundaries of different lithologies, particularly those occurring as intrusion within the sedimentary zone as seen in the Northern section of the study area and those falling within the basement region as seen especially those within the southern section of the study area according to our geological map reference.

The main structural trend in the study area is reported to be in the E-W with highest frequency represented with red coloration on the Rose diagram (Figure 7), NE-SW and N-S with Green coloration on the rose diagram as seen in Figure 8, the extracted magnetic structures are displayed in Figures 8a and 8b and the distribution is seen to follow localized remanent magnetization on the residual anomaly map each of the established trend depicts a particular episode of deformation. These findings are consistent with those obtained by previous authors who have worked on this portion of the Benue Trough such as such as who all established a NE-SW trending structures from the Benue Trough also near Dong, Guyok, Lau (Musa et al., 2021; Ikechukwu, 2018; Chinwuko et al., 2013; Sawatu et al., 2019). A group researcher also established a NNE-SSW, NE-SW and NNW-SSE trend within the same region (Onuba et al., 2008).

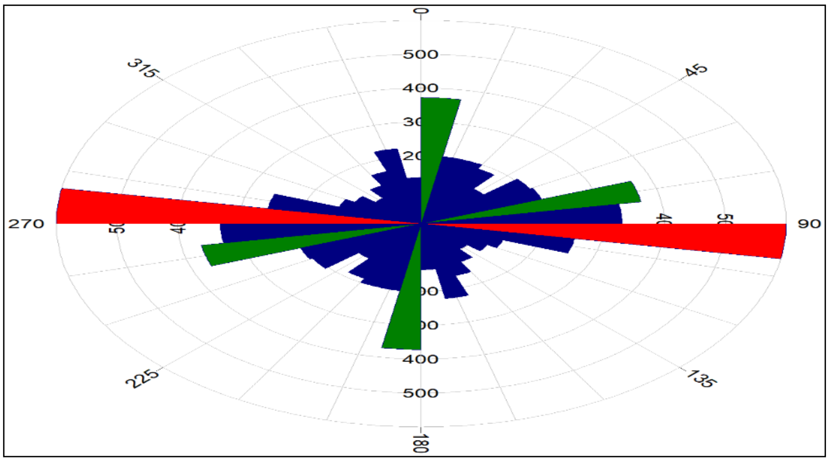

Figure 7: The Structural Trend analysis on lineament extracted from the second Vertical derivatives map plotted on the Rose diagram.

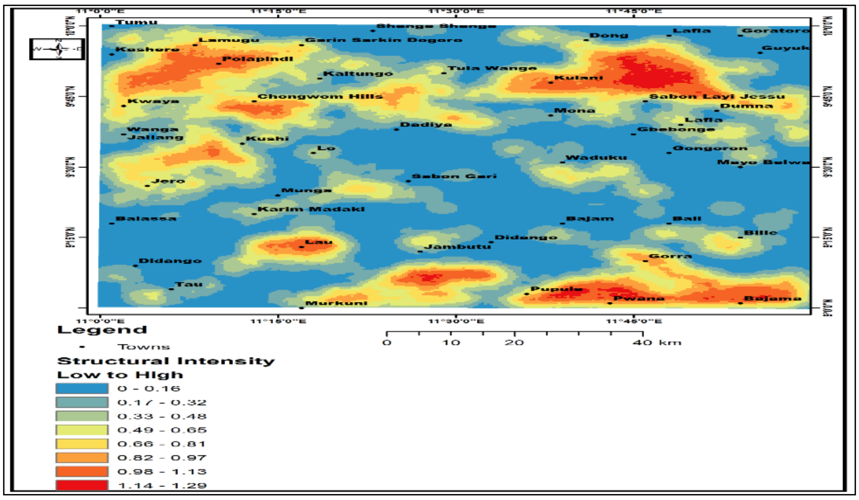

Figure 8a: The structural intensity map the intensity of the structural activities across the study area., red colored zones are the areas with High structural activities and the blue zones are the areas with low structural activity

