Stability of Fe-bearing hydrous phases and element partitioning in the system MgO-Al_2O_3-Fe_2O_3-SiO_2-H_2O in Earth’ s lowermost mantle

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We performed experiments on a synthetic hydrous gel consisting of a model composition of subducted slabs in the MgO–Al_2O_3–Fe_2O_3–SiO_2–H_2O system and containing ~7 wt.% water. The experiments were conducted in laser-heated diamond anvil cells under high pressure–temperature (*P*-*T*) conditions corresponding to the lowermost mantle using *in situ* synchrotron X-ray diffraction and *ex situ* transmission electron microscope techniques. The hydrous δ-phase AlOOH–FeOOH–$MgSiO_2(OH)_2$–SiO_2 (with an orthorhombic symmetry and the space group of *Pnnm*) coexists with bridgmanite (Bdg), post-perovskite (pPv), or both in a broad *P-T* range of 104–126 GPa and 1900–2500 K, whereas the pyrite-type (py) $FeOOH_x$ phase was only observed to coexist with the pPv phase by *in situ* XRD. Chemical analysis on recovered samples showed that (i) in the Bdg-bearing assemblage quenched from 104 GPa and 1900 K, the Bdg phase contains ~8 at.% Al and ~11 at.% Fe, and the coexisting hydrous δ-phase contains ~70 at.% Al and ~14 at.% Fe; (ii) in the pPv-bearing assemblage quenched from 117 GPa and 2050 K, the pPv phase contains ~7 at.% Al and ~16 at.% Fe, and the coexisting hydrous δ-phase contains ~81 at.% Al and ~9 at.% Fe. The considerable $Fe_2O_2(OH)_2$ (8–13 mol%) and SiO_2 (9–13 mol%) content in the δ-phase does not reduce its thermal stability; therefore, the Fe-bearing δ-phase can transport water to the lowermost mantle along the mantle geotherm. The dense py-phase may accumulate in the lowermost mantle in the presence of the pPv phase. In a hydrous system, Al_2O_3 depletion in both the Bdg and pPv phases can significantly reduce the width of the Bdg to pPv transition compared with the width in a dry system. On the other hand, significant Fe enrichment in pPv relative to the coexisting Bdg lowers the transition pressure to the depth of the D′′ discontinuity. Accordingly, the depth and thickness of the Bdg to pPv transition in subducted hydrous basaltic crustal materials might explain the seismically detected D′′ discontinuity. The formation of the dense hydrous py-phase in subducted slabs may contribute to chemical heterogeneities in the lowermost mantle.

Keywords: deep lower mantle, hydrous phase, bridgmanite to post-perovskite transition, synchrotron X-ray diffraction, multigrain analysis

