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Aeromagnetic-Based Lithostructural Interpretation of the Ilesa Basement Complex, Southwestern Nigeria

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Quantitative lithostructural characterisation of the Ilesha Basement Complex in southwestern Nigeria remains poorly constrained despite its documented metallogeny. This study applies high-resolution aeromagnetic (HRAM) data, processed through Reduction-to-Equator (RTE), Total Horizontal Derivative (THDR), and Analytic Signal Amplitude (ASA) filters, to delineate magnetic domains, structural lineaments, and lithologic contacts. The survey was flown at 500 m line spacing and 80 m terrain clearance and processed using Oasis Montaj. Three magnetic domains are identified: high-amplitude anomalies (55.1-155 nT) in the northwest, attributed to amphibolite and mafic-intruded migmatitic gneiss; intermediate anomalies (6.0-55.1 nT) in the east, corresponding to quartzite and quartz-schist; and low-amplitude anomalies (-76.6 to 6.0 nT) in the south, reflecting granitic intrusions of low magnetic susceptibility. Manual THDR lineament extraction yielded 64 lineaments (2.5-16 km), dominated by NE-SW orientations (92%) linked to Pan-African thermotectonism (~600 Ma), with a subordinate E-W set (8%) interpreted as relict Liberian fabric (>2500 Ma). Sequential upward continuation at 500 m and 750 m indicates that brittle fault systems in the south-southwestern sector extend to depths of approximately 0.5-0.75 km; this estimate is preliminary and should be validated using Euler deconvolution or spectral analysis in future work. The conjugate fault geometry (sinistral NNW-SSE and dextral WNW-ESE) is consistent with NNE-directed Pan-African compression. The results establish a repeatable HRAM-based lithostructural framework for poorly exposed crystalline basement terrains of West Africa. It is recommended that follow-up studies apply Euler deconvolution and geochemical sampling of the identified ASA contact zones to validate the depth estimates and lithological attributions reported here. The findings have direct practical implications for groundwater exploration, mineral prospectivity assessment, and structural hazard mapping in the Ilesha schist belt and analogous basement terrains across West Africa.

Keywords: Aeromagnetics; lithostructure; lineament; Pan-African; Ilesa schist belt

Introduction

The basement complex of Nigeria is a critical component of the West African Craton, comprising a Precambrian mobile belt flanked by older cratonic provinces. The basement terrains of southwestern Nigeria record polyphase deformation acquired across multiple orogenic episodes (Ogunkoya *et al.*, 2023; Akinlabi *et al.*, 2023). Despite this structural complexity, the subsurface characterisation of these deformation fabrics remains poorly understood due to the extensive lateritic cover and limited bedrock exposure. High-resolution aeromagnetic surveys (HRAM) offer a cost-effective, non-invasive approach to imaging subsurface lithological and structural architecture (Adeniyi *et al.*, 2024; Narimi *et al.*, 2024; Adedokun *et al.*, 2025).

The Ife-Ilesa Schist Belt in southwestern Nigeria encompasses the Ilesa Basement Complex, which comprises lithostratigraphic units including migmatite-gneiss complexes, quartzite, quartz schist, and granitic intrusives (Bolarinwa & Adeleye, 2015; Ogunkoya & Alasi, 2025). The basement region exhibits polyphase deformation expressed by folds, faults, and fractures, with dominant fabrics trending NE-SW and NW-SE (Ogunkoya & Alasi, 2025). The Total Horizontal Derivative (THDR) is preferred over the tilt-angle derivative for lineament extraction in this study because it produces sharp, well-defined amplitude maxima directly over source boundaries and is less sensitive to depth variations, making it more reliable for mapping steeply dipping contacts in the low-latitude magnetic environment (Verduzco et al., 2004; Adedokun *et al.*, 2025; Ogunkoya *et al.*, 2025).

The Ilesa Basement Complex has gone through different degrees of deformation related to major Precambrian orogenic episodes, notably the Pan-African (~600 Ma), the older Liberian (~2500 Ma) and Eburnean (2000 Ma). Analyses of the aeromagnetic lineaments of the southwestern Nigerian basement terrains reveal that the orientations of the structures can be classified based on their relationship to discrete orogenic events, with the Pan-African orogeny generally accounting for most of the extracted lineaments (Adedokun *et al.*, 2025; Oladunjoye *et al.*, 2016). The combination of HRAM data interpretation with depth estimation using Euler deconvolution and source parameter imaging (SPI) enables the distinction of fault systems based on their temporal significance and kinematic nature, a key step in understanding crustal deformation (Akinlabi *et al.*, 2023).

