

Kinetics of the Phase Transformation of Olivine to Wadsleyite: Comparative Study of Natural Fe-bearing Olivine and Synthetic Forsterite

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Introduction

Understanding the kinetics of the phase transformation of olivine to its high-pressure polymorphs is critical to modeling the extent of metastable olivine in subducting slabs. Previously we obtained the growth rates of wadsleyite during the phase transformation at various pressures and temperatures in natural San Carlos olivine (Fe-bearing). They are significantly lower than those obtained by other workers for forsterite at similar conditions. It is important to investigate the discrepancy because olivine is Fe-bearing in subducting slabs.

Methods and Materials

The starting materials were San Carlos olivine and synthetic forsterite. The powdered samples were dried in a vacuum oven at 160°C for several hours prior to sample loading. Powdered NaCl (mixed with BN) was used as the pressure standard. The sample assembly was compressed to about 12 GPa at room temperature by using a 250-ton large-volume press coupled with a T-cup device and then annealed in the stability field of olivine at 1200°C for 180 minutes. Following hot pressing, the temperature (T) was decreased to 550°C and kept constant while the pressure (P) was increased to the target value. The temperature was then increased again rapidly to 1000°C. Time-resolved x-ray diffraction patterns were collected every 2 to 5 minutes for both samples while the sample assembly remained under the constant P and T conditions. The pressure was calculated on the basis of Decker's

equation of state for NaCl, and the temperature was measured by a W-3% Re versus W-25% Re thermocouple.

Results

There was a profound difference in the kinetics of the phase transformation of olivine to wadsleyite in two samples. The result is somewhat counterintuitive. We observed complete transformation of forsterite to wadsleyite during the experiment. However, during the same timeframe, there was little transition in the San Carlos olivine sample. This work demonstrates that rates obtained on analog materials (i.e., forsterite) cannot be directly applied to natural olivine systems. The discrepancy is because the rate at which defects are annealed out in the forsterite sample during the hot-press stage is slower than that in an Fe-bearing sample.

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