Hot plumes entrain higher $^{3}He/^{4}He$

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Volcanic hotspot lavas erupted at the Earth's surface—sourced by upwelling mantle plumes—provide information about the geochemistry of different domains in the Earth's interior. A long-standing problem in geochemistry is to constrain the distribution of geochemical reservoirs in the Earth's interior. Unfortunately, the geochemistry of lavas at the Earth's surface provide little information about the depth of the geochemical domains sampled by the lavas.

Konter and Becker (2012) [1] compared a variety of geophysical parameters with the Sr-Nd-Pb isotopic geochemistry of hotspot lavas to constrain the location of geochemical reservoirs in the Earth's mantle. They showed that the proportion of the mantle "C" component—presumed to host high $^{3}He/^{4}He$—in hotpost lavas exhibits an inverse relationship with seismic shear-wave velocity anomalies at 200 km depth: hotspots with a higher fraction of the C component overlie shallow mantle with slower seismic shear-wave velocity anomalies (thought to relate to higher mantle temperatures) than hotspots with a lower shear-wave anomalies at 200 km. They proposed that these correlations should be made based on helium isotopes.

Therefore, we compare maximum $^{3}He/^{4}He$ at hotspots with seismic shear-wave velocities at 200 km depth [2]. Confirming Konter and Becker's (2012) observation, we show that plume-fed hotspots with higher $^{3}He/^{4}He$ (i.e., higher proportion of the C component) overlie lower seismic shear-wave velocity anomalies at 200 km than lower $^{3}He/^{4}He$ hotspots. This is also consistent with recent observations showing an inverse relationship between $^{3}He/^{4}He$ and shallow mantle seismic shear-wave velocity anomalies [3]. We also find that higher $^{3}He/^{4}He$ hotspots are associated with higher hotspots buoyancy fluxes than lower $^{3}He/^{4}He$ hotspots. The relationship between $^{3}He/^{4}He$, buoyancy flux, and upper-mantle shear-wave velocity anomalies suggests that hotter plumes are more buoyant and entrain more of a deep-seated high $^{3}He/^{4}He$ component than low $^{3}He/^{4}He$ hotspots. This is most easily explained if the high $^{3}He/^{4}He$ domain is denser than low $^{3}He/^{4}He$ mantle components, and the primordial domain is only entrained by the hottest, most buoyant plumes.

[1] Konter and Becker (2012) *G-cubed* **13**, Q02004. [2] Jackson *et al.* (2017), *Nature* **542**, 340-343. [3] Crossey *et al.* (2016), *EPSL* **435**, 22-30.