Fluid inclusion and optical cathodoluminescence properties of quartz from the Santa Rita porphyry deposit, New Mexico

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Porphyry copper deposits represent one of the world's most important source of copper, with precious metals commonly being recovered as by-products. Hypogene ores in these deposits are comprised of large, low-grade stockwork and disseminated sulfide zones that are spatially associated with shallowly emplaced plutonic stocks and dike swarms. The stockwork zones in porphyry deposits are composed of multiple cross-cutting vein generations that differ in morphology, vein mineralogy, and associated alteration. The present contribution reports on the results of a microanalytical study that was performed to further establish the ore-forming processes in the porphyry environment. This study, integrating optical microscopy, fluid inclusion investigations, optical cathodoluminescence (CL) microscopy, and electron microprobe analysis, focused on samples from the Santa Rita porphyry deposits in New Mexico. The earliest veins at Santa Rita are composed of vitreous quartz surrounded by potassic alteration of the host rocks. Two generations of hydrothermal quartz can be distinguished in these veins. Early quartz (Q1) is characterized by bright blue/purple CL colors and shows high concentrations of Ti. This early quartz is overprinted by rare quartz (Q2) showing darker CL colors and generally lower Ti concentrations. Both quartz types contain abundant hypersaline liquid and vapor inclusions. The early vitreous quartz veins are crosscut by chalcopyrite-pyrite veinlets that are surrounded by K-feldspar+chlorite alteration selvages. The chalcopyrite+pyrite veins contain subordinate amounts of Q2, which clearly formed prior to the chalcopyrite and pyrite. CL imaging revealed that sulfide grains commonly crosscut primary growth zones in the quartz, suggesting that mineralization was accompanied by the dissolution of the earlier formed Q2. The quartz crystals are crosscut by secondary trails of intermediate-density fluid inclusions that show negative crystal shapes. Fluid inclusion microthermometry revealed that these fluid inclusions homogenize at around 400°C through critical or near-critical behavior. The inclusions exhibit two-step ice melting during freezing runs. These results indicate that the inclusions have a critical or near-critical density and contain significant amounts of CO_2. It is hypothesized here that ore formation at Santa Rita occurred from this intermediate-density fluid, not the earlier fluids that experienced phase separation at high temperatures.