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Justifying Ground Magnetic Follow-Up on Structural Lineament from Aeromagnetic Interpretation for Pegmatite Mineralization in the Thickly Covered Terrain of Nasarawa State, Nigeria

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ABSTRACT
The global surge in lithium demand, driven by its indispensable role in renewable energy technologies and electric mobility, has positioned pegmatite-hosted lithium deposits as critical strategic resources. The Nasarawa region of North Central Nigeria, situated within the Pan-African reworked mobile belt of the Nigerian Basement Complex, hosts significant pegmatite mineralization; however, exploration efforts are impeded by extensive lateritic and sedimentary cover that masks surface expressions of mineralization. This study presents a ground magnetic follow-up investigation targeting structural lineaments previously identified from aeromagnetic interpretation to delineate structural features and zones considered prospective for concealed pegmatite-hosted lithium mineralization in the thickly covered terrain of Nasarawa State. Ground magnetic data were acquired using a GEM-19 Overhauser magnetometer system, with survey lines oriented perpendicular to the dominant NE-SW structural trend at 100 m line spacing and 20 m station spacing. Data processing included diurnal correction, IGRF removal, reduction to pole (RTP), and advanced enhancement techniques including first vertical derivative (FVD), second vertical derivative (SVD), analytical signal amplitude (ASA), and tilt derivative (TDR). Structural lineament extraction was performed using supervised digitization techniques to map faults, fractures, and structural intersections controlling pegmatite emplacement. The results reveal multiple episodes of structural brittle deformation and shearing, resulting in cross-cutting magnetic lineaments in varying directions, with dominant trends in NNE-SSW, NE-SW, NNW-SSE, and WNW-ESE orientations interpreted as fracture-controlled pegmatite intrusions. Integrating ground magnetic data with structural lineament mapping has identified potential mineralization pathways, providing a robust framework for targeting concealed pegmatite-hosted lithium mineralization in the study area.

KEYWORDS: Pegmatite, Tilt Derivative, Lineament, Structures, Basement, Lithium

I. INTRODUCTION
This research expands on the groundwork laid by our previous regional aeromagnetic study (Olaniyan *et al*., 2026a). The regional study successfully employed integrated aeromagnetic geophysical techniques, including First Vertical Derivative (FVD), Analytical Signal Amplitude (ASA), Tilt Derivative (TDR), and Trend Analysis, to identify structural lineaments and magnetic anomalies that serve as proxies for mineralized zones in the Nasarawa pegmatite belt. The findings from that reconnaissance-level investigation revealed that moderate magnetic anomalies exhibiting distinct horizontal and vertical gradient variations, particularly at intersections of NE-SW trending structures with high fault densities, are indicative of potential pegmatite-hosted mineralization zones (Olaniyan *et al*., 2026a). However, while aeromagnetic surveys provide valuable regional-scale structural delineation, they inherently lack the spatial resolution required for detailed characterization of individual structures and their intersections. The regional aeromagnetic data, acquired at flight line spacings appropriate for regional

reconnaissance, cannot adequately resolve the subtle magnetic signatures of narrow pegmatite bodies (typically 2-30 m in width) at shallower depths (5-15 m). Moreover, the extensive lateritic and sedimentary cover that masks surface expressions of mineralization in Nasarawa State poses a significant challenge: while aeromagnetic data can detect regional structural trends, the specific locations of mineralized fractures within these trends remain ambiguous without higher-resolution follow-up investigations. This realization motivated the current ground magnetic follow-up study. The rationale is threefold: (1) to validate and refine the structural lineaments identified from aeromagnetic interpretation through higher-resolution ground-based measurements, (2) to provide detailed anomaly characterization that can distinguish between barren fractures and potentially mineralized structures based on magnetic signature characteristics, and (3) to generate a prioritized target list for subsequent exploration activities (trenching and drilling) based on quantitative depth estimates and structural complexity analysis. By conducting ground magnetic surveys at 100 m line spacing and 20 m station spacing significantly denser than the regional aeromagnetic grid we can achieve the spatial resolution necessary to map individual pegmatite-hosting fractures and their intersections, which represent the most favourable sites for mineralization emplacement. The justification for this follow-up investigation is further strengthened by the recognition that magnetic data alone cannot confirm the presence of pegmatite structures. Rather, magnetic surveys delineate the structural architecture and alteration halos that host mineralization. Our regional study identified the structural framework; the current ground magnetic study aims to characterize this framework at the scale necessary for targeted exploration. The integration of these two scales of investigation regional aeromagnetic reconnaissance followed by detailed ground magnetic characterization provides a robust, cost-effective exploration strategy specifically tailored to the thickly covered terrain of Nasarawa State, where conventional prospecting methods have demonstrated poor effectiveness.

