

U-Pb geochronology of hydrothermal garnet by 193nm LA-ICP-MS

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We tested an *in-situ* U-Pb dating method for grossular-andradite (grandite) garnet from the Mackenzie Gulch Cu-Au skarn where titanite in the skarn assemblage and zircon in associated felsic dykes yielded overlapping ages of 387 ± 4 Ma and 386 ± 2 Ma respectively. Textural equilibrium between grandite, titanite, and other skarn minerals (e.g., chalcopyrite, calcite and diopside) provide compelling evidence for coeval crystallization of hydrothermal garnet.

The isotopic homogeneity of the skarn garnet was confirmed using NIST610 as external standard with ablation conditions optimized to minimize laser-induced elemental fractionation. Actinide concentrations range from <1 to 10 ppm U and <1 to 16 ppm Th, necessitating large craters (>100 μm diameter) to achieve suitable precision on the measured $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{238}\text{U}/^{206}\text{Pb}$ ratios. Concentrations of U and Th are strongly correlated with Ce whereas the latter is inversely correlated with Ti. Zoning is strongly oscillatory such that wide-area BSE imaging and elemental mapping is required to identify zones enriched in U. Inclusion of P and Zr in the ICP-MS mass list is used to filter spots that encounter inclusions of phosphates and zircon. External calibration using NIST610 yielded an inverse isochron lower intercept age of 386 ± 5 Ma when anchored at the common-Pb composition of galena in the skarn system. The highest-U domains are near-concordant. In contrast, external calibration using Plesovice zircon produced a strongly biased age of ~420 Ma.

Having established the coeval and unimodal nature of its age, the MacKenzie Gulch grandite was subsequently used as an external standard, with common-Pb corrected prior to down-hole fractionation. Standardization using this approach was applied to other well-constrained skarn systems and produced lower intercept ages in-line with existing geochronology. Thus, this work has demonstrated that given single-digit U concentrations, hydrothermal garnet can be accurately and precisely dated. Inheritance is unlikely and textural equilibrium with other major minerals provides a direct link between isotopic ages and mineral parageneses.