Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34523

Multicomponent diffusion in basaltic to andesitic melts: Toward a temperature- and composition-independent eigenvector matrix

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Multicomponent diffusion in natural silicate melts controls many igneous processes such as magma mixing and crystal growth. In *N*-component silicate melts, multicomponent diffusion is characterized by an $(N - 1) \times (N - 1)$ diffusion matrix $[D]$, whose eigenvectors define $N - 1$ eigen-components that diffuse independently. Each eigenvalue represents the diffusion coefficient for the corresponding eigen-component. Previous studies have demonstrated that diffusion eigenvectors in 8-component SiO_2-TiO_2-Al_2O_3-FeO-MgO-CaO-Na_2O-K_2O basaltic melts are invariant with temperature [1]. In this work, we extend this investigation to andesitic compositions to test the temperature independence of diffusion eigenvectors in more evolved melts. Thirteen diffusion couple experiments were carried out at 1250, 1350, and 1500 °C: twelve andesite-andesite couples and one basalt-andesite couple. The diffusion couples were designed to produce significant gradients in every eigen-component, enabling the determination of the diffusion matrix using fewer experiments at a given temperature. Diffusion profiles from the twelve andesite-andesite diffusion couple experiments can be fitted well simultaneously with a single eigenvector matrix, supporting the hypothesis that the eigenvectors are temperature invariant in andesitic melts.

The eigenvector matrix obtained from the andesitic melt is similar to that in basalt, indicating possible compositional invariance across the basaltic–andesitic range. To further test this hypothesis, we simultaneously fit the andesitic diffusion couple profiles in this study and basaltic diffusion couple profiles from previous investigations using a single eigenvector matrix [1-3]. All diffusion profiles are well reproduced using a single eigenvector matrix, with fitting quality comparable to that obtained using two separate eigenvector matrices, supporting the hypothesis that diffusion eigenvectors are both temperature- and composition-independent at least from basaltic to andesitic melts. Among the seven eigenvalues as functions of temperature, the three largest eigenvalues in basalt are similar to those in andesite, but the four smaller eigenvalues in basalt melt are greater than those in andesite. The extracted eigenvector matrix and eigenvalues are incorporated into an updated open-access diffusion calculator to compute multicomponent diffusion profiles in basaltic to andesitic melts.

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[2] Guo and Zhang (2018). *GCA,* 228, 190–204.
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