Over the past few years, lithium has emerged as a strategic mineral of global significance, primarily because of its indispensable role in modern technologies. Historically, the exploration and classification of pegmatites—particularly rare-element-bearing pegmatites—have underscored their economic potential in hosting lithium, tantalum, niobium, and other rare metals (Cerny, 1982; London, 1986). Aeromagnetic surveys are widely recognized as a valuable tool for regional reconnaissance, particularly for delineating structural lineaments and magnetic anomalies that may be associated with mineralized zones (Nabighian *et al*., 2005). However, the application of magnetic methods for direct detection of pegmatite-hosted bodies remains inherently indirect; high-resolution magnetic surveys primarily capture intrusion-related and metamorphic signatures linked to mineralization rather than the weakly magnetic ore bodies themselves (Fedi and Pilkington, 2012). Recent methodological developments have underscored the effectiveness of combining aeromagnetic data with ground magnetic surveys in mineral exploration programs (Adewumi *et al*., 2024). Advanced edge enhancement techniques, including analytic signal amplitude (ASA), total horizontal derivative (THD), tilt derivative (TDR), and first vertical derivative (FVD), have proven particularly useful in delineating geological contacts and structural boundaries that control mineralization (Verduzco *et al*., 2004; Cooper and Cowan, 2006). Structural controls are of critical importance in this context: fault systems oriented in NE-SW and NW-SE directions have been identified as major conduits for mineralizing fluids, with dip angles between 65° and 82° and maximum depths approaching 600 m (Odeyemi *et al*., 2021). The rationale for conducting ground magnetic follow-up surveys on lineaments derived from aeromagnetic interpretation rests on the need for enhanced subsurface resolution. Ground-based magnetic measurements offer significantly improved spatial resolution and more detailed anomaly characterization compared to regional airborne surveys, thereby facilitating the precise mapping of mineralized structures at shallower depths (Okonkwo and Akinlalu, 2023). In analogous geological contexts, integrated ground magnetic and VLF-EM

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surveys have successfully identified mineralized pegmatite veins through the spatial correlation of high-amplitude residual positive magnetic anomalies with zones of elevated conductivity (Kolawole *et al*., 2024). Additionally, ground magnetic data permit the application of sophisticated filtering routines such as reduction to pole at low latitude (RTPLL), Gaussian smoothing, and Butterworth filtering which enhance signal-to-noise ratios and better focus anomaly peaks directly over their causative sources (Fashina *et al*., 2025). This study addresses follow-up on structural lineaments identified from aeromagnetic data that coincide with prospective mineralization zones, and justifies the targeted ground magnetic survey to reveal concealed pegmatite-hosted lithium mineralization in the study area.

Pegmatites are often composed of non-magnetic to weakly magnetic minerals (quartz, feldspar, mica). However, their economic value lies in their association with rare-metal mineralization which is intimately linked to magnetic contrast with the host rock. In the basement complex of Nasarawa State, pegmatites are typically hosted within migmatites, gneisses, and schists. Hydrothermal alteration along shear zones frequently results in the breakdown of primary magnetite to hematite or goethite, creating a negative magnetic anomaly relative to the unaltered host rock. Magnetic susceptibility contrast between a weakly magnetic pegmatite and a moderately magnetic host rock generates a measurable magnetic gradient. Structural magnetic lineaments like fractures, even if non-mineralized, act as conduits and are often marked by linear magnetic lows or highs due to secondary magnetization along the fracture plane. Therefore, ground magnetic surveys are not designed to directly "see" the pegmatite, but rather to map the structural architecture and alteration halos that host the mineralization. The method is particularly suitable in thickly covered terrains where outcrop is scarce due to lateritic overburden.

