

Diffusive isotope fractionation of Zr in silicate melts

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In recent years, several studies have documented significant fractionation of Zr isotopes within igneous systems, the origins of which have been debated [1-3]. Both ab initio predictions [4] and zircon growth experiments [5] indicate that equilibrium fractionation is not responsible for the observed large ^{94/90}Zr variations in many natural igneous systems, and instead some studies have posited that diffusive isotope fractionation of Zr during mineral growth in silicate melts is the driving mechanism behind these variations [4-6]. Nevertheless, this diffusive isotope fractionation hypothesis has not been directly tested, nor have experiments been conducted to quantify the magnitude of isotope separation resulting from diffusion. To test this hypothesis, we have conducted a series of experiments aimed at measuring the diffusive β-parameter $[(D^H/D^L) = (m_L/m_H)^\beta]$, where D is the diffusion coefficient, m is the mass of the isotope, and the letters L and M refer to the light and heavy isotope, respectively] for Zr in silicate melts with varying SiO₂ and H₂O concentrations. At this writing, we have successfully performed time-series experiments at 1450 °C and 1 GPa pressure on a Tonga arc basaltic andesite that was doped with ZrO₂, in addition to preliminary experiments on anhydrous synthetic melts ranging from 45 - 65 wt. % SiO₂, at the same P-T conditions. Aliquots for isotopic analysis from the basaltic andesite experiments have been successfully recovered by micro-drilling the experimental products and are in the process of being analyzed for ^{94/90}Zr. We will present results from these experiments and discuss their implications for quantifying the degree of kinetic Zr isotope fractionation taking place in melts and for further disentangling the mechanisms responsible for the ^{94/90}Zr variations observed in natural igneous systems.

References:

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