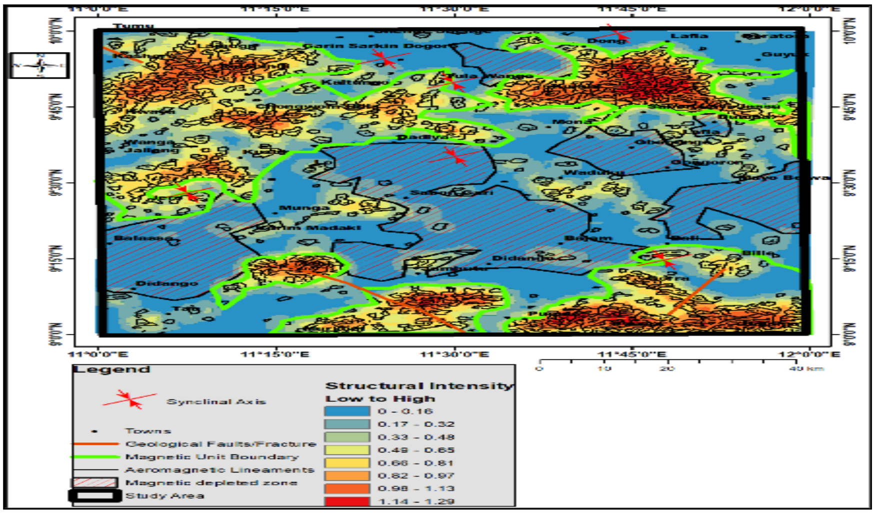

Figure 8b: The structural map over the area superimposed on the structural intensity map

4.4 Analytical Signal

Similar NNE-SSW, NE-SW and NNW-SSE trends in the residual anomaly, first vertical and the horizontal gradient map are reflected in the analytical signal map of the study area displayed in Figures 9. The analytical signal shaded image of the study region has a range of response on both high to low which implies level of magnetic basement occurrences with depth, and of which are of shallow depth origin and some of which may also occurs as outcrop in the study area. The structural orientation of the study area is also visible on the analytical signal map, which is consistent with the trend observed on the vertical and horizontal derivatives map. Areas in the southern part of the study area have a lot of signals and this is because these areas are underlain by the basement rocks, other areas within the north, northeastern and the northwestern part of the study area are underlain by the sedimentary rocks, but these areas are characterized by the occurrences of high level magmatic intrusive and volcanics rocks such as the granitic rocks and some volcanic rocks such as basalts as observed on the geological reference map which corresponds to the observed signals on the analytical signal map as shown in Figure 9, the other the remaining signals are scattered in other areas observed closures can generally be attributed to the wide variation in susceptibility of rock-units in zones of fracturing/faulting.

