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Elastic properties of delta-AlOOH under high-pressure: Implications for high Vs anomaly in the mantle transition zone

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delta-AlOOH is a high-pressure polymorph of diaspore (alpha-AlOOH) and boehmite (gamma-AlOOH) (Suzuki *et al*., 2000). Since delta-AlOOH is identified to be stable from 20 to 120 GPa, and temperatures up to 2300 K, this phase is considered to be a possible carrier and reservoir of water in subducting cold slab into the deep mantle (Ohtani *et al*., 2001; Sano *et al*., 2004; 2008). In order to investigate the effect of composition on seismic velocities in subducting slab, it is important to measure the elastic properties of delta-AlOOH at high pressure.

We have conducted high-pressure acoustic-wave velocity measurements of delta-AlOOH using Brillouin spectroscopy and also explored the chemical bonding of delta-AlOOH by Raman spectroscopy at high pressure in a diamond anvil cell. We obtained sharp peaks from transverse acoustic mode (V_S) of delta-AlOOH over the entire pressure range explored up to a pressure of 89 GPa. The peaks from longitudinal acoustic mode (V_P) of delta-AlOOH were masked by the diamond shear acoustic modes from 35 GPa. The pressure dependence of the aggregate velocities for the delta-AlOOH at 300 K suggests that the hydrogen-bonding symmetrization with the space group changes from $P2_1nm$ to *Pnnm* occurs during compression above 7 GPa. The shear and adiabatic bulk moduli and their pressure derivatives at zero pressure were determined to be K_0 = 192.2(8) (GPa), G_0 = 158.8(3) (GPa), $(dK/dP)_0$ = 3.63(6), and $(dG/dP)_0$ = 1.35(6) for the pressures above 15 GPa. Raman spectroscopic measurements have shown that the B_1 mode frequencies of $P2_1nm$ disappeared around 6 GPa and A_g mode frequencies of *Pnnm* appeared above 5.6 GPa, which also indicates the hydrogen-bonding symmetrization around 6 GPa. These results indicate that delta-AlOOH becomes harder by the hydrogen-bonding symmetrization and probably exists as a phase (*Pnnm*) with the symmetric hydrogen bonding in the mantle transition zone and lower mantle.

Shear wave velocities for delta-AlOOH are larger than those of hydrous wadsleyite (by 30 %), hydrous ringwoodite (by 29 %), and majorite (by 29 %). Those of delta-AlOOH are approximately 7 % below those of stishovite. The delta-AlOOH phase thus found to be one of the hardest phases compared to the minerals of mantle transition zone. The existence of delta-AlOOH may contribute to the cause of high V_S and V_P anomalies. Shear velocities for sediment containing delta-AlOOH phase are larger than those of pyrolite (by 10 %) and MORB (by 5 %). The subducting slabs often stagnate at the transition zone before reaching the lower mantle. Particularly beneath Korean peninsula, there is a high V_S anomaly (~2 %) in the lower part of the transition zone (Zhang *et al*., 2012). The seismic data under the eastern part of northeast China (NEC) also indicates a slight positive anomaly of V_S (~1 %), but the V_S value observed around 600 km depth under NEC is ~1 % lower than that beneath Korea. We explain the difference in the V_S anomalies beneath the NEC and Korea by the amount of sediment containing the delta-AlOOH phase and the stagnating duration. If sediments stagnate at the transition zone before reaching the lower mantle in this region, we can estimate that the higher V_S anomaly (~1 %) than NEC would correspond to sediments with 13.4 vol% in stagnant slab. The average oceanic crust subduction rate is estimated to be about 8 cm/yr around Japan. Assuming this estimated rate of subduction, the slab stagnetion has lasted for at least 30 million years.

Keywords: delta-AlOOH, Brillouin scattering, Raman spectroscopy, subducting slab, high pressure