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Research Paper

Comparison of the Performance of Different Deep Learning Architectures for Multi-Source Data Integration in Porphyry Copper Deposit Exploration

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***Abstract*:** Mineral prospectivity mapping aims to delineate zones with high probabilities of hosting undiscovered mineralisation. In regions with complex geology, it requires the intelligent integration of diverse geoscience datasets such as geology, remote sensing, geochemistry, and geophysics. Recent advances in deep learning offer powerful tools for fusing large, multi dimensional datasets and capturing non linear relationships that conventional statistical models struggle to handle. This study develops and evaluates a suite of convolutional neural network (CNN) based segmentation models for predicting porphyry copper mineralisation potential in the Pariz and Chahargonbad districts of the southwestern Kerman Province, Iran, a segment of the Urumieh–Dokhtar magmatic arc hosting numerous porphyry copper deposits. Five U Net architectures with pre trained backbones (ResNet50, MobileNetV2, EfficientNetB0, VGG16, and DenseNet121) were trained on eleven normalised indicator layers: one geochemical anomaly map derived from 1 238 stream sediment samples using a deep autoencoder, distance and density maps of faults, presence and distance maps for phyllic, argillic, and propylitic alterations extracted from PRISMA hyperspectral imagery with a V Net classifier, and presence/distance maps for intrusive bodies. To address severe class imbalance, the training employed focal loss and balanced mini batches, and large images were subdivided into patches. Model performance was assessed using 39 known mineral occurrences, buffered by 100 m to account for positional uncertainty, with a 70/30 train/test split. The DenseNet121 U Net achieved the highest individual performance (AUC ≈ 0.900), while an ensemble of all models offered comparable robustness. The resulting prospectivity map agrees well with known mineralised zones and highlights a previously unrecognised target in the southwest of the study area. These results demonstrate that deep CNNs are effective tools for integrating heterogeneous exploration data and improving mineral prospectivity mapping.

Keywords: Deep learning, Mineral potential mapping. Unet, Porphyry copper deposits, Unet backbones.

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