

Hydrothermal Rutile Microinclusions in Quartz as Vectoring and Fertility Indicators in Lithocap Environments

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Mineral-based vectoring tools are widely used in porphyry–epithermal exploration to constrain fluid evolution, metal fertility, and proximity to mineralization, commonly relying on the geochemistry of key alteration minerals such as chlorite, epidote, and white mica. However, the influence and exploration significance of mineral microinclusions hosted within these minerals remain poorly constrained, despite their potential to preserve critical information on hydrothermal processes and metal transport. This study focuses on hydrothermal rutile microinclusions hosted in quartz from the Veladero lithocap, a high-sulfidation Au–Ag deposit located in El Indio Belt, Argentina. The work forms part of ongoing research investigating how mineral microinclusions hosted within alteration minerals can influence the apparent chemistry of their hosts and the performance of mineral-based vectoring and fertility assessment tools.

Cathodoluminescence imaging is used to define textural domains within hydrothermal quartz related to different stages of lithocap evolution, while electron probe microanalysis (EPMA) provides major-element constraints on rutile compositions. Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses of quartz are coupled with microinclusion deconvolution techniques to reconstruct the original trace-element chemistry of rutile microinclusions.

Rutile microinclusions are evaluated in the context of locally anomalous silver contents in the host quartz (up to ~30 ppm), interpreted to reflect Ag-bearing sulfosalt microinclusions associated with zoned Au–Ag mineralization near the base of the lithocap. EPMA analyses of rutile microinclusions indicate compositions consistent with hydrothermal rutile formed at moderate temperatures in relatively oxidizing fluids. Preliminary LA-ICP-MS analyses of rutile microinclusions hosted in hydrothermal quartz display trace-element signatures consistent with proximity to a hydrothermal heat source.

The integration of rutile microinclusion chemistry, quartz textures, and metal distributions provides a basis to assess hydrothermal fertility and develop new mineral-based vectoring tools in high-sulfidation epithermal systems, complementing microinclusion studies in greenrock and transitional environments across the porphyry–epithermal system.