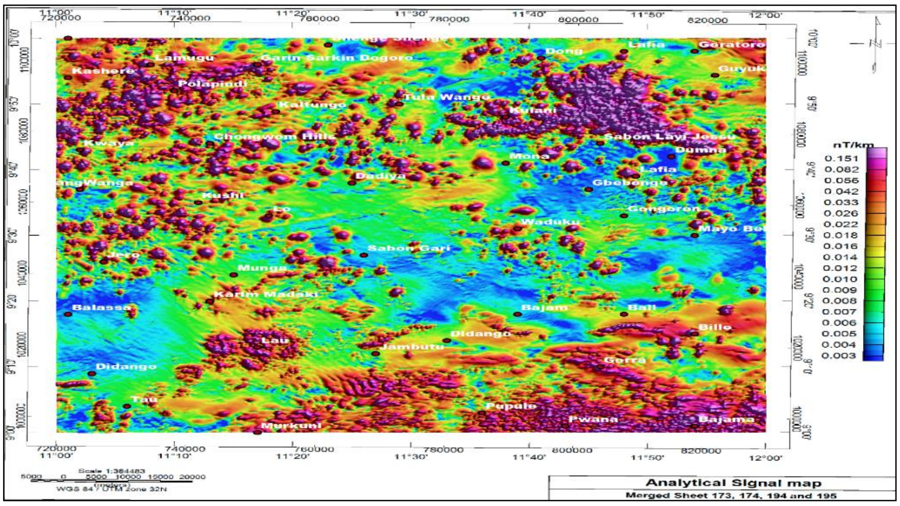

Figure 9: The Color Shaded Analytical map of the study area

4.5 Source Parameter Imaging (SPI)

The depth estimation of the multiple anomaly sources in the research area was done using source parameter imaging; the depth varies from location to location. Through several mathematical operations using different grids, the depth to the magnetic and gravitational sources was ascertained. Therefore, careful data filtering was carried out to obtain accurate estimations of the local wave number and, consequently, the depth. The SPI_RTE depth (Figure 10) ranges from -2189.2m (2.189km) to a depth of around -105.6m (0.105km). The portion exhibiting the shallow depth are depicted with pink coloration and the deep depth are depicted with blue coloration. The study area was divided into three main category, these include the area with shallow magnetic basement depth ranging from the depth of -182m to depth above -105.6m to the surface, some of the magnetic bodies occurs as outcrops the second category are those between the depth of -787.6m to depth of -182m classified as average depth (depicted between light blue to orange coloration) and the third category which is considered as the deep basement are those that occurred between the depth of -787.6m to around -2189.2m in the subsurface which are represented by the deep blue to normal blue coloration on the map in Figure 10.

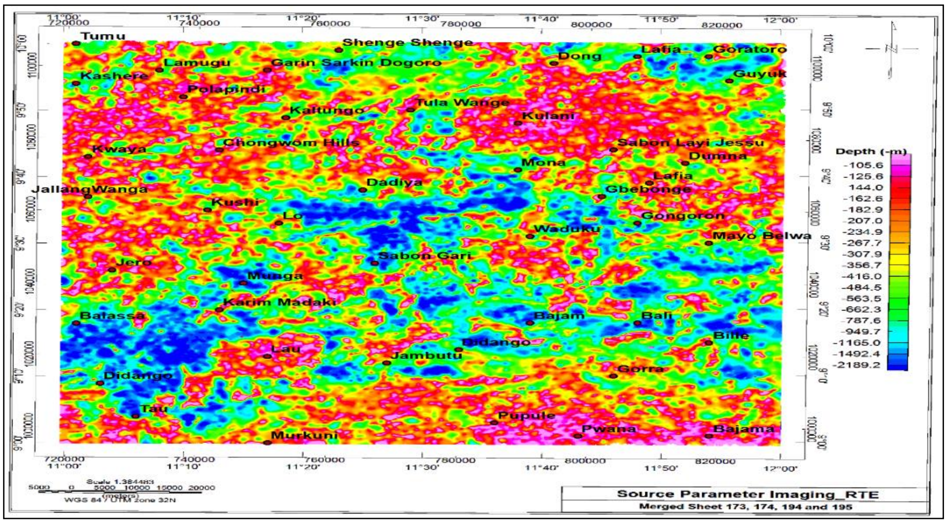

Figure 10a: The Source Parameter Imaging (SPI) applied to the RTE map of the study area.

