Geochemical variations in a single basaltic flow at 9°30'N on the East Pacific Rise

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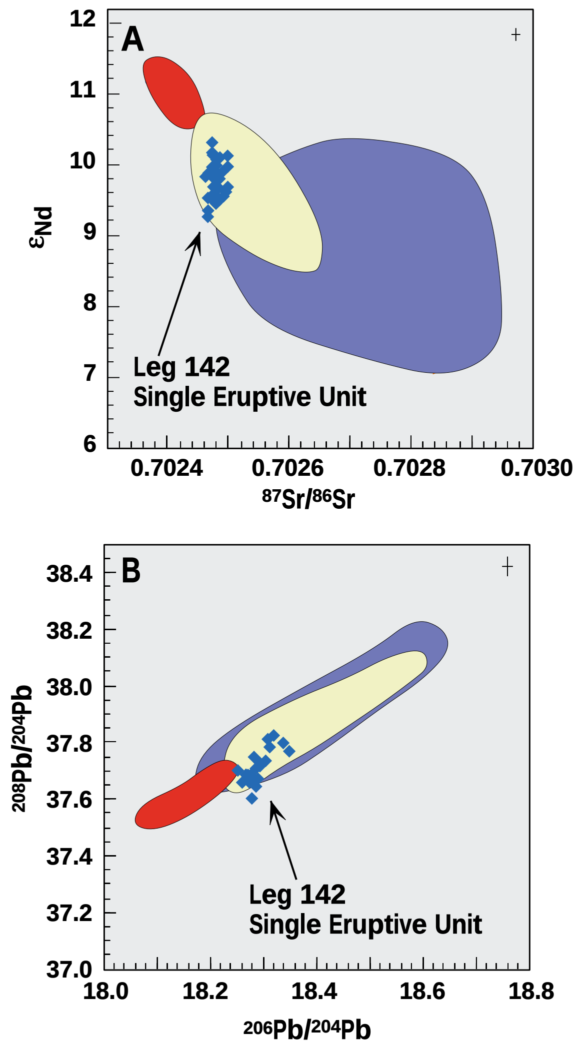
For many years, it was widely held that fast-spreading ridges such as the East Pacific Rise (EPR) were underlain by expansive magma chambers that thoroughly mixed melts prior to eruption. This assumption was supported by initial indications that erupted lavas at fast-spreading ridges were geochemically homogeneous. Recent studies of the EPR, however, have revealed small but analytically significant geochemical variations in axial lava compositions. If the variations observed over tens of kilometers are no greater than the ones observed on the scale of meters, then subtle regional variations must be regarded as *geologically* homogeneous, and, accordingly, meaningless. It is therefore important to establish the magnitude of geochemical variation within a single lava flow, in order to put more regional studies into context.

A long-standing assumption in ridge crest studies is that trace element concentrations and isotopic ratios are identical within individual eruptive units. ODP Leg 142 provided the unique opportunity to examine numerous basaltic samples from within two eruptive units, sampled from up to 15 m depth along the East Pacific Rise. The Sr, Nd, and Pb isotope ratios from the lava field are statistically indistinguishable from each other when compared to the magnitude of analytical error using F-tests at the 95% confidence level. These results confirm the simplifying assumption that single eruptive units are isotopically homogeneous. In contrast, significant variations in the trace elements occur within a single eruptive unit at the 95% confidence level. Moreover, isotopic and trace element variations in samples collected from along the EPR crest between 9° and 10°N are significantly greater than the limited variations observed within this single lava flow, suggesting that even subtle geochemical heterogeneity observed along axis is in fact geologically meaningful (see figure).

Finally, these results suggest that geochemical characteristics of the underlying mantle, not shallow magma chamber processes, are the major factors controlling compositional variation at mid-ocean ridges. Large-scale phenomena such as mantle convection may be primarily responsible for the degree of isotopic heterogeneity at mid-ocean ridges, whereas complex mantle melting processes control trace element characteristics.

Reference

Harpp, Karen S., Geochemical variations in a single basaltic flow at 9°30'N on the East Pacific Rise, *ODP Proc., Sci. Results, 142,* 9-21.



Isotopic variation in Leg 142 basalts compared to axial samples from East Pacific Rise segments.

A) Strontium isotopic ratios versus neodymium isotopic ratios. Basalts from a single eruptive unit at 9°30'N on the EPR (ODP Leg 142) are presented as solid diamonds. The red field includes data from the 20.88°-21.43°S segment of the EPR, the large blue field displays data from the 12°50'N EPR segment, and the yellow field shows data from the 9°-10°N EPR segment (includes the location of Site 864, Leg 142).

B) Lead isotopic ratio variation in the samples, same fields as in A. Note the greater magnitude of isotopic variation in every EPR segment compared to data from the single Leg 142 lava field. Error bars represent one standard deviation in analytical precision. See original paper for data references.