Deep Learning-Based Prediction of Structural Lineaments from Aeromagnetic Data for Groundwater Exploration in Crystalline Basement: Case Study in the Ouagadougou Sheet, Burkina Faso

(oral presentation)

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ABSTRACT

Failure rates of boreholes remain particularly high within the West African Craton. In Burkina Faso, where this geological setting covers approximately 80% of the national territory, failure rates reach up to 40%. Drilling site selection relies primarily on lineament analysis supplemented by ground-based geophysics, typically limited to 1D soundings. However, lineament identification techniques remain highly subjective, depending strongly on operator experience, image quality, and chosen enhancement methods. Likewise, the 1D geophysical approaches used to validate interpreted structures can be misleading, especially in contexts where complex weathering profiles produce ambiguous geophysical signatures. The diversity of satellite derived products further limits the reproducibility of extraction workflows, while the considerable thickness of weathered layers frequently masks deeper tectonic structures, reducing the effectiveness of conventional strategies. To overcome these limitations, this study proposes an objective and reproducible approach for predicting structural lineaments using deep learning, based on aeromagnetic derivatives covering the one-degree square of Ouagadougou. We develop a ResUNet++ type model tailored for deep segmentation, integrating advanced multiscale feature extraction modules, residual blocks, and attention mechanisms to capture more effectively the magnetic patterns associated with fractures, tectonic contacts, and alteration zones. This architecture is particularly suited for crystalline basement environments, where structural contrasts are subtle and discontinuous. We trained the model on paired patches of aeromagnetic imagery and validated magnetic lineaments serving as ground truth labels, ensuring a direct correspondence between magnetic anomalies and mapped structures. It demonstrates excellent performance on an independent test set, with an F1 score exceeding 0.93 and an area under the ROC curve close to 0.98. These results indicate consistent segmentation despite strong class imbalance, with high precision (0.9815) and satisfactory recall (0.8866), reflecting a conservative behavior that limits false positives and improves interpretative reliability. Overall, this approach provides an objective framework for mapping deep structural features and strengthens the value of aeromagnetic data for groundwater exploration. It offers promising perspectives for improving borehole targeting beyond the conventional depths of 80–100 m in crystalline basement regions of West Africa, where locating productive aquifers remains a persistent challenge.

Keywords: Aeromagnetics, Structural lineaments, Deep learning, Deep aquifers, Burkina Faso