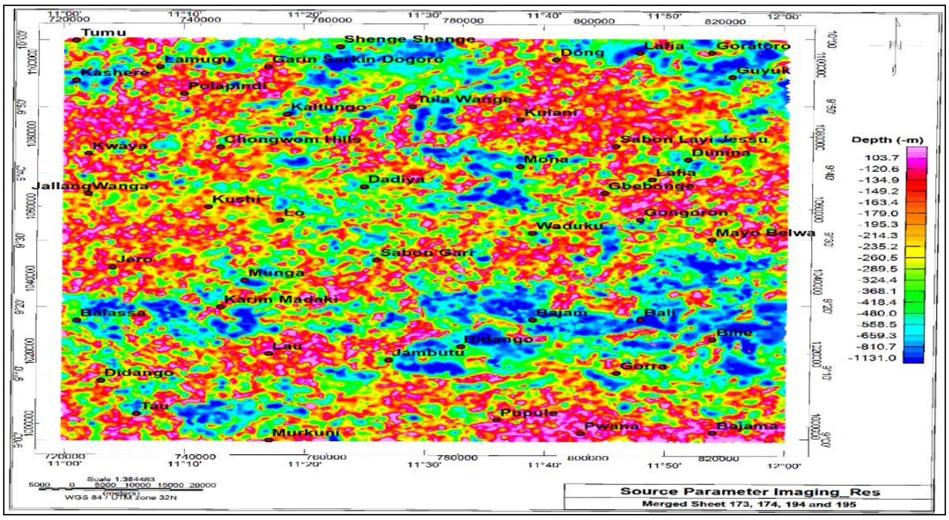

Figure 10b: The Source Parameter Imaging (SPI) applied to the Residual map of the study area.

The total depth statistics include more than 70 percent of the total area of the map is observed to have a shallow depth value, which is an indication that the causative bodies within these region are of near surface and is also inference of basement surface outcrop with the study area. The towns falling within the shallow basement includes Pupule, Pwana, Bajama, Murkuni, Jerp Kushi, Dadiya, Kaltungo, Polapindi, Lamugu, Kwaya, Kulani, Sbon Layi Jessu, Lafia, Dong, Tumu and some part of Waduku. These findings are consistent with the geologic map of the research areas. The basement complex is observed to occupy areas with a shallow depth, whilst the sediments are seen to occupy areas with deep depth variations.

The depth variation observed from the application of the source parameter imaging over the residual anomaly map of the study area shows a depth values range from -103.7m to 1,131m below the surface, this shows distinct variation from the result of the depth range observed on the SPI_RTE map as the maximum observable depth is about 1.1km when compared with the 2.2km depth values observed over the SPI_RTE map this is consistent with the earlier statement regarding the residual anomaly filter enhancing the localized near surface magnetic signature and attenuation of the long wavelength, deep seated magnetic bodies signature. The minimum depth observed on each map has no major value difference (103.7 and 105.6m) this is because the residual anomaly producing the observed shallow depth is preserved in both map (Figures 10a and 10b) as we know that the RTE is a sum of the region anomaly plus the residual anomaly map. The depth values obtained from these depth assessments are in line with some of the earlier research conducted by a number of authors in the middle part of the Benue basin including Ofoegbu and Onuoha, which obtained a depth to basement between 2 to 3.35km, some researchers also obtained a SPI depth values between 741m and 1,162m in areas around Kaltungo, Dong, Kashere and others (Sawatu et al., 2019; Ofoegbu and Onuoha, 1991). Chris also obtained a thickness of 2.27km over the area and Ofoegbu estimated deep depth of 3.3km and a shallow depth of 830m (Chris, 1979; Ofoegbu, 1984).

4.6 Litho-Structural Interpretation

Geologic map of the study area with superimposed lineaments from the Aeromagnetic vertical derivatives of the RTE, and the faults and fractured zone identified from the geological map (Figure 8), together with the alteration zones also from the magnetic data, and a structural intensity map depicting the structural frequency and intensity distribution across the study area and the various magnetic units boundary which can be considered as the contacts and the inferred lithological contacts from the geological map was incorporated to produce a litho-structural map template for Solid mineral explorations in the study areas, as we considering the fact that several factors affect the mineralization potential of an area these factors are but not limited to the lithology (rock type), environment type (basement or sedimentary environment), and various definitive feature such as boundaries of magnetic units, Structures dislocating or affecting the morphology of magnetic units, Depth and attitude of magnetic units, Any superposition of magnetic units, Lithological units, Chemical changes, a structural synthesis relating distribution of inferred lithologies and structure which can be extracted from the magnetic data helps in our assessment of the mineral potential on our area of study.

