Sound velocities of δ-AlOOH up to CMB pressures with implications for the seismic anomalies in deep mantle

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Recent experimental data indicate that the hydrous mineral δ-AlOOH can be stable throughout the lowermost mantle. This phase is, therefore, a possible carrier and host of water in the deep mantle. In order to further our understanding of the global circulation of water (or hydrogen) and its associated influence on the seismic structure in the deep mantle, it is important, therefore, to clarify the physical properties of δ-AlOOH such as elasticity or sound velocities under high-pressure conditions relevant to deeply subducted slabs.

To uncover the physical properties of δ-AlOOH under deep mantle pressure conditions, we have conducted high-pressure acoustic wave velocity measurements of δ-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 δ-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 δ-AlOOH above 15 GPa 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 δ-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 δ-AlOOH is ~7% lower than that of bridgmanite under lowermost mantle pressure conditions because of the significantly lower value of the pressure derivative of the shear modulus. By comparing our results with seismic observations, we can infer that δ-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.