Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.12294

The dichotomous nature of Mg-in-plagioclase partitioning: Implications for diffusion chronometry

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Plagioclase is a widespread phase in magmatic rocks and is an important archive of magmatic processes. Modelling diffusion of Mg in plagioclase is used to estimate the timescales of magmatic processes that operate weeks to decades before eruption. To do this, however, requires knowledge of how the anorthite composition of plagioclase influences partitioning of Mg.

Here we compiled a database of 904 calculated Mg in plagioclase partition coefficients using mineral rim-melt pairs from phase equilibria experiments and natural samples. The dataset includes a comprehensive range of plagioclase compositions (An_{15} - An_{90}), melt compositions (40 – 78 wt% SiO_2) and temperatures (75 –1400 °C). We find that Mg-in-plagioclase partition coefficients depend on these parameters, which is in agreement with previous studies [1]. Crucially, we find that the dependence on anorthite content has a major inflection at compositions that correspond to the C1-I1 structural phase transition (An_{60} at 1000 °C). Mg-in-plagioclase partition coefficients have a positive dependence on anorthite in the C1 domain, and a negative dependence in the I1 domain. We also find that this change in partitioning behaviour can account for Mg distributions in natural plagioclases observed in mafic to silicic systems including the Galápagos, Santorini, Krakatau and Toba.

The dichotomous nature of Mg-in-plagioclase partitioning has significant implications for diffusion chronometry. The shape of Mg 'quasi-state' equilibrium profiles will largely depend on the structural state of plagioclase. Crystals that have compositional zones on either side of the C1-I1 transition could potentially develop flat 'quasi-state' equilibrium profiles. The temperature dependence of the C1-I1 transition means that equilibrium profiles in these crystals could be used to estimate crystal storage temperatures. Our new empirical partitioning relationship is particularly important for interpreting plagioclase Mg profiles in intermediate and silicic systems, and for setting up initial conditions for modelling. Profiles that were previously interpreted to show little diffusion, may be close to equilibrium and *vice versa*. This will be highly significant for understanding thermal states and magmatic histories of at a range of tectonic settings.

[1] Dohmen, R., & Blundy, J. (2014). *American Journal of Science*, *314*(9), 1319-1372.