The Ilesa Basement Complex is regionally significant because it belongs to the Ife-Ilesa Schist Belt, which shows documented potential for gold and other metallic mineralisation (Bolarinwa & Adeleye, 2015). Despite this significance, a detailed quantitative lithostructural framework derived from aeromagnetic interpretation is absent. Prior geophysical investigations in the area predominantly addressed groundwater potential through shallow resistivity techniques (Okpoli & Akinbulejo, 2022; Ogunkoya *et al.*, 2023), leaving the deeper structural architecture unresolved. No published study has applied HRAM derivative analysis specifically to characterise the lithostructural architecture of this schist belt from a tectonic perspective, a gap this study directly addresses.

The present study applies aeromagnetic enhancement and interpretation techniques to characterise the lithostructural framework of the Ilesa Basement Complex. The specific objectives are: (i) to delineate the magnetic domains and their corresponding lithologies using RTE-TMI mapping; (ii) to extract structural lineaments and characterise dominant tectonic trends using THDR analysis and rose diagrams; (iii) to map lithologic contacts and discontinuities using ASA; (iv) to identify and classify shallow fault systems through sequential upward continuation; and (v) to integrate derivative products into a coherent lithostructural framework and tectonic model for the study area.

Literature Review

The application of aeromagnetic derivative techniques to structural delineation in the Ilesha Basement Complex has strong precedent in the literature. Ogunkoya *et al.* (2023) applied First Horizontal Derivative (FHD), First Vertical Derivative (FVD), and Analytic Signal Method (ASM) to potential field data of Ilesha Sheet 243, demonstrating that lineament concentration is highest in the southwestern sector and extends toward the central zone, with Euler deconvolution yielding magnetic source depths of 1096-4168 m. Ozebo *et al.* (2017) similarly evaluated aeromagnetic data of the same area using ASM and Local Wavenumber (LWN), confirming that ASM produces more continuous contact locations and shallower depth estimates (0.348-1.28 km) compared to LWN (0.478-1.51 km). Both studies consistently identify a dominant NE–SW structural orientation attributed to Pan-African thermotectonism (~600 Ma), alongside a subordinate E-W lineament set interpreted as a relict Liberian fabric (>2500 Ma) subsequently modified by Pan-African deformation. Ogunkoya and Alasi, (2025), in a comprehensive review of aeromagnetic studies across the Ilesha schist belt, confirmed that this NE-SW structural grain is the most persistent finding across all published investigations, reflecting the pervasive influence of the Trans-Saharan Mobile Belt on the regional basement fabric. These findings provide a direct regional context for the lineament extraction and rose diagram analysis presented in Section 5.2, validating the dominant NE-SW orientation of the 64 lineaments extracted from the THDR map of this study. The convergence of structural results across independent datasets and processing techniques strengthens confidence in the derivative aeromagnetic framework adopted here for lithostructural characterisation of the Ilesa Basement Complex.

Geological Setting

The study area is located within the Ife-Ilesa Schist Belt of Osun State, southwestern Nigeria, approximately between latitudes 7°30′N and 7°50′N, and longitudes 4°40′E and 4°55′E (Figure 1). The geological units shown in Figure 1 are delineated after the Nigerian Geological Survey Agency (NGSA, 2009) 1:100,000 geological map of the Ilesha Sheet 243. The schist belt forms the southwesternmost extension of the Trans-Saharan Mobile Belt, a Pan-African orogen developed along the margin of the West African Craton (Odeyemi, 1988).

The dominant rocks of the area comprise migmatite-gneiss complex of probable metasedimentary parentage. They are interlayered with quartzite, quartz schist, and pelitic schist. Pan-African-aged granitoids of different compositions, such as porphyritic biotite granite and granodiorite, intrude these supracrustal sequences, which are jointly grouped as the Older Granite suite (Bolarinwa & Adeleye, 2015). Amphibolite bodies that occur as conformable lenses within the schist belt are interpreted as metamorphosed mafic intercalations. The amphibolites show high magnetic susceptibility compared to the felsic gneissic host rock. Occurrences of ferruginous quartzite and banded iron formation, while not volumetrically significant, are important magnetic indicator horizons in the sequence.

