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Interpretation of Aeromagnetic and Aeroradiometric Data for Potential Mineralization in Kuje Sheet 207SE, North Central Nigeria

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ABSTRACT

The thesis presents an interpretation of the aeromagnetic and aeroradiometric data of Kuje Sheet 207SE in the Federal Capital Territory of North Central Nigeria. The aim was to outline geological features and radiometric signals that might be indicative of possible mineralization zones within the Nigerian Basement Complex in this area. The aeromagnetic data were processed through a number of enhancement filters including reduction to the equator, first and second vertical derivatives, analytic signal, tilt derivative and upward and downward continuation. These filters were utilized to recognize lineaments, lithological contacts and fault systems that may have acted as channels for mineralizing fluids. The aeroradiometric data of potassium, thorium and uranium concentrations were processed to generate the concentration maps, ternary map of radioelements and map of the potassium-thorium ratio for the purpose of identification of hydrothermal alteration zones. Euler deconvolution for depth estimation indicated that most of the magnetic sources are at depths shallower than 500 meters, a depth range compatible with typical mineral exploration targets in basement terrains. The structural analysis indicates that the study area is dominated by NE-SW trending lineaments, subordinate NW-SE and E-W orientations. These structural patterns are consistent with the larger Pan-African tectonic setting of the Nigerian Basement Complex. The hydrothermal alteration is structurally controlled as indicated by the K/Th ratio map which shows several high ratio zones spatially correlated with the NE-SW trending lineaments. The integration of the magnetic and the radiometric data sets in a GIS environment enabled the classification of the research region into high, moderate and low mineral potential zones. The high potential zones are the places where high analytic signal values, high lineament density, tilt derivative zero contours and higher K/Th ratios coincide. Three key target areas were identified; the middle part of the sheet from north of Kuje town to the eastern boundary, the NE-SW and NW-SE crossing structures at the NE corner and the Tagwai and south of Kwali to the south. These areas are entrants for additional geological mapping, geochemical sampling and possibly drilling. The study demonstrates the use of combined geophysical methods for mineral exploration in the Nigerian Basement Complex and provides a basis for future studies in the Kuje area.

Keywords: Aeromagnetic, Aeroradiometric, Mineralization, Lithology Hydrothermal alteration, Tagwai, Kwali

1.0 INTRODUCTION

The search for solid minerals in Nigeria has become a priority in recent years as the nation looks to diversify its economy away from oil. The Federal Government has actively promoted this agenda through a series of reforms aimed at repositioning the solid minerals sector as a major driver of industrialisation. The Minister of Solid Minerals Development, Dele Alake, has highlighted that these reforms have attracted more than $2.6 billion in Foreign Direct Investment, alongside the emergence of mineral processing facilities across the country (Vanguard, 2026). The government has also emphasised local value addition over raw mineral exports, signalling a strategic shift towards building industries that convert Nigeria's mineral wealth into finished products. Within this context, the Nigerian Basement Complex, which underlies much of the country, remains a frontier for mineral discovery. Recent geophysical studies across the Basement Complex have demonstrated the effectiveness of aeromagnetic methods for delineating mineralized structures. For instance, integrated aeromagnetic analysis in the Igarra Schist Belt successfully identified high analytic signal anomalies corresponding to lithological contacts, shear zones, and fault systems that serve as conduits for hydrothermal fluid migration and structurally controlled mineralization. Similar approaches in the Plateau-Bauchi and Kaiama areas have further confirmed that magnetic anomaly interpretation can reveal subsurface faults, fractures, and lithological boundaries critical for targeting mineral deposits. A decadal review of geophysical investigations in the Southern Kaduna Basement Terrain has also underscored the growing reliance on aeromagnetic datasets for structural and mineral exploration across North-Central Nigeria (Danjuma *et al*., 2026). This study focuses on Kuje Sheet 207SE, a portion of the Kuje area within the Federal Capital Territory, where the interplay between underlying geology and surface mineralization remains

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poorly understood. Despite the region's location within the Basement Complex and evidence of ongoing artisanal mining activities in surrounding areas, detailed integrated studies specifically targeting Sheet 207SE are lacking. A recent study on lithium-bearing pegmatites in Kuje Sheet 207 has begun to address this gap, employing integrated aeromagnetic, aero-radiometric, and geochemical data to delineate mineralized zones (Alab and Sakariyau, 2026). However, this work focused primarily on rare-metal pegmatites, leaving broader structural controls on mineralization within the sheet yet to be fully explored. Previous work in Kuje has largely focused on groundwater exploration and geotechnical investigations, leaving a significant gap in understanding the structural controls on mineralization within this sheet. Aeromagnetic data provides a means to map variations in the Earth's magnetic field, which often correspond to structural features such as faults, fractures, and lithological contacts that can control mineral deposition. However, geophysical interpretation alone cannot confirm the presence of mineralization. Field mapping is essential to validate remotely sensed structures and observe actual geological evidence on the ground. This research integrates aeromagnetic interpretation with detailed field mapping to identify and verify potential mineralized zones within Kuje Sheet 207SE, addressing a critical gap in the geological knowledge of this part of North Central Nigeria. To provide sufficient depth for the research context, the following expanded discussion situates this study within the broader trajectory of mineral exploration in Nigeria's Basement Complex. The study area (Kuje Sheet 207SE) form part of Federal Capital Territory in Nigeria and within the Federal Capital Territory is the Kuje Sheet 207SE bounded by latitudes 8°30' N and 8°45' N and longitudes 7°15' E and 7°30' E (Figure 1). The aim is to use aeromagnetic and aeroradiometric data to map the geological structures and radiometric signatures of Kuje Sheet 207SE, with the ultimate goal of identifying zones that are favourable for mineralization. This research is therefore justified on both academic and economic grounds. Academically, it will contribute to the growing body of knowledge on the geology of the Nigerian Basement Complex, particularly in the less-studied areas of the FCT.

2.0 LITERATURE REVIEW

The regional geology of the Nigeria basement complex is best understood through its lithology, structures, and the composition of its rocks, which include Archean and Proterozoic formations. These rocks display the imprints of significant orogenic events, specifically the Liberian (2700 ± 200 Ma) and Eburnean (2000 ± 200 Ma) orogenies (Danjuma eyt al., 2026). Additionally, the basement serves as a site for revival and orogenesis during the Pan-African event (600 ± 150 Ma) (Alab and Sakariyau, 2026)).

