Machine Learning Approach to Automated Mineral Identification from RGB Reflected Light Microscopy

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This study assesses the performance of common machine learning (ML) methods in classifying mineral phases in reflected light microscopy imagery. Mineralogy, modal composition, and classified maps are generated from pixel-based analysis of RGB inputs from petrographic image data generated using a Zeiss Axioscan 7 Geo. Methods are divided into unsupervised clustering and supervised classification approaches to quantify efficacy and workflow requirements. Methods tested include k-means clustering, k-nearest-neighbor, and random forest supervised classification. Unsupervised k-means optimization is based on within-cluster sum-of-squared distance. Supervised methods are trained on 107 single-mineral phase cropped image patches. Target mineral phases include pyrite, chalcopyrite, bornite, chalcocite/digenite, magnetite, hematite, titanite, and a silicate background class to isolate opaque phases. Samples are sourced from the Red Chris and Lorraine porphyry deposits. Training data is generated using conventional reflected light petrography to determine mineral phase and validated with overlaid mineralogy maps from energy dispersive spectroscopy (EDS) generated from automated scanning electron microscopy (SEM). The training data is then generated as single-phase, homogeneous patches cropped from whole samples. Method success is evaluated using pixel-level assessment of reserved patches for testing (80-20 split) to quantify accuracy. K-Means demonstrates a viable means for quickly assessing the number of mineral phases present, while random forest provides the addition of target mineral detection, modal abundances, and labelled mineralogical maps.

By leveraging the convenience of standard petrographic analysis with the scalability of ML algorithms, reflected light imaging offers a rapid and cost-effective means of quantifying opaque mineral assemblages and modal abundances through pixel-based classification. This approach utilizes petrographic thin sections and digital microscopy to quantitatively classify opaque minerals, avoiding the expense and specialty equipment needed for SEM automated mineralogy. In contrast to labour intensive techniques such as point counting and manual petrographic review, ML analysis is a rapid alternative for high-throughput and field-adjacent mineralogical assessments.