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A dynamic diffusion experiment in ferropericlase

F. Heidelbach (1), M. P. Terry (1), M. Bystricky (2,4) and C. Holzapfel (3)

(1) Bayerisches Geoinstitut, Universität Bayreuth, Bayreuth, Germany, (2) Geologisches Institut, ETH Zürich, Zürich, Switzerland, (3) Institut für Funktionswerkstoffe, Universtät des Saarlandes, Saarbrücken, Germany, (4) now at: LMTG-OMP, Universite Paul Sabatier, Toulouse, France (florian.heidelbach@uni-bayreuth.de)

We examined the effects of deformation on a continuous Fe/Mg interdiffusion reaction between ferropericlase and periclase to provide insights into the interplay between metamorphic reactions and deformation. In order to simulate simultaneous deformation with a continuous reaction, a torsion experiment was carried out on a diffusion couple of polycrystalline cylinders of periclase (MgO) and ferropericlase ($Mg_{0.605}Fe_{0.395}O$) jacketed in nickel. The interface between the two phases was perpendicular to the torsion axis. The experimental conditions were 1300˚C, 300 MPa, and a shear strain rate 1.4x10^{-4} $s^{-1}$for 5.5 hours which gave a bulk shear strain (γ) of 2.7. However, all of the strain was partitioned into the softer ferropericlase (γ = 5.4) where deformation lead to the development of a crystallographic preferred orientation and a grain refinement at high shear strains. Pure periclase showed no signs of deformation.

Composition mapping and quantitative traverses were made normal to the interface using the electron microprobe. The results indicate that diffusion is faster at the edge of the sample where shear strain is highest and slower in the center where strain is approximately zero. Simulations of the chemical profiles from the edge and center profiles to were performed by using the composition-dependence

$D = (D_{01} + D_{02} * X_{FeO}^{1.17})\ \mathrm{exp}A*X_{FeO}$ (**1**)

consistent with the expression given in previous studies for a similar composition range as investigated in this study. The simulation utilized a finite difference scheme with distance divided into steps of 1 μm, time divided into steps of 1 sec., and a normalized concentration. The diffusion profile in the center was reproduced extemely well by the simulations using Eq. **1**, whereas some slight inconsistencies exist for the

profile at the edge where shear strain is the highest. The diffusion coefficients derived at the center and the edge of the diffusion couple deviate by a factor of 1.2 to 1.4 between X_{FeO} = 0.1 and 0.3. A possible explanation for this increase of the diffusion coefficients is the grain refinement due to deformation in the ferropericlase which enlarges the grain and subgrain boundary area per volume and thereby enhances the contribution of grain boundary diffusion.