An elevated ^{142}Nd signature in the Réunion mantle source

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Despite billions of years of mantle convection, ocean islands preserve isotopic evidence for ancient sources that have persisted in Earth's deep mantle. Although it was previously shown that such heterogeneity is restricted to long-lived radiogenic isotope systems, recent work has demonstrated that some modern intraplate lavas also preserve $^{182}W/^{184}W$ signatures generated during the lifetime of ^{182}Hf ($t_{1/2}$ = 8.9 Ma). We show that La Réunion, a volcanically active ocean island, hosts lavas and cumulates with elevated $\mu^{142}Nd$ (^{146}Sm-^{142}Nd, $t_{1/2}$ = 103 Ma) that are normally distributed (W >0.98) about a mean of +3.8 ±1.2 (2SE, n = 40) that is distinct from the terrestrial standard (P <0.001) with a maximum of +7.0 ±0.6 (2SE, n = 2). Such radiogenic values are challenging to explain given the relatively unradiogenic and homogenous $\varepsilon^{143}Nd$ signature of Réunion (+4.22 ±0.57, 2SD). However, this signature can be reproduced in a two-stage model for a 4.39 Ga differentiation event, consistent with Pb isotope constraints, assuming a bulk Earth with chondritic Sm/Nd and $\mu^{142}Nd = -2.3$. The average Réunion ^{142}Nd-^{143}Nd signature also can be reproduced for a bulk Earth with a more negative $\mu^{142}Nd$, however given an Earth with chondritic Sm/Nd, the Réunion source is incompatible with a bulk Earth possessing $\mu^{142}Nd < -18$. This finding is consistent with the recent discovery that Earth is enriched in s-processes Nd relative to ordinary chondrites, which have $\mu^{142}Nd \approx -20$. All acceptable two-stage models require degrees of Sm/Nd differentiation that increase for later differentiation times. If the Réunion Nd isotope signature was not formed in a two-stage evolution scenario, it may result from geologically recent mixing between an ancient incompatible element depleted reservoir possessing elevated $\mu^{142}Nd$ and $\varepsilon^{143}Nd$ and a distinct, enriched reservoir. This enriched reservoir may represent recycled crustal material, however this would be difficult to reconcile with the long-lived radiogenic isotope signature of Réunion. In either case, the Réunion source must sample an ancient sequestered reservoir that witnessed a differentiation event within the first ~500 Ma of Earth history. This and other aspects of Réunion's unique geochemistry reveal that ocean islands have untapped potential to learn about Earth's early history.