ISOTOPE AND TRACE ELEMENT EVIDENCE FOR DEPLETED LITHOSPHERE IN THE SOURCE OF ENRICHED KO'OLAU BASALTS

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Introduction

Of all the lavas of the Hawai'ian volcanoes those of the Ko'olau volcano show the widest range in chemical composition. Lavas from Ko'olau volcano form the most "enriched" end of the chemical compositional spectrum of Hawai'ian volcanics and are characterized by low $^{143}Nd/^{144}Nd$, low $^{176}Hf/^{177}Hf$, low $^{206}Pb/^{204}Pb$, high $^{207}Pb/^{204}Pb$ for a given $^{206}Pb/^{204}Pb$ and are thought to have relatively high SiO_2-contents compared to other Hawai'an volcanics. At the same time, the post-erosional Honolulu Volcanic Series (HVS) of the Ko'olau volcano form the most depleted end of the isotope spectrum of Hawai'ian volcanics and have been variously interpreted to be the result of assimilation of the approximately 90 Ma old oceanic lithosphere that overlies the plume, incorporation of ancient depleted lithosphere or melting of garnet pyroxenites brought to the surface by these lavas. Previously, the enriched isotope characteristics of the Ko'olau basalts have been interpreted to be due to the influence of pelagic sediments [1], while their purported high SiO_2 content has been proposed to be related to a source with a relatively dominant pyroxenite component [2]. Eclogite or pyroxenite lithologies also have been invoked for the sources of other Hawai'ian volcanoes, and it has been argued on the basis of high Sr-content that a gabbroic component is present in the source of Hawai'ian lavas [4]. However, based on the correlation of Th-excesses with Nd and Hf isotopic compositions, Stracke et al. [5] argued against the presence of either a pyroxenite or an eclogite component in the source of Hawai'ian magmas. We have measured the Hf and Nd isotopic compositions of thirty-eight basalts from the Ko'olau drill hole, Hawai'i.

Results and Discussion

The basalts show limited variations in both $^{176}Hf/^{177}Hf$ and $^{143}Nd/^{144}Nd$ (ε_{Nd} varies from +4.2 to +7.3 and ε_{Hf} from +8.0 to +12.3). Their correlated variation has an R-squared of 0.86. The data form an array with a slope of 1.2 on an ε_{Hf}-ε_{Nd} isotope correlation diagram, while the slope of all Hawai'ian basalt data is 0.98. Both slopes are significantly shallower than that of the mantle array of 1.4 defined by ocean island basalts. Previous studies have shown that a shallow slope in Hf-Nd isotope space can be related to ancient pelagic sediments in the mantle source. However, the combined variations in Ko'olau basalts of Hf-Nd-Pb-Os isotopic compositions and trace element ratios, such as La/Nb, Th/La, and Sr/Nd, are not consistent with the simple addition of a sediment component to the mantle. We instead propose that the shallow slope on the Hf-Nd isotope correlation diagram for Ko'olau shield stage basalts can be better explained if the enriched endmember contains either an ancient oceanic lithosphere component or the high-$^{176}Hf/^{177}Hf$ component observed in the Salt Lake Crater peridotite xenoliths (which also have a depleted lithosphere origin). Since Ko'olau basalts have high $^{187}Os/^{188}Os$ (0.135-0.160) and the Salt Lake Crater xenoliths have $^{187}Os/^{188}Os$ up to 0.13 [3] Os-isotopes are consistent with the latter being a component in the enriched Ko'olau source.

Our new data confirm that the Hf and Nd isotope variations in Ko'olau basalts define a slope which is less steep than that of the ocean island basalt array. The Hf-Nd-Pb-Sr isotope variations combined with trace element variations for Ko'olau basalts cannot be readily reconciled with only a recycled pelagic sediment component. Rather, the relatively high $^{176}Hf/^{177}Hf$ (at low $^{143}Nd/^{144}Nd$) of the Ko'olau enriched endmember indicates that ancient depleted lithosphere, similar to residual lithosphere after MORB melting, is a component in the Ko'olau mantle source. The new KSDP data further allows for re-assessment of the high-MgO Ko'olau endmember, which is found to be similar in composition to Kilauea parental magmas. These most likely represent melts from the garnet stability field that have interacted with plume-type mantle. The Ko'olau isotopic signatures, including the radiogenic Os, could be an integral part of a peridotite mantle that has undergone some episode of melt infiltration which is not mineralogically distinct.

References

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