The Soret effect and the isotope mass effect on diffusion of sulfur isotopes in a reduced, anhydrous basaltic melt

Marc-Antoine Fortin[1], E. Bruce Watson[1], Richard A. Stern[2], Shuhei Ono[3]

[1]Department of Earth & Environmental Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180, USA
[2]Canadian Centre for Isotopic Microanalysis, Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB T6G 2E3, Canada
[3]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Isotopes of major, trace and volatile elements have been shown to fractionate based on their diffusivities, leading to significant effects on isotope ratios. Similarly, isotope fractionation can also occur because of the Soret effect (fractionation in a thermal gradient). Here, we report experimental characterizations of both the isotopic mass effect on diffusion and the Soret effect on S isotopes in a dry, reduced basaltic melt. We investigated these effects separately using a piston-cylinder apparatus to generate dry basaltic quenched glass under oxygen fugacities where sulfide species predominate. For the diffusive fractionation experiment, S atoms were induced to diffuse at 1350 °C and 1 GPa in a diffusion couple consisting of high and low S concentration halves; in the Soret experiments, homogeneous S concentration compositions were put in a thermal gradient of ~175 °C, with end temperatures between 1400 and 1500 °C, and 1 and 1.5 GPa pressures. The experiment run products were analyzed by secondary ion mass spectrometry (SIMS) and isotope ratio mass spectrometry (IRMS). In contrast with the isotopes of most elements investigated previously (Ca, Li, Mg, Fe, Cl), no significant diffusive isotope fractionations beyond analytical precision were found between ^{32}S and ^{34}S (β=0). These data suggest that diffusive fractionation effects on S isotopes are not important—at least for dry basaltic systems where S predominantly exists as sulfide species—and can therefore be safely ignored when interpreting data from analogous natural systems. However, we also report potential Soret fractionations as large as approximately 1‰ for δ^{33}S, 2.1‰ for δ^{34}S, 3.8‰ for δ^{36}S, and 40 ppm for elemental S, with enrichments of S and its heavier isotopes at the colder ends of the thermal gradients.