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Stable and transient isotopic trends in the crustal evolution of Zealandia Cordillera

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Abstract

We present >500 zircon $\delta^{18}O$ and Lu-Hf isotope analyses on previously dated zircons to explore the interplay between spatial and temporal magmatic signals in Zealandia Cordillera. Our data cover ~8500 km^2 of middle and lower crust in the Median Batholith (Fiordland segment of Zealandia Cordillera) where Mesozoic arc magmatism along the paleo-Pacific margin of Gondwana was focused along an ~100 km wide, arc-parallel zone. Our data reveal three spatially distinct isotope domains that we term the eastern, central, and western isotope domains. These domains parallel the Mesozoic arc-axis, and their boundaries are defined by major crustal-scale faults that were reactivated as ductile shear zones during the Early Cretaceous. The western isotope domain has homogenous, mantle-like $\delta^{18}O$ (Zrn) values of 5.8 ± 0.3‰ (2 St.dev.) and initial ε_{Hf} (Zrn) values of +4.2 ± 1.0 (2 St.dev.). The eastern isotope domain is defined by isotopically low and homogenous $\delta^{18}O$ (Zrn) values of 3.9 ± 0.2‰ and initial ε_{Hf} values of +7.8 ± 0.6. The central isotope domain is characterized by transitional isotope values that display a strong E-W gradient with $\delta^{18}O$ (Zrn) values rising from 4.6 to 5.9‰ and initial ε_{Hf} values decreasing from +5.5 to +3.7. We find that the isotope architecture of the Median Batholith was in place before the initiation of Mesozoic arc magmatism and pre-dates Early Cretaceous contractional deformation and transpression. Our data show that Mesozoic pluton chemistry was controlled in part by long-lived, spatially distinct isotope domains that extend from the crust through to the upper mantle. Isotope differences between these domains are the result of the crustal architecture (an underthrusted low-$\delta^{18}O$ source terrane) and a transient event beginning at ca. 129 Ma that primarily involved a depleted-mantle component contaminated by recycled trench sediments (10–20%). When data showing the temporal and spatial patterns of magmatism are integrated, we observe a pattern of decreasing crustal recycling of the low-$\delta^{18}O$ source over time, which ultimately culminated in a mantle-controlled flare-up. Our data demonstrate that spatial and temporal signals are intimately linked, and when evaluated together they provide important insights into the crustal architecture and the role of both stable and transient arc magmatic trends in Cordilleran batholiths.

Keywords: Cordilleran magmatism, Zealandia, zircon, O isotopes, Hf isotopes; Isotopes, Minerals, and Petrology: Honoring John Valley