As we understand that most of our mineral deposit especially the metallic types, such as lead, zinc, graphite, chalcopyrite, wolframite etc. and precious metals are structurally controlled hence the needs to incorporate all the structures. Areas where the aeromagnetic lineaments coincide with geologic contacts, are regarded as potential zones of hydrothermal deposits, the areas are that are worthy of consideration for mineral deposit includes Kulani, Sabo Layi Jessu, Dumna, Lau, Kaltungo, Gorra, Jambutu, Pupule and Lamugu. The Structural intensity map is displayed in Figures 11 and 12, this shows the structural intensity variation over the study are the areas which is as a result of the granitic activities over the area in both the basement section in the south and the Sedimentary section underlying the north and the north-western part of the study area, the areas with high structural activities are displayed by reddish coloration and the low intensity are displayed with blue coloration; the areas with high structural activities includes Kulani, Polapindi, Lamugu, Kwya, Lo, Jero, Sabon Layi Jessu, Gorra, Murkuni, Pupule, Pwana Bajama and Lau, some of the listed areas can be considered to have the likelihood of having mineral deposits within the study area.

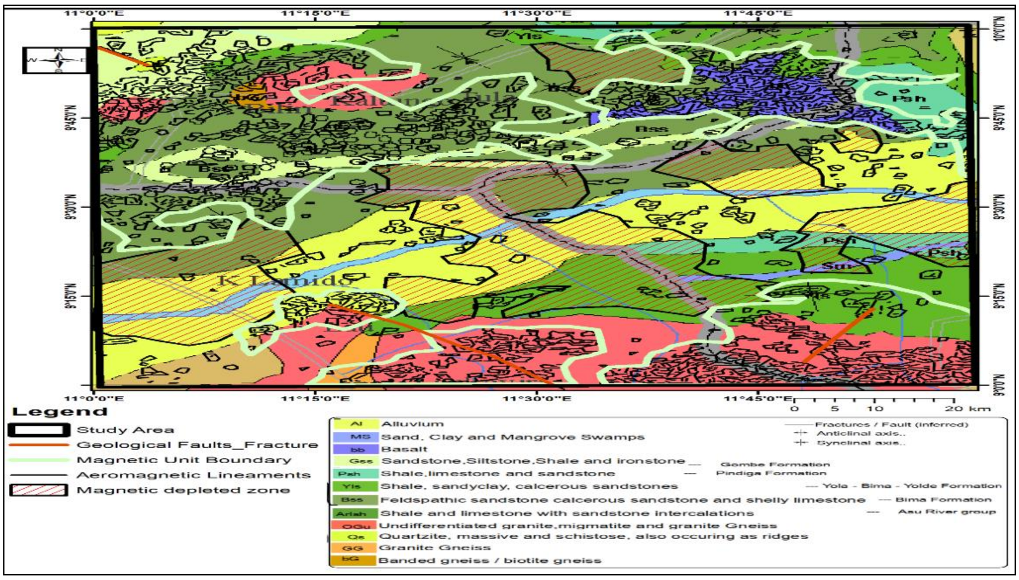

Figure 11: The various extracted structures over the area superimposed on the geological map of the study area to produce a Litho-structural map.