The basement rocks of the Ilesa area have undergone at least two phases of ductile deformation, consistent with local structural mapping and petrographic studies of Bolarinwa and Adeleye (2015). The oldest identifiable fabric (D1) occurs as an E-W trending foliation preserved as relict banding in the migmatitic gneisses, attributed to the Liberian orogeny (>2500 Ma). This fabric has been largely transposed by a pervasive NE-SW trending foliation associated with the Pan-African tectonic event (650 ± 150 Ma). Late-stage brittle deformation is registered by NNW-SSE and WNW-ESE trending fault and fracture systems, attributed to post-orogenic extension or strike-slip tectonic activity. This polyphase deformation history makes the Ilesa Basement Complex a suitable target for integrated aeromagnetic characterization.

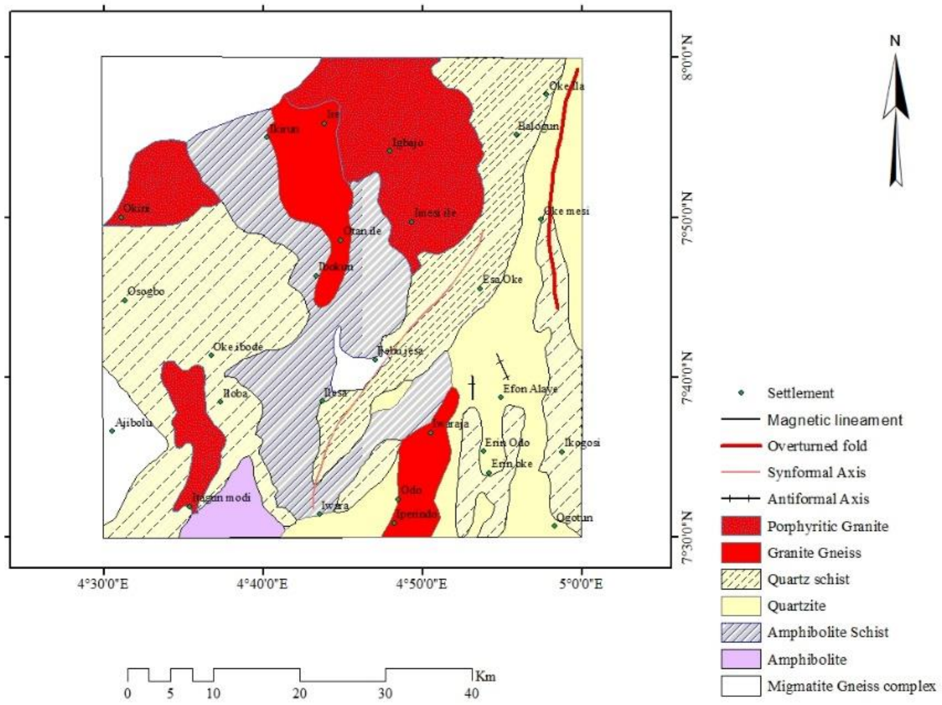


Figure 1: Geological map of the Ilesa study area showing the distribution of major lithological units and the location of the survey area within the Ife-Ilesa Schist Belt
Source: Geological delineation after NGSA (2009)

Data and Methodology

Data acquisition

The aeromagnetic data utilized in this research was collected by Fugro Airborne Surveys for the Nigerian Geological Survey Agency (NGSA) in the course of the national high-resolution aeromagnetic survey of Nigeria (NGSA, 2008). The survey encompassed Sheet 243 (Ilesha) and was flown at a flight-line spacing of 500 m in a NW-SE direction with tie-lines at a spacing of 2000 m in a NE-SW direction. Terrain clearance was maintained at 80 m above ground level, assuring good resolution for structural and lithological mapping. Diurnal correction was applied using base station magnetometer records, with the International Geomagnetic Reference Field (IGRF) removed to obtain the anomalous field.

