Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.22783

# Multicomponent diffusion in natural silicate melts: Toward a universal eigenvector matrix

**BOBO BAI**[1] AND YOUXUE ZHANG[2]

[1]University of Michigan, Ann Arbor
[2]University of Michigan
Presenting Author: bbai@umich.edu

Multicomponent diffusion in natural silicate melts is fundamental to understanding igneous processes such as magma mixing. In *N*-component silicate melts, multicomponent diffusion is characterized by an *N*-1 square matrix, termed the diffusivity matrix [*D*]. Eigenvectors of [*D*] define *N*-1 eigen-components that diffuse independently of each other. Diffusion eigenvectors in basalt appear to be roughly temperature independent [1]. In this study, we hypothesize that diffusion eigenvectors in natural silicate melts are also roughly compositionally independent. We use a single eigenvector matrix, [*P*], to simultaneously fit concentration profiles from 27 diffusion couple experiments at three temperatures from [1-2], and one additional experiment conducted in this work. The goodness of our fitting further supports the temperature independence of [*P*].

Oxide concentrations were converted into eigen-component "concentrations", $Z_i$, and plotted against distance for both the 28 diffusion experiments in basalt and those from literature in rhyolitic to basaltic melts. If [*P*] is compositionally invariant, all $Z_i$ profiles should be monotonic. Approximately 96% of >1000 plots are monotonic, showing that we are getting close to a universal eigenvector matrix. Notably, all $Z_i$ profiles during quartz dissolution in basalt/rhyolite and olivine dissolution in basalt/andesite are monotonic. About 2% (23 out of 1190) show clear uphill diffusion, including one with $Z_3$ in our diffusion-couple experiment, and 22 with $Z_1$, $Z_2$, $Z_4$ and $Z_5$ in diopside/rutile dissolution in andesite, diopside/plagioclase dissolution in basalt, and diffusion couple experiments in haplo-basalt, implying the need to further constrain [*P*]. The other 2% show complexities but it is less clear whether they reflect uphill diffusion.

We propose to study multicomponent diffusion in eigen-component space through $Z_i$ vs x plots. This approach combines the full rigor of multicomponent treatment with the simplicity of effective binary diffusion treatment. For example, a few well-designed experiments will suffice to extract all eigenvalues at desired melt composition. Moreover, this approach can treat the compositional dependence of eigenvalues. Lastly, its applicability is self-testable: If there are non-monotonic eigen-component profiles, for example, the approach should not be used.

2. Guo and Zhang (2018). *GCA,* 228, 190-204.
1. Guo and Zhang (2020). *CG,* 549, 119700.