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Visualizing trace element distribution in quartz using cathodoluminescence, electron microprobe, and laser ablation-inductively coupled plasma-mass spectrometry

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Abstract

Cathodoluminescent (CL) textures in quartz reveal successive histories of the physical and chemical fluctuations that accompany crystal growth. Such CL textures reflect trace element concentration variations that can be mapped by electron microprobe or laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Trace element maps in hydrothermal quartz from four different ore deposit types (Carlin-type Au, epithermal Ag, porphyry-Cu, and MVT Pb-Zn) reveal correlations among trace elements and between trace element concentrations and CL textures. The distributions of trace elements reflect variations in the physical and chemical conditions of quartz precipitation. These maps show that Al is the most abundant trace element in hydrothermal quartz. In crystals grown at temperatures below 300 °C, Al concentrations may vary by up to two orders of magnitude between adjacent growth zones, with no evidence for diffusion. The monovalent cations Li, Na, and K, where detectable, always correlate with Al, with Li being the most abundant of the three. In most samples, Al is more abundant than the combined total of the monovalent cations; however, in the MVT sample, molar Al/Li ratios are ~0.8. Antimony is present in concentrations up to ~120 ppm in epithermal quartz (~200–300 °C), but is not detectable in MVT, Carlin, or porphyry-Cu quartz. Concentrations of Sb do not correlate consistently with those of other trace elements or with CL textures. Titanium is only abundant enough to be mapped in quartz from porphyry-type ore deposits that precipitate at temperatures above ~400 °C. In such quartz, Ti concentration correlates positively with CL intensity, suggesting a causative relationship. In contrast, in quartz from other deposit types, there is no consistent correlation between concentrations of any trace element and CL intensity fluctuations.

Keywords: Quartz, trace elements, cathodoluminescence, LA-ICP-MS, electron microprobe