New constraints from halogen abundances and lithium isotopes on the behavior of water in the mantle

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Peridotite water concentrations correlate poorly in many xenolith suites with indices of melt extraction (e.g., spinel Cr#) or metasomatic enrichment (cpx La/Sm), contrary to predictions based on the incompatible behavior of H_2O during melting. To further investigate the processes that control water abundances in the mantle, we analyzed halogen abundances and Li isotope ratios in two suites of variably melt-depleted and metasomatized spinel peridotites from the Colorado Plateau (CP) and Rio Grande Rift (RGR) that have previously been studied for NAM water content.

The North American lithosphere records variable metasomatism by melts and fluids generated from dehydration of the subducted Farallon slab. Halogen abundances in CP and RGR xenoliths are elevated relative to primitive mantle, with Cl content ranging from ~6-314 ppm and I and Br abundances ranging up to ~150 and ~900 ppb, respectively. However, contrary to in arc basalts, water does not correlate with halogen enrichment. Rapid diffusion of water, either prior to or during xenolith ascent, has been proposed as a mechanism for decoupling H_2O with other tracers of melting and metasomatism.

Diffusive influx of Li into mantle xenoliths from host magmas during xenolith ascent or sub-solidus cooling has been shown to generate anomalously low δ^7Li values in both bulk peridotites and pyroxene separates. δ^7Li values spans a wide range in the CP and RGR xenoliths, from ~+5 to -5 ‰, and is negatively correlated with LREE enrichment, consistent with diffusive influx of ^{6}Li and coupled melt/xenolith reaction immediately prior to or during ascent, eruption, and cooling. A broad correlation between bulk peridotite δ^7Li and pyroxene H_2O/Ce is consistent with diffusive water loss concurrent with Li influx. Because estimated Li diffusivity is ~1 order of magnitude lower than for H, if Li-isotopes have been affected by diffusive processes during xenolith ascent, it is probable that NAM water abundances have also been affected by melt/xenolith diffusive exchange. Thus, Li isotopes may serve as a useful filter for selecting samples least affected by recent diffusive resetting. Ony samples that record equlibrium inter-mineral δ^7Li values should be used to constrain pre-eruptive mantle water abundances.