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The fundamental deep mantle source of volcanic hotspots formed in multiple Hadean-aged events

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Despite its presence in nearly every volcanic hotspot, the origins and history of the 'focus zone' (FOZO; also prevalent mantle, PREMA, or common component, C) are the least constrained among the major geochemical components of hotspots. The origins of FOZO have been variably characterized as relatively ancient, relatively young, or continuously evolving. The long-lived isotopic composition of FOZO is clearly not primitive, but rather must reflect discrete or continuous depletion events in Earth's mantle that occurred at unknown times in the past.

We utilize the short-lived ^{142}Nd isotopic system ($t_{1/2}$ = 103 Ma) to interrogate these characteristics in two hotspots with strong FOZO components: the Juan Fernandez hotspot (E. Pacific Ocean), and the Crozet hotspot (Indian Ocean). Whereas the Juan Fernandez hotspot has a tightly clustered, FOZO-like Sr-^{143}Nd-Pb isotopic signature, the two islands of Crozet (Possession and Penguin), have distinct Sr-^{143}Nd-Pb signatures that bracket the isotopic composition of Juan Fernandez. The ^{142}Nd compositions of these hotspots are similarly distinct: the Juan Fernandez islands reflect a statistically well-mixed source with μ^{142}Nd = +1.8 ±1.1 (95% c.i., n = 13) whereas the Crozet islands reflect a less well-mixed source with compositions of μ^{142}Nd = -1.5 ± 1.8 (Possession, n = 6) and +0.2 ±0.9 (Penguin, n = 11; all Crozet: -0.1 ±0.8). The μ^{142}Nd compositions of the two hotspots are statistically resolved (P <0.005).

The fact that the Sr-^{143}Nd-Pb isotopic signatures of Possession and Penguin Islands bracket those of Juan Fernandez means that a variety of mixing models using a globally singular FOZO composition. However, it is impossible to analogously reconcile the mainly negative ^{142}Nd signatures of the Crozet hotspot with the statistically distinct, positive ^{142}Nd isotopic signatures of Juan Fernandez. This means the FOZO components of these hotspots must have divergent Hadean histories. The deep mantle must therefore play host to not one, but potentially a variety of primordial, FOZO-like domains that were thus far undetectable in 2- or 3-dimensional analyses of He-Sr-Nd-Pb isotopic compositions. Expanded analysis of multi-dimensional and short-lived isotopic datasets in modern volcanic hotspots may therefore be able to elucidate Earth's remaining memory of its foundational events.