Data processing

Oasis Montaj v6.4.2 (Geosoft Inc., 2007) was used for all data processing. The processing sequence consisted of: (i) IGRF correction to remove the regional magnetic field of the Earth; (ii) Reduction to Equator (RTE) transformation to shift magnetic anomalies to a position vertically above their sources, reducing the asymmetric distortion caused by the oblique geomagnetic inclination at low latitudes. For the Ilesa area, the IGRF inclination is approximately -8° and declination is approximately -1°. At such low inclination values, RTE can be unstable and susceptible to amplification of noise along the flight-line direction; the ASA filter was therefore used in tandem to mitigate residual remanent magnetisation effects (Verduzco *et al*., 2004); (iii) gridding of the RTE-TMI data at a cell size of 100 m through minimum curvature interpolation, appropriate for the 500 m line spacing; and (iv) sequential upward continuation of the RTE-TMI grid to 500 m and 750 m for regional-residual separation and preliminary fault depth estimation. It is acknowledged that upward continuation alone provides only approximate depth estimates; quantitative depth validation using Euler deconvolution or spectral analysis is recommended in follow-up work.

Enhancement and interpretation techniques

Three enhancement filters were applied to the RTE-TMI grid to enhance structural and lithological information.

The Total Horizontal Derivative (THDR) is the vector sum of the horizontal partial derivatives of the RTE-TMI field in the x and y directions. The filter generates maximum amplitude over magnetisation contrasts such as lithologic contacts and fault planes and is less sensitive to remanent magnetisation effects compared to tilt-derivative filters. Magnetic lineaments were extracted manually from the THDR greyscale map. It is acknowledged that manual extraction introduces subjectivity; future work should incorporate automated lineament extraction algorithms or edge-detection filters for statistical validation of the mapped lineament population. Lineament orientations were quantified using rose diagrams.

The Analytic Signal Amplitude (ASA) is the total gradient of the magnetic field combining both horizontal and vertical derivatives. The positive, bell-shaped anomalies produced by the ASA are centred directly over the boundaries of magnetic sources, making it equally effective irrespective of magnetisation direction and therefore a robust technique for contact mapping at low magnetic latitudes where remanent magnetisation effects may persist after RTE transformation (Verduzco *et al*., 2004).

Sequential upward continuation was applied to the RTE-TMI grid at 500 m and 750 m. As continuation height increases, short-wavelength anomalies from shallow sources attenuate progressively, while long-wavelength anomalies from deep-seated sources persist. Abrupt lateral amplitude contrasts at both continuation levels are interpreted as fault zone indicators (Parasnis, 1986; Oladunjoye et al., 2016). The depth range of 0.5-0.75 km for inferred faults is based on the observation that fault-related anomaly contrasts diminish between these two continuation levels; this should be treated as a qualitative depth estimate pending quantitative validation.

The lineament map thus obtained was superimposed on the RTE-TMI grid using ArcGIS 10.3 for the lineament-anomaly analysis. Concordant lineations (folds and metamorphic banding) with the underlying magnetic anomaly fabric are interpreted as occurring through ductile deformation. Discordant lineations (faults and fractures) occur through brittle deformation that post-dates the development of the ductile fabric (Oladunjoye *et al*., 2016).

Results

RTE-TMI magnetic anomaly distribution

The RTE-TMI map (Figure 2) reveals three spatially distinct magnetic domains characterized by contrasting anomaly intensities. High amplitude anomalies (55.1-155 nT) shown in red-pink colours occur in the northwestern part of the study area. These anomalies are interpreted as indicative of relatively shallow, mafic-rich lithologies, most probably amphibolite bodies and mafic-intruded migmatitic gneiss with elevated magnetic susceptibility values (Telford *et al*., 1990). It is noted, however, that magnetic highs do not unequivocally indicate mafic composition; magnetite-bearing felsic rocks, remanently magnetised units, or structurally elevated basement can produce similar responses. Without direct susceptibility measurements or petrophysical constraints, the lithological attribution here is interpretive and should be tested against field data. The spatial alignment of these anomalies with the regional NE-SW structural trend suggests that magnetic source geometry is structurally controlled.

Green shades depict intermediate amplitudes of 6.0-55.1 nT concentrated in the eastern sector. These magnetic anomalies are oriented broadly in the N-S direction and lithologically associated with quartzite and quartz-schist units. The lithologies have been assigned intermediate magnetic susceptibility values (Telford et al., 1990). The regular patterning of zones of intermediate amplitude, separated by zones of relatively low, is interpreted to be due to periodic structural repetition of schistose and quartzitic units by folding or imbrication.