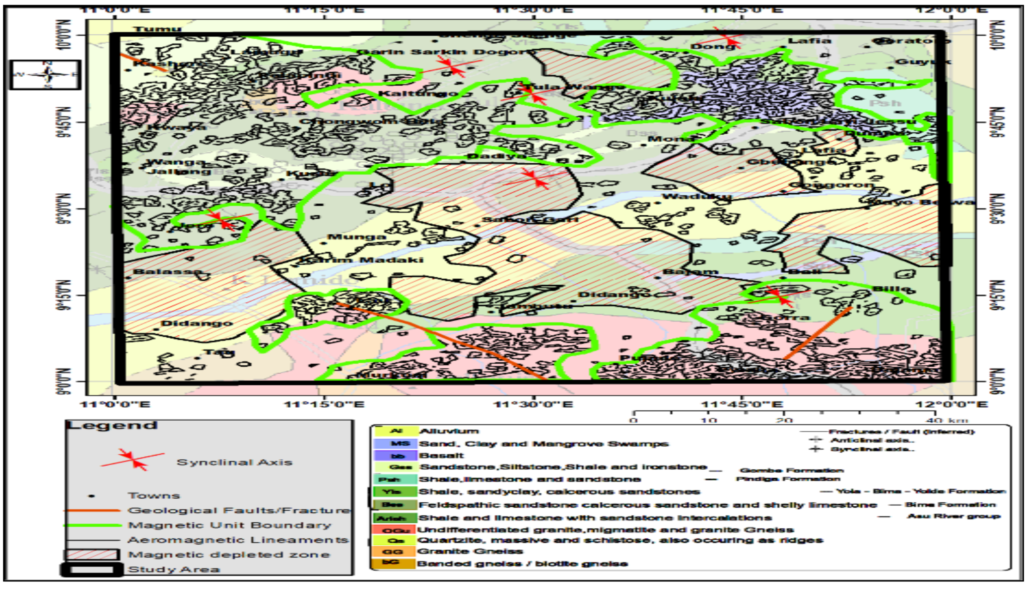

Figure 12: The interpreted litho-structural map over the area with emphasis on the extricated structures map of the study area to produce a Litho-structural which were used identify areas with mineralization map potentials.

5. Conclusion

The aeromagnetic data over part of the upper Benue trough covered by the sheet 173 (Kaltungo), 174 (Guyok), 194 (Lau), and 195 (Dong) shows a variations in magnetic anomaly from different areas of the map with different anomaly wavelength and different sources as seen from the residual map of the area, the various vertical derivatives, the Horizontal, derivatives and the analytical signals shows a lot of signals coming from a shallow source and most of the sources were being able to be mapped by the vertical derivatives which is an indication of them being from Basement outcrop in the south region around Pwana, Bajama, Pupule, Gorra, Bille, Jambutu, Didngo, Lau, and Tau, and the basement occurrences as intrusion within the sedimentary section covering the North, North-eastern, North western in regions such as Kwya, Kashere, Lamumgu, Polapindi, Kaltungo Tula wange, Kulani, Dunma Guyuk and Sabon Layi Jessu in most part of the study area.

Three major episodes of deformation are observed and the first episodes is in the E-W direction which is assumed to be the last episodes of deformation due to its stronger imprint on the local geology considering the principle of cross cutting relationship in geology, the second main episode of deformation are in the NE-SW and the oldest episode of deformation are that in the N-S direction, The depth to these bodies was determined by the source parameter imaging ranging from -2200 to about

-103m and it was observed that most of these bodies are from surface outcrop or near surface magnetic intrusions within the sediments. The thickness and dept observed from the area are deep enough to be considered for areas with hydrocarbon prospect consistent with the depth proposed by Nwachukwu which determined the of 2km sediment thickness for a considered depth for petroleum maturation.

However, from our analysis results, it can be deduced that the petroleum prospect in the study areas is very unlikely this is due to a lot of Igneous activity in the study area, also the depth of occurrence and the maximum thickness of the sediments which is 2.2km is favorable for the formation of Hydrocarbon but considering the sediments Space and accommodation is not very broad (i.e., the larger portion of the area falls within depth above 2km), however the prospect in the area should be that of the other base metal mineralization which is prominent in the other section of the Benue Trough such as the southern Benue through, these minerals which results from the hydrothermal alteration due to Igneous activity should be considered, since these minerals are structurally controlled and there are lot of structures in the areas which are favorable for mineralization.

The results of the study revealed several potential locations for solid mineral deposits in the north-east Benue Trough. These areas were found to have high magnetic anomalies, indicating the presence of underground mineral resources. Additionally, the study also identified the types of minerals that may be present based on the magnetic signatures. The aeromagnetic study of the north-east Benue Trough has provided valuable insights into the potential for solid mineral resources in this region. The results can be used by stakeholders to plan further exploration and development of these resources, contributing to the economic growth of Nigeria.

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