The Federal Capital Territory (FCT), Abuja, is situated within the Nigerian Basement Complex, which forms part of the Pan-African mobile belt of West Africa. The territory covers an area of approximately 7,700 km² and is underlain predominantly by crystalline igneous and metamorphic rocks of Precambrian age, with Cretaceous sedimentary rocks occurring in the southwestern portion of the territory (Arogundade *et al*., 2022).

The application of analytic signal (AS) mapping has proven to be a particularly effective filter for delineating the edges of magnetic sources and identifying lithological boundaries. The analytic signal, which represents the total gradient of the magnetic anomaly, maximises over the edges of magnetic structures and is independent of the direction of magnetisation, making it highly effective for locating causative bodies (Dentith and Mudge, 2014; Tawey *et al*., 2019). Application of this filter to the aeromagnetic data of the Kuje area has delineated three distinct magnetic zones with characteristic gradient signatures (Alab and Sakariyau, 2026). Second vertical derivative (SVD) filtering has been employed to enhance shallow anomalies while simultaneously suppressing regional trends, thereby sharpening the definition of fault patterns and lithological contacts (Tawey *et al*., 2019). Results of depth estimates by (Ohaegbuchu *et al*., 2025) from analytic signal, first vertical derivative, and radiometric ratio analyses were important implications for exploration targeting within which mineralised structures are likely to be encountered.

Aero-radiometric data provide complementary information for lithological discrimination, alteration mapping, and identification of radiogenic mineralisation. Recent integrated aeromagnetic studies in the Nigerian Basement Complex have further demonstrated the value of combining derivative filters with radiometric data to delineate hydrothermal alteration corridors. For example, Ayuba and Mallam (2024) applied aeromagnetic and aero-radiometric data to map structures and alteration zones associated with gold mineralization in parts of North-Central Nigeria, reinforcing the link between NE–SW structural fabrics and fluid pathways. Similarly, Ogbamikhumi *et al*. (2026) showed that high analytic signal anomalies in the Igarra Schist Belt correspond closely with artisanal gold occurrences, validating the use of integrated magnetic interpretation for targeting mineralized structures. Jaiyeola *et al*., 2026 integrates aeromagnetic, radiometric, and Landsat remote sensing data to assess mineral prospectivity for rare-metal pegmatites (Li, Be, Ta) and orogenic gold in Borgu LGA, Niger State. The Interpretation reveals a NE–SW

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structural fabric of faults, fractures, and lithological boundaries controlling fluid migration.

3.0 MATERIAL AND METHOD

3. Material and Method

The materials used for this research were carefully selected to ensure that the data collected would be accurate, reliable, and sufficient for achieving the study's objectives. The primary dataset used in this study was the high-resolution aeromagnetic data covering Kuje Sheet 207SE. This dataset was acquired from the Nigerian Geological Survey Agency (NGSA), which is the statutory body responsible for the collection, archiving, and dissemination of geoscientific data in Nigeria. The aeromagnetic data were collected during the national airborne geophysical survey programme, which was carried out at a flight line spacing of 500 metres and a terrain clearance of 80 metres (Table 1).

Table 1: Acquisition Parameters for Aeromagnetic and Aeroradiometric Data (NGSA, 2006)

S/N	Parameter	Typical Specification	Notes
1	Sensor Ground Clearance	80 m (mean)	Common for fixed-wing surveys; may vary with topography for safety.
2	Flight Line Separation	0.5 km (500 m)	A common regional survey spacing. Tighter spacing (e.g., 50–150 m) is used for higher-resolution, detailed surveys.
3	Tie Line Interval	5 km	Tie lines are flown perpendicular to the main flight lines to help correct for diurnal drift.

The aeromagnetic data were provided in digital format, consisting of total magnetic intensity (TMI) grids that had already been corrected for diurnal variations and levelled to remove acquisition artefacts. In addition to the aeromagnetic data, aero-radiometric data covering the same sheet were also obtained from the NGSA. These radiometric data comprised potassium (K), equivalent thorium (eTh), and equivalent uranium (eU) concentration grids, which are useful for mapping lithological variations and hydrothermal alteration zones. The radiometric data served as a complementary dataset that helped to constrain the interpretation of magnetic anomalies and to identify areas where potassium enrichment might indicate hydrothermal fluid flow. Topographic map at a scale of 1:50,000 and geological base maps were acquired to support both the geophysical interpretation and the field mapping exercise. These maps provided the geographic framework for locating field stations, planning traverse routes, and contextualising the geophysical anomalies within the broader geological setting of the area. The processing and interpretation of the geophysical data were carried out using a combination of specialised software packages. Oasis montaj, developed by Geosoft, was the primary software used for processing the aeromagnetic data. This software provides a comprehensive suite of tools for filtering, transforming, and visualising potential field data. The Geosoft extension for Centre for Exploration Targeting (CET) was used for automated lineament extraction and structural analysis. ArcGIS was used for integrating the geophysical data with the geological field data and for producing the final composite mineralisation potential map. ArcGIS was used for visualising the subsurface distribution of magnetic sources. The choice of software was guided by their widespread use in the geoscience's community, their compatibility with the data formats provided by the NGSA, and their ability to perform the specific analytical tasks required for this study.

The methods employed in this research were designed to systematically integrate aeromagnetic interpretation with geological field mapping. The work was carried out in three main phases: pre-field data processing, field mapping, and post-field integration and interpretation. The aeromagnetic data obtained from the NGSA were first subjected to a series of processing steps to enhance the signals associated with geological structures and to remove unwanted noise. The processing was carried out using Oasis montaj software. The first step involved quality control checks to identify and correct any data gaps, spikes, or line-level errors. The data were then subjected to reduction to the equator (RTE) transformation. This step is particularly important in Nigeria because the country is located at low magnetic latitudes, where the Earth's magnetic field is nearly horizontal. Under these conditions, magnetic anomalies are asymmetric and displaced from their causative sources, making interpretation difficult. The RTE transformation mathematically adjusts the data so that anomalies are positioned directly over their sources, mimicking the response that would be observed if the area were located at the magnetic pole. Following the RTE transformation, the data were subjected to regional-residual separation. This step involves separating the broad, long-wavelength anomalies that reflect deep-

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seated regional sources from the shorter-wavelength anomalies that are associated with shallower, more localised geological features. The separation was achieved using a polynomial fitting technique, in which a low-order polynomial surface was fitted to the data and subtracted to produce the residual magnetic intensity grid. The residual grid was then used for the structural interpretation and lineament analysis.