The southern part of the area is characterized by low amplitude anomalies (-76.6 to 6.0 nT) in blue shades. The low values are a consequence of deep magnetic sources and/or the presence of granitic and granodioritic intrusions of low magnetic susceptibility. The progressive southward deepening of magnetic sources suggests a granitic body beneath thin metamorphic cover.

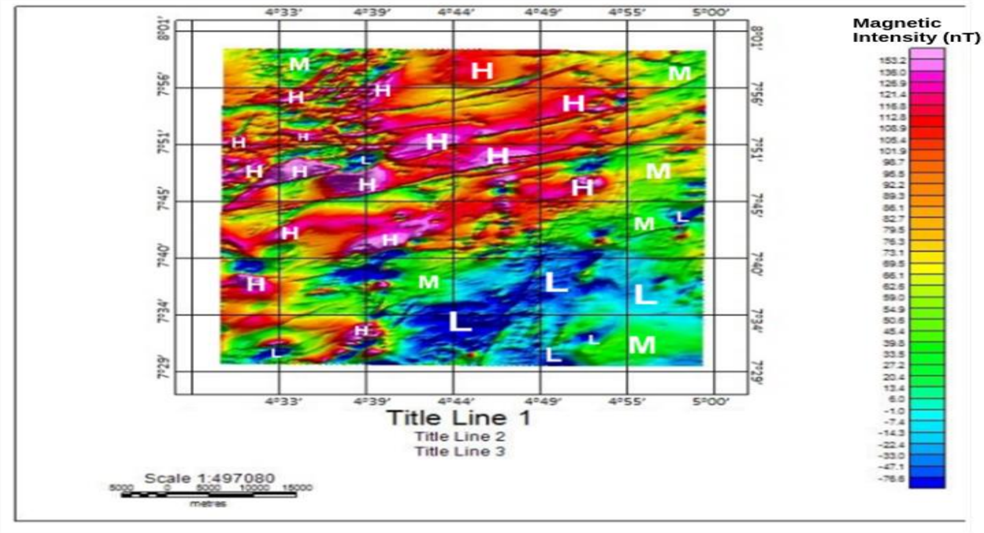
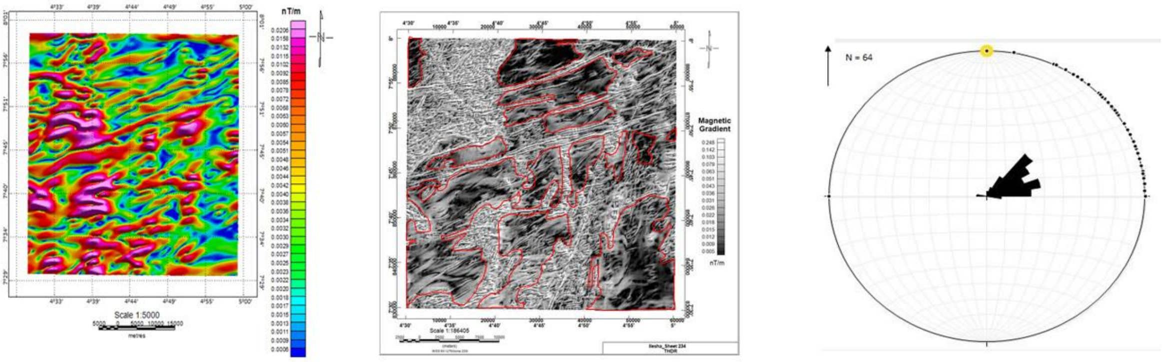


Figure 2: Reduced-to-Equator Total Magnetic Intensity (RTE-TMI) map

Lineament analysis

The THDR map (Figure 3a) produced well-defined amplitude maxima that delineate magnetic contacts across the study area. Manual extraction from the THDR greyscale map (Figure 3b) yields a total of 64 lineaments ranging from 2.5 to 16 km in length, with the mean value of about 9.25 km (Alao *et al*., 2025).

Rose diagram analysis (Figure 3c) reveals two dominant structural families. The NE-SW trending family, which makes up 92% of all lineaments, is the dominant structural grain of the area, representing a Pan-African thermotectonic overprint (D2/D3). The E-W subordinate family (8%) is viewed as remnants of the Liberian D1 fabric that have been rotated or truncated within the Pan-African structure, consistent with regional observations of Adedokun *et al*. (2025).



