How to distinguish source, mantle temperature, melting processes and crustal modification in MORB?

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The past 40 years have seen recurring themes on the origin of chemical variations in MORB. One emphasizes process—in the crust or mantle. A second emphasizes variations in extent of melting caused by mantle temperature and lithospheric thickness; a third claims large major element heterogeneity. The ideas can be tested with increasing rigor by the ocean ridge data they must account for. MORB glasses are invaluable, because they average over large volumes, eliminating many of the fascinating complexities apparent in mineral scale observations of gabbros and peridotites. A clear test of the importance of crustal processes exists because plagioclase is stable only at low pressures. Sr is compatible in plagioclase, while incompatible during mantle melting, so crustal processes separate Sr from elements such as Zr and Nd. Simple discriminants show that while crustal processes are important, they do not control the global variability of MORB compositions. Experimental data, correlations with axial depth, crustal thickness and seismic velocities are also all entirely and quantitatively consistent with an important role for mantle temperature in controlling MORB compositions, and rule out an important role for variations in mantle major element composition. Suggestions that these conclusions depend on the method of fractionation correction fail simple tests. The variations in part reflect hot spots, because of higher the mantle tempratures there, but also exist with the same systematics distant from hot spot influence. Lithospheric thickness is also important at slowest spreading rates. Highly incompatible trace elements are not explained by the major element models, obvious from the factor of 100 variations in concentrations. Mantle heterogeneity must play an important role. The trace elements and isotopes are not consistent with varying amounts of recycled ocean crust as an underlying cause, but instead require the movement of very low degree melts. There may also be a role for complex melting processes that are just beginning to be understood quantitatively. Fascinating variations around hot spots display “geochemical moats” that imply refertilized depleted mantle adjacent to the hot spot. In general, the vast amount of MORB data now requires a deep knowledge of global variations and the intricate differences among regions and ridge segments to be properly interpreted.

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