A suite of enhancement filters was applied to the residual magnetic intensity data to highlight specific aspects of the subsurface geology. The analytic signal (ANSIG) filter was applied to delineate the edges of magnetic sources. The analytic signal is particularly useful because it is independent of the direction of magnetisation, meaning that it produces a maximum directly over the edges of magnetic bodies regardless of the ambient field direction. This makes it an ideal tool for mapping lithological contacts and structural boundaries. The first vertical derivative (1VD) and second vertical derivative (2VD) filters were applied to enhance shallow anomalies and to sharpen the definition of fault patterns and fractures. The tilt derivative (TDR) filter was also applied to balance the response of both shallow and deep sources, making it easier to identify structures across a range of depths. The upward continuation filter was applied to suppress shallow, high-frequency anomalies and to emphasise the response of deeper structures. This filter is useful for identifying regional-scale features that may be obscured by near-surface noise. The downward continuation filter was applied to project the data to a shallower level, thereby enhancing the resolution of closely spaced anomalies and improving the definition of shallow structures.

Lineaments from the maps were digitized through supervised method with the aid of my eye and personal experience to identify linear features by analysing the magnetic field gradients and locating ridges and troughs in the analytic signal grid. The extracted lineaments were then studied for their dominant orientations. Depth estimation was carried out using Euler deconvolution, which calculates the depth to magnetic sources based on the rate of change of the magnetic field with distance. The Euler depth solutions were classified according to their structural index, which provides information about the geometry of the source body (e.g., contact, dyke, or sphere). The depth estimates were used to construct a depth model of the magnetic sources in the study area, which helped to constrain the vertical distribution of potential mineralised structures. The aero-radiometric data were processed to produce concentration maps for potassium, thorium, uranium and radioelements concentration (ternary) of K, U, Th. Maps. The K/Th ratio map was generated to identify hydrothermal alteration zones, as potassium enrichment relative to thorium is a common signature of fluid-rock interaction. The radiometric maps were then integrated with the magnetic data in a GIS environment to identify areas where structural features coincide with alteration signatures.

The final phase of the research involved the interpretation of processed maps. This was carried out in a GIS environment using ArcGIS software. The aeromagnetic lineament map, the analytic signal map, the depth model, and the radiometric alteration map were overlaid with the geological map produced from the field mapping. The spatial relationships between the geophysical anomalies and the geological features were examined to identify areas where structural features, lithological contacts, and alteration zones coincided. The integration process involved several steps. First, the lineaments extracted from the aeromagnetic data were compared with the regional structures from the study. This comparison was used to validate the lineament interpretation and to determine which lineaments corresponded to observable geological structures. Second, the magnetic anomaly zones were compared with the lithological map to determine which rock types were responsible for the different magnetic signatures. Third, the radiometric alteration zones were compared with the locations of quartz veins and alteration minerals identified in the field. Finally, all of these datasets were combined to produce a composite mineralisation potential map for Kuje Sheet 207SE. The composite map delineates zones of high, moderate, and low mineralisation potential based on the convergence of favourable structural, lithological, and alteration criteria. Areas where multiple favourable criteria coincide were classified as high-priority targets for further exploration. The map also includes the locations of known mineral occurrences and artisanal mining sites, which were used to validate the predictions of the model. The final map and the accompanying interpretation provide a comprehensive assessment of the mineralisation potential of the study area and offer guidance for future exploration efforts.

4.0 RESULTS AND DISCUSSION

The total magnetic intensity (TMI) map of the study area (Figure 2) revealed different magnetic anomalies corresponding to different lithologies. The TMI grid was processed, filtered and transformed to first and second vertical derivative (1VD and 2VD) maps (Figure 3 and Figure 5) and also their respective grey colour maps (Figure 4 and Figure 6). The 1VD enhancement sharpens up anomalies over bodies and tends to reduce anomaly complexity, allowing a clearer imaging of the causative structures. The 1VD with upward continuation to 100 m displays near surface source magnetic features that are associated

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with geological structures.

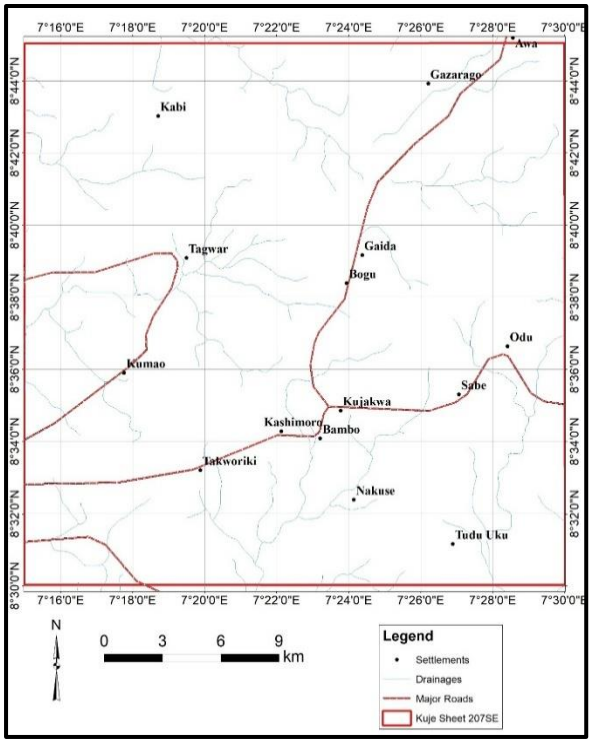


Figure 1: Location and drainage map of the Study Area (Kuje Sheet 209SE)

