American Mineralogist, Volume 98, pages 1604–1609, 2013

Influence of H_2 fluid on the stability and dissolution of Mg_2SiO_4 forsterite under high pressure and high temperature

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Abstract

High-pressure and high-temperature experiments were carried out in a Mg_2SiO_4-H_2 system using laser-heated diamond-anvil cells to understand the influence of H_2 fluid on the stability of forsterite. In situ X-ray diffraction experiments and Raman spectroscopic measurements showed the decomposition of forsterite, and formation of periclase (MgO) and stishovite/quartz (SiO_2) in the presence of H_2 after being heated in the range between 2.5 GPa, 1400 K and 15.0 GPa, 1500 K. Transmission electron microscopic observation of the samples recovered from 15.0 GPa and 1500 K showed that the granular to columnar periclase grains maintained the original grain shape of forsterite, indicating that the periclase crystals crystallized under high temperature. On the other hand, euhedral columnar stishovite crystals were found at the boundaries between residual forsterite grains and reacted periclase. This implies that the SiO_2 component was dissolved in H_2 fluid, and that stishovite was considered to have crystallized when the solubility of the SiO_2 component became reduced with decreasing temperature. Additional experiment on a SiO_2-H_2 system clearly showed the dissolution of quartz in H_2 fluid, while those on a MgO-H_2 system, periclase was hardly dissolved. These lines of evidence indicate that forsterite was incongruently dissolved in H_2 fluid to form periclase crystals in the Mg_2SiO_4-H_2 system, which is different from what was observed in the Mg_2SiO_4-H_2O system. The results indicate that the stability of forsterite is strongly affected by the composition of coexisting C-O-H fluid.

Keywords: H_2 fluid, forsterite, X-ray diffraction, transmission electron microscope, laser-heated diamond-anvil cells