In situ X-ray and ultrasonic measurement under the conditions of mantle transition zone

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Seismic velocity data has high quality information about the structure of the Earth. Combining seismic velocity data with elastic velocity data of mineral, we can clarify the composition and the condition in the Earth interiors. It is widely accepted that 410, 520 and 660 km seismic wave velocity discontinuities are responsible for high-pressure phase transformations of olivine. Ringwoodite, high pressure polymorph of olivine, is considered to be the most abundant mineral at depths between 520km and 660km in the mantle transition region, and it is important to accurately determine the elastic wave velocities in order to discuss the mineralogy and the composition of the mantle transition zone. In this study, we have developed ultrasonic measurement system by combining with synchrotron X-ray, and succeeded to measure the elastic wave velocity of ringwoodite at high pressure and high temperature corresponding to the mantle transition zone.

In-situ X-ray experiments were performed using Kawai-type high-pressure apparatus SPEED-1500 at SPring-8. The unit cell volumes of pressure marker (NaCl, Au) and sample (ringwoodite) were measured for estimation of pressure and sample length. Also, X-radiography was used for direct measurement of sample length at high pressure and high temperature. The ultrasonic signals were generated and received by a LiNbO3 transducer (10º Y-cut), which can produce both longitudinal and shear waves at the same time.

We have successfully measured elastic wave velocities of (Mg0.9Fe0.1)2SiO4 ringwoodite up to the conditions of ~18 GPa and ~1800 K, which correspond to mantle transition condition. P-wave and S-wave velocities at 18 GPa, 1800 K were ~4% and ~5 % slower than those at 18 GPa, 300 K, respectively. Especially, S-wave velocity had large temperature dependence, and the velocity at 18 GPa, 1800 K was slower than that of ambient condition. The detail of elasticity of ringwoodite will be introduced.