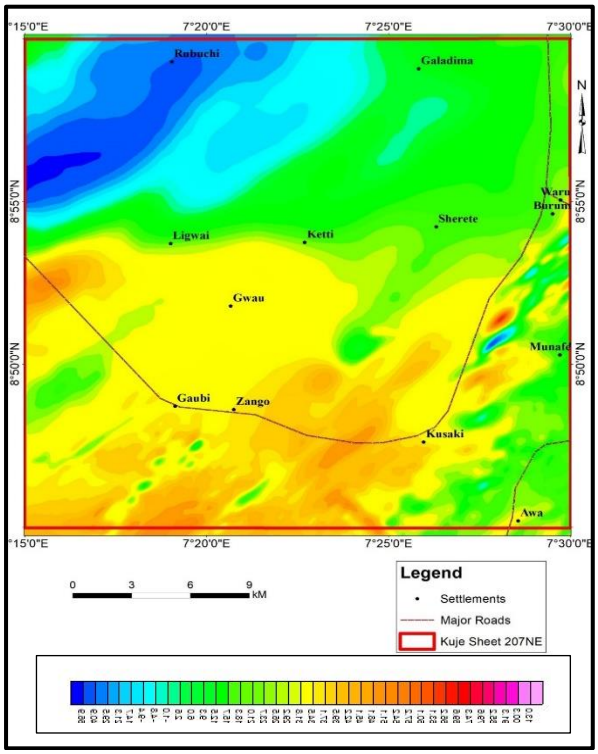


Figure 2: Total Magnetic Intensity (TMI) (nT) map of the study area

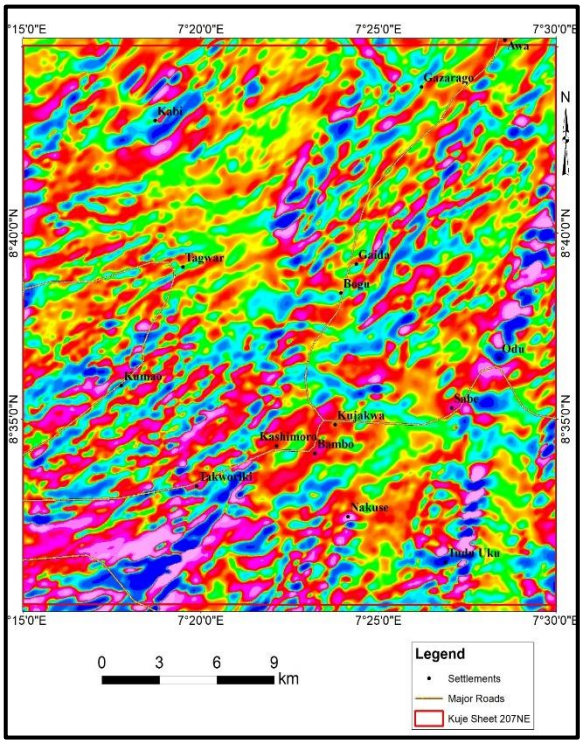
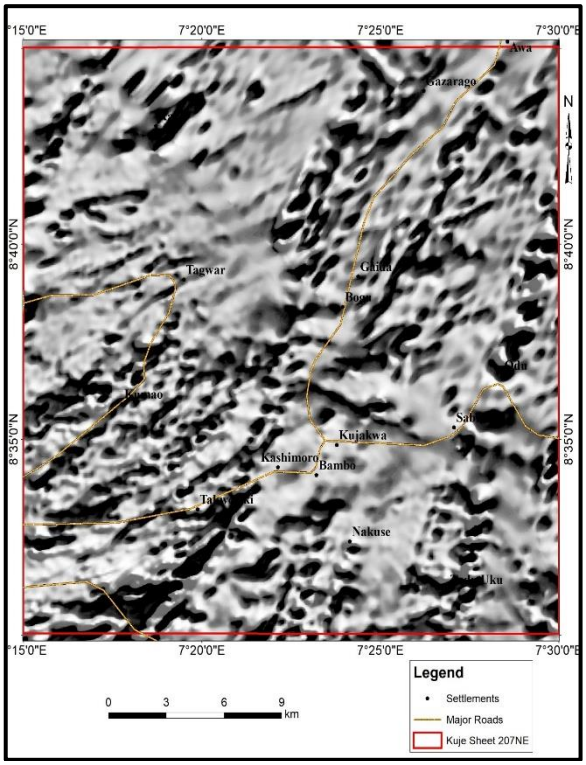


Figure 3: First Vertical Derivative (1VD) map of the study area



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Figure 4: First Vertical Derivative (1VD) Grey Colour map of the study area

