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Progressive depletion of radioactive heat producing elements in the lower crust recorded in zircon trace element systematics of granulite xenoliths from the Geronimo Volcanic Field, southern Basin and Range, USA

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Zircon U-Pb geochronology and Hf-isotope analyses of granulite xenoliths from Geronimo Volcanic Field (GVF), SE Arizona, constrain the timing of processes that shaped the composition of the lower crust of the southern Basin and Range. Quartzofeldspathic orthogneisses yield U-Pb zircon ages of ~1.65 Ga, consistent with the age of the Mazatzal terrane where GVF is located; discordant U-Pb zircon ages of ~1.48-1.42 Ga suggest modification during the Picuris Orogeny (~1.4 Ga). Metadiorite granulites have similar Nd model ages (~ 1.4 Ga). However, zircon U-Pb dates of 35-25 Ma and εHf(t) values ranging from -17 to 0 suggest modification of this Proterozoic crust during Farallon slab subduction and rollback.

Zircon trace elements provide additional insights into the behavior of radiogenic heat-producing elements during this long crustal history. Quartzofeldspathic zircons show a strong positive correlation between Eu/Eu* and Dy_N/Yb_N (r^2 = 0.95) with highest Eu/Eu* and Dy_N/Yb_N ratios in cores. In contrast, metadiorites have higher Dy_N/Yb_N and a negative correlation between Eu/Eu* and Dy_N/Yb_N (r^2 = 0.62), with cores at the low Eu/Eu* – high Dy_N/Yb_N end of the array. Despite contrasting REE systematics, Th/U ratios correlate positively with Dy_N/Yb_N for both granulite groups but tend to decrease from core to rim of individual zircon grains only in metadiorites. Variations in Th and U concentration also differ for the two granulite groups. Both show similar Th contents, but metadiorites have significantly lower U. Metadiorite zircon Th/U ratios are controlled by the variation in Th content, whereas quarztofeldspathic zircon Th/U ratios are controlled primarily by changes in U content.

We interpret these trends as evidence that quartzofeldspathic zircons record water-fluxed anatexis, with initial loss of apatite (decreasing Th) and successive U and Th mobility controlled by zircon dissolution / recrystallization. The decrease in Eu/Eu* reflects sequestration of Eu in peritectic feldspar as anatexis progressed. In contrast, metadiorites record interaction with small degree partial melts formed during Farallon slab rollback. Physical evidence for these fluids is found in the form of rare SiO_2-rich (>70wt%) melt inclusions in the metadiorites. Thus, both granulite groups record progressive loss of U and Th but via different mechanisms.