SEG-MJD 2016 Conference

Mineralogy and Geochemistry of Hydrothermal Alteration Zones in the Sungun Porphyry Cu-Mo Deposit, Northwestern Iran, Tethyan Metallogenic Belt: Footprints for Porphyry Copper Exploration

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The Sungun porphyry Cu-Mo deposit is located in the northern Urumieh-Dokhtar magmatic arc, northwestern Iran, Tethyan metallogenic belt. The Cu-(Mo) mineralization at the Sungun deposit is associated with Oligocene quartz diorite to quartz monzonite porphyry stocks intruded within Eocene volcanic rocks and Cretaceous sedimentary carbonate rocks.

Four distinct types of hypogene alteration zones passing away from the central potassic, phyllic, argillic, and peripheral propylitic zones are recognized in the Sungun deposit. Copper mineralization is accompanied mainly by intense phyllic and potassic alteration zones. The common mineral assemblage within the central potassic zone consists of secondary biotite, K-feldspar, quartz, sericite, pyrite, chalcopyrite, molybdenite, bornite, magnetite and, to a lesser extent, anhydrite and rutile. The enrichment in K, Cu, and Mo and depletion of Na, Ca, Mn, Mg, and Fe are correlated with the occurrence of disseminated chalcopyrite, bornite, and vein molybdenite and the replacement of plagioclase and hornblende by K-feldspar and biotite, respectively. The medial phyllic alteration is characterized by sericite, quartz, pyrite, clay minerals ± gypsum assemblages. This zone was accompanied by enrichment in Cu, Mo, and Si and depletion of Na, K, and Fe, which reflect the formation of chalcopyrite, molybdenite, and quartz, together with the sericitization of alkali feldspar and destruction of ferromagnesian minerals. The propylitic alteration is characterized by chlorite, epidote, albite, calcite, sericite, quartz, and clay mineral assemblages, reflected by enrichment in Ca, Si, and Fe and depletion in Na, K, and Mg. The outer argillic zone is represented by kaolinite, illite, and montmorillonite minerals that substitute for the plagioclase and mafic minerals in andesite and tuff, which correlated with the enrichment in Al and Na and depletion of Fe, Mg, and Ca.

Mineral compositions were determined on hydrothermal biotite, sericite (muscovite), chlorite, and illite from various alteration halos. Within the intense phyllic alteration zone, the K/(K + Na + Ca) ranges from 0.0 to 0.75, indicating the replacement of darker, Na-rich mica by the lighter, more K rich mica along grain boundaries in BSE images. Sericite (muscovite) from both phyllic and phyllic-argillic alteration zones is mainly phengitic in Al vs. Fe + Mg + Mn and Al vs. K + Na + 2Ca compositional variation diagrams. Most chlorite grains represent minor amounts of K + Na + 2Ca (<0.02) apfu. Both Fe- and Mg-bearing chlorites are associated with hematite-bearing samples. Potassic and phyllic alteration zones are enriched in Cu, Mo, As, Sb, Bi, Se, Te, Li, Sn, and W. Copper, Mo, Te, Se, and Bi are commonly below the detection limit and rarely detected in biotite, sericite, and chlorite. The enrichment in W, Sn, and Ti is correlated to high abundances of sericite (muscovite) and illite within phyllic and argillic zones. Li enrichment is attributed to increased concentrations of chlorite in the propylitic alteration zone. The depletion of Pb, Zn, Ni, Co, Cr, Mn, V, and Sc in biotite, sericite, and illite is correlated to the redistribution of those elements within the peripheral propylitic zone.

Therefore, the detection of trace element gradients in altered rocks and mineral chemistry are potentially valuable vectoring tools for porphyry copper exploration.