The global systematics of ocean ridge basalts and their origin

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Testing models of melt generation and mantle source variations beneath ocean ridges requires a set of ridge basalt (MORB) compositions corrected for shallow-level processes. We compiled such a data set, with both individual sample and segment means for 241 segments that span the range of spreading rate, axial depth, and MORB chemical compositions. Particular attention was paid to fractionation correction. Multiple lines of evidence show that plagioclase fractionation, a key parameter in correcting observed FeO and Al_2O_3 contents back to primary magmas, occurs consistently between 8 and 9 wt. % MgO, with the exception of hydrous magmas. Data were evaluated individually for each segment to assure reliable fractionation correction, and segment means are reported normalized to both MgO of 8 wt. % and also to a constant Mg/(Mg+Fe). Both sets of corrected compositions show systematic relationships among the major elements.

The data can be used to describe the global systematics of ocean ridge basalts, and test competing models for generating the observed diversity. The principal component of chemical variation is consistent with variations in mantle temperature of ~200ºC beneath ridges. Comparisons with experimental data and pMELTS calculations show that variations in mantle composition at constant mantle temperature produce trends that are largely orthogonal to the observations. Still, there is clear evidence for mantle major element heterogeneity beneath some hot spots, and beneath back-arc basins.

Moderately-incompatible trace elements correlate with certain major elements, but cannot be explained by the same melting models. While the lowest-T mantle (highest Na_8) melts have a dry solidus shallower than the garnet field, these samples have the highest Sm/Yb ratios. And the inferred range in melting extent (F) based on Na_8 is insufficient to explain the range observed in Sm/Yb and Zr/Y, even excluding segments with highly enriched MORB. This apparent conflict can be resolved by considering volatiles, which produce a region of deep, low-F melts below the dry solidus.