II. MATERIALS AND METHODS

This study employed ground magnetic follow-up survey specifically designed to validate and refine structural interpretations derived from airborne data, with the ultimate goal of delineating pegmatite-hosting fracture networks in a thickly covered terrain. The methodology is structured into four interconnected phases: (1) survey design and grid parameterization, (2) field acquisition and real-time quality control, (3) rigorous pre-processing and correction of temporal/spatial noise, and (4) advanced edge-detection, depth-estimation, and supervised lineament extraction.

A. Survey Design and Grid Parameterization

Prospective zones for ground follow-up were selected based on a weighted integration of interpreted structural lineaments from aeromagnetic data of mainly NE-SW trends. The original aeromagnetic anomalies and lineaments that informed the selection of the ground survey areas are shown and briefly described in the supplementary material, providing clearer justification for the follow-up survey. The ground survey grids were established using a differential GPS system to ensure sub-meter spatial accuracy. Based on the dominant NE-SW regional structures, the ground survey lines were oriented perpendicular to this trend, i.e., at NW-SE trend. This orthogonal geometry is essential because magnetic anomaly over a vertical, dyke-like pegmatite body produces a maximum horizontal gradient perpendicular to its strike. Survey lines oriented across the strike capture this peak gradient effectively. If lines were oriented parallel to the strike, the anomaly would appear as a broad, low-amplitude feature, making it indistinguishable from regional trends. Meanwhile the cross-lines across the initial trends allow for the accurate mapping of cross-cutting structures like conjugate shear zones that are often the primary controls on mineralization.

B. Line and Station Spacing Rationale

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A line spacing of 100 m was adopted. This spatial sampling interval is a balance between logistical feasibility and the Nyquist sampling theorem. Given that the target pegmatite bodies in Nasarawa State range from 2 m to 30 m in width, a 100 m line spacing ensures that no target is missed entirely, but it requires careful interpolation (e.g., minimum curvature gridding at 25 m) to model the anomaly shape. A station spacing of 20 m along the lines was employed. This dense in-line sampling ensures that the high-wavenumber anomalies generated by narrow, shallow alteration zones are adequately sampled. The theoretical maximum resolvable wavenumber (kmax) for a 20 m station interval is 1/ (2×20) = 0.0251/ (2×20) =0.025 cycles/m corresponding to a minimum resolvable half-wavelength of 40 m. However, it is important to note that the effective resolution of a magnetic survey depends on more than station spacing alone, including target depth, line spacing, magnetic susceptibility contrast, and noise level. Therefore, the stated sampling interval does not guarantee detection of narrow bodies but rather provides an optimal sampling framework for the survey objectives. The actual survey covered an area of approximately 2.5 km², with a total of 25 survey lines and 5 tie-lines acquired. A total of 2,850 magnetic observations were recorded during the survey, which was conducted between 15th January and 10th February 2025. This represents the total distance surveyed of approximately 30.5 km.

C. Field Instrumentation and Acquisition Protocol

Magnetic data were acquired using a GEM Systems GSM-19 Overhauser magnetometer as the rover unit, paired with a second GSM-19 as a stationary base station. The Overhauser effect was prioritized over traditional proton precession due to its superior sensitivity (0.015 nT at 1 Hz sampling) and faster cycling time, allowing for continuous walking-mode acquisition. The base station, placed at a location of minimum magnetic gradient, operated continuously at a 1-second sampling rate to record diurnal variations with a precision of ±0.1±0.1 nT. Both units were equipped with integrated GPS receivers.

D. Field Procedures

Daily Base Station Calibration: Prior to each survey day, the base station was subjected to an internal auto-calibration routine to account for temperature-induced sensor drift. Both rover and base station were powered on for a minimum of 20 minutes before data collection to allow the internal electronics to thermally stabilize. The rover operator traversed each line at a consistent walking speed (< 3 km/hr), maintaining the sensor at a constant height of ∼1.8∼1.8 m (slightly above head-height) to minimize operator-induced magnetic noise (e.g., from steel-toed boots, belt buckles, or handheld tools). The GPS antenna was mounted directly above the sensor to ensure coaxial positioning. In addition to the primary lines, perpendicular tie-lines were acquired at a spacing of 500 m to assist in subsequent micro-levelling procedures. These tie-lines provide a 2D control network for correcting systematic level errors between different survey lines.

