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Disproportionation of bridgmanite and an origin of deep lower mantle chemical heterogeneity

LI ZHANG, YONGJIN CHEN, ZIQIANG YANG, LU LIU, YANPING YANG, PHILIP DALLADAY-SIMPSON, JUNYUE WANG AND HOKWANG MAO

Center for High Pressure Science and Technology Advanced Research

The deep lower mantle structure is dominated by two large low-shear velocity provinces at depth greater than 2000 km. Seismic imaging reveals the presence of broad plumes originated at the base of the lower mantle beneath many prominent hot spots [1], implying that deep processes at the base of the mantle might greatly influence the whole mantle dynamics. Bridgmanite (Mg,Fe)(Fe,Al,Si)O_3 is the dominant mineral in the lower mantle and the lower mantle is a potential water reservoir. The compositional models of the lower mantle are largely dependent on the physical and chemical properties of bridgmanite throughout the lower mantle under both hydrous and dry conditions. Combining in situ X-ray diffraction at high pressure with ex situ chemical analysis on the recovered samples, we are able to obtain detailed chemical information of bridgmanite under the lower mantle conditions. Bridgmanite is nearly dry in coexistence with a hydrous phase [2]. In our experiments, we found that the presence of H_2O (in coexistence with a hydrous phase) stabilizes ferrous iron in bridgmanite under pressure-temperature conditions of the deep lower mantle [3], in contrast to iron-depletion in dry bridgmanite as a result of the disproportionation [4]. Further, we observed a strong temperature dependence of iron-depletion in dry bridgmanite over the temperature range of 2000-2400 K. Figure 1 shows iron-depletion in bridgmanite with Fe#=91 (Fe#=100 MgO/(MgO + FeO) in mole) as a result of the disproportionation at 104 GPa and 2250 K compared to $(Mg_{0.85}Fe_{0.15})SiO_3$ (Fe#=85) in the starting material. Our results would provide a mineralogical explanation for the compositional stratification and lateral heterogeneity in the deep lower mantle [5].

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