Ultrasonic velocity measurement of deep Earth hydrous phase (Al-bearing phase D) under high pressure and high temperature

*Toru Inoue[1,2], Chaowen Xu[2], Steeve Gre'aux[2], Masamichi Noda[1], Wei Sun[2], Hideharu Kuwahara[2], Yuji Higo[3]

1. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2. Geodynamics Research Center, Ehime University, 3. Japan Synchrotron Radiation Research Institute

Water plays an important role in the Earth's interior, which affects the physical and chemical properties of the surrounding materials, for instance, elasticity, rheology, electrical conductivity, and melting behaviors (e.g. [1,2]). The dense hydrous magnesium silicates (DHMSs) are the primary water carriers into the mantle transition zone (MTZ) and could play an important role in delivering water down to the middle part of the lower mantle (LM) (e.g. [3,4]). Among DHMSs, phase D (PhD) is regarded as a potential carrier of water from the MTZ to the LM [4,5]. Recently, it was clarified that PhD can accommodate significant amount of Al_2O_3 (56.6 wt%) and the Al-bearing PhD is stable up to 2273 K at 26 GPa [6], which may possibly exist in a realistic slab composition and temperature.
To interpret seismic anomalies related to the presence of hydrated regions, direct velocity measurement of hydrous phases is needed. However, the sound velocity of PhD has been poorly investigated, because ultrasonic measurement requires well sintered samples with high purity, which was difficult to achieve for PhD. In this work, we succeeded to synthesize well-sintered Al-bearing PhD, and report the longitudinal (V_P) and shear (V_S) velocities, as well as the density of the Al-bearing PhD up to 22 GPa and 1300 K.
A polycrystalline Al-bearing PhD sample was synthesized at 24 GPa and 1373 K for 1 hour, from a mixture of MgO, SiO_2, $Mg(OH)_2$ and $Al(OH)_3$ by using the 2000-ton Kawai-type apparatus installed at the Geodynamics Research Center (GRC), Ehime University. The recovered sample appeared well-sintered, which is accompanied by little porosity, chemical homogeneity, and is free of accessory phase.
In situ ultrasonic experiments were conducted at the BL04B1 beamline of SPring-8 at high pressures and high temperatures up to 22 GPa and 1300 K. The sample was first squeezed at room temperature and then heated to high temperature. Then the temperature was decreased to 300 K in step of 200 K. The press load was increased after the first data collection cycle, and then, the temperature was increased to high temperature to start another data collection cycle during cooling.
The room temperature data up to 20.5 GPa were fitted to a third-order Birch-Murnaghan equation of state and yielded K_{T0} = 143 (5) GPa, and K_{T0}'= 5.8 (7), which is much lower K_{T0} than that of Mg-PhD (K_{T0} = 166 (3) GPa). The compressional (V_P) and shear (V_S) velocities increase with increasing pressure while they decrease with increasing temperature up to 22 GPa and 1300 K. Modeled velocities of Al-bearing PhD in hydrous pyrolite along normal mantle geotherm are calculated and will be presented.

Refefrences

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