Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.24302

The Influence of Plume Buoyancy Flux on Trace Elements in Oceanic Island Basalts

PROF. WILLIAM M. WHITE, PHD

Cornell University

Presenting Author: wmw4@cornell.edu

Most oceanic island volcanic chains are underlain by negative s-wave velocity anomalies extending to the lowermost mantle, confirming that they are produced by mantle plumes [1]. Hence, oceanic island basalts (OIB) provide a sample of the Earth's lower mantle. When conduit advection is considered [2], nearly all plumes rise from the interiors of two large scale seismic anomalies in the lower mantle known as Large Low Shear Wave Velocity Provinces (LLSVPs) with no preferential location near their boundaries. Variations in radiogenic and stable isotope ratios of OIB suggests considerable composition heterogeneity among plumes. However, the limited correlation between radiogenic isotope ratios and their respective parent/daughter ratios suggests that varying extent and depth of melting produce significant additional trace element variation in OIB. These factors might reasonably be controlled by plume temperature as well as lithospheric thickness [3], which limits the depth to which plumes can rise and hence melt. Stepwise regression of parent/daughter ratios against their respective isotope ratios and lithospheric thickness confirms the importance of lithospheric thickness in trace element fractionations. However, there are no significant correlations between trace element fractionation and either seismic or petrological estimates of plume temperature. Instead, estimates of plume buoyancy flux from [2] appear to be an important and often dominant control on trace element fractionations. For trace element ratios sensitive to residual garnet, such as the Lu/Hf, lithospheric thickness is the dominant secondary factor while for other pairs, such as Sm/Nd, plume flux is the dominant secondary factor. For example, Figure 1 compares averaged Sm/Nd in 26 oceanic island volcanic chains predicted from e_{Nd}, plume flux, and lithospheric thickness with the prediction from e_{Nd} alone. The former combination explains 68% of the variation in Sm/Nd. This suggests that current seismic and petrological estimates of plume temperatures are inaccurate, and that plume buoyancy flux is closely related to plume temperature.

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[2] Jackson, M. G., Becker, T. W. & Steinberger, B. *Geochem., Geophys., Geosys.*, 2021: 22, e2020GC009525.

[3] Humphreys, E. R & Niu, Y., *Lithos,* 2009: 112, 118-136

Figure 1