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Magmatic-hydrothermal evolution in the Wasatch Igneous Belt revealed by spatially resolved multi-method garnet U-Pb petrochronology

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Determinations of the timing and duration of magmatic-hydrothermal processes are of fundamental importance in mineral systems science. Recent development of garnet U-Pb geochronology provides information on the longevity of hydrothermal activity recorded in garnet-bearing skarns. However, applications to natural systems have principally relied on lower precision laser ablation methodologies (±2%, 2σ), often limiting the ability to resolve discrete hydrothermal events. Micro sampling of spatially resolvable domains within skarn garnets and subsequent analysis by high precision ID-TIMS (±0.1%, 2σ) provide an opportunity to directly assess the duration and episodicity of hydrothermal processes, separate from geochronology derived from primary magmatic minerals.

Geochronology and geochemical analyses were performed in skarns from within the Wasatch Igneous Belt (WIB), Utah. Skarns associated with the Cottonwood Intrusive Suite and Alta stock were characterized by electron microprobe and laser ablation techniques. Garnet compositions span the grossular–andradite solid-solution series (And_{10}–And_{99}) and yielded U-Pb laser ablation dates from ~29–36 Ma throughout the WIB. Alta samples (n = 22) yielded dates from ~29–36 Ma, while Cottonwood Intrusive Suite samples (n = 2) yielded dates from ~29–33 Ma. Total U concentrations and textural considerations were used to identify eight suitable samples for micro milling and subsequent ID-TIMS analyses. Calculated ID-TIMS dates largely show less intrasample variability than the laser ablation results. However, intersample age variations indicate skarn formation occurred in the southern Alta aureole (34.33 ± 0.06 Ma [χ^2 = 0.078]) first, followed by punctuated episodes of skarn formation in the northern Alta aureole (from 33.47 ± 0.01 Ma [χ^2 = 0.676] to 33.33 ± 0.02 Ma [χ^2 = 0.32]). Dispersion in dates from the lone Cottonwood Intrusive Suite skarn (30.32 ± 0.08 to 30.61 ± 0.04 Ma) indicate a longer, more complex, crystallization history.

The new garnet results, interpreted alongside structural, petrologic, and geochronologic data from throughout the WIB, indicate that protracted magmatic activity produced pulsed fluid release and skarn formation over >3 Myr. Evolution of the permeability structure of the intrusion-aureole complex was likely driven by physical and/or chemical processes that periodically created and/or destroyed infiltration pathways for mineralizing fluids.