The effects of melt extraction and melt-rock reaction on abyssal peridotite geochemistry

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Abyssal peridotites from the slow to ultra-slow spreading Southwest Indian Ridge (SWIR) have trace element characteristics indicative of variable degrees of melting, melt-rock reaction, and melt extraction. Unravelling the superimposed effects of these processes is key to understanding mid-ocean ridge systematics. Peridotites at fast spreading ridges have low modal Cpx and low Cpx Ce concentrations, indicating high degrees of melting and extraction. As spreading rate decreases, the ranges of modal Cpx and Ce concentrations increase, indicating that a variety of processes, including melt-rock reaction, affects abyssal peridotite compositions.

Scale lengths of melt-rock reaction vary from the kilometer-scale (e.g., within a dredge) to the centimeter-scale (e.g., within a single sample). Ranges of trace element concentrations produced by melt-rock reaction can cover more than 2 orders of magnitude for light rare earth elements (LREE). In some peridotites, the presence of gabbro or pyroxenite veins clearly demonstrates the occurrence of melt-rock reactions. In one such suite of pyroxenite veined peridotites from the SWIR Oblique Segment, large local-scale isotopic heterogeneities are observed. Trace element analyses place constraints on the melt-rock reaction processes responsible for the isotopic and chemical heterogeneities. In contrast, a second Oblique Segment dredge has peridotites which are uniformly depleted in REE with variable modal Cpx contents, suggesting that these peridotites had variable modal compositions prior to the onset of melting. In two samples from the ridge-transform intersection of the SWIR with the Atlantis II Fracture Zone, Cpx compositions vary from typical, depleted REE patterns to Cpx with 2-3 orders of magnitude enrichment in LREE, over a lengthscale of ~2 cm. We suggest that LREE enrichment in these samples was produced by chromatographic reaction with an infiltrating melt. The absence of Eu anomalies in the cores of all clinopyroxenes indicates that this melt addition occurred a depths greater than the plagioclase stability field. Our detailed trace element analyses of abyssal peridotites indicate that more varied processes are involved in melt extraction and over a wider range of depths than previously observed.