American Mineralogist, Volume 89, pages 285–293, 2004

Nucleation and growth kinetics of the α-β transformation in Mg_2SiO_4 determined by in situ synchrotron powder X-ray diffraction

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ABSTRACT

The kinetics of the α-β transformation in Mg_2SiO_4 was studied by in situ synchrotron powder X-ray diffraction (XRD) at nine pressure-temperature conditions in the ranges 13.4–15.8 GPa and 850–1100 °C. The transformation from olivine occurred by grain-boundary nucleation and interface-controlled growth mechanisms. Infrared analysis of the recovered samples indicates that a small amount of water, 750 ± 100 ppm by weight, was present in the samples although the experiments were carried out under nominally dry conditions. Nucleation and growth rates were determined by fitting the rate equation for the grain-boundary nucleated transformation to the kinetic data. The activation energy and activation volume for growth were estimated to be 348 (137) kJ/mol and 1.7 (4.5) cm^3/mol, respectively. The growth kinetics determined in this study bear upon the field of metastable olivine in the subducting slab as the water contents of samples studied are well known. Nucleation rates were estimated to be relatively large, even at small overpressure conditions, which is consistent with the small activation energy for nucleation derived in this study.