



Reaction Rim Growth in a thermal Gradient

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Time-dependent measurements of the growth rates of reaction layers between incompatible mineral pairs provide a means to measure bulk diffusion rates, if a model for the diffusional fluxes of all involved chemical components is available. In addition to bulk diffusivity, the experiments yield insights on critical effects in reaction rim growth, such as the effect of reaction-induced strain or chemical fractionation effects at the reaction front and across reaction layers.

Here we present first data on the growth of polycrystalline orthopyroxene (Opx) layers between single crystals of olivine (Ol) and quartz (Qtz), where a sequence of reactant interfaces between ca. 1 mm thick plates is placed along a thermal gradient. By this technique it is possible to investigate an entire temperature series in one single experiment. The single crystals of Qtz and Ol were cut with defined crystallographic orientation. This allowed the measurement of hydrogen contents in Qtz and Ol by polarized FTIR spectroscopy before and after the runs. Experiments were conducted in a piston-cylinder apparatus at 1.8 GPa, 1000 °C at the hot end of the capsules, and 100 °C less at the cold end. Boron-nitride was used as the pressure medium in the inner part of the assembly.

In order to detect the effect of water traces on bulk diffusivity, and thus the growth rates of the polycrystalline Opx layers, three types of experiments were performed. Type 1 used "wet" (about 70 ppm H₂O) natural Ol from Pakistan (ca. Fo₉₄). Type 2 used "bone-dry" (<<1 ppm H₂O) synthetic forsterite (Fo). Type 3 used this same synthetic Fo, but some water (50-100 ppm) was introduced by replacing one Qtz plate by finely-ground (11-20 μm) Qtz powder equilibrated with air moisture.

Opx layers on the natural Ol grew at approximately doubled rate (i.e., diffusivity enhanced by about a factor 4) compared to the synthetic Fo. After experiment there was still no water detectable in the synthetic Fo ($\ll 1$ ppm). Remarkably, even when some water was added to the capsules as adsorbed on Qtz powder, still no OH in Fo was detectable after experiment. Considering the fast diffusion of H in Ol this points to hydrogen loss into the pressure medium. The apparent activation energy deduced from the experiments is in line with the 250-500 J/mol range (depending on water activity) from the literature, but experiments with larger temperature gradients are needed to obtain more precise data. Experimental investigation of mineral reaction kinetics in the presence of very small amounts of water is experimentally challenging, but necessary for the understanding of subsolidus reactions in water-poor (but not absent) parts of the upper mantle and lower crust.