Compositions of Hawaiian basalts preclude eclogite mantle plumes

M.D. NORMAN[1] , J.M. RHODES[2], AND M.O. GARCIA[3]

[1] Australian National University, Canberra ACT 0200 AU; Marc.Norman@anu.edu.au
[2] University of Massachusetts, Amherst MA 01003 USA; jmrhodes@geo.umass.edu
[3] University of Hawai'i, Honolulu HI 96822 USA; garcia@soest.hawaii.edu

Ocean island volcanoes are considered to be the surface expression of deep-seated mantle plumes. The range of radiogenic isotopic compositions in ocean island basalts relative to mid-ocean ridge basalts has lead to the widespread view that recycled oceanic and continental crust is a common constituent of mantle plumes. The physical and chemical consequences of recycled eclogite within mantle plumes are not well understood, and several models have been proposed to explain the geochemistry of OIB in terms of variable contributions from eclogitc and peridotitic source components.

Olivine-poor pyroxenite has been proposed as an endmember source for Hawaiian tholeiites [1]. To test this model, we examined the trace element compositions of tholeiites from Mauna Loa and Kilauea volcanoes. Mauna Loa tholeiites have high SiO_2 contents and enriched isotopic compositions compared to adjacent Kilauea volcano. These contrasting characteristics have been explained by greater contributions from an eclogitic plume to Mauna Loa, whereas Kilauea tholeiites are derived predominantly from peridotite [1,2].

We emphasized Sc, V, and Ni abundances of inferred parental magmas because these relatively compatible trace elements should be sensitive to large variations in the proportions of olivine and pyroxene during melting. Estimates of parental magma compositions can be made from log-log plots of elements that are compatible in olivine (Mg, Ni) vs. incompatible elements (Al, Zr, Y, REE). Mauna Loa parental magmas have 15-16% MgO, 600-800 ppm Ni, 850-1050 ppm Cr, 25-27 ppm Sc, and 215-230 ppm V. Mauna Loa and Kilauea tholeiites have similar Sc, V, and Ni contents over a wide range of MgO.

Melting models predict that an olivine-free pyroxenite plume would produce melts with V and Sc contents significantly lower than observed for any Mauna Loa tholeiite. In contrast, the compositions of Mauna Loa parental melts, and the similar Ni-Sc-V compositions of tholeiites from Kilauea and Mauna Loa are more consistent with a peridotite source.

References

[1] Sobolev A.V., Hofmann A.W., Sobolev S.V., and Nikogosian (2005) Nature 434, 590-597.
[2] Hauri E.K. (1996) Nature 382, 415-419.