(a) (b) (c)

Figure 3: (a) Total Horizontal Derivative (THDR) colour-shaded map of Ilesa showing magnetic contact locations as peak amplitudes; (b) THDR grayscale map with extracted magnetic lineaments overlain; (c) Rose diagram of lineament orientations

Table 1: Classification of extracted lineaments and associated tectonic events

Lineament Proportion (%)	Dominant Trend	Tectonic Event	Approximate Age (Ma)
92	NE-SW	Pan-African	~600
8	E-W	Liberian	>2500

Analytic signal amplitude and lithologic contact mapping

The ASA map (Figure 4) shows a series of high-amplitude areas over the western, southwestern and northeastern parts of the study area, with a maximum amplitude value of 0.0318 nT/m.

The amplitude peaks are interpreted as lithologic contacts separating bodies or units with contrasting magnetic susceptibility, namely the contact between mafic amphibolite and gneiss or schistose rocks. The angular contact geometry of the western sector is suggestive of intrusive emplacement of mafic bodies along pre-existing structural discontinuities. Unlike the other high amplitude zones, those in the northeastern sector are more diffuse, suggesting either a gradational lithologic transition or a structural attenuation of the contacts.

The interpreted contact zones on the ASA map (Figure 4) are indicated by white lines. Cross-referencing these contacts with the geological map shown in Figure 1 confirms their coincidence with the mapped contacts between migmatitic gneiss and schistose metasedimentary rocks, validating the interpretation.

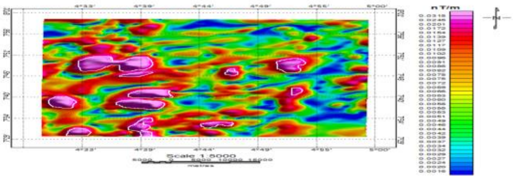
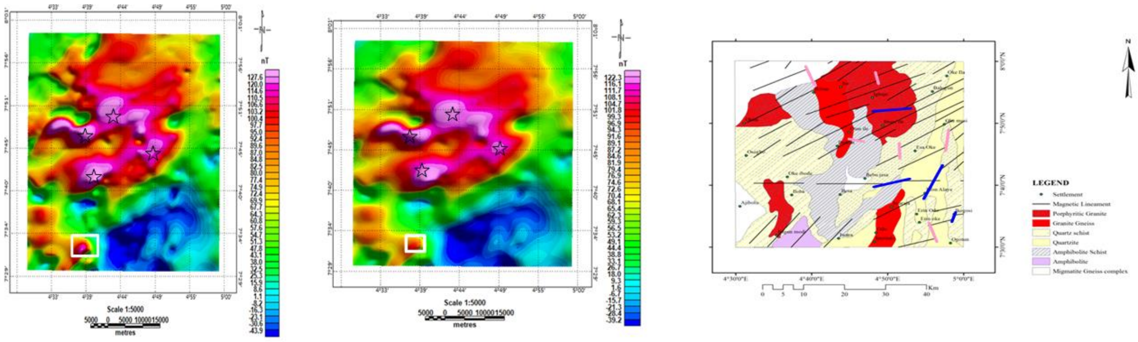


Figure 4: Analytic Signal Amplitude (ASA) map of the Ilesa study area. White lines denote interpreted lithologic contact zones. High-amplitude zones correspond to boundaries between mafic amphibolitic bodies and the surrounding gneissic-schistose host sequence

Depth estimation and fault delineation

Sequential upward continuation of the RTE-TMI field to heights of 500 m and 750 m (Figure 5a, b) shows a gradual attenuation of short-wavelength anomalies related to shallow sources, while longer-wavelength anomalies associated with deep sources remain largely unchanged. The white rectangular markers in Figure 5 indicate inferred fault zones identified from sharp lateral amplitude contrasts. The development of these fault signatures is highest in the south-southwestern sector of the study area and declines from 500 m to 750 m continuation depths, indicating that the inferred faults extend to depths of at least 0.5-0.75 km.