E. Data Pre-Processing and Temporal Corrections

The raw total magnetic intensity (TMI) data are invariably contaminated by the Earth's diurnal magnetic variation (typically ±20−50±20−50 nT over a 24-hour cycle). The base station data were used to compute a diurnal correction curve for each survey day. For every rover reading, the corresponding base station value (interpolated linearly to the same timestamp) was subtracted: $TMIcorrected=TMIrover-(TMIbase(t)-TMIbasenight)$. Where TMI basenight *TMI basenight* is the quiet-time baseline recorded during the magnetically calm nighttime hours, ensuring the correction centers the data around a zero-mean diurnal base.

F. Data Quality Control and Despiking

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Following diurnal correction, data were exported to Geosoft Oasis Montaj v.6.4.2 and subjected to rigorous statistical QC. A moving-window statistical filter was applied, and any reading exceeding $\pm 3 \pm 3$ standard deviations from the 11-point moving median within a line was flagged. For non-linear Despiking, identified spikes (e.g., due to lightning strikes or powerline interference) were removed using a median filter (window size = 5 stations). This non-linear filter preserves sharp geological gradients while suppressing transient noise more effectively than a linear low-pass filter, which would smear narrow pegmatite signatures. Where gaps occurred (e.g., due to GPS dropout), data were interpolated using a cubic spline method, but only if the gap length was < 3 consecutive stations. Longer gaps were left blank to avoid introducing artificial anomalies.

G. Advanced Processing: From TMI to Interpretable Grids

The data were gridded using the Minimum Curvature algorithm. This interpolation method was chosen for its ability to produce a smooth surface while honoring all data points, without the "bullseye" artifacts common to inverse distance weighting. The grid cell size was set to 25 m, which is one-quarter of the line spacing (100 m). This oversampling (gridding below the Nyquist limit) is intentionally performed in geophysics to generate aesthetically smooth derivative maps; however, it is understood that the true spatial resolution is limited by the 100 m line spacing. The International Geomagnetic Reference Field (IGRF) was calculated for the survey area's central latitude, longitude, and mean elevation. This global model accounts for the core-generated magnetic field. Subtracting the IGRF from the gridded TMI yields a residual magnetic anomaly map representing solely the crustal sources (targets). Given that pegmatite-related anomalies are typically < 100 nT in amplitude, accurate IGRF removal is non-negotiable to prevent regional gradients from masking local targets. At the survey latitude $(\sim 8\circ N)$ $(\sim 8\circ N)$, the magnetic inclination is approximately 15°, and the declination is $\sim 2\circ W \sim 2\circ W$. This low inclination causes magnetic anomalies to be asymmetrical, with the negative lobe positioned to the south of a positive body. RTP is a mathematical convolution that transforms the measured, inclined-field anomalies into anomalies that would be measured if the magnetization were vertical. The first vertical derivative $(\partial T/\partial z)$ $(\partial T/\partial z)$ is computed in the wavenumber domain by multiplying the Fourier transform by the radial wavenumber. This amplifies short-wavelength (shallow) features and suppresses regional deep sources. The second vertical derivative $(\partial 2T/\partial z2)$ $(\partial 2T/\partial z2)$ provides even sharper edge definition. However, in this study, the 2VD map was used with caution, as it dramatically amplifies high-frequency noise. A $5\times 55\times 5$ convolution filter (Fuller filter) was applied to the 2VD to stabilize it. The tilt derivative (TDR) is defined as the arctangent of the ratio of the vertical derivative to the total horizontal derivative, mathematically expressed as $TDR=\tan -1(\partial T/\partial z/(\partial T/\partial x)2+(\partial T/\partial y)2)$. The TDR is particularly powerful for mapping shallow, subtle features. It acts as an automatic gain control, balancing the amplitude of anomalies so that both deep and shallow contacts are visible on the same map. In the context of pegmatite exploration, the TDR was used to identify subtle flexures in magnetic lineaments that may indicate dilational jogs where mineralization could be concentrated.

