Inferring the "geochemical geometry" of mantle plumes

M. G. JACKSON[1*]

[1]Dept. of Earth Science, UC Santa Barbara, Santa Barbara, CA, 93106-9630, USA ([*]correspondence: jackson@geol.ucsb.edu)

Oceanic hotspot lavas exhibit tremendous isotopic variability, indicating that the mantle sources of the hotspots are geochemically heterogeneous. Geographic patterns in the geochemistry of hotspot lavas suggest that there must be spatial relationships among the different geochemical reservoirs in the mantle that are sampled by upwelling mantle plumes. A well-known geochemical separation of parallel volcanic lineaments at Hawaii – the Loa and Kea trends – has led to a conceptual model where the geochemical heterogeneities are highly organized within upwelling mantle plumes, and this reflects that spatial distribution of geochemical components in the deepest mantle. Similar patterns are emerging from a suite of hotspots globally, and the Samoan hotspot provides a particularly illuminating case.

At the Samoan hotspot, Pb-isotopic compositions in lavas indicate the presence of several geochemical groups. Each geochemical group corresponds to a different geographic lineament of volcanoes, and each group has a geochemical signature that relates to one of the canonical low $^3He/^4He$ mantle endmembers: EMII, EMI, HIMU and DM. Each of the four geochemical groups forms an array in Pb-isotopic space that trends toward a common component, forming an "X-shape" in Pb-isotopic space. The common component is defined by the region of Pb-isotopic space where the four arrays intersect, and is characterized by having the highest $^3He/^4He$ (up to 34 Ra, or ratio to atmosphere) in the Samoan hotspot. These mixing relationships provide a clear picture of the geochemical geometry of the Samoan plume. However, owing to the sparse datasets that couple high-precision Pb-isotopic measurements with $^3He/^4He$ measurements on the same sample, it is not yet clear whether the geochemical geometry observed in the Samoan plume is feature that is common to mantle plumes globally.