HETEROGENEITY IN THE UPPER MANTLE FROM Nd ISOTOPIC COMPOSITION OF THE ABYSSAL PERIDOTITES

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Introduction

Melting models for the basaltic volcanism at mid-ocean ridges are dependent on our assumptions of the nature of the mantle material that melts. Some insights on the source of the volcanism comes from abyssal peridotites, which are the residues after melting. The melting process cannot change the isotopic composition of the heavy elements. Therefore, if the abyssal peridotites are the sole source for the basalts then the basalts and peridotites should have the same isotopic composition. However, previous studies have shown that at some segments of the South West Indian Ridge (SWIR) the abyssal peridotites have a more depleted Nd-isotopic composition [1], while at the Oceanographer fracture Zone in the Atlantic Ocean the peridotites and basalts have similar isotopic compositions [2]. Here we follow up with the study of samples from more locations on the SWIR as well as peridotites from the Mid Cayman Rise.

Experimental

Clinopyroxene concentrated were produced by first magnetic separation of crushed samples followed by handpicking under binocular microscope to ensure pure separates. One hundred milligram of mineral separate was leached to remove the majority of alteration products. This resulted in a mass loss of 20-50%. TNd and Sr pure separates were produced using standard ion exchange techniques and were analyzed using thermal ionization mass spectrometry . For some samples the amount of Nd available for analysis was less then 10 nanograms. Blank levels for the total chemistry were just several picograms thus the isotopic composition was not compromised by high blank levels. Some mineral grains were mounted in epoxy and subsequently polished. The minerals in these polished mounts were analyzed for trace elements using laser ablation ICP-MS.

Results and Discussion

The SWIR peridotites from three different dredges all show LREE (light rare earth elements) depletions, however the samples from the three dredges have distinct Nd-isotopic characteristics. The six peridotites analyzed from dredge VAN-7-85 have high Nd-isotope ratios (0.513086-0.513320) all higher than the Nd-isotope ratios of the associated basalts. The cpx from these peridotites are also some of the most depleted in terms of REE with Ce being less than 0.1 times and Yb less than 10 times chondritic. Basalts from this area range from LREE depleted to LREE enriched and the cpx are not in equilibrium with the associated basalts. Nd-isotope ratios of the dredge VAN 7-78 is more homogeneous (0.513003-0.513046) and overlapping with the associated basalts. The LREE are less depleted (Ce 2-5 times chondritic) than dredge 85. The least depleted cpx could be in equilibrium with associated basalts. In contrast to these two dredges, cpx from the VAN 7-96 are most enriched in Nd-isotope ratios (0.512885-0.512933). LREE in the cpx are more enriched (8 times chondritic) than those at the two other locations and show highest normalized concentrations for the middle REE (Sm-Eu-Gd, up to 11 times chondritic). However, these cpx are too depleted in the HREE Hto be in equilibrium with the associated basalts.

MCR peridotites dredged from two different locations show extreme LREE depletion pattern with CeN less than 0.1 times chondritic and Yb less than 10 times chondritic, and are not in equilibrium with the associated basalts. Nd-isotope ratios of these two locations have a restricted range (0.513111 to 0.513278) which overlaps with the basalt (0.513115-0.513190) and extends to higher ratios.

Conclusions

At both SWIR and MCR, peridotites are on average more depleted in Nd-isotope ratios than the associated basalts. This systematic depletion requires an enriched component with lower solidus. Lack of correlation between isotopic composition and degree of major element depletion in the abyssal peridotite indicates that this enriched component is not peridotitic. Although the range in Nd-isotopic composition of a single dredge is significant, the range is smaller than observed at peridotite massifs over a similar lengthscale. However, the range in trace element compositions observed in a single dredge is larger than can be explained by variations in degree of melting as a single dredge is often less then a few kilometers in length. This indicates that the MORB mantle exhibits significant heterogeneity in the peridotitic component.

References

[1] Salters, V.J.M. and Dick H.J.B. , Nature, 418, 68-72 (2002).
[2] Cipriani, A. etal., Geology, 32, 657-660, (2004)