Mg isotope heterogeneity in the mantle

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Studies of mantle Mg isotopes have revealed large variations in similar samples (e.g. San Carlos olivines) [1, 2]. To date, it is uncertain whether these variations are real, and if so, what their actual causes are. In addition, there is a debate raging in the literature on whether we even know if the mantle is chondritic or not with regard to Mg isotopes. Recent work on Li isotopes has documented striking isotopic zoning in mantle materials resulting from late stage diffusive fractionation. A similar process might be responsible for causing variability in Mg isotopes and might help resolve some of the dilemmas and perplexing observations. Hence we explore this possibility in more detail by analysing large suites of peridotites, MORB, OIB and chondrites at very high precision.

The peridotites show isotopic heterogeneity significantly greater than analytical uncertainty for both Mg and Li isotopes. Analyses show that the Li isotope variation is largely caused by diffusion. Given that the two isotopic systems co-vary in these samples, this suggests that the Mg heterogeneity may, at least partly, also be caused by diffusive processes. By using known diffusivities of Li and Mg, we have constructed a model of the diffusional co-behaviour of the two isotopic systems. This ultimately allows us to determine whether this peridotite heterogeneity reflects mantle heterogeneity, or is an artefact of shallow level processes such as eruption (for xenoliths) and emplacement (for orogenic peridotites).

This data set, combined with the diffusion models, also allows definition of primitive mantle values of δ^7Li = 3.5±0.5‰ and δ^{26}Mg = -0.20±0.06‰. Interestingly, while MORB and chondrites are identical to the mantle for Li isotopes, these two populations are statistically distinct (at 95%, but not at 99% confidence levels) and isotopically lighter than the mantle for Mg isotopes.

[1] Teng *et al*. (2007), *EPSL*, **261**, 84-92. [2] Wiechert & Halliday (2007), *EPSL*, **256**, 360-371

High-precision CA-ID-TIMS U-Pb zircon age constraints from Western European Lower Carboniferous volcanic ash layers

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Numerous diagenetically altered volcanic ash layers (K-bentonites and tonsteins) are interbedded within Carboniferous sedimentary sequences of Western Europe. A number of these Carboniferous ash layers have been dated by ^{40}Ar/^{39}Ar sanidine and U-Pb zircon SHRIMP methods. However, ID-TIMS U-Pb zircon dating, which offers significant improvements in precision over ^{40}Ar/^{39}Ar and U-Pb SHRIMP techniques, has had limited application with only four ID-TIMS ages presented in the Geologic Time Scale 2004 [1].

Chemical abrasion-isotope dilution-thermal ionisation mass spectrometry (CA-ID-TIMS) U-Pb zircon geochronology was undertaken on four Lower Carboniferous (Visean and Namurian A) diagenetically altered volcanic ash layers. Visean ash layers were sampled from biostratigraphically well-constrained sequences in Belgium, where they occur as volcanogenic palaeosols within a shallow marine carbonate sequence. Namurian samples were collected from England, where K-bentonite horizons occur interbedded with basinal, ammonoid bearing, black shales.

By using the same isotopic spike throughout (Earthtime 202-205-233-235), zircon U-Pb TIMS ages from different ash layers can be compared against one another without the need to consider uncertainties in isotopic spike composition or U decay constants, both of which are major sources of systematic uncertainty [2]. This relative dating approach yielded ^{206}Pb/^{238}U ages with uncertainties as low as 0.015% (2σ, corresponding to ~50 ka on a Lower Carboniferous age). These data will be integrated with high-resolution palaeoclimatic proxy records to characterise high-frequency Carboniferous glacial-interglacial cycles which are preserved within the cyclic sedimentary record of Western Europe.

[1] Davydov *et al*. (2004) in: A Geological Time Scale 2004, 222-248. [2] Schoene *et al*. (2006) *Geochim.Cosmochim. Acta* **70**, 426-445.