Epidote Trace Element Chemistry as an Exploration Tool: El Teniente Porphyry Cu-Mo Deposit Case Study

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A common feature of many deeply eroded porphyry and epithermal deposits is the presence of laterally extensive (up to 5–10 km wide), zoned hydrothermal alteration halos. Where these deposits are hosted in volcanic and igneous terranes, epidote is a commonly occurring and easily recognizable mineral within the hydrothermal alteration halo. The propylitic alteration halo surrounding the giant El Teniente porphyry Cu-Mo deposit in central Chile is no exception.

The intensity of propylitic alteration of the El Teniente host rocks is proportional to their proximity to mineralizing intrusions. However, this spatial relationship has been complicated by multiple intrusive events that have produced a number of coalescing ore shells and associated alteration halos. Near the inferred center of mineralization (<1 km), propylitic alteration is characterized by intense epidote-actinolite–dominated, replacement-style textures with lesser amounts of magnetite, pyrite, and chlorite. Pyrite-rich veins are also common. Approximately 1 to 2 km from the deposit center, alteration is dominated by extensive epidote-chlorite-quartz-hematite ± albite-calcite-anhydrite vein networks and patchy epidote- and epidote-chlorite–dominated replacement textures. Farther away from the deposit (>2 km), alteration is characterized by moderate to weakly disseminated and replacement chlorite ± epidote-hematite assemblages. Distal propylitic alteration of Farellones Formation andesites and diorites (up to approx. 7 km west and 4–5 km south of El Teniente) has produced hematite-chlorite assemblages.

Our rock chip sampling, conducted as part of AMIRA international research project P765A, detected Cu and Mo anomalism up to ~3 km laterally from the inferred center of porphyry-related mineralization at El Teniente. Anomalous concentrations of Pb and Zn in rock chip sampling also extend laterally to distances of ~2.5 km. However, other trace metals such as As and Sb do not show anomalous values in whole-rock geochemistry. In contrast, propylitic epidote is significantly enriched in As, Sb, and Pb. As and Sb concentrations in epidote are generally greater than 250 and 100 ppm, respectively, and are detected between 0.9 and 4.5 km from the deposit center. Significantly, these peak concentrations were obtained from rock chip samples that contained, on average, less than 200 ppm As and 5 ppm Sb. Hydrothermal epidote is also enriched in several other trace and minor elements relative to whole-rock concentrations. These elements include Mn, Sr, V, and Bi. There is also variable enrichment in the rare-earth elements La, Ce, and Yb relative to whole-rock geochemical analysis, particularly near the deposit center. Our mineral chemical study of hydrothermal epidote at El Teniente has shown that mineral chemistry analyses can be used to effectively identify the geochemical footprint of the deposit, beyond the limits of conventional rock chip analyses.