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Conditions of Formation for Magmatic-Hydrothermal Features in the Sn-Mineralized Heemskirk Granite, Western Tasmania, SE Australia

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Abundant Sn skarn, greisen, and vein-type Ag-Pb-Zn deposits are spatially associated with the Heemskirk Granite from western Tasmania, southeastern Australia. Significant cassiterite deposits include the Federation, St Dizier, Severn, Queen Hill, and Montana Sn deposits, which are estimated to host at least 1.07 Mt at 0.98 to 1.91% Sn. We have investigated the CL characteristics, trace elements, and microthermometry of quartz from tourmaline patches, tourmaline-quartz orbicules, tourmaline miarolitic cavities, tourmaline-quartz-muscovite ± cassiterite veins, and Pb-Zn sulfide veins from the Heemskirk Granite. SEM-CL analyses reveal that CL-bright quartz cores are typically cut by dark to gray CL patches, CL-dark streaks, and healed fractures, offset by cobweb-like networks and jigsaw puzzle pieces, and/or overprinted by gray to bright CL growth zones. LA-ICP-MS analyses show that Al, Li, Ti, Na, K, Fe, Ge, and Rb are the most abundant trace elements in the quartz, although sub-microscopic fluid inclusions in quartz can contribute trace elements (especially Na, K, Rb, and Ca) to these analyses. The average Ge/Ti and Al/Ti ratios in quartz increase progressively from 0.04 in tourmaline patches, to 0.18 in tourmaline veins, indicating that evolved fluids were responsible for formation of these distinctive tourmaline-quartz features within the granite carapace. Increasing Sn concentrations in quartz from tourmaline patches (median = 0.115 ppm) to tourmaline-muscovite veins (median = 0.174 ppm) have been detected, consistent with Sn contents being gradually enriched in the evolved, late-stage magmatic-hydrothermal fluids. Quartz grains associated with Pb-Zn sulfide veins have much higher Sb concentrations (median = 2.73 ppm) than other types of quartz (medians < 0.06 ppm), which may be useful for base metal exploration. Liquid-rich (type I), vapor-rich (type II), and halite-bearing (type III) fluid inclusions have been identified in quartz from the tourmaline-rich textural features and sulfide veins. Microthermometric measurements show that fluid inclusions have homogenization temperatures and salinities ranging from 156° to 460°C and 2 to 15 wt % NaCl equiv (type I), 334° to 550°C and 6 to 8 wt % NaCl equiv (type II), and 170° to 530°C and 31 to 56 wt % NaCl equiv (type III). Combined microthermometry and Ti-in-quartz geothermometry demonstrate that tourmaline patches, orbicules and cavities formed at temperatures of 500° to 565°C and lithostatic pressures of 0.6 to 1.3 kbar (depth of 2.8 to ≥ 5 km). Tourmaline-muscovite ± cassiterite veins formed at temperatures of 310 ± 20°C and hydrostatic pressures of 0.1 to 0.3 kbar (depth of ca. 1 km). Pb-Zn sulfide quartz veins precipitated under lower temperature-pressure conditions (280 ± 40°C; hydrostatic pressure of 80 bar). Depositional mechanisms, including decompression, decreasing temperature, and/or mixing with external water could have played a positive role in the generation and precipitation of the quartz-rich features and related Sn-sulfide mineralization.