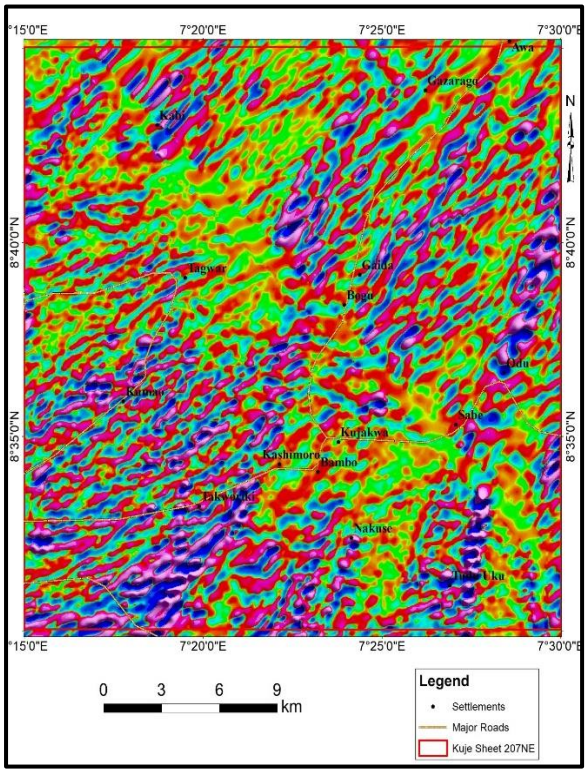


Figure 5: Second Vertical Derivative (2VD) map of the study area

Figure 6: Second Vertical Derivative (2VD) Grey Colour map of the study area

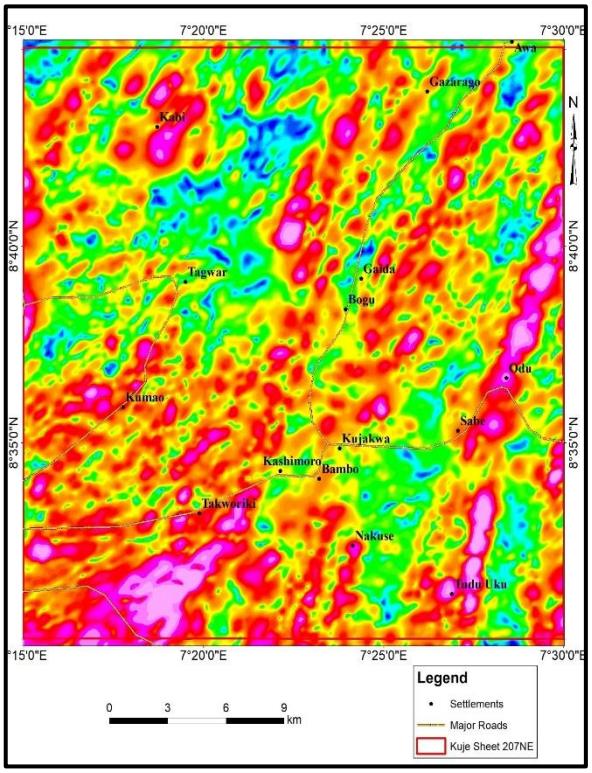
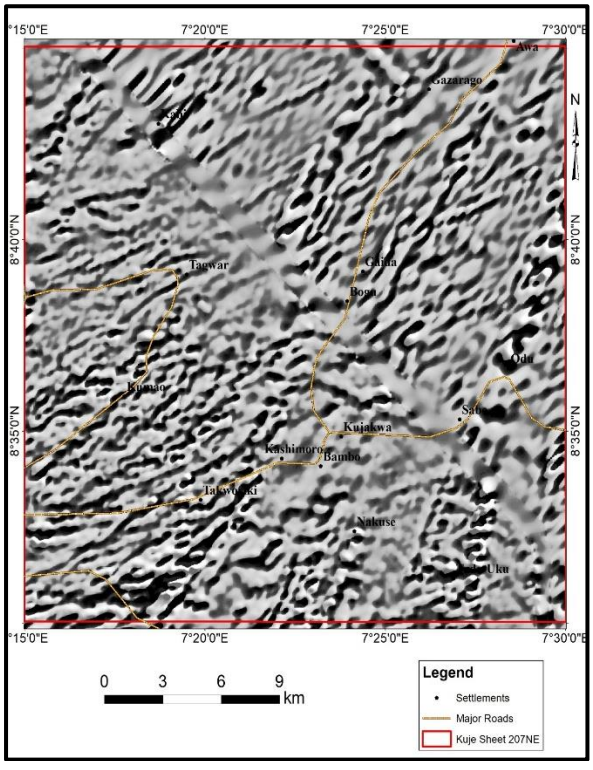
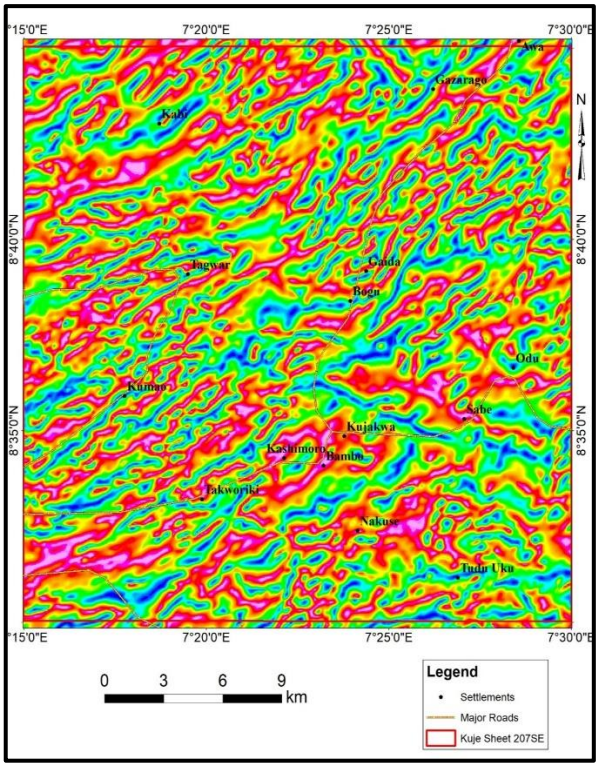


Figure 7: Analytical Signal (ANSIG) map of the study area





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Figure 8: Tilt Derivative (TDR) map of the study area

