The Hadean geochemical heritage of the Réunion hotspot source

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The two subaerial volcanoes of Réunion Island are among the most isotopically homogeneous of Earth's intraplate magmatic systems. Both volcanoes are characterized by elevated, yet moderate $^{3}He/^{4}He$ ratios (12-15 R_A) that indicate a primitive, deep mantle history, yet this range is less extreme than Earth's 'primary' volcanic hotspots, such as Hawai'i and Samoa. Here we report the W isotopic composition of Réunion basalts, which may track differentiation occurring before 4.5 Ga, and show they overlap the He-W isotopic trend defined by these nominally more primitive hotspots. Although this implies that geographically disparate hotspots have mantle sources with a shared Hadean heritage, the restricted $^{3}He/^{4}He$ composition of Réunion requires that the nature of its interaction with depleted and/or post-Hadean mantle domains is distinct from other hotspots. Thorough mixing along a linear He-W trajectory between an upper mantle-like domain and a Hawai'i/Samoa endmember may have resulted in a homogenous Réunion source while other hotspots retained heterogeneous compositions similar to both primitive and upper mantle. An observed lack of correlation between $\mu^{182}W$ and $\mu^{142}Nd$, both of which represent short-lived radiogenic systems ($t_{1/2}$ = 9 and 103 Ma, respectively), among Réunion basalts implies that a geochemical relic of multiple, independent Hadean processes are preserved in the Réunion mantle source. One domain that contains appreciable W but that lacks Nd is Earth's core. If the primitive endmember to the Hawai'i and Samoa sources represents a relatively high influence of core material on the bulk mantle, the Réunion source may be a well-mixed domain with proportionally smaller core influence. Limited amounts (<1%) of core material are needed to recreate observed W isotope compositions, however this would also result in unrealistically high highly siderophile element abundances that are not observed in Hawai'i, Samoa, or Réunion. The He concentrations of domains involved in the Hadean events that gave rise to the Réunion $\mu^{182}W$ and $\mu^{142}Nd$ signature are empirically unknown. However, endogenous and exogenous domains with differing He concentrations would cause distinct mixing behaviors and may partially explain both the Réunion He-Nd-W isotopic signature relative to other hotspots and the fact that $^{3}He/^{4}He$ appears to be related to both $\mu^{142}Nd$ and $\mu^{182}W$ while $\mu^{142}Nd$ and $\mu^{182}W$ remain uncorrelated.