A new method for statistical analysis of divalent cation diffusion data in garnet

X. CHU[1]* AND J. J. AGUE[1,2]

[1]Department of Geology and Geophysics, Yale University, New Haven, CT, 06520-8109, USA
(*correspondence: xu.chu@yale.edu; jay.ague@yale.edu)
[2]Peabody Museum of Natural History, Yale University, New Have, CT, 06511, USA

Diffusion profiles preserved in garnets have been widely used to estimate the time scales of tectono-petrological processes. The cornerstone of these estimates is the knowledge of diffusion coefficients in garnets, which have been studied extensively in experiments to obtain their dependence on physical conditions. We present a new statistical framework to analyze diffusion data for divalent cations (Fe, Mg, Mn, and Ca) using the Arrhenius relationship accounting for temperature, pressure, oxygen fugacity [1], and garnet unit-cell dimensions [2].

Our approach is based on Bayesian statistics and is implemented by the Markov chain Monte Carlo method [3]. The analysis incorporates recent data [4, 5, 6] in addition to the data compilation in ref. [2]. All reported experimental uncertainties are taken into account in our formulation, and the data are weighted by the precision of the experimental conditions. We also include the inter-run bias to estimate the reproducibility and other experimental variability not explicitly accounted for in the Arrhenius relationship.

The initial results show that at low temperatures (500–600 °C), the self-diffusion coefficients calculated with the updated model parameters may be as much as one order of magnitude smaller than those in ref. [2]. The dependence of self-diffusion coefficients of Fe, Mn and Ca on oxygen fugacity is weakly constrained by the existing experiments, reflecting the need for more data covering a wider range of redox states.

Our statistical analysis provides a solid framework to obtain a permissible range of self-diffusion coefficients for divalent cations constrained by the existing data. This, in turn, will facilitate petrological and time scale modeling of garnet diffusion with well-defined uncertainty bounds.

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