

MS27-2-3 Crystal structure and equation of state of Al-bearing bridgmanite at high pressure and high temperature

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Abstract

MgSiO₃-rich bridgmanite is the most abundant mineral phase in pyrolitic and basaltic phase assemblages at the pressure and temperature conditions of Earth's lower mantle. Al is typically incorporated in the crystal structure of bridgmanite through the Fe³⁺+AlO₃ and AlAlO₃ charge coupled (CC) mechanisms, and through MgAlO_{2.5} oxygen vacancy (OV) mechanism. MgO-saturated systems, such as pyrolite (Mg/Si ~ 1.3) stabilize the OV mechanism at shallow lower mantle conditions, while the CC mechanisms become more and more abundant with increasing pressure and become dominant at mid- and deep-lower mantle conditions. It has been argued that the formation of oxygen vacancies in bridgmanite would cause a substantial softening of its bulk modulus. However, so far experimental studies have not provided a definite proof to such hypothesis due to the lack of well characterized samples.

In this study, we synthesized several Fe-free Al-bearing bridgmanite crystals with different compositions in a multi-anvil apparatus. The recovered samples were then characterized using an electron probe microanalyzer to accurately determine the degree of OC and CC substitution of each sample. Single-crystals of bridgmanite with different CC and OV contents were then tested and selected by means of single-crystal X-ray diffraction. High-pressure and high-temperature diffraction measurements were conducted in resistively-heated diamond anvil cells at the Extreme Conditions Beamline P02.2 of PETRA-III (DESY, Hamburg). By fitting equations of state to the pressure-volume-temperature datasets and by refining the crystal structure of the three samples, the stability and elasticity of bridgmanite solid solutions at lower mantle conditions will be discussed.