Iron isotopes in the eastern North Atlantic

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Iron (Fe) is a crucial nutrient for phytoplankton and the marine food chain, and low dissolved Fe concentrations limit growth in many regions of the oceans. Knowledge of the sources, sinks and cycling of Fe in the ocean is vital to our understanding of marine biogeochemical cycles; however, concentration measurements alone are often unable to discriminate between different fluxes and processes. Fe isotope ratios address this limitation, and provide us with the unique opportunity to discriminate between biological utilization of Fe, Fe from continental shelf sediments or aerosols, and Fe from hydrothermal activity. Fe isotope values also allow investigation of internal cycling of Fe, and provide an insight into the relative importance of kinetic and equilibrium controls on dissolved Fe concentrations in the oceans.

This study presents new methodology for the simultaneous extraction of dissolved Fe, Cd and Zn from seawater using a chelating resin, followed by ion-exchange column purification and isotopic analysis by Neptune multi-collector ICP-MS. This method has been developed in order to make determinations of multiple isotope systems in the same sample as part of the GEOTRACES program, and generates a lower blank than previous methods [1].

We present the first Fe isotope (δ^{56}Fe) depth profiles from the GEOTRACES A10 (North Atlantic) Transect. This work focuses on A10 stations along 17.4° N (North Africa to Cape Verde), where multiple sources of dissolved Fe, a pronounced oxygen minimum zone at depth, and internal cycling of Fe complicate the dissolved Fe picture. δ^{56}Fe values indicate surface input of isotopically heavy Fe, biological utilisation at the surface and input of isotopically light Fe from the sediments. Relatively little variation in δ^{56}Fe through the intermediate ocean adds support to the hypothesis that rapid exchange between the dissolved and particulate Fe pools may be important in controlling dissolved Fe concentrations and δ^{56}Fe in the North Atlantic.

[1] Seth G. John and Jess. F. Adkins, 2010. Marine Chemistry 116, 65-76.

Mantle thermal anomalies associated with large igneous provinces

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The classical mantle plume model involves heat transport across the core-mantle boundary, heating the lowermost mantle, leading to a thermally buoyant mantle upwelling; melting of the upwelling material in the upper-mantle can generate large volumes of mantle-derived melt in geological short time periods such as large igneous provinces (LIPs). If correct, this is of fundamental importance for the thermal evolution of our planet. A key prediction of the thermal plume model is that some melts generated by the plume should show evidence of having been generated from mantle with a higher potential temperature than the ambient upper mantle.

Testing the ‘hot mantle’ prediction has proved controversial. Olivine-melt thermometry has been the most popular approach but has been used to argue for both large and negligible temperature anomalies in the mantle in regions of intraplate volcanism [e.g. 1,2]. This approach invariably involves the back-calculation of an observed lava composition, via olivine addition, to a melt composition thought to be in equilibrium with an observed primitive olivine composition. Since the primitive olivine and its host basalt are not in equilibrium, it is unclear if *any* form of recalculation will produce a melt composition that ever existed. In particular, because Mg-Fe diffusion in olivine is rapid at high-temperatures [3], primitive olivine are unlikely to simply be ‘early crystallization products’ from the parent to the host melt. Differentiation to produce an evolved residual magma occurs much more slowly than diffusive Mg-Fe exchange will change the olivine composition.

In an attempt to overcome these problems we have applied the Al-in-olivine thermometer [4] to primitive olivine-spinel pairs from several LIPs as well as primitive MORB. This thermometer is based on the exchange of Al between olivine and spinel and requires no back-calculation of initial compositions. Also, as Al diffusion in olivine is much slower than Mg-Fe diffusion this thermometer has a better chance of preserving the temperature of initial crystal growth. However, the thermometer can only record the temperature at co-saturation of these two phases and will not (directly) recover mantle temperatures. Application to primitive MORB from several locations, containing primitive olivine (Fo up to 91.3), gives maximum olivine-spinel co-precipitation temperatures of 1300°C. Applying the same approach to LIPs (N. Atlantic igneous province, Gorgona, Madagascar) gives higher temperatures in all locations of up to 1450°C. Relative temperature differences between MORBs and LIPs suggest that LIPs are generated by melting hotter than average mantle. The absolute temperatures for MORB are consistent with the thickness of oceanic crust.

[1] Putirka K.D., et al. (2007) *Chemical Geology* **241**, 177-206. [2] Falloon T.F., et al. (2007) *Chemical Geology* **241**, 207-233. [3] Dohmen R., et al. (2007) *Physics and Chemistry of Minerals* **34**, 389-407. [4] Wan Z., et al. (2008) *American Mineralogist* **93**, 1142-1147.