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Deep Crustal Processes and temporal evolution of the Mazatzal lower crust of the southern Basin and Range: evidence from granulite xenoliths.

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Lower crustal granulite xenoliths from the Geronimo Volcanic Field (GVF), southeastern Arizona, provide critical insight into the timing and processes that shaped the Mazatzal Province and the southern Laurentian margin. In situ zircon U-Pb geochronology and Hf-isotope analyses reveal a complex history of Paleoproterozoic crust formation, Mesoproterozoic modification, and Cenozoic reworking during subduction-related magmatism.

Quartzofeldspathic orthogneisses record an event at ~1.65 Ga, consistent with Mazatzal terrane accretion; however, inherited zircon cores and Hf-isotope data indicate mantle extraction as early as ~2.4 Ga, suggesting that the Mazatzal crust incorporated older Paleoproterozoic components. Mesoproterozoic zircon populations (~1.48–1.42 Ga) and intermediate εHf(t) values provide evidence for significant tectonomagmatic modification during the Picuris Orogeny and the widespread ~1.4 Ga A-type granite event. Young zircon rims (~50-15 Ma), suggest later alteration of the Mazatzal during Tertiary magmatism associated with Farallon slab subduction.

Metadioritic xenoliths yield predominantly Cenozoic zircon ages (~35–25 Ma), concurrent with the mid-Tertiary ignimbrite flare-up and Farallon slab rollback. However, their ~ 1.4 Ga Nd wholerock model ages, a wide range in εHf(t) values (−17 to 0), zircon textures, and trace element systematics, suggest recrystallization of zircon due to limited anatexis, and/or interaction with small-degree partial melts rather than wholesale replacement by juvenile magmas.

Modeling of εHf(t) evolution indicates that juvenile mantle input at ~2.4 Ga and ~1.65 Ga alone cannot account for the observed isotopic variability of the sample set, and are instead consistent with inclusion of a third juvenile addition at ~1.4 Ga. This addition explains up to ~75% of the observed εHf(t) range, implying that Mesoproterozoic mantle-derived magmatism contributed substantially to lower crustal growth. This interpretation reduces the need for large-scale juvenile addition during the Cenozoic and supports a model of progressive crustal construction through multiple mantle input events during the Proterozoic.

Collectively, these results support a model in which the Mazatzal lower crust formed through Paleoproterozoic mantle extraction and accretion, was augmented by juvenile Mesoproterozoic magmatism at ~1.4 Ga and was subsequently modified during Farallon subduction. This prolonged, multi-stage evolution highlights the importance of episodic mantle input and crustal reworking in stabilizing and modifying continental lower crust.