THE HAWAIIAN PLUME IS REPLACING THE PACIFIC LITHOSPHERE: EVIDENCE FROM PERIDOTITE XENOLITHS FROM OAHU AND KAUAI

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Introduction

Subduction of basaltic oceanic crust is a key mechanism for introducing chemical heterogeneities into the Earth's mantle. Together with the crust however, the associated depleted lithosphere is also subducted. In the mantle, basaltic crust has a lower solidus while the depleted lithosphere has a higher solidus temperature than the ambient mantle. Thus, if a recycled depleted lithosphere is part of an upwelling plume, it could survive melting and be more easily recognized in mantle xenoliths associated with plume volcanism, than its basaltic counterpart. Here we report on new isotope data from peridotite xenoliths from Oahu and Kauai, and we show that plume material of recycled origin is recognized in these peridotites.

Results and Discussion

Isotope and trace element analyses were performed at the Geochemistry Division, NHMFL, using a Finnigan MAT-262 TIMS, the ISOLAB (a modified VG 54 MS with Hot-SIMS) and a Finnigan ELEMENT ICP-MS. Two Kauai peridotites overlap the post erosional Kauai lava compositions in Sr-Nd isotope space. A third Kauai peridotite has higher $^{87}Sr/^{86}Sr$ (0.70422) and lower $^{143}Nd/1^{44}Nd$ (0.51291) than any published Kauai lava and extends towards more radiogenic Sr (for a given Nd) than the Hawaiian lavas in general (Fig. 1). This sample has depleted characteristics with high Mg# (0.925) and Cr# (0.31), and low HREE in cpx. It also has the highest La/Yb ratio and largest Ti depletions yet determined in Hawaiian peridotites. In contrast, three peridotites from SLC have less radiogenic $^{87}Sr/^{86}Sr$ for a given $^{143}Nd/^{144}Nd$ than all other analyzed Hawaiian peridotites and lavas (Fig. 1). One peridotite straddles the so-called *LoNd* array, thought to represent mixing between HIMU and EM-I mantle components. In Hf-Nd space, this peridotite falls below the Hawaiian lava array having lower $^{176}Hf/^{177}Hf$ (0.28287) than the most isotopically enriched Koolau lavas suggesting that both depleted and enriched compositions are present in mantle peridotites, perhaps alleviating the need for an enriched pyroxenitic lithology in the Hawaiian plume. The new peridotite data shows greater Sr and Nd isotope variation in the Hawaiian peridotites than previously thought, and supports our conclusions from the Hf-Os systematics for a highly heterogeneous lithosphere. The total Sr-Nd-Hf isotope variability in the Oahu and Kauai peridotites cannot be explained by metasomatism of the Pacific lithosphere with erupted Hawaiian - type melts.

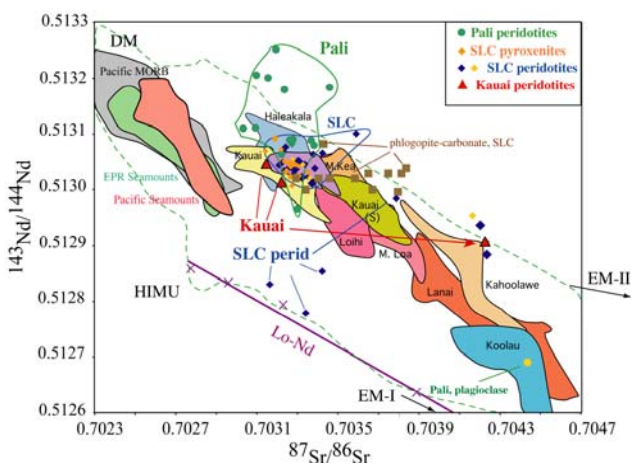

Fig. 1. Sr-Nd isotope compositions of Oahu and Kauai peridotites compared with data from the Hawaiian lavas and Pacific MORB and seamounts.

Conclusions

We propose that the observed isotope heterogeneity in the Oahu and Kauai peridotites reflects the presence of plume-derived peridotites within the Pacific lithosphere. The Pali peridotites have compositions compatible with the 90 million year old Pacific lithosphere beneath Oahu. The SLC are best explained as fragments of an ancient (>1 billion year old) recycled mantle lithosphere that is brought to the surface by the Hawaiian plume. The similar temperatures of last equilibration of both the SLC and Pali peridotites (800-1000°C) suggests that plume and Pacific mantle peridotites are juxtaposed beneath Oahu at depths as shallow as 60 km. This provides independent evidence for thinning of the 90-100 km thick Pacific lithosphere by the Hawaiian plume, downstream from the present day plume center under the Big Island. The preliminary Kauai data suggests that such heterogeneity could be observed in the Kauai lithosphere. Additional analyses on Kauai peridotites will text the lateral extent of replacement of the lithosphere by plume-derived material.