Oxygen isotope constraints on the origin of high-Cr garnets from Kimberlites

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The association between diamonds and high-Cr, sub-calcic garnets from kimberlites suggests these garnets have experienced high pressure and temperature conditions in the mantle. However, their oxygen isotope compositions were generally reported to be lower than those of coexisting olivines that have typical upper-mantle values, correlate negatively with their Cr-contents, and display subtle inter-mineral disequilibria [e.g. 1, 2, 3]. These observations require sub-calcic garnets either were derived from high-temperature hydrothermally-altered, Cr-rich crustal materials during deep slab subduction or have experienced cryptic metasomatism by high-Cr, high-Mg, but ^{18}O-depleted melts during their ascent to the surface of the earth.

We investigated the 'Cr-effect' on determining oxygen isotope compositions of high-Cr garnets. Mixtures of garnet standards (GMG-2) and various amounts of pure Cr-metal were measured for δ^{18}O-values by infrared-laser fluorination technique (ILFT). Experiments show that oxygen isotope compositions of sample mixtures vary systematically as a function of the Cr-content and O_2-yield. Mass-balance and spectroscopic analyses indicate the correlation between the measured δ^{18}O-value and Cr-content is an analytical artifact mostly due to quantitative fractionation between the extracted-O_2 and chromium oxyfluorides in the sample chamber during the ILFT analyses (~0.086‰ for 1 wt. % Cr_2O_3 present). After applying our experimentally-calibrated correction method to garnets from South Africa and Canada [2, 4], our study reveals an equilibrium oxygen isotope fractionation between the Cr-poor garnet and coexisting olivine (i.e. Garnet ≥ Olivine). More importantly, the high-Cr garnets (Cr_2O_3>5%) have a δ^{18}O-value of ~6.0±0.1‰, suggesting the involment of ^{18}O-enriched crustal materials during their formation.

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Geochemical evidence for crustal assimilation at mid-ocean ridges

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While the majority of eruptions at spreading centers produce lavas with relatively limited basaltic compositions, dacites have erupted at several mid-ocean ridges (MOR). MOR dacites have remarkably consistent major and trace element trends and isotopic ratios, suggesting similar processes control their chemistry. The geochemistry of MOR dacites suggests that assimilation is important in their petrogenesis. These lavas are characterized by elevated Cl, U, Th, Zr, and Hf; low Nb and Ta and relatively low δ^{18}O (~5.6 vs. expected ~6.9). Petrologic modelling suggests that fractional crystallization and assimilation of altered crust will produce magmas consistent with MOR dacite compositions. Small amounts of partial meting and assimilation of oceanic crust may also be significant in the petrogenesis of evolved MORB. Thus, we investigate if these crustal processes affect interpretations of mantle source compositions by changing primary incompatible element concentrations and isotopic ratios. MOR dacites exhibit limited radiogenic isotope ratios that lie between ratios of spatially related basaltic lavas. We interpret this as geochemical homogenization of partial melts from a range of basaltic compositions within the crust during assimilation.