Two Billion Year old Depletion of MORB Mantle Recorded by Abyssal Peridotites

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Introduction

We report on major and trace element abundances and isotopic compositions of clinopyroxene (cpx) and major element contents of spinels from abyssal peridotites (APs) from Southwest Indian Ridge (SWIR), Mid Cayman Rise (MCR) and Mid Atlantic Ridge (MAR).

Some of the peridotites show evidence of melt infiltration or re-equilibration, which is identified by high Na and Ti content in clinopyroxene (cpx) and the elevated rare earth element (REE) patterns, although they do not contain plagioclase. The majority of the APs do not have any chemical or mineralogical indicators of re-equilibration with a melt. These APs with a "pristine" residual signature are the focus of this report.

Results

At the SWIR, 7 APs from a single dredge have uniform major element composition with moderately depleted signature (Mg# 0.91). However, these peridotites have a large range in REE content and some of them are strongly depleted in light REE (Ce_N = 0.003, N denotes bulk earth normalized). At MCR, major elements and REE are all moderately depleted but the variation in light REE content is large (Ce_N=0.0018-0.14), which is even larger than the SWIR peridotites. MAR peridotites are very homogeneous in major element composition and in comparison to SWIR and MCR, these peridotites are characterized by lower middle to heavy REE (Dy_N = 7, Yb_N = 1) indicating, on an average, higher degree of melting.

Nd-isotope ratios of SWIR and MCR APs span a large range, which partially overlap with the Nd-isotope ratios of the associated basalts but also extend to more radiogenic ratios. However, MAR peridotites are all identical to the local basalts in Nd-isotope ratios.

Discussion

APs are assumed to represent the top of the residual mantle. Therefore, the APs of a single dredge should have undergone a similar degree of depletion because they followed the same P-T-t path. However, at each location APs show considerable variation in trace element ratios. This variation from a limited geographic area, for example MCR is only 100 km long, and even at a single dredge level, which is typically less than 1 km, cannot be explained by the variation of degree of melting alone, requiring significant source variation.

This variation can be explained by a two component mantle whereby one component has a lower solidus. This lower solidus component will melt first and will draw heat from the high solidus component thereby enhancing its melting and retarding the melting in the high solidus component. Alternatively, by assuming that all APs at a location has undergone similar degree of melting, and assuming a depleted mantle composition for the average source of the local ridge basalts one can calculate the degree of melting of that mantle section based on the average REE pattern of the local ridge basalt. This allows the calculation of the Sm/Nd ratios of APs before melting. With the measured $^{143}Nd/^{144}Nd$ and calculated Sm/Nd ratios one can calculate a model age. These model ages for the local asthenosphere range from several hundred Ma to ages as old as 2.2 Ga. These older ages are consistent with Os depletion ages. These calculations also show that the MORB mantle is not only heterogeneous in composition at a small scale, but also heterogeneous in age.

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