Causes of the compositional variability of ocean floor basalts

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The chemistry of Ocean Floor Basalts (OFBs) have been much studied for the insights that the compositions of their parental magmas are expected to give into the thermal structure of the mantle, and its compositional heterogeneity. One of Mike O'Hara's seminal contributions was to show that OFBs were not primary magmas but have undergone extensive low-pressure differentiation [1]. He also emphasised that individual magmatic eruptions are products of complex magmatic systems [2] [3]. Volcanoes are not formed by isolated events, but are sites of long-term activity, in which repeated cycles of replenishing magma mixes with earlier magma, causing eruption. In the intervals between replenishment cycles, fractional crystallization proceeds. The inevitable result is that erupted OFBs, like other basalts, are products of a complex mixing plus differentiation process [4].

If the compositions of OFBs are to be used to infer differences in the conditions of melting due to mantle thermal structure, etc., first it is necessary to disentangle the effects of this low-pressure evolution.

Here we look at the deviations from the global average trend of > 30 minor and trace element concentrations in the global array of OFBs. The global trends are taken as the logarithms of the concentrations of the elements as a function of MgO concentration. Correlations among the deviations feature a strong correlation of Na with Sr and Eu, indicating that the anti-correlation of Na with Fe in OFBs at a local scale is likely due to variations in the fractions of plagioclase to olivine to augite crystallized during their low-pressure evolution, rather than reflecting differences in depth or extent of partial melting. Thus the variability of OFB compositions probably reveals little about mantle thermal structure. A Principal Component Analysis of the variabilities reveals two more-or-less equally important principal components, suggesting two fundamentally distinct processes have affected incompatible trace-element concentrations during OFB petrogenesis.

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