Compressional behavior of δ-(Al, Fe)OOH to lower mantle pressures

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Abstract

Delta-AlOOH is an important hydrous mineral for understanding the water cycle in the deep Earth. In a hydrous slab penetrating Earth's lower mantle, δ-AlOOH forms a solid solution with Phase H (MgSiO4H2) and ϵ-FeOOH (e.g., Ohtani et al., 2001; Nishi et al., 2015; Ohira et al., 2014). This phase may modulate Earth's deep water cycle, influencing the dynamics and the travel times of seismic waves in the lower mantle. However, the elasticity and related properties of this phase have not been constrained.
In this contribution, we report the behavior of δ-(Al, Fe)OOH at high pressures. The P-V profiles of polycrystalline δ-(Al0.95, 57Fe0.05)OOH (AF5) and δ-(Al0.88, 57Fe0.12)OOH (AF12) (Kawazoe et al., 2017) were measured using X-ray diffraction up to 65 GPa using a membrane diamond anvil cell at BL10XU, SPring-8. The Debye sound velocity (vD), Lamb-M$\acute{}$ossbauer factor (fLM), and the spin state were determined using nuclear resonant inelastic X-ray scattering and synchrotron M$\acute{}$ossbauer spectroscopy at sector 3, Advanced Photon Source.

A change in the compressibility was observed in the P-V data of AF5 and AF12 at 10-12 GPa, which is in the vicinity of a $P21nm$ to $Pnnm$ structural transition. At similar pressures, fLM and vD exhibit minimum values. We interpret this *softening* to be related to the onset of proton tunneling that is suggested in pure δ-AlOOH (Sano-Furukawa et al., 2009; Kuribayashi et al., 2014; Bronstein et al., 2017). However, the significant depression of sound velocity was observed only in δ-(Al, Fe)OOH, not in the pure Al-endmember δ phase (Mashino et al., 2016), thus the incorporation of Fe has the potential to enhance the softening of this phase. With increasing pressure, another change in the compressibility was observed, which may be caused by the high-spin (HS) / low-spin (LS) transition of Fe3+ in

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the δ phase. We will discuss the implications of our results for Earth's lower mantle.
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