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Underrated and Overlooked: the Magmatic–hydrothermal Transition Recorded by Trace Elements-in-Quartz

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In exploration, quartz is commonly considered an inconsequential mineral although, with the advent of analytical techniques such as LA-ICP-MS, this is changing. The ability to measure trace element variations in quartz provides a new window into the evolution of mineral deposits.

Granites are typically host to late-stage magmatic-hydrothermal mineralisation, such as Sn and other commodities that are considered critical metals. The Nebo, Bobbejaankop and Lease granites in the Zaaiplaats Tin Field of the Bushveld Complex, are host to various expressions of endogranitic Sn-mineralisation. Zaaiplaats comprises the Nebo Granite at the base that grades into the Bobbejaankop Granite and then the Lease Granite, which forms the fine-grained cupola. These granites exhibit an increasing degree of hydrothermal alteration respectively, with mineralisation restricted to the Bobbejaankop and Lease phases. High-grade Sn-bearing tourmaline-quartz hydrothermal pipes radiate up through the Bobbejaankop into the Lease Granite and terminate below the roof contact.

Trace element analysis of quartz from these granites exhibit evidence that supports the suggested fractionation and fluid-saturation models of ore genesis. The Al/Ti and Ge/Ti ratios in quartz increase from the base to roof and illustrate the sequential evolution of the system and an increasing degree of fluid-rock interaction. The quartz from the high-grade pipes is distinct with very low-Ti, high-Al and high-Ge, which indicates crystallisation from a very low-temperature late-stage and highly acidic fluid.

The trace element data displays a shift from an ordered magmatic fractionation-controlled evolution to a hydrothermally-controlled system that reflects more erratic trends. Therefore, trace element variations in quartz are able to define the point of fluid-saturation and record the magmatic-hydrothermal transition. The identification of the most evolved and fluid-saturated facies can guide exploration by indicating lithologies with the best mineralisation potential. The use of trace elements-in-quartz extends beyond granite-hosted deposits and may be applicable to various mineralised systems.