Characterization of Epithermal Quartz Veins by Scanning Electron Microscope-Cathodoluminescence and Laser-Ablation Inductively-Coupled Mass Spectrometry

Jaime Campo,[1*] Brian Rusk,[1] and Mark Simpson[2]

[1]Western Washington University, Bellingham, WA 98225
[2]Wairakei Research Centre, RD4, Taupo, New Zealand 3384

*E-mail, campoj@students.wwu.edu

Quartz plays an important role in unraveling the history of a hydrothermal ore deposit, due in part to its resistance to weathering, chemical simplicity, and stability across a broad range of temperatures. Each subsequent quartz generation reflects the physio-chemical conditions of hydrothermal fluids during mineral precipitation. The application of scanning electron microscope-cathodoluminescence (SEM-CL) reveals microtextures not observable by other petrographic techniques, reflecting concentrations of intrinsic and extrinsic crystal lattice defects often related to the incorporation of trace elements. We analyzed samples for CL textures and trace element concentrations determined by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) from four low-sulfidation epithermal ore deposits in New Zealand. Chosen samples include the Karangahake, Favona, Tokatea, and Broken Hills ore deposits, representing various depths in epithermal systems from ~100-400m.

The incorporation of trace elements into quartz is primarily governed by temperature. Successful application of the Ti in quartz thermobarometer is dependent on the predictable relationship between Ti concentrations in quartz and temperature of deposition. Ti and Al correlate strongly with CL intensity in quartz. Ti shows a strong positive relationship and Al showing a variable positive or negative relationship with CL activity. The interaction between Al and CL activity is highlighted in epithermal quartz, as Ti concentrations are typically below level of detection (LOD).

SEM-CL images, photomicrographs, and backscattered electron (BSE) images are used in conjunction to find the purest regions of quartz possible to sample. We analyzed for elements typically found in trace element concentrations in quartz including Ti, Al, Li, K, Na, Ca, Fe, Sb, and P. B, Be, Ge, Ga, Sn, Ba, Cs, Ag, Sr, Rb, and As were included in the analysis as well.

Al concentrations were found to be the greatest, ranging from 1000-4000 ppm. Li, Na, Fe, and K range in concentration from a few ppm up to 300ppm. Ge, Ga, Sn, Sb, Ag, and As appear in quantities of a few ppm or less. No distinct trends have been found between the different ore deposits, but population groupings appear in Al, Li, Ga, Ge, Sb, and As. Trends become evident within samples, such as Tokatea TK24, which was found to decrease in Sb from 60ppm to <5 ppm while increasing to maximum values of Al, Li, and Ge over time. Although the TitaniQ thermobarometer is not calibrated for the low pressures and temperatures of epithermal quartz, Ti concentrations of <1 ppm are consistent with low temperatures (<300^{o}C) of formation.

CL textures observed in samples include chalcedonic banding, spheroidal texture, bladed growth, feathery texture, and oscillatory zoning in euhedral comb quartz textures. CL textures, intensity, and spectral wavelength may vary drastically between quartz generations. Comb quartz typically shows a homogenous distribution of bright CL intensity and may exhibit oscillatory zoning, reflecting periods of rapid growth into open space. Periods of slow growth result in CL weak or CL absent textures and typically contain more contaminants. No direct link between textures or CL patterns has been noted, however, the Karangahake sample showed a disturbance in CL patterns immediately surrounding pyrite.