Relationship between Abyssal Peridotites and Mid-Ocean Ridge Basalts through Nd Isotopes

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Introduction

It is well established that abyssal peridotites are the residue after melting at mid-ocean ridges [1, 2]. However, it is less clear whether peridotite is the only lithology that contributes to mid-ocean ridge volcanism and we previously argued that, for the South West Indian Ridge (SWIR), an additional component is needed [3]. This conclusion was based on the fact that mid-ocean ridge basalts (MORB) and abyssal peridotites from this area have different $^{143}Nd/^{144}Nd$ ratios, with the MORB being less radiogenic. It was argued that a component with a lower solidus then peridotite contributed to MORB at the SWIR. In this study we investigated whether this lower solidus component is present at other locations. In addition we investigated the extend of the heterogeneities in the sub ridge mantle.

Experimental

To maximize the possible effect of a lower solidus component we concentrated on two ridge segments fore which the basalt chemistry indicates a low degree of melting: mid-Atlantic Ridge near the Kane Fracture Zone and the mid-Cayman Rise (MCR). Both basalts and peridotites were analyzed for these areas. For the peridotites we separated the clinopyroxene using mineral separation techniques and final “clean up” through hand picking under a microscope. Regular dissolution and separation techniques were used to prepare Nd separates for isotope analyses. Separates were analyzed on our multi-collector inductively coupled plasma mass spectrometer (Thermoquest NEPTUNE) in static mode. Additionally the trace element content of the clinopyroxenes were determined by laser ablation ICP-MS.

Results and Discussion

Abyssal peridotites and basalts have similar Nd-isotopic compositions at the Kane Fracture Zone, while at the mid-Cayman Rise the peridotites extend to more radiogenic compositions. The MCR results require a lower solidus component to contribute to the basalts. Additionally, the rare earth element abundance patterns for the basalts show little variation while the clinopyroxenes of the peridotites display a large variation in trace element patterns. Since the peridotites are from the upper part of the mantle they must have experienced very similar degrees of melting. Therefore the variation in the rare earth element patterns have to represent heterogeneities that were present before melting. With the trace element composition of the basalts and assuming an average depleted mantle source [4] we calculated the average amount of melt extracted at the top of the melting zone. For the MCR and the Kane area this is 10% and 14% respectively. With these degrees of melting we can now calculate the composition of the individual peridotites before melting and take this trace element composition in combination with the Nd-isotopic composition to calculate model ages for this MORB source. This calculation yields ages that are between 500 Ma and 1.4 Ga and are similar to the Re-depletion ages that are found at other places along the ridge [5, 6].

Conclusions

A low solidus component is required to explain the full spectrum of MCR basalts and peridotite alone cannot explain the basalts. There is significant heterogeneity in composition and age of the sub-ridge mantle and the melting process acts to average out these heterogeneities.

Acknowledgements

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References

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