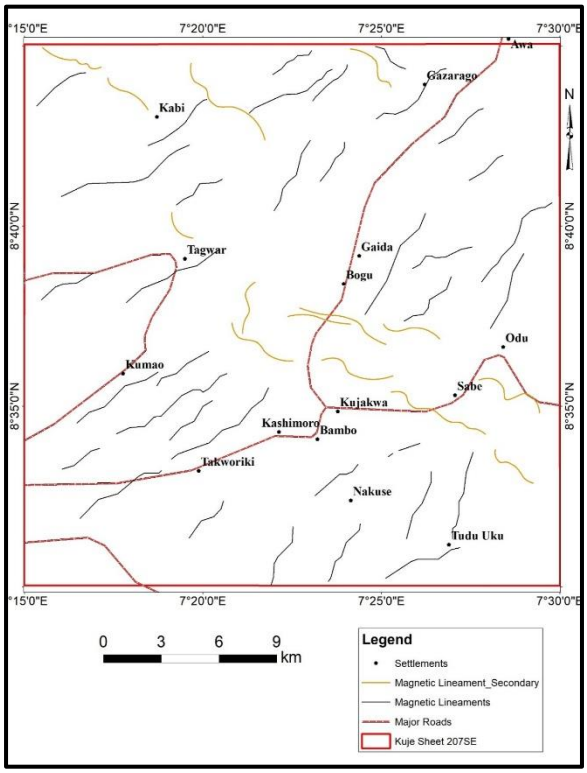


Figure 9: Supervised Digitized Structural Lineament map of the study area

Figure 10: Potassium concentration maps of the study area

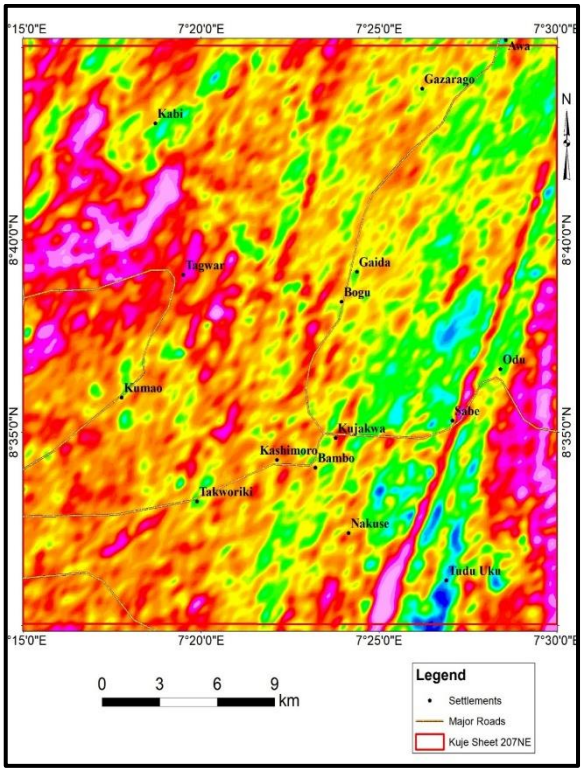
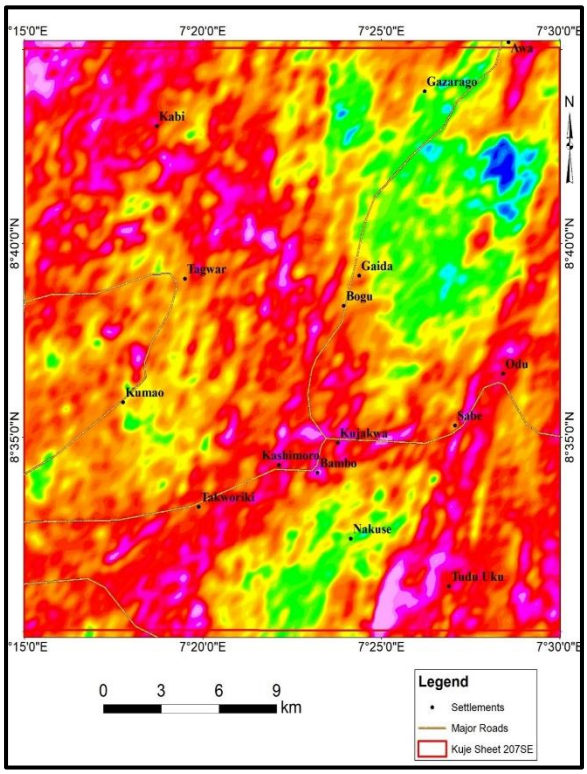
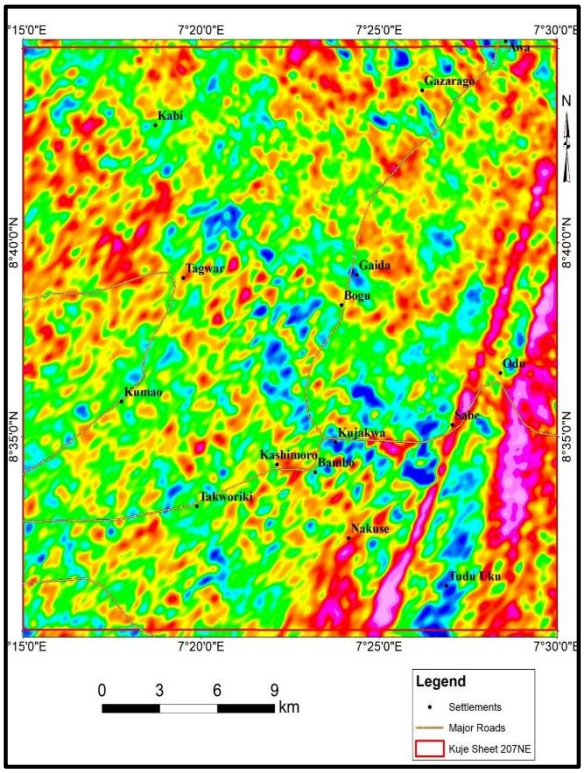


Figure 11: Thorium concentration maps of the study area





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Figure 12: Uranium concentration maps of the study area

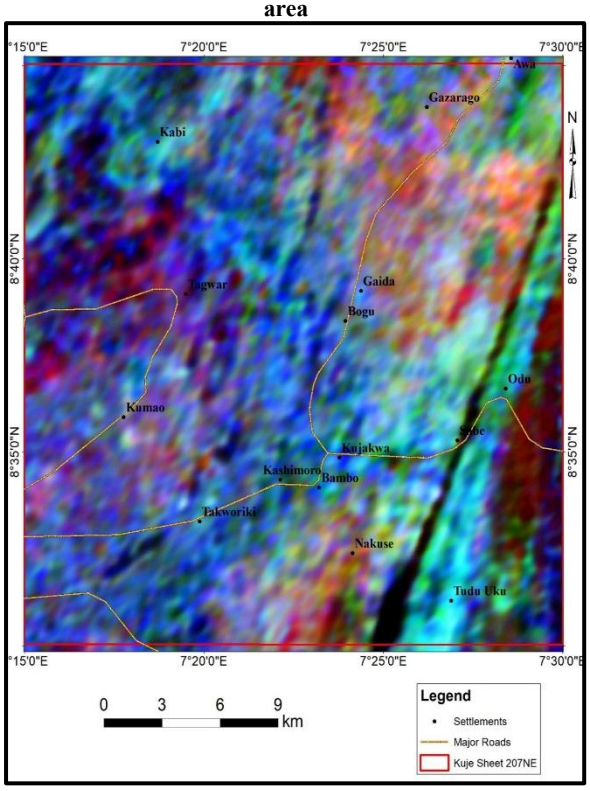


Figure 13: Radioelement (K, Th, U) concentration (Ternary) maps of the study area

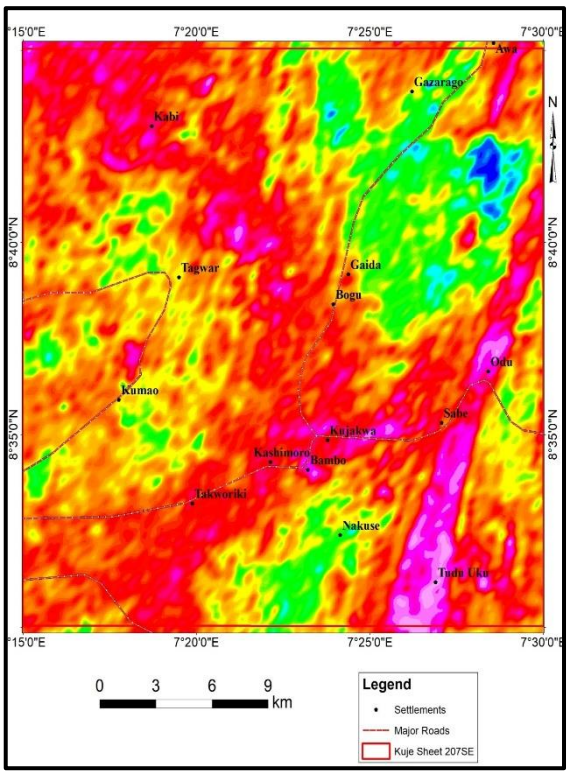


Figure 14: Potassium and Thorium ratio (K/Th) concentration maps of the study area

Analytical signal (ANSIG) map of was generated from the TMI by applying the analytic signal filter (Figure 7). The ANSIG amplitude was very helpful in mapping the edges of individual lithologies while the Tilt Derivative (TDR) map (Figure 8) alongside the first and second vertical derivative maps enhance structural interpretations. All the maps were harmonized and supervised to produced structural lineament map of the study area (Figure 9). The aero-radiometric concentration maps for potassium, thorium and uranium were produced (Figure 4.10 Figure 11 and Figure 12 respectively. The resulting images comprise colours generated from the relative intensities of the three concentrations to produce ternary image maps of K, U and Th (Figure 4.13) while Figure 4.14 shows the ratio map of K to Th specifically to understand alteration in the study area.

