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# Global Na8-Fe8 Systematics of MORBs: Implications for Mantle Heterogeneity, Temperature, and Plumes

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In a global examination of Na8-Fe8-axial depth variations of mid-ocean ridge basalt (MORB) glass compositions from the Smithsonian database, we find that modeling of MORBs as the product of large variations in potential temperaure (Klein and Langmuir, 1987, JGR, 92, 8089) is not supported by Na8-Fe8-depth data for any ridge segment of any length. However, the observed inverse and positive Na8-Fe8 variations are in excellent agreement with the systematics of solidus melts in the plagioclase/spinel lherzolite transition in the CaO-MgO-$Al_2O_3$-$SiO_2$-$Na_2O$-FeO system at 0.93-1.5 GPa, and 1240-1260˚C (Presnall *et al*., 2002, GCA, 66, 2073). This system contains all the main mantle mineral phases in this pressure range (ol, opx, cpx, pl, sp) and ∼99% of both the extracted melts and the source. Thus, chemical systematics of melts at the solidus provide very strong constraints on the major-element chemistry of melting processes. On the surface that defines solidus melt compositions in the pl/sp lherzolite transition interval, contours of constant pressure are nearly parallel to contours of constant MgO, but are at a high angle to contours of $Na_2O$. An inverse Na8-Fe8 correlation occurs for melting at constant pressure. In contrast, positive Na8-Fe8 correlations occur when short diapirs progressively melt as they rise. Melts having the highest MgO/FeO are extracted last from the tops of these diapirs. In this modeling, we find that the southern Atlantic mantle from Bouvet to about 26˚N is relatively homogeneous, whereas the Atlantic mantle north of about 26˚N shows significant long-range heterogeneity. The mantle between the Charlie Gibbs and Jan Mayen fracture zones is strongly enriched in FeO/MgO, perhaps by a trapped fragment of basaltic crust in a Caledonian suture (Foulger *et al*., 2005, Spec. Paper 388,

595). The strongly enhanced melt productivity at Iceland is explained as the product of this enrichment, not a hot plume. The East Pacific Rise and Galapagos Ridge sample mantle that is heterogeneous over short distances. The mantle beneath the northern part of the Indian Ocean is fairly homogeneous and is depleted in FeO/MgO relative to the mantle beneath the Red Sea. Our model replaces plumes and large variations in potential temperature with mantle heterogeneity and uniformly low temperatures of MORB generation.