Sound velocities of delta-AlOOH up to lowermost mantle pressures; Implications for the seismic anomalies in deep mantle

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It is widely recognized that the presence of water in the deep Earth’s interior, which may be transported to such depths by various hydrous minerals in subducting slabs, can significantly affect the physical and rheological properties of the mantle. Most hydrous minerals become thermodynamically unstable under the pressure-temperature conditions corresponding to the upper part of the upper mantle (e.g., Ohtani, 2006). However, recent experimental data indicate that the hydrous mineral delta-AlOOH can be stable throughout the lowermost mantle (Sano et al., 2008; Ohira et al., 2014; Ohtani et al., 2014). This phase is, therefore, a possible carrier and host of water in the deep mantle. To uncover the physical properties of delta-AlOOH under deep mantle pressure conditions, we have conducted high-pressure acoustic wave velocity measurements of delta-AlOOH by using Brillouin spectroscopy combined with high-pressure Raman spectroscopic measurements in a diamond anvil cell up to pressures of 134 GPa. There is a precipitous increase by ~14% in the acoustic velocities of delta-AlOOH from 6 to 15 GPa, which suggests that pressure-induced O-H bond symmetrization occurs in this pressure range. The best fit values for the high-pressure form of delta-AlOOH of K_0 = 190 (2) (GPa), G_0 = 160.0 (9) (GPa), $(\partial K/\partial P)_0 = K_0'$ = 3.7 (1), and $(\partial G/\partial P)_0 = G_0'$ = 1.32 (1) indicate that delta-AlOOH has a 20–30% higher V_S value compared to those of the major constituent minerals in the mantle transition zone, such as wadsleyite, ringwoodite, and majorite. On the other hand, the V_S of delta-AlOOH is ~7% lower than that of bridgmanite under lowermost mantle pressure conditions. By comparing our results with seismic observations, we can infer that delta-AlOOH could be one of the potential causes of a positive V_S anomaly observed at ~600 km depth beneath the Korean peninsula and a negative V_S jump near 2800 km depth near the northern margin of the large low-shear-velocity province beneath the Pacific.

Keywords: delta-AlOOH, Brillouin scattering, seismic anomaly, transition zone, lower mantle

