

Deep Learning-Driven Integration of Aeromagnetic and Radiometric Data for Mineral Prospectivity Mapping in the Abakaliki Region, Southeastern, Nigeria

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The Abakaliki area of Ebonyi State, situated within the Lower Benue Trough of southeastern Nigeria, is renowned for its intricate structural framework and substantial mineral potential, particularly for base metals and associated mineralization. This study presents a novel integrated interpretation of aeromagnetic and radiometric data to delineate structurally controlled and alteration-related mineral zones across the Abakaliki region.

Aeromagnetic data were processed to obtain reduced-to-pole and residual magnetic anomaly maps, from which analytic signal amplitude (ASA), tilt derivative, and total horizontal derivative (THDR) were derived to enhance fault structures and lithologic boundaries. Spectral radiometric data (K, U, Th) were processed to generate ternary composites and alteration-sensitive ratio maps (K/Th, U/Th) for identifying hydrothermal alteration signatures.

To enhance the detection of subtle anomalies, the Analytical Hierarchy Process (AHP), a decision-making framework that considers multiple criteria to structure complex problems, and a Deep Learning algorithm (Convolutional Neural Network (CNN) were developed to classify and predict high-prospectivity zones using combined aeromagnetic-radiometric attributes. Euler deconvolution and spectral depth analyses were employed to validate the depth and geometry of the anomalous sources.

The study reveals strong spatial correlations among magnetic lineaments, radiometric enrichments, and predicted mineralization zones, confirming the effectiveness of the Deep Learning a data-driven processing workflow. This approach offers a reproducible, data-driven framework for mineral exploration in the Abakaliki region of Nigeria and similar underexplored terrains worldwide.