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90 million years of the Galapagos plume: the evolution of lithological heterogeneity

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During 90 million years of evolution the Galapagos mantle plume has cooled from a mantle potential temperature of 1800 to 1400°C [1] and is inferred to sample pyroxenite [2], however the evolution of lithological heterogeneity is poorly understood. To investigate lithological evolution, here we present new stable Fe isotope data for samples from the hot plume head (Tortugal, Gorgona, Curaçao [3]), transitional plume head to steady-state plume track terranes [4] and modern Galapagos basalts from multiple radiogenic isotope domains, including the high $^3He/^4He$, negative $\mu^{182}W$ Fernandina volcano.

Fe isotopes have been used to complement existing tracers of mantle geochemical heterogeneity (particularly in OIB sources), because mineral- and redox- specific equilibrium fractionation effects link the melt isotopic composition to source mineralogy and melting degree. Among OIB, Fe isotope variability relative to MORB – in particular, isotopically heavy basalts associated with some mantle plumes – has been attributed at least partly to a pyroxenite lithology in the OIB source [5,6]. We find that the modern Galapagos plume has higher $\delta^{57}Fe_{primary}$ than primary MORB, and had lower, BSE-like $\delta^{57}Fe_{primary}$ in the past.

We show that, although the proportion of pyroxenite-derived melt has increased through time, the cooling plume has contained a small, and diminishing, proportion of pyroxenite over its lifetime, consistent with geodynamic models of decreasing entrainment of dense material (such as an LLSVP) as the plume evolves [7]. The small proportion of pyroxenite throughout plume evolution also suggests that geochemical signatures of primordial mantle ($\mu^{182}W$ anomalies, high $^3He/^4He$, which may be also hosted in LLSVPs; [8]) may be diluted approximately uniformly by recycled components throughout plume evolution and therefore could be identified in early plume localities, providing important constraints on lower mantle evolution and its entrainment into the upper mantle.

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