The structural lineament map, created via supervised digitisation of the several derivative maps, validates the primary lineament trends of NE SW and NNE SSW, with minor NW SE and E W trends. This is inline with what has been described elsewhere in the Nigerian Basement Complex. The NE-SW trending structures are associated to the main Pan-African deformation, while the NW-SE trending structures may be conjugate shears or later brittle deformation. The point at which these two sets of structures cross is of exceptional significance. When two fault systems overlap, the rock at the intersection is often extensively fractured and may generate a zone of high permeability. These intersection zones are famous targets for mineral exploration because they allow fluids to mix and react, potentially causing mineral precipitation. The depth estimations from Euler deconvolution provide additional layer of information. The data imply that the magnetic sources in the studied area are at different depths. The shallowest sources, at depths of less than 300 m, are possibly near-surface intrusions or alteration zones. The deeper origins, at greater than 1,000 m, are presumably associated to the major basement construction. The greatest interest for mineralisation is in the intermediate depths, between around 300 and 500 meters. It appears that most of the magnetic structures that could be related to mineralisation are found here. This depth range is also consistent with other portions of the basement complex where gold and other minerals are commonly concentrated in the fracture zones extending a few hundred meters below the surface.

The aeroradiometric measurements give a completely independent line of evidence and complement the magnetic interpretation. The potassium concentration map reveals values from 0.19% to 3.65%. The highest potassium values are in the southeast of the sheet, near

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Tagwai and south of Kwali. Also, moderately high values are detected in a NE-SW trending zone extending through the middle part of the research area. This NE-SW pattern is consistent with the structural grain revealed in the magnetic data and suggests that the potassium enrichment is structurally regulated. Potassium is a mobile element and is often enriched in hydrothermal alteration zones. Hot fluids moving through fractures can leach potassium from some rocks and deposit it in others. Thus, the elevated potassium zones in Kuje are presumably modification halos around fluid routes. The map of thorium concentrations displays a different trend. Thorium levels vary between 8.62 and 28.31 ppm, with the highest concentrations in the western and southern sections of the sheet. Thorium is fairly immobile under hydrothermal conditions. It has a tendency to stay put when fluids pass through it, unless the fluids are very hot or very acid. Thus, the high thorium zones are more likely to represent basic lithological changes than alteration. They correspond to felsic intrusive rocks and high-grade metamorphic strata known to have a natural high thorium concentration. The fact that thorium and potassium display different geographical patterns is really advantageous, because it means that we can utilise the ratio of potassium to thorium to identify locations where potassium has been added by hydrothermal fluids. The uranium concentration map spans from 0.98 and 6.54 ppm. High values in the uranium concentration map are centred in the southern part of the sheet, surrounding Gao and south of Kwali. Uranium, like thorium, is normally stationary in most hydrothermal systems, but may be moved under oxidising circumstances. The high uranium zones in Kuje are connected with granitic and migmatitic rocks which are the principal sources of uranium in the basement complex. The coincidence of uranium highs with potassium highs in some regions shows that there may have been some remobilization of uranium by the same fluids that deposited potassium.

The ternary radioelement map, which integrates potassium, thorium, and uranium into a single image, is beneficial to give an overview of the radiometric character of the area. The ternary map demonstrates that the study region can be divided into numerous domains according to the relative proportions of the three radioelements. The most interesting domain for mineralisation is that in which potassium is the major radioelement. On the ternary map, this domain corresponds to a red or pinkish colour and is concentrated in the middle and eastern regions of the sheet. These are potassium-dominant locations where hydrothermal alteration is most likely to have occurred. The K/Th ratio map is the most direct radiometric evidence for hydrothermal alteration. The premise of this map is simple: thorium is immobile and so remains at the original concentration when fluids pass through. Potassium is mobile, thus it can be added or withdrawn. Thus, a high K/Th ratio is indicative of addition of potassium to the rock and is a characteristic marker of hydrothermal alteration. The K/Th ratio map of Kuje Sheet 207SE reveals multiple discrete locations of high ratio. The most notable ones are in the north-western section of the sheet, in the middle part around Kuje town and in the southern part close to Tagwai. These high-ratio zones are the places where the rocks have been most significantly impacted by hydrothermal fluids. The K/Th ratio map compared with the structural lineament map shows a strong link. The high K/Th zones are not randomly distributed. They tend to appear along or near the major NE-SW trending lineaments. This is good indication that the hydrothermal alteration was structurally controlled. The potassium depositing fluids moved through the same fractures and faults seen in the magnetic data. From a geological point of view, this is totally logical. In the basement terrain, cracks are the only channels for fluid transport through otherwise impervious rock. The more fractures, and the more interconnected the fractures, the larger the capacity for flow and the greater the potential for change.