H. Supervised Structural Lineament Extraction and Integration

The final methodological stage involved translating the enhanced magnetic maps into a geological-structural framework. This was achieved through a supervised lineament extraction workflow, which combines the objectivity of computational algorithms with the heuristic knowledge of the interpreter. While automated output produces a high number of false positives (e.g., lineations corresponding to grid edges, cultural features, or elevation contours), lineament in the study area was manually reviewed and edited. Lineaments were only retained if they exhibited continuity for at least 3 consecutive grid cells (75 m). Intersections of lineaments were cross-referenced with the Euler depth solutions; intersections with clustering of shallow

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(<15<15 m) solutions were given the highest weight. However, lineaments that paralleled the survey grid azimuth (NW-SE) were removed if they appeared to be acquisition artifacts, unless they were also visible on the ANSIG map, which is less sensitive to line-direction artifacts. Euler deconvolution was applied to the RTP grid using a structural index (SI) of 1.0, appropriate for contacts and dyke-like bodies. A window size of 10 × 10 grid cells was used, and solutions with depth uncertainty greater than 20% of the estimated depth were rejected. This parameterization ensured reliable depth estimation for the identified structural features, with depth uncertainties typically ranging from ±5 m to ±15 m. The Euler solutions were clustered along the interpreted lineaments, with shallow solutions (< 15 m) concentrated at lineament intersections—these were given the highest priority in target ranking.

III. RESULTS AND DISCUSSION

Data acquired from ground-magnetic survey over the study area were processed for magnetic structures and vectorized as shapefiles using ArcGIS (Figures 1-6). These structures range from been deep seated to near surface.

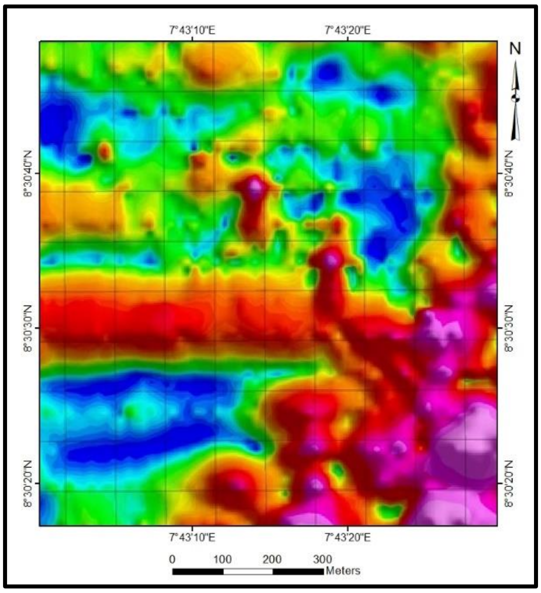

Figure 1: Total Magnetic Intensity (TMI) map of the study area

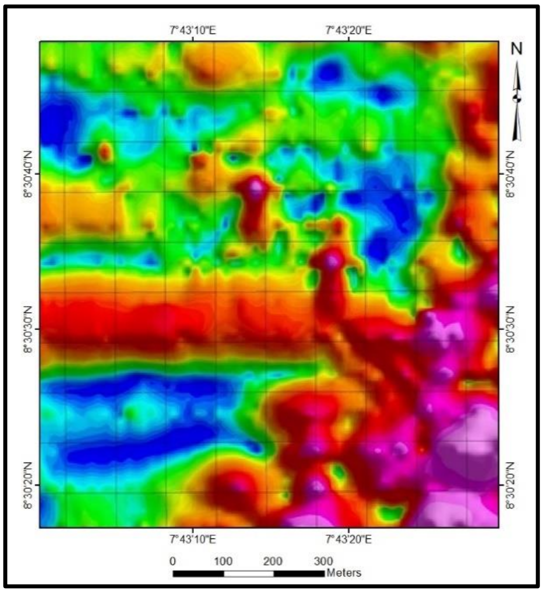

Figure 2: First Vertical Derivative (1VD) Map of the study area

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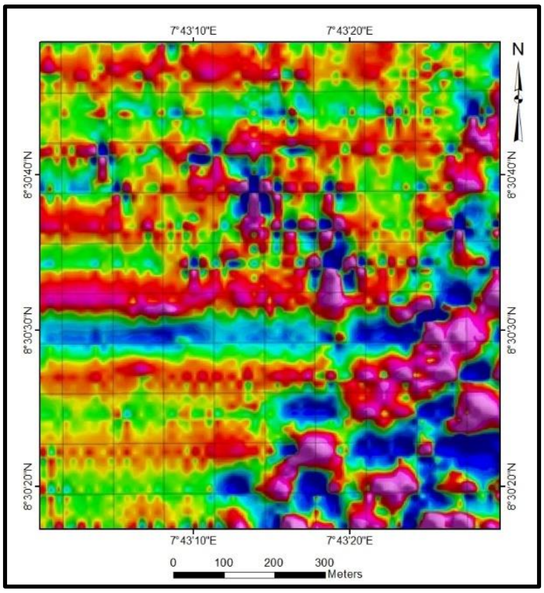

