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Relating altered rocks to equivalent protoliths using clustering and classification of geochemical data at the Minto copper-gold mine, Yukon, Canada

Shawn B Hood*, Matthew J Cracknell

*ARC Industrial Transformation Research Hub for Transforming the Mining Value Chain (TMVC) at the ARC Centre of Excellence in Ore Deposits (CODES), Hobart, Australia, Tasmania, Email: Shawn.Hood@gmail.com

Linking protolith rocks to their equivalent altered counterparts in mineral deposits facilitates interpretation of original rock geometry and computing relative mass changes during metasomatism. However, deducing such relationships becomes elusive when dealing with very large databases of geochemical data; identifying sample pairs for altered and unaltered equivalents is challenging, correlations between elements may not be intuitive, and large amounts of data are laborious to interpret manually. Machine learning offers potential solutions to problems involving large numbers of data, many variables or features, and complicated relationships between variables.

Here we present a workflow to process a whole rock geochemical dataset and produce labels for groups of similar least-altered protolith rocks, and then apply these labels to groups of altered rocks. Protolith samples were clustered using K-Means, a technique that involves partitioning n observations into K clusters such that each sample is associated to the cluster belonging to the nearest mean. This clustering approach is analogous to visually assigning samples to groups based on X-Y geochemical plots, e.g., granite AFM diagrams that geologists commonly use. The advantage of K-Means clustering is that many variables can be considered simultaneously. Altered samples were classified using Random Forests, a supervised classification algorithm, based on the cluster results for the protoliths groups.

This approach allows the rapid association of altered samples to their likely corresponding protolith. Interpreting the results gives insight into original protolith geometry, and undertaking further processing can improve the understanding of chemical changes during alteration. Generating and spatially interpreting results took only a few hours, including QaQc and trialling different pre-processing approaches, and was completed without costly geochemical software. Cross section interpretations of protolith geometry, i.e., before ore deposit formation, has an added benefit of lithology label confidence measures from Random Forests.

The motivation of this workflow is to assist geologists working with large drillhole datasets including geochemical information and manual logging information. A common task during exploration is to provide interpretations of site geology, and information about the effects and spatial extent of alteration related to mineralisation. These, in turn, give exploration and mining teams a basis for understanding the potential role of original rock geometry controls on the location of ore, or hallmarks of enveloping alteration zones. The aim of this workflow is to provide a high-speed approach to processing drillhole information that is reproducible and objective. However, the method is not intended to be a “black box”, and carefully selection of samples and consideration of results by a geologist is still required.