THE ISOTOPIC COMPOSITION OF MAGNESIUM IN MANTLE OLIVINE: RECORDS OF DEPLETION AND METASOMATISM

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The multi-collector (MC)-ICPMS enables the in-situ measurement of radiogenic (eg Sr, Os) and stable metal (eg Li, Mg, Fe) isotope systems; the latter offers a new field of investigation at the micron scale.

We have investigated Mg isotopic variations in the lithospheric mantle by analysing olivine in peridotite xenoliths and megacrysts. High-precision in-situ measurements of $^{26}Mg/^{24}Mg$ and $^{25}Mg/^{24}Mg$ are made using a laser ablation microprobe and MC-ICPMS. Measurements are done using a standard-sample bracketing technique with an in-house olivine standard. Replicate analyses of this standard give a precision of 0.20 per mil (2sd) for $\delta^{26}Mg$ (= $[(^{26}Mg/^{24}Mg)_{sample}/(^{26}Mg/^{24}Mg)_{standard}-1]x1000$) and 0.12 per mil (2sd) for $\delta^{25}Mg$. The analysed olivine grains represent the lithospheric mantle beneath Archean cratons (Siberia, Kaapvaal, Slave), Phanerozoic fold belts (SE Australia) and oceanic islands (Kerguelen Is).

Results from olivines show significant heterogeneity in the lithospheric mantle: $\delta^{26}Mg$ ranges from 0.90-5.40 per mil and $\delta^{25}Mg$ from 0.35-2.70 per mil. There is a broad trend from lighter Mg isotopic compositions in depleted Archean xenoliths to heavier Mg in the Phanerozoic samples. Samples with petrographic evidence of refertilisation or modal metasomatism show large ranges in δMg values. Sheared peridotite xenoliths from the Kaapvaal and Slave cratons show a shift to higher δMg associated with the introduction of fluids with an 'asthenospheric' signature. 'Dry' or unmetasomatised peridotites from SE Australia have isotopically heavy Mg, whereas olivine in cryptically and modally metasomatised peridotites (amphibole+apatite–bearing) become progressively heavier,both absolutely and relative to pyroxene and amphibole, with increasing degrees of metasomatism. The heterogeneity measured in individual samples suggests that the processes controlling Mg isotopic fractionation are preserved on the intra-grain scale, and indicates the importance of kinetic processes in controlling isotope fractionation at high temperatures. The in-situ measurement of Mg isotopes provides a valuable new method for investigating processes in the mantle.