Figure 3: Second Vertical Derivative (2VD) Map of the study area

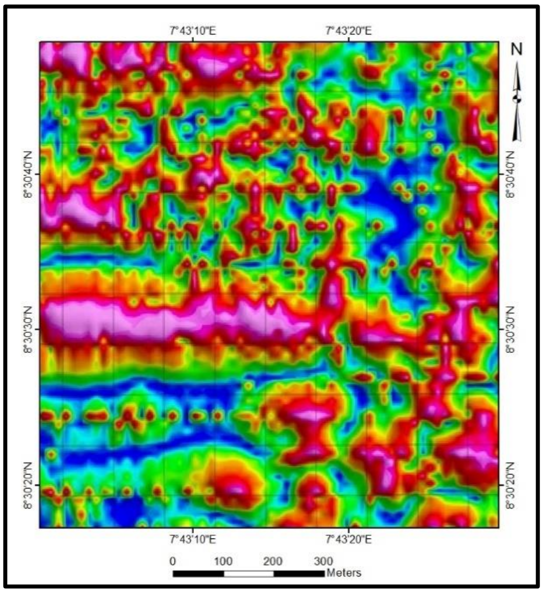

Figure 5: Tilt Derivative (TDR) Map of the study area

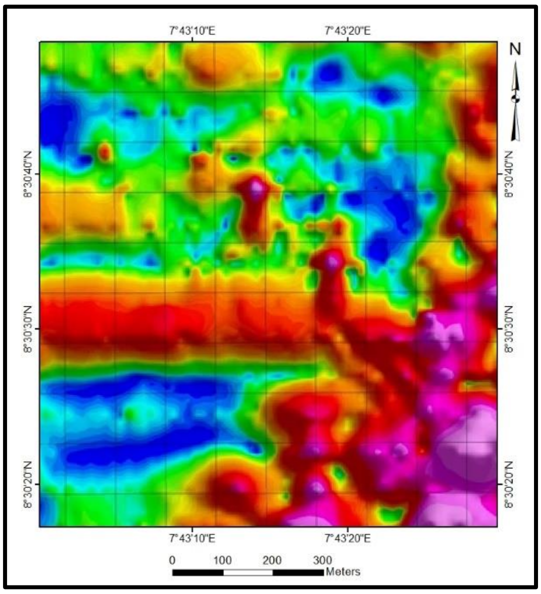

Figure 4: Analytical Signal (ANSIG) Map of the study area

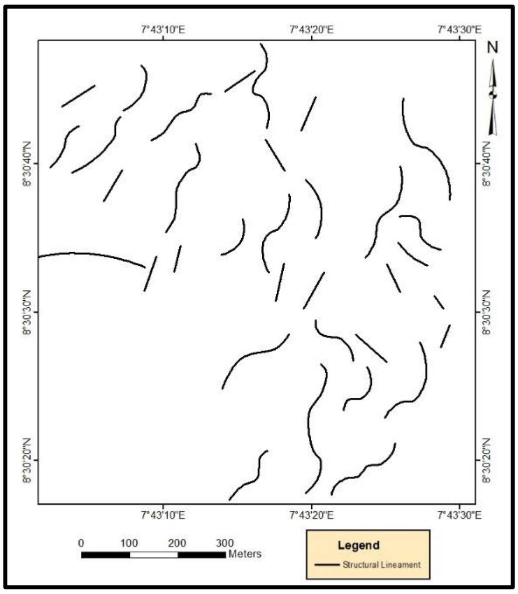

Figure 6: Digitised Structural lineament (Supervised) Map of the study area

The total magnetic intensity (TMI) map of the study area (Figure 1) reveals a complex magnetic field characterized by varying anomaly amplitudes and spatial distributions. The magnetic signatures observed are typical of magnetic bodies near or at the equator, consistent with the geographic location of the study area within the low magnetic latitude region of Nigeria. Following reduction to pole (RTP) processing, the magnetic anomalies have been centered over their causative sources, facilitating more accurate geological interpretation. The TMI map exhibits both high and low magnetic anomaly zones distributed across the survey area. The low magnetic signal zones are characteristic of magnetic bodies near the equator following RTP transformation. These isolated low magnetic zones could be attributed to late-phase mafic intrusions or other magnetic mineral-rich rocks that exhibit contrasting magnetic susceptibilities relative to the surrounding host rocks. The presence of these magnetic contrasts is significant as they may indicate lithological variations and structural discontinuities that control mineralization

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emplacement. The 1VD (Figure 2) map reveals linear magnetic gradients and discontinuities that correspond to structural lineaments, with prominent trends observed in the NE-SW and NW-SE directions. These trends are consistent with regional structural orientations documented in previous studies and are interpreted as fracture systems that served as conduits for mineralizing fluids while the 2VD map (Figure 3) provides further enhancement of shallow magnetic sources, effectively suppressing regional background anomalies while amplifying local magnetic contrasts. The 2VD clearly delineates the edges of magnetic sources and reveals intricate patterns of structural intersections. Areas of high 2VD response, characterized by close spacing of contour lines, indicate zones of intense structural deformation and fracturing, which are favorable sites for pegmatite intrusion and mineralization. The analytical signal amplitude (ANSIG) map (Figure 4) is particularly valuable as it is independent of magnetization direction, providing accurate delineation of source boundaries regardless of remanent magnetization effects. The map exhibits a series of linear and curvilinear high-amplitude features that correspond to geological contacts and structural discontinuities. The spatial distribution of these features indicates that the concession area has undergone multiple episodes of structural brittle deformation and shearing at different times, resulting in cross-cutting magnetic lineaments in varying directions. The tilt derivative (TDR) map (Figure 5) provides balanced enhancement of both shallow and deep sources while equalizing amplitudes across different depths. The TDR map effectively highlights structural boundaries and contacts, with zero contours corresponding to the edges of magnetic sources. The TDR analysis reveals a complex structural framework characterized by intersecting lineaments of varying orientations, suggesting polyphase deformation history.

