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Cathodoluminescence features, trace elements, and oxygen isotopes of quartz in unidirectional solidification textures from the Sn-mineralized Heemskirk Granite, western Tasmania

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Abstract

Distinctive quartz-rich unidirectional solidification textures (USTs) occur in apical carapaces of the Sn-mineralized Heemskirk Granite in western Tasmania (SE Australia). They are spatially associated with abundant tourmaline-filled orbicules and cavities that have been overprinted by widespread tourmaline-quartz veins. Multiple UST-quartz layers that are intercalated with aplitic layers, and can locally extend for hundreds of meters. Individual UST layers consist dominantly of hexagonal quartz (>95%) with minor K-feldspar, plagioclase, biotite, muscovite, and magnetite. Scanning electron microscope-cathodoluminescence (SEM-CL) reveals that the aplitic quartz is homogeneous and CL-bright with minor CL-dark patches. The bases of the UST quartz crystals are homogeneous and CL-bright with minor thin CL-dark fractures, whereas the trigonal apexes of the UST-quartz display CL-oscillatory growth zones. LA-ICP-MS analyses show that UST-quartz has lower Ti, Li, and Sn than aplitic quartz, but higher Al, Li, Na, K, Mn, Fe, Ge, Rb, and Cs concentrations. At a pressure of ca. 1.3 kbar, the Ti-in-quartz geothermometer yields temperatures of 545 ± 40 and 580 ± 20 °C for the UST and aplitic quartz, respectively. The UST-quartz has higher Al/Ti values of 5.8 to 32, and Ge/Ti values of 0.02 to 0.16, than quartz phenocrysts in aplite layers, which is consistent with crystallization from a highly evolved fluid. The O-isotopic compositions (+5.1 to +10.2‰) of UST and aplitic quartz are consistent with magmatic source circulated by minor meteoric and/or formation waters. Magnetite crystals in USTs have low Cr, V, Ni, Co, Cr, Sc, and high Ti, Al, Mn, Sn, Ga contents, and are overgrown by chlorite. These minerals are interpreted to have formed at UST-melt interface where hydrothermal fluids reacted with igneous minerals. The results show that the UST layers in the Heemskirk Granite precipitated from magmatic-hydrothermal aqueous fluid exsolved from granitic melt during emplacement into the shallow crust (6–10 km). Such UST layers are characteristics of mineralized intrusions, and therefore provide significant indications for mineral exploration.

Keywords: Unidirectional solidification textures, cathodoluminescence, quartz trace elements, magnetite, exsolved aqueous fluid, Sn-mineralized granite