Thermal and Chemical Diffusion in the Liquid System Albite-Anorthite

DEPAOLO, D. J[1], WATKINS, J. M[2] AND RYERSON, F. J[3]

[1]Dept of Earth and Planetary Science, U. California, Berkeley, CA 94720 (depaolo@eps.berkeley.edu)
[2]Department of Geological Sciences, University of Oregon, Eugene, OR 97403 (jwatkins529@gmail.com)
[3]Lawrence Livermore National Laboratory, Livermore, CA 94550 (ryerson1@llnl.gov)

Recent work has shown that there are thermal diffusion effects that generate large isotopic variations in silicate liquids over temperature intervals that are not uncommon in igneous systems. Most of the experiments that have been done used natural liquid compositions that are complex, hence it has been difficult to analyze the results in terms of thermodynamic driving forces. We have focused our work on simple liquid systems where mixing properties and partial molar quanitities are reasonably well know. The simplest system we have worked with is Albite-Anorthite, which is a nearly ideal liquid solution that behaves as a two-component system. We have done an inter-diffusion couple with low-An and moderate-An compositions, as well as a thermal diffusion experiment using an An_{20} starting composition. With these experiments we have measured the bulk Ca (or An) chemical diffusion coefficient, the ratio of the diffusion coefficients of ^{44}Ca and ^{40}Ca, and the thermal diffusion and thermal isotopic effects for the same overall liquid composition. Both the chemical diffusion couple and the thermal diffusion experiment yielded large Ca isotopic effects (5-8‰ in $^{44}Ca/^{40}Ca$). The thermal experiment yielded a 10% variation of An content over a ca. 75°C temperature difference, and a 5‰ range of $^{44}Ca/^{40}Ca$. The data from the two experiments allow us to calculate the chemical and isotopic Soret coefficients as well as the thermal-chemical coupling constants, because we can also estimate $d\mu/dx$ from the mixing properties of Ab-An liquids and the endmember thermodynamic properties. Our data provide the most rigorous tests of models for both the thermal-chemical diffusion and thermal isotopic effects, and pose some interesting issues for interpreting the available data on natural basalt-rhyolite liquid compositions.