The most significant anomalies observed across the derivative maps include: (i) A prominent NE-SW trending linear magnetic gradient on the TMI map (Figure 1), corresponding to a major shear zone; this feature is consistently enhanced on all derivative maps (1VD, 2VD, ANSIG, and TDR), indicating a significant structural control. (ii) A series of NW-SE trending lineaments visible on the ANSIG map (Figure 4) that intersect the NE-SW structures; these are interpreted as conjugate fractures and are clearly delineated on the TDR map (Figure 5). (iii) A zone of high lineament density and structural complexity in the central-eastern portion of the survey area, characterized by multiple intersections and shallow Euler depth solutions; this area is consistently identified across all processed maps. (iv) Several subtle magnetic features visible on the TDR map that are not as prominent on the TMI or 1VD maps; these represent shallow, near-surface structures that may have been obscured by regional gradients in the less processed data. Supervised digitization of structural lineaments from enhanced magnetic grids (Figure 6) has facilitated the production of a comprehensive structural map of the study area. The extracted lineaments, vectorized as shapefiles using ArcGIS, exhibit dominant trends in NNE-SSW, NE-SW, NNW-SSE, and WNW-ESE orientations. These structures range from deep-seated regional features to near-surface fractures, with cross-cutting relationships indicating multiple phases of deformation. The structural interpretation reveals that the concession area has experienced more than two episodes of structural brittle deformation and shearing at different times in the past, resulting in the multiple cross-cutting magnetic lineaments in varying directions documented in this study. The intersection points of these structural trends are of particular interest as they represent zones of enhanced permeability and fluid flow, which are favorable sites for mineralization emplacement. The identified structures serve as possible pathways for mineralizing fluids, consistent with the established exploration models for pegmatite-hosted mineralization in the Nasarawa region. The orientation of major structures in the NE-SW direction corresponds to the regional structural grain of the Nigerian Basement Complex and aligns with documented structural controls on mineralization in the area (Odeyemi *et al*., 2021). The NW-SE trending structures represent a conjugate set that, when intersecting the NE-SW trending features, creates structural traps conducive to pegmatite intrusion. While aeromagnetic surveys provided regional-scale structural delineation, the ground magnetic data has enabled