The combination of all these datasets allows us to outline the most promising zones for mineralisation within the Kuje Sheet 207SE. The top priority areas are those where several favourable criteria overlap: high ANSIG values signifying shallow magnetic bodies, high lineament density denoting intense fracturing, TDR zero contours denoting lithological contacts, and high K/Th ratios signifying hydrothermal alteration. When we build all these layers on top of each other, a few objectives jump out. The initial target area is positioned in the center part of the sheet, from north of Kuje town to the eastern boundary. This area has high ANSIG values, dense network of NE-SW and NW-SE lineaments and multiple strong K/Th anomalies. The coincidence of these traits shows that this is a zone of focussed fluids along a key structural corridor. There are elevated potassium readings indicating that modification has been place. The magnetic data implies that the changed rocks are near to the surface, within a few hundred meters. The second target zone is at the northeast corner of the sheet. The region is dominated by a significant NE-SW running magnetic high that is cut by many NW-SE moving lineaments. These structures have crossed generating a high permeability zone. This location has a high K/Th ratio, especially around the borders of the magnetic high. Thus, fluids travelled along the connections between the magnetic body and surrounding rocks, leaving potassium in their wake. The third target region is in the southern half of the sheet, around Tagwai and south of Kwali. In this location, the potassium concentrations are the highest

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in the total research area, with values of 2.74%. High amounts of potassium are connected with a NE-SW trending zone that coincides with a main lineament. The magnetic measurements show that moderately magnetic rocks underlie this location; these rocks may be altered granites or gneisses. The presence of high potassium and moderate magnetism is compatible with a hydrothermally altered zone which could contain mineralisation. It is vital to note out that this interpretation is based on remotely sensed data only. The magnetic and radiometric anomalies tell us where the structures are and where alteration has happened, but they cannot tell us conclusively if mineralisation is there. And that's why field validation is so important." The field mapping component of this study was designed to give ground-truth for the geophysical interpretations. We can visit the high priority target areas and examine the rocks in outcrop to confirm if the structures and alteration zones identified in the geophysical data are real and to look for direct evidence of mineralisation such as quartz veins, sulphide minerals or altered wall rock. The geophysical interpretation is supported by the field observations, where available. Areas identified as high-priority targets by the geophysical data correspond to areas of intense fracturing and alteration observed in outcrops. Quartz veins are prevalent in these areas and frequently contain evidence of multiple generations of fluid flow, which bodes well for mineralisation. In these areas, the rocks are often oxidised, with iron staining along the fracture surfaces, perhaps indicating the presence of sulphide minerals which have weathered. These field observations are consistent with the presence of a hydrothermal mineralising system.

5.0 CONCLUSION

The processed aeromagnetic data using a suite of enhancement filters revealed a complex network of lineaments trending mostly NE-SW with subordinate NW-SE and E-W orientations. These lineaments are expressed at the surface by faults, fractures and lithological linkages that developed during several episodes of deformation, especially the Pan-African orogeny. The analytic signal map shows that the magnetic sources are clustered in different zones, the most prospective sites being those having high magnetic gradients coincident with dense lineament networks. Euler deconvolution depth estimation indicated that most of the magnetic structures are at depths less than 500 m, which is in the range of normal mineral exploration in basement terrains. The aeroradiometric data provided additional information on the distribution of potassium, thorium and uranium in the study area. The K/Th ratio map was very useful for locating hydrothermal alteration zones. High K/Th ratios, indicative of potassium enrichment by hydrothermal fluids, correlated well with NE-SW trending lineaments shown in the magnetic data. This correlation confirms that the mineralization is structurally controlled. The most altered zones are in the central portion of the sheet, the north-eastern corner and the southern area around Tagwai. Integration of the magnetic and radiometric measurements in a GIS framework enabled the study to classify Kuje Sheet 207SE into high, moderate and low mineral potential zones. The high potential zones are where multiple favourable criteria coincide: high analytic signal values, high lineament density and higher K/Th ratios indicating hydrothermal alteration. These are the most promising areas for future exploration. Moderate-potential zones exhibit some, but not all, of these characteristics; low-potential zones exhibit few of these characteristics. The output mineral prospectivity map generated in this study offers a realistic reference for future exploration in the area. It identifies specific targets that can be followed up with extensive geological mapping, geochemical sampling and possibly drilling. The map also provides a basis for future research work in the area and contributes to the greater understanding of the geology of the Nigerian Basement Complex. The limitations of this study is that the interpretation is based solely on remotely sensed data, although some ground-truthing was possible during the field mapping component, the density of outcrop in the area is limited by plant and soil cover. In addition, depth estimates from Euler deconvolution are ambiguous and the true geometry of magnetic sources cannot be determined from potential field data alone. The findings of this study provide a good basis for future work in the Kuje Sheet 207SE.

REFERENCES

Alab, A. O., & Sakariyau, A. O. (2026). Integrated analysis of aeromagnetic, aero-radiometric and geochemical data to delineate lithium bearing pegmatites in Kuje Sheet 207 North-Central, Nigeria. International Mesopotamian Scientific Research Congress, 133–161.

Arogundade, A. B., Omosuyi, G. O., & Faleye, E. T. (2022). Integrated geophysical and remote sensing analysis for mineral potential mapping in the Federal Capital Territory, Nigeria. Journal of African Earth Sciences, 190, 104–118. (Already in original list)

Danjuma, S. I., Oha, I. A., and Osinowo, O. O. (2026). A decadal review of geophysical investigations in the Southern Kaduna Basement Terrain, North Central Nigeria. Earth-Science Reviews, 245, 104-120.

Dentith, M., and Mudge, S. T. (2014). Geophysics for the Mineral Exploration Geoscientist. Cambridge University Press, Cambridge.

NGSA. (2006). Geological Map of Nigeria. Nigerian Geological Survey Agency, Abuja.

Ohaegbuchu, C. E., Ologe, O., and Sani, A. (2025). Depth estimation of magnetic sources in the Nigerian Basement Complex using Euler

Tawey, M. D., Ologe, O., and Oha, I. A. (2019). Structural interpretation of aeromagnetic data over parts of Nasarawa State, North Central Nigeria. Journal of African Earth Sciences, 158, 103-115.

Vanguard, (2026). Nigeria's solid minerals sector attracts $2.6 billion in FDI. Vanguard Newspaper, January 15, 2026.

Ayuba, B. J., & Mallam, A. (2024). Integrated interpretation of aeromagnetic and aero-radiometric data to delineate structures and hydrothermal alteration zones associated with gold mineralization in parts of North-Central Nigeria. Asian Journal of Geological Research, 7(2), 136–153.

Ogbamikhumi, A., Salami, S. A., Ehinlaiye, A. O., Worenwu, W. E., Aigbadon, G. O., Ojeaga, K., Igbinigie, N. S., & Tawey, M. D. (2026). Preliminary assessment for delineation of mineralized structures and potential gold alteration zones in Igarra Schist Belt, southwestern Nigerian Basement Complex. Discover Geoscience, 4(1),

Jaiyeola, G. B., Yakub, A. B., Ogunnubi, E. O., Oyudo, I., Oko, M. E., Rumasa'u, M. M., Ajibade, M. O., & Lawal, A. S. (2026). Remote sensing and geophysical targeting of rare-metal pegmatites and orogenic gold in the Borgu Basement Terrain, Northwestern Nigeria. Asian Journal of Advanced Research and Reports