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CNN-Assisted Depth Estimation and Structural Interpretation in Marcelândia, Alta Floresta Gold Province

Gabriel Santos (UFPA), Daniel Leal Souza (Postdoc), José Frank Vanzeler Gonçalves (UFPA), Saulo S. Martins (UFPA)

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Introduction

The Alta Floresta Gold Province (AFGP), part of the Juruena-Teles Pires tectonic domain in the southwestern Amazonian Craton, exhibits a complex geological framework composed of Paleoproterozoic granitoids, metavolcanosedimentary sequences, and structurally controlled gold mineralization. Aeromagnetic surveys—based on magnetic potential methods and rock susceptibility—offer critical insights into subsurface structures in this setting. This study targets the Marcelândia region (sheet 1121, Geological Survey of Brazil – SGB/CPRM) as a representative area. We apply a convolutional neural network (CNN)-based methodology to detect and estimate the depth of magnetic lineaments, aiming to identify features such as dikes, faults, and intrusions linked to mineralizing processes.

Materials and Methods

To integrate geophysical and geological interpretation using a machine learning approach, we applied a workflow based on CNNs for structural segmentation and depth estimation. The aeromagnetic dataset, representative of the AFGP, was processed to generate the tilt derivative, which enhances magnetic lineaments. This enhanced grid was then analyzed using a pre-trained CNN with a 21×21 sliding window, estimating the probability of structural features across five depth ranges (0–25 m to $>$226 m), including areas without lineaments.

The resulting probability maps were combined into an RGB image, with blue, green, and red representing shallow, intermediate, and deep features. DBSCAN clustering was used to isolate coherent structures to refine geological interpretation, and Principal Component Analysis (PCA) extracted dominant orientations. These were summarized using rose diagrams to identify structural trends associated with potential mineralized zones.

Results and Conclusions

The CNN-based analysis successfully identified structural lineaments at three depth intervals: shallow (0–75 m), intermediate (75–150 m), and deep ($>$150 m). Most detected features were concentrated in the shallow and intermediate ranges, revealing significant near-surface structural complexity. The RGB composition highlighted clear structural compartmentalization across the study area, allowing the visualization of lineament distributions with depth. Clustering and PCA revealed a predominant W–E structural trend. This dominant orientation is consistent with known regional deformation patterns and may reflect reactivation of conjugate shear zones.

These results demonstrate the effectiveness of integrating aeromagnetic data with machine learning techniques for structural interpretation. The identified structural trends and their depth distributions offer valuable insights into the tectonic evolution and potential mineralized zones within the AFGP.