(a) (b) (c)

Figure 5: Upward continuation of the RTE-TMI field at (a) 500 m and (b) 750 m continuation heights. White rectangles indicate inferred fault zones identified from abrupt lateral amplitude contrasts. (c) THDR-extracted magnetic lineaments superimposed on the geological map of the Ilesa area (NGSA, 2009), showing sinistral (red/purple) and dextral (blue) fault traces

The superposition of extracted THDR lineaments on the geological map (Figure 5c) identifies nine fault traces, of which six (66.7%) are sinistral and three (33.3%) are dextral (Table 2). Most sinistral faults are parallel to NNW-SSE and NNE-SSW orientations, while dextral faults show WNW-ESE and E-W orientations. The geometry of the conjugate fault system is consistent with broadly NNE-directed compressional stresses during the Pan-African orogeny.

Table 2: Distribution of sinistral and dextral faults identified from lineament-geological map superposition

Location	Sinistral Faults	Dextral Faults	Sinistral (%)	Dextral (%)	Fault Orientations
Ilesa	6	3	66.7	33.3	NNW-SSE, NNE-SSW, WNW-ESE, E-W

Ductile and brittle deformation framework

The integrated lineament, RTE-TMI map allows spatial differentiation between ductile and brittle deformation domains. Areas in which extracted lineaments are concordant to the underlying anomaly fabric are classified as ductile deformation zones, associated with foliation-parallel shear, transposition banding and isoclinal folds. Zones of lineament-anomaly discordance, where lineament truncations and deflections of anomaly contours occur, are classified as brittle deformation zones associated with faulting and fracturing post-dating the ductile fabric development.

The central and northeastern parts of the study area are dominated by ductile deformation zones characterized by NE-SW trending concordant fabrics, interpreted as the principal Pan-African-age deformation front. Brittle deformation zones are dominant in the SW, SE and S-C sectors, where discordant NE-SW and E-W lineaments intersect the anomaly fabric, indicating late reactivation of faults or post-orogenic extension.

Discussion

The aeromagnetic data from the Ilesa Basement Complex provide a lithostructural architecture broadly consistent with previously published surface geology, while significantly adding to it. The RTE-TMI map reveals three magnetic zones, high amplitude northwestern anomalies, intermediate amplitude eastern anomalies, and low amplitude southern anomalies, reflecting systematic lateral changes in lithology corresponding to the distribution of mafic-intruded migmatitic gneiss, quartzite/quartz-schist, and granitic intrusions (Figure 2). The RTE-TMI map can therefore serve as a lithostructural mapping tool in areas covered by regolith.

The dominance of NE-SW-trending lineaments (92%) in the study area establishes a clear structural control of Pan-African tectonism on the basement architecture of the Ilesha Schist Belt. The geological structures observed in this study correspond with those already recorded in the basement terrains of southwestern Nigeria (Oladunjoye *et al.*, 2016; Adedokun *et al.*, 2025). The 8% subordinate E-W structural lineament encapsulates an imprint of the older Liberian deformation, which survives as relict fabric elements within the Pan-African terrane that was pervasively reworked. Eburnean structural trends (approximately 2000 Ma) are absent from the lineament suite. Their presence in parts of the West African Craton suggests they were entirely overprinted by Pan-African activity or poorly expressed in this crustal segment.

The conjugate fault system comprising sinistral NNW-SSE and dextral WNW-ESE faults is consistent with a NNE-directed compressional regime and a transpressional tectonic environment during the Pan-African orogeny. There is kinematic compatibility between NE-SW shortening and the sinistral sense of shear on NNW-SSE faults, as documented in analogous schist belt settings in southwestern Nigeria. The attenuation of fault-related anomaly contrasts between the 500 m and 750 m upward continuation levels suggests that the inferred brittle faults are confined to the uppermost 0.5-0.75 km of the crust, consistent with late Pan-African or post-orogenic extensional reactivation. However, this depth estimate is qualitative; it is recommended that future studies apply Euler deconvolution or source parameter imaging (SPI) to provide defensible quantitative depth constraints, and that the interpreted fault kinematics be cross validated against existing mapped geology and structural datasets.

The ASA-derived lithologic contacts help constrain emplacement geometries of mafic bodies in the schist belt. The sharply defined linear orientation of contacts in the western region of the area suggests that amphibolitic or similar mafic intrusive bodies were emplaced under fault-controlled conditions, probably along pre-existing NE-SW shear zones.

