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Intensity of quartz cathodoluminescence and trace-element content in quartz from the porphyry copper deposit at Butte, Montana

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Abstract

Textures of hydrothermal quartz revealed by cathodoluminescence using a scanning electron microscope (SEM-CL) reflect the physical and chemical environment of quartz formation. Variations in intensity of SEM-CL can be used to distinguish among quartz from superimposed mineralization events in a single vein. In this study, we present a technique to quantify the cathodoluminescent intensity of quartz within individual and among multiple samples to relate luminescence intensity to specific mineralizing events.

This technique has been applied to plutonic quartz and three generations of hydrothermal veins at the porphyry copper deposit in Butte, Montana. Analyzed veins include early quartz-molybdenite veins with potassic alteration, pyrite-quartz veins with sericitic alteration, and Main Stage veins with intense sericitic alteration. CL intensity of quartz is diagnostic of each mineralizing event and can be used to fingerprint quartz and its fluid inclusions, isotopes, trace elements, etc., from specific mineralizing episodes. Furthermore, CL intensity increases proportional to temperature of quartz formation, such that plutonic quartz from the Butte quartz monzonite (BQM) that crystallized at temperatures near 750 °C luminesces with the highest intensity, whereas quartz that precipitated at ~250 °C in Main Stage veins luminesces with the least intensity

Trace-element analyses via electron microprobe and laser ablation-ICP-MS indicate that plutonic quartz and each generation of hydrothermal quartz from Butte is dominated by characteristic trace amounts of Al, P, Ti, and Fe. Thus, in addition to CL intensity, each generation of quartz can be distinguished based on its unique trace-element content. Aluminum is generally the most abundant element in all generations of quartz, typically between 50 and 200 ppm, but low-temperature, Main Stage quartz containing 400 to 3600 ppm Al is enriched by an order of magnitude relative to all other quartz generations. Phosphorous is present in abundances between 25 and 75 ppm, and P concentrations in quartz show little variation among quartz generations. Iron is the least abundant of these elements in most quartz types and is slightly enriched in CL-dark quartz in pyrite-quartz veins with sericitic alteration. Titanium is directly correlated with both temperature of quartz precipitation, and intensity of quartz luminescence, such that BQM quartz contains hundreds of ppm Ti, whereas Main Stage quartz contains less than 10 ppm Ti. Our results suggest that Ti concentration in quartz is controlled by temperature of quartz precipitation and that increased Ti concentrations in quartz may be responsible for increased CL intensities.

Keywords: Butte, porphyry copper, veins, quartz, cathodoluminescence, trace elements, hydrothermal, CL