Ocean drilling: MORB geochemistry in the third (and fourth) dimension

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Most of our knowledge on the composition and formation of the oceanic igneous crust derives from lava samples collected from active ridge axes by dredging or submersible. However, lavas erupted at the ridge axis eventually make up the lowermost part of the extrusive section. If these differ in composition from those emplaced off-axis, then compilations of axial mid-ocean ridge basalt (MORB) may not yield an accurate estimate of the composition of the bulk crust.

Lavas drilled from the oceanic crust provide another way to estimate the composition of the bulk crust. In addition, they record changes in MORB chemistry over both long and short timescales. We have shown previously [1] that mantle temperatures recorded in the major element composition of ancient drilled MORB vary systematically over long timescales (10^6-10^8 a) in rifted ocean basins due to continental insulation effects. The chemical stratigraphy of lavas from individual drillsites could be used to investigate chemical changes over 10^3-10^5 a timescales, which may result from variations in fractionation, magma replenishment rates or source and melting effects.

We carried out major element analysis of 340 fresh glasses (>110 also for trace elements) from 30 different DSDP and ODP sites in the Atlantic and Pacific. First results indicate that lavas from single drill sites are remarkably uniform in their chemical composition when compared to the chemical variation present at the corresponding segment of the active ridge axis. We find systematic chemical variations with depth, sigmoidally shaped in the slow-spread crust of site 417D (Atlantic) and unregularly-shaped in the drillcore of site 1256D, drilled into superfast-spreading crust. This may indicate major differences in the residence time of magma in crustal magma chambers as well as in the magma replenishment rate, e.g. size and time intervals of rising magma batches. The oscillation between magmatic differentiation and magma recharge may be responsible for some of the globally observed trace element patterns in MORB as recently suggested by [2] but based on predominantly dredged samples.

[1] Brandl et al. (2013), Nature Geoscience, doi: 10.1038/ngeo1758. [2] O'Neill, H.St.C and Jenner, F.E. (2013), Nature, doi: 10.1038/nature11678.

Testing models for continental growth and melt-rock interaction from ^{186}Os-^{187}Os isotopes in southwest usa mantle xenoliths

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Melting in the convecting mantle results in lower density residual peridotite that may stabilize as subcontinental lithospheric mantle (SCLM), results in juvenile crust production, and is likely a primary mechanism to grow continents over Earth history. Perdidotite and pyroxenite xenoliths provide a compositional record of formation and subsequent modification of the SCLM.

Xenolith samples 3 classic locales in the Southwestern United States - Dish Hill (California), Kilbourne Hole (New Mexico), and Vulcan's Throne (Arizona), span an 860 kilometer-wide region within two crustal provinces, the 2.0-2.3 Ga Mojavia, and the 1.7-2.0 Ga Yavapai-Mazatzal provinces. Preliminary $^{187}Os/^{188}Os$ data for spinel-bearing peridiotites show positive correlations with melt depletion indicators such as Al_2O_3. Applying the aluminachron age concept gives ^{187}Re-^{187}Os model ages ranging from 2.0 to 2.3 Ga, broadly consistent with the ages of the overlying continental crustal provinces. If so, these data support models where continental growth is directly linked to stabilization of its underlying SCLM via partial melting in the convecting mantle. It also indicates that large off-craton continental regions may grow in rapid pulses through large-scale mantle melting events. A potentially viable alternative is that the aluminachrons record melt-rock interaction subsequent to earlier partial melting. If so, then these data instead only provide minimum model ages of partial melting via the lowest $^{187}Os/^{188}Os$ ratio measured in each suite and thus may be unrelated to the initial stages of juvenile crust production leading to continental growth, and alternatively represent later continental magmatic processes.

To futher evaluate the timing and mechanisms of SCLM stabilization and evolution and their potential link to continental growth, Os isotope data for pyroxenites from these locales will be presented to constrain compositional signatures imparted to the peridotites via melt addition or melt-rock interaction. Further, the first high-precision ^{186}Os-^{187}Os measurements of continental peridotite xenoliths will be obtained to monitor Pt-Re-Os fractionation events. Coupled ^{186}Os-^{187}Os fingerprints partial melting versus melt-rock interaction to the Os budgets of each of these xenolith suites.

DOI:10.1180/minmag.2013.077.5.2
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