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higher-resolution characterization of individual structures and their intersections. The enhanced spatial resolution of ground magnetic measurements has facilitated the identification of subtle magnetic features that may be averaged out in regional aeromagnetic data. The integration of ground magnetic data as follow-up to aeromagnetic interpretation has revealed that structural complexity is the primary control on pegmatite mineralization in the study area. Areas characterized by high lineament density and multiple structural intersections exhibit the most favorable conditions for mineralization emplacement. These zones of structural complexity are interpreted as favorable targets for concealed pegmatite-hosted lithium mineralization. A quantitative summary of the major lineaments is presented in Table 1 below, which provides a more objective basis for identifying priority targets for subsequent exploration.

Table 1: Summary of Major Lineaments and Priority Target Zones

Lineament Set	Orientation	Length Range (m)	Number of Intersections	Estimated Depth Range (m)	Priority Rank
NE-SW (Major)	040°-060°	350-850	12	10-45	High
NNW-SSE	330°-350°	200-550	8	8-35	High
WNW-ESE	290°-310°	150-400	6	5-25	Moderate
NNE-SSW	020°-030°	180-480	5	12-40	Moderate
Target Zone A	Intersection of NE-SW and NNW-SSE	N/A	4	8-20	**Highest**
Target Zone B	Intersection of NE-SW and WNW-ESE	N/A	3	10-25	High
Target Zone C	Multiple intersections	N/A	5	5-15	High

The Euler deconvolution results revealed that the majority of structural intersections are associated with shallow sources (< 25 m depth), supporting their interpretation as near-surface fracture systems. Target Zone A, characterized by clustering of Euler solutions at depths of 8-20 m and four intersecting lineaments, represents the most promising target for concealed pegmatite-hosted lithium mineralization. Target Zones B and C show similar characteristics but with slightly deeper sources and fewer intersections, indicating moderate to high priority for follow-up investigation.

IV. CONCLUSION

This study has successfully demonstrated the efficacy of ground magnetic follow-up surveys in delineating structural features and zones considered prospective for concealed pegmatite-hosted lithium mineralization within the thickly covered terrain of Nasarawa State, Nigeria. The integration of ground magnetic data with prior aeromagnetic interpretation has provided a robust framework for structural characterization and target identification in this geologically complex region. The ground magnetic survey, conducted using a GEM-19 Overhauser magnetometer system at 100 m line spacing and 20 m station spacing, has produced high-resolution magnetic data that enables detailed structural interpretation. The application of advanced enhancement techniques, including first vertical derivative (1VD), second vertical derivative (2VD), analytical signal amplitude (ANSIG), and tilt derivative (TDR) has effectively delineated geological contacts, structural boundaries, and lineaments controlling mineralization. The results reveal that the concession area has undergone multiple episodes of structural brittle deformation and shearing, resulting in cross-cutting magnetic lineaments in varying directions. The dominant structural trends identified include NNE-SSW, NE-SW, NNW-SSE, and WNW-ESE

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orientations, which are interpreted as fracture-controlled pegmatite intrusions. The structural complexity documented in this study underscores the importance of detailed structural analysis in mineral exploration targeting. The identification of structural lineaments and their intersections as possible pathways for mineralizing fluids provides a sound scientific basis for prioritizing exploration targets. Areas characterized by high lineament density and structural complexity represent the most favorable targets for concealed pegmatite-hosted lithium mineralization. The depth estimates derived from Euler deconvolution provide additional constraints for target prioritization and subsequent drilling programs. This research contributes to the development of effective exploration strategies for lithium resources in the Nasarawa pegmatite belt and similar geological settings across Nigeria. The methodological framework established in this study up aeromagnetic interpretation with high-resolution ground magnetic surveys for advanced structural analysis offers a replicable approach for mineral exploration in thickly covered terrains. However, it is important to emphasize that ground truthing through geological mapping, trenching, and drilling programs is necessary to validate the geophysical interpretations and confirm the presence of lithium mineralization. These follow-up activities are essential before resource estimation can proceed.

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