Elastic wave velocity measurement of serpentinite toward quantitative evaluation of serpentinizaiton at outer-rise region

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Recent geophysical surveys at outer-rise regions observed the seismic velocity reduction reaching mantle (e.g. Fujie et al. 2013; Shillington et al. 2015). This is interpreted as sea water could penetrate along outer-rise faults that cut through the oceanic crust, thereby reaching the oceanic mantle and promoting serpentinization (e.g Ranero et al., 2003). Serpentinizaiton at outer-rise region is estimated based on elastic wave velocity of serpentinite measured from laboratory experiments (Christensen 2004). However, their experimental results don’t consider the effect of porosity and pore water in elastic wave velocity, and it is possible to overestimate serpentinizaiton. To estimate the degree of serpentinizaition considering the effect of porosity and pore water, we measured elastic wave velocity of serpentinite showing various porosity on wet condition.

Experimental samples were collected from Mineoka Belt in Japan and dredged from deep seafloor at South Mariana Trench and Tonga Trench. They are low-temperature serpentinite composed of lizardite and chrysotile. Based on petrographic analyses, the degree of serpentinization of those sample was ~100 %. Porosity was measured by the gas expansion method beads on the isothermal gas equations, ranging 0.6-26.7 %. Intra-vessel deformation and fluid flow apparatus at Hiroshima University were used to measure elastic wave velocity. Elastic wave velocity was measured from the pulse transmission method that the amplitude and the frequency of a trigger wave are 5 V and 2 MHz, respectively. After measurements under dry condition, measurements under wet conditions injecting pore water were performed. Pore pressure was set at 10 MPa using a syringe pump. Confining pressure was up to 200 MPa at both experiments.

Elastic wave velocities increased with increasing confining pressure. On the dry experiment, *P* and *S*-wave velocity at 200 MPa of confining pressure show 3.6 to 5.4 km/s and 2.1 to 3.0 km/s, respectively, and a trend that the velocity decreases with increasing porosity. On the wet experiments, *P*-wave velocity increased from that on the dry experiment and *S*-wave velocity slightly decreased. We calculated bulk and shear modulus based on the experimental results, ranging 17-48 GPa and 10-25 GPa, respectively, at 200 MPa on the dry experiments. Bulk modulus on the wet experiments is 1.1-1.5 times