This is in harmony with the synorogenic emplacement of mafic magmas in a transpressional tectonic environment (Bolarinwa and Adeleye, 2015). A permeability and fluid flow potential also characterised these contact zones, possibly linked to hydrothermal mineralisation and groundwater.

The lithostructural framework developed in this study contributes to our understanding of the tectonic evolution of the Ife-Ilesa Schist Belt within the context of the Trans-Saharan Mobile Belt. The spatial distribution of ductile (central/northeastern) and brittle (southwestern/southeastern) deformation is consistent with a transition from mid-crustal compressional orogenesis at peak Pan-African metamorphism to shallow brittle faulting during exhumation/cooling, analogous to orogenic collapse models in Precambrian mobile belts

Several limitations of this study should be acknowledged. First, depth estimation was based solely on sequential upward continuation at 500 m and 750 m; without Euler deconvolution or source parameter imaging (SPI), the reported depth range of 0.5-0.75 km for brittle fault systems must be treated as a qualitative preliminary estimate. Second, structural lineament extraction was performed manually from the THDR greyscale map, a process inherently subject to operator subjectivity; automated extraction algorithms would improve reproducibility and statistical robustness. Third, the lithological attributions presented in Section 5.1 are based solely on magnetic anomaly character and regional geological context; no ground-truth petrophysical data (e.g., rock magnetic susceptibility measurements or borehole data) were available to verify these interpretations independently. These limitations notwithstanding, the HRAM derivative framework presented here constitutes a meaningful advance in the lithostructural characterisation of the Ilesa Basement Complex and provides a methodologically reproducible template for analogous basement studies.

Conclusion

This study has applied high-resolution aeromagnetic processing and derivative analysis to establish a quantitative lithostructural framework for the Ilesa Basement Complex in southwestern Nigeria. Three magnetic domains identified from the RTE-TMI map reflect systematic lateral lithological variations: mafic-intruded migmatitic gneiss in the northwest (55.1-155 nT), quartzite and quartz-schist in the east (6.0-55.1 nT), and granitic intrusions in the south (-76.6 to 6.0 nT). These interpretations are tentative in the absence of direct susceptibility measurements and should be tested against petrophysical data in future fieldwork. THDR lineament analysis identifies a Pan-African-dominated structural fabric (NE-SW, 92%) consistent with regional deformation chronology, with subordinate E-W Liberian relics (8%). ASA mapping delineates lithologic contacts that may control fluid migration pathways and merit further investigation for hydrothermal mineralisation potential. Upward continuation analysis tentatively localises brittle fault systems to depths of approximately 0.5-0.75 km in the south-southwest sector, forming a conjugate pattern consistent with NNE-directed Pan-African compression.

The integration of derivative products with the regional geological map reveals a spatial partitioning between ductile deformation zones in the central and northeastern sectors and brittle fault zones in the southwestern and southeastern sectors. This pattern is interpreted as evidence of a progressive tectonic transition from deep crustal compressional orogenesis during peak Pan-African metamorphism to shallow extensional faulting during orogenic exhumation and collapse. Collectively, these findings offer a methodologically reproducible HRAM-based framework for lithostructural characterisation applicable to other poorly exposed crystalline basement terrains across West Africa.

Based on the findings of this study, the following recommendations are made: (i) Euler deconvolution and source parameter imaging (SPI) should be applied to the existing aeromagnetic dataset to provide quantitative depth estimates for the identified fault systems and lithologic boundaries, replacing the qualitative upward continuation estimates reported here; (ii) rock magnetic susceptibility measurements and petrographic sampling should be conducted on the mapped lithological units to validate the magnetic domain attributions; (iii) geochemical sampling of ASA-delineated contact zones, particularly in the western sector where mafic emplacement is inferred, is recommended to assess hydrothermal mineralisation potential; (iv) automated lineament extraction algorithms should be applied in follow-up work to remove operator subjectivity from the structural analysis; and (v) the HRAM derivative framework developed here should be extended to adjacent sheets of the Ife–Ilesa Schist Belt to establish a regional lithostructural model for the broader Trans-Saharan Mobile Belt in southwestern Nigeria.

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Data Availability Statement

The aeromagnetic dataset used in this study is the property of the Nigerian Geological Survey Agency (NGSA) and may be accessed through the agency upon reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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