EVIDENCE FOR A DEPLETED COMPONENT IN HAWAIIAN VOLCANISM FROM HAFNIUM-NEODYMIUM ISOTOPE SYSTEMATICS OF GARNET PYROXENITES

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Introduction

Characteristic of Hawaiian and other oceanic island volcanism is the eruption of small volume, highly alkalic, and incompatible element enriched "post-erosional" lavas at end of volcano. These lavas are isotopically more depleted than the voluminous tholeitic, shield-building stage volcanism requiring a trace element enriched, but long term depleted mantle source. The presence of garnet pyroxenite xenoliths in the post erosional lavas from Oahu, Hawaii, provide a unique opportunity to study the deeper (>60km) lithosphere and the processes taking place therein. Here we present the first comprehensive major, trace element and Hf, Nd and Sr isotope investigation of clinopyroxene and garnet mineral separates from a set of garnet clinopyroxenite xenoliths from the Salt Lake Crater, Oahu, Hawaii, in order to constrain their origin in the context of Hawaiian volcanism.

Results and Discussion

Thermobarometric calculations suggest that these SLC garnet pyroxenites last equilibrated at 20-30kb (60-90km) and about 1200 C. These temperatures are about 200-300 degrees C hotter than the temperature of the lithosphere at these depths. The calculated melts in equilibrium with these pyroxenites better resemble the Honolulu Volcanics (HV), rather than MORB or EMORB. In terms of Lu-Hf and Sm-Nd isotope systematics all clinopyroxene-garnet mineral pairs analyzed here show, within error, zero-age. The SLC pyroxenites have relatively radiogenic Hf isotope compositions (ε_H =11.8- 18), for a given Nd, (ε_{Nd} = 7.2-8.5) and define a distinct steep slope (3.2) in ε_{Hf}-ε_{Nd} isotope space, similar to the Honolulu Volcanics but unlike most other ocean island basalts (OIB). The above evidence suggests that these pyroxenites are zero-age cumulates from melts isotopically similar to the Honolulu Volcanics. However the distinct steep slope in Hf/Nd isotope space of both SLC pyroxenites and HV lavas require an endmember component that falls above the OIB array. Such an endmember is identified in the SLC spinel peridotites that have extremely radiogenic Hf and unradiogenic Os isotope compositions and have been explained as ancient (> 1Ga) depleted recycled oceanic lithosphere [1,2]. However, the radiogenic Os isotope compositions in similar pyroxenites [3] require that such ancient lithosphere cannot directly contribute (directly by melting, or indirectly by reaction) to melts that give rise to the pyroxenites. Instead, melts derived from this depleted lithosphere must mix with a (presumably) plume-derived melt with radiogenic Os isotopic composition to generate these pyroxenites and, by inference based on the similarities, the Honolulu Volcanics. Irrespective of the Os isotopes however, the Hf/Nd isotopes clearly require a previously depleted component to contribute to these pyroxenites.

Conclusions

The zero-age Lu-Hf, Sm-Nd isotope systematics of the SLC garnet pyroxenites and their Hf-Nd isotope similarity to the host Honolulu volcanics points to a genetic link between the two. The relatively radiogenic Hf isotope ratios require a depleted component, unlike MORB, in the source of these pyroxenites. Whether this depleted lithosphere is an ancient (>1Ga old) depleted lithospheric component intrinsic to the Hawaiian plume (i.e. recycled old lithosphere) or the 100Ma old lithosphere that lies beneath Oahu, is not entirely clear. Based on the isotopic similarities between the recent Honolulu volcanics and old (70Ma) volcanics from the Emperor seamounts, Frey et al [4] suggested that a depleted component, intrinsic to the hot spot, must have been present in the source of both lavas. In this case, we consider it more likely that the depleted component recognized in these pyroxenites resides within the Hawaiian plume and its signature becomes more evident in the winding stage of volcanism where it is not diluted by the voluminous shield-stage plume melts.

References

[1] Bizimis et al., EPSL, **217**, 43-48 (2004).
[2] Bizimis et l., AGU, Fall meeting Abstracts (2004)
[3] Lassiter et al., EPSL, **178**, 269-284 (2000).
[4[Frey et al., G^3 (in press)