Improved Porphyry Alteration Models Using Hyperspectral Mapping of Core: The Importance of Mica Abundance, Chemistry, and Crystallinity

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Detailed mapping of mica abundance, chemistry, and crystallinity via hyperspectral core imaging reveals spatial distributions, transitions, paragenetic relationships, and assemblages not previously identified and mapped in copper porphyry. General chemistry and crystallinity of major mica classes (white mica, chlorite, biotite) and their relationship to copper (and gold) mineralization are well known in relation to accepted porphyry formation models. However, the fine spatial and spectral fidelity afforded by modern hyperspectral core imagers (~0.5 mm and 4 nm, respectively) coupled with recent textural classification developments (~150,000 pixels per meter of imaged core surface) results in a modified understanding of typical porphyry alteration zonation, assemblages, and paragenesis.

This work focuses on the exploration-phase Copper Basin porphyry system in central Arizona. Approximately 1,137 m of cut core from seven separate boreholes was scanned using a mobile, automated, hyperspectral core logging system. Three sets of measurements were made including digital photography (0.05 mm), hyperspectral imaging (0.5 mm), and laser profiling (0.02 mm). All three datasets are spatially coregistered and linked to absolute core depths. The hyperspectral data was analyzed for mineralogy. Twelve distinct minerals and several subspecies of mineral classes including chemical and crystalline variation within white mica, chlorite, carbonate, and biotite were identified and mapped. Distinctive alteration assemblages are identified that correspond not only to mineralization (as measured by coregistered fire assay data), but also to type lithology. The white mica + kaolinite ± montmorillonite and the chlorite + phlogopite assemblages are the main identified suites for the analyzed core at Copper Basin. Though typical for porphyry, it is the chemical and crystallinity variation, particularly within the mica species, that reveals new patterns and correlations.

We analyzed in detail the spectral variation that correlates to known lithology, alteration, and mineralization in an attempt to refine exploration models. In particular, we focused on the spatial distribution of iron-rich minerals and mineral subspecies, including biotite-phlogopite and the iron-bearing white mica (phengite) and chlorite (chamosite). When compared with copper assay (over 1-m intervals), a number of correlations are revealed. At a larger scale, the chlorite + phlogopite assemblage is highly correlated to copper mineralization as well as higher iron chemistry (phengite + chamosite). Application of white mica ternary diagrams (where white mica abundance, chemistry, and crystallinity) to hyperspectral image data reveals more fine-scale variability where pervasive versus veined textures are mapped and correlate in certain parts of the project to higher copper assay. In addition, highly abundant, highly crystalline, iron-rich white micas, whether in veins or more pervasive, correlate best to higher copper assay.

These detailed mineralogical maps not only inform exploration models (based on limited greenfields drilling and/or step-out drilling from defined resource), but will also add to required mineralogical data input at future mine planning stages.