

Predictive Analysis of Hydrothermal Alteration Haloes by Integrating X-Ray Diffraction (XRD) with Remote Sensing-Based Machine Learning Algorithms in the Gabal Monqul area, Egypt

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Owing to limited outcrop exposure and intricate alteration processes, investigation in dry areas like Eastern Desert of Egypt is still challenging. The current study addressed these challenges by integrating X-ray diffraction (XRD) mineralogical data with multispectral remote sensing data to elucidate the occurrence of gold-bearing sulfide dissemination in the Gabal Monqul area (Eastern Desert, Egypt), interpreting the hydrothermal alteration haloes as indicative of porphyry-style mineralization. Cu-sulfide (+Au) mineralization in the study area is associated with various alteration zones within porphyritic biotite granite, and its contact with arc metavolcanic meta-andesite and Dokhan Volcanic dacite.

Representative samples of the altered rocks were analyzed for mineral composition using XRD to assess phase composition, structure, and microstructural features. Remote sensing-based machine learning algorithms (MLAs) have been used to enhance geological mapping and facilitate the localization of significant minerals by overcoming the traditional mapping obstacles.

Regarding geological mapping, both support vector machines (SVMs) and maximum likelihood classifications (MLCs) have displayed various degrees of efficiency. Notably, the MLC-classified image from ASTER had the highest Kappa coefficients (0.8093), thereby indicating the efficiency of the MLC learning algorithm in improving the accuracy of geological maps. Furthermore, the independent component analysis (ICA) method has proven to be particularly effective for discriminating between different mineralization types and delineating hydrothermal alteration patterns. It's to identify Fe-oxide zones in the Dokhan Volcanic, Hammamat Sediments, and porphyritic biotite granite, as well as granodiorite, highlighting its utility in characterizing complex geological features.

XRD data indicate that granodiorite and porphyritic biotite granite, along with Dokhan Volcanic and Hammamat Sediments exhibit propylitic alteration type. While phyllic alteration is mostly encountered in porphyritic biotite granite and granodiorite. A carbonate alteration zone locally occurs within the contact between the arc metavolcanic and porphyritic biotite