MAGNESIUM ISOTOPIC COMPOSITION OF OLIVINE BY LASER ABLATION MULTIPLE COLLECTOR ICPMS

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A method has been developed for in situ high precision measurements of $^{26}Mg/^{24}Mg$ and $^{25}Mg/^{24}Mg$ in olivine using a laser ablation microprobe and multi-collector ICPMS. The technique has been used to investigate magnesium isotopic variations in olivine from the lithospheric mantle. The olivine grains analysed are from a selection of mantle-derived peridotite xenoliths and megacrysts chosen to represent the lithospheric mantle beneath Archaean cratons (Siberia, Kaapvaal, Slave), Phanerozoic fold belts (southeastern Australia) and oceanic islands (Kerguelen Island).

Olivine from the dunite at Almklovdalen (ALM-1; Fo = 92.9), Norway has been developed as a laser standard. Hand-picked fragments of this olivine and olivine from spinel lherzolite xenoliths from San Carlos (SC-1; Fo = 91.1), USA, were prepared as solutions and analysed against SRM980 Mg to verify the in situ technique. Potential matrix effects and interferences were assessed by spiking SRM980 with Fe, Ca, Cr and Ti. All in situ measurements were made using a standard-sample bracketing technique with ALM-1 olivine as the standard. The compositions are expressed as per mil deviation (δMg) and normalised to the isotopic composition of SRM980. Replicate analyses of the Almklovdalen olivine indicate a precision of 0.20‰ (2sd) for δ^{26}Mg and 0.12‰ (2sd) for δ^{25}Mg. The results for the olivines show that there are significant variations in δ^{26}Mg and δ^{25}Mg in the lithospheric mantle.

The overall range determined so far is from 0.90 to 5.40‰ δ^{26}Mg and 0.35 to 2.70‰ δ^{25}Mg. A broad trend is discerned from lighter Mg isotopic compositions in more depleted Archaean xenoliths to heavier compositions in the Phanerozoic samples from SE Australia and Kerguelen. Individual grains and samples show δ^{26}Mg variations greater than the external precision determined for ALM-1 suggesting that the processes controlling Mg isotopic fractionation are preserved on the microscopic scale. Samples with petrographic evidence of refertilisation or modal metasomatism show the largest ranges in δMg values. The sheared peridotite xenoliths from the Kaapvaal and Slave cratons provide evidence for a shift to heavier δMg values associated with the introduction of fluids with an 'asthenospheric' signature. The effect of modal metasomatism on δMg is evident in the spinel lherzolites from SE Australia. The trend is to heavier isotopic compositions in cryptically metasomatised and modally metasomatised (amphibole+apatite-bearing) lherzolites. The variation in the Mg isotopes of the olivine grains suggests that parts of the sample have been significantly modified by fluids moving along distinct pathways. The variations observed in δMg in olivine in individual samples indicates re-equilibration and the importance of kinetic processes in isotope fractionation at high temperatures. The results obtained so far indicate that the in situ measurement of Mg isotopes provides a valuable new method for investigating processes in the mantle.