SURPRISES IN ABYSSAL PERIDOTITES: IMPLICATIONS FOR MELT MIGRATION BENEATH OCEAN RIDGES

Y. Niu

Department of Geosciences, University of Houston, Houston, TX 77204, USA Phone: 1-713-743-9312; Fax: 1-713-748-7906; E-mail: yniu@mail.uh.edu

Since Mike’s two classic papers [1,2], the last 35 years have seen much progress on MORB petrogenesis because of improved experimental/theoretical approaches and because of rapid growth of geochemical database on MORB samples from the global ocean ridge system. Our current understanding of MORB genesis also owes a great deal to the studies [3-5] of abyssal peridotites - interpreted as mantle melting residues for MORB. Recent studies [6,7] have confirmed the complementary relationship between MORB and abyssal peridotites, but also revealed the hidden complexities in these peridotites such as olivine addition [6-8] and melt refertilization [7-9]. These same studies [6,7] have simultaneously excited serious debates on the petrogenesis of abyssal peridotites [10-14]. These debates are actually different views on the same observations: modes and major element compositions of residual minerals, and trace element data on residual clinopyroxene (Cpx) [3-5]. I report here whole-rock ICP-MS trace element data on abyssal peridotites including samples previously studied for Cpx trace elements [5]. Residual Cpx shows highly depleted light rare earth elements (LREEs) with flat-to-elevated middle-heavy REEs (e.g., \([\text{Ce}]_N = 0.25\pm0.51\) [mean\(\pm\)1\(\sigma\)]; \([\text{Yb}]_N = 6.09\pm2.59\); \([\text{Nd}/\text{Sm}]_N = 0.29\pm0.14\); \([\text{Nd}/\text{Dy}]_N = 0.14\pm0.11\)), which is consistent with varying extents of melt depletion [5]. In contrast, whole-rock data of the same samples [15] show elevated abundances of LREEs with flat to enriched LREE patterns (e.g., \([\text{Ce}]_N = 0.57\pm0.74\); \([\text{Yb}]_N, 0.72\pm0.41\); \([\text{Nd}/\text{Sm}]_N = 1.18\pm0.41\); \([\text{Nd}/\text{Dy}]_N = 0.70\pm0.38\)). If the constituent Cpx records the melting process, the whole-rock data would suggest post-melting LREE addition. The significant correlations of LREEs with high-field strength elements (HFSEs) (e.g., \(R_{\text{Ce}−\text{Zr}} = 0.730, R_{\text{Nd}−\text{Zr}} = 0.789, R_{\text{Ce}−\text{Nb}} = 0.836, R_{\text{Nd}−\text{Nb}} = 0.900\)) suggest that this LREE
addition is magmatic refulertilization (vs. serpentinization). The observation that this magmatic refulertilization did not affect Cpx composition is informative. There are two possibilities: (A) The refulertilization took place in the "cold" thermal boundary layer atop the mantle through which the ascending melts cooled and crystallized olivine out accompanied by some melt entrapment, giving rise to excess olivine and elevated LREE abundances in the bulk tock [6-8]. (B) The ascending melts, when percolating along grain boundaries, could only affect Cpx crystal "rims", which together with the rest of the rock had been serpentinized; the Cpx trace elements were determined from unaffected Cpx "cores" [5]. In either scenario, the following statements are true: (1) the ascending melts will interact with the advanced residues, seen on petrographic scales; (2) the interaction is not chemically reactive; and (3) porous flow is significant even at the "cold" shallow depths. These statements are supported by unexpectedly large, yet correlated variations of HFSEs (Nb = 0.5-1840; Ta = 0.1-71; Zr = 9-18605; Hf = 1-590; Nb/Ta = 0.8-200; Zr/Hf = 2.4-336) exhibited by the entire data set [16].