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Experimental constraints on the diffusion of volatile and redox-sensitive elements in pyroxenes

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Diffusion of major and trace elements (e.g. Fe-Mg, Li, etc.) in pyroxene group minerals is a powerful witness and tool to track the timescales of various processes in magmatic systems. Diffusion of volatile elements (e.g. Cu, Li) enable us to estimate timescales of volatile-driven processes. Redox-sensitive elements (e.g. V) may also be used to identify changes, if any, in the redox condition of a magmatic system. The relative variations in diffusion rates between these two groups of elements can provide a complementary record of timescales, as preserved in pyroxenes. In this study, we present preliminary data on diffusion experiments of Li, Cu, and V in gem-quality enstatite ('Opx-7') and naturally occurring diopside from Otter Lake, Canada ('OL-Di'). For Cu and Li diffusion in pyroxenes, we designed an experimental setup in evacuated silica tubes, where two powder-couple diffusion experiments buffered by either NNO or IW solid powder were simultaneously annealed in a muffle furnace at T = 950-1100°C, P = 1 atm for 6-96 hours. For Vanadium diffusion, we used a thin film experiment following [1] in a vertical furnace buffered at log (fO_2) = -10 at T = 950-1200°C, P = 1 atm for 66-162 hours. The pyroxene cubes were analyzed using laser ablation ICP-MS (Cu, Li) and Time-of-Flight secondary ion mass spectrometer (V). We find that in addition to Cu, which was deliberately added to the powder as a reservoir, the Otter Lake diopside also acted as a source of Li within the capsule. We propose that the light and volatile lithium diffused out of the diopside and into the Li-poor enstatite. The vacuum seal prevented the volatile Cu and Li from escaping the capsule. We modelled the diffusion profiles from both Opx-7 and OL-Di for Li, Cu, and V to constrain diffusion coefficients. Future directions include investigating the effect of fO_2 diffusion for the elements of interest. The results of these studies may be useful to study volatile metal diffusion in magmatic and volcanic systems.

[1] Dohmen R, Becker HW, Meissner E, Etzel T, Chakraborty S (2002). Eur J Mineral 14(6):1155–1168.