Highway to Grade: The Importance of an Early Quartz Vein Stockwork for Channeling Late Ore-Bearing Fluids While Favoring Sulfide Precipitation

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At the Radio Cu-Au-(Mo) porphyry deposit, located three kilometers west of the Altar Cu-Mo-(Au) porphyry (San Juan, Argentina), mineralization is closely associated with a dense quartz vein stockwork. Copper-Fe sulfides are mainly observed within A- or B-type veins or disseminated along the vein periphery, as well as within quartz UST layers in the core of the system, whereas molybdenite occurs exclusively within B-type veins.

Conventional petro-chalcographic studies and cathodoluminescence (CL) imagery indicate that Cu-Fe-Mo sulfide precipitation within quartz veins (and UST) post-date volumetrically dominant first-generation barren quartz veins. Moreover, Cu-Fe and Mo sulfides are associated with a second fine-grained quartz generation that is commonly accompanied with variable amounts of chlorite, calcite, sericite, anhydrite, and/or hematite, typically filling cracks, bands, centerlines, and/or interstitial spaces between the first-generation quartz, reflecting a multi-episodic vein formation.

Microprobe titanium (Ti) analyses support these observations, considering that Ti concentrations are positively correlated with CL bright intensity and temperature of quartz formation in several porphyry deposits. The first-generation quartz unrelated to ore from UST layers and A- and B-type veins is characterized by bright-CL quartz, with Ti concentrations varying from 100 to 180 ppm, 50 to 140 ppm, and 55 to 150 ppm, respectively. In contrast, the second-generation quartz bearing Cu-Fe sulfides and molybdenite possesses lower Ti concentrations—35 to 65 ppm and 10 to 30 ppm, respectively—and is characterized by dull-CL quartz with wavy growth zonation.

The early development of a quartz vein stockwork may be analogously compared to a network of "highways." As quartz undergoes thermal contraction during cooling and partial dissolution as it reaches its area of retrograde solubility, it enhances the vein permeability, eventually channeling later ore-bearing fluids, while favoring the generation of spaces for sulfide precipitation.