Evidence for and consequences of melting a marble-cake mantle

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Mid-ocean ridge basalts (MORB) and abyssal peridotites (APs) are thought to be complementary samples of the convecting upper mantle, with MORB generated by decompresion melting of the upper mantle and APs representing the melt-depleted residues of this process. Although melt refertilization and reactive melt transport are also important, this simplified picture predicts that MORB and APs should on average have similar radiogenic isotope signatures. However, recent studies indicate that APs have more heterogeneous Nd- and Hf-isotopes than MORB and extend to much more "depleted" isotopic compositions [1,2]. In addition, average Os-isotope compositions of APs and ocean island peridotite xenoliths are significantly sub-chondritic, and require greater melt depletion of average upper mantle (>10%) [3] than is estimated from inversion of MORB compositions [4].

Preferential sampling of fertile domains within the mantle during melt generation provides an explanation for the apparent mismatch between MORB and AP isotopic compositions. During partial melting of heterogeneous mantle, fertile domains (both fertile peridotites and eclogite/pyroxenite lenses) preferentially contribute to melt production relative to refractory (e.g., harzburgitic) domains. Preferential sampling of fertile and isotopically less depleted peridotite can account for a portion of the isotopic mismatch between MORB and APs. In addition, the presence of metasomatic sulfides in some APs with suprachondritic $^{187}Os/^{188}Os$ values typically not observed in AP wholerocks [5] suggest that these peridotites record melt-rock reaction involving melts derived from eclogite or pyroxenite components. The role of eclogite or pyroxenite melting in MORB genesis can be further examined by forward modeling of melt generation from heterogeneous mantle using the pMELTS software. Mixing of eclogite- and peridotite-derived melts should generate correlations between major element and isotopic compositions in suites of MORB from individual ridge segments, and should also produce correlations between Os- and U-series isotopes in zero-age MORB.

[1] Stracke et al. (2011) *EPSL* 308, 359-368 [2] Byerly & Lassiter (2014) *Geology* 42, 203-206. [3] Lassiter et al. (2014) *EPSL* 403, 178-187. [4] Workman & Hart (2005) *EPSL* 231, 53-72. [5] Alard et al. (2005) *Nature* 436, 1005-1008.