American Mineralogist, Volume 106, pages 715–729, 2021

Oxygen isotope ratios in zircon and garnet: A record of assimilation and fractional crystallization in the Dinkey Dome peraluminous granite, Sierra Nevada, California

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Abstract

The 119 Ma Dinkey Dome pluton in the central Sierra Nevada Batholith is a peraluminous granite and contains magmatic garnet and zircon that are complexly zoned with respect to oxygen isotope ratios. Intracrystalline SIMS analysis tests the relative importance of magmatic differentiation processes vs. partial melting of metasedimentary rocks. Whereas $\delta^{18}O$ values of bulk zircon concentrates are uniform across the entire pluton (7.7‰ VSMOW), zircon crystals are zoned in $\delta^{18}O$ by up to 1.8‰, and when compared to late garnet, show evidence of changing magma chemistry during multiple interactions of the magma with wall rock during crustal transit. The evolution from an early high-$\delta^{18}O$ magma [$\delta^{18}O(WR) = 9.8‰$] toward lower values is shown by high-$\delta^{18}O$ zircon cores (7.8‰) and lower $\delta^{18}O$ rims (6.8‰). Garnets from the northwest side of the pluton show a final increase in $\delta^{18}O$ with rims reaching 8.1‰. In situ REE measurements show zircon is magmatic and grew before garnets. Additionally, $\delta^{18}O$ in garnets from the western side of the pluton are consistently higher (avg = 7.3‰) relative to the west (avg = 5.9‰).

These $\delta^{18}O$ variations in zircon and garnet record different stages of assimilation and fractional crystallization whereby an initially high-$\delta^{18}O$ magma partially melted low-$\delta^{18}O$ wallrock and was subsequently contaminated near the current level of emplacement by higher $\delta^{18}O$ melts. Collectively, the comparison of $\delta^{18}O$ zoning in garnet and zircon shows how a peraluminous pluton can be constructed from multiple batches of variably contaminated melts, especially in early stages of arc magmatism where magmas encounter significant heterogeneity of wall-rock assemblages. Collectively, peraluminous magmas in the Sierran arc are limited to small <100 km^2 plutons that are intimately associated with metasedimentary wall rocks and often surrounded by later and larger metaluminous tonalite and granodiorite plutons. The general associations suggest that early-stage arc magmas sample crustal heterogeneities in small melt batches, but that with progressive invigoration of the arc, such compositions are more effectively blended with mantle melts in source regions. Thus, peraluminous magmas provide important details of the nascent Sierran arc and pre-batholithic crustal structure.

Keywords: Peraluminous granite, garnet, zircon, Sierra Nevada, oxygen isotopes, REE, SIMS; Isotopes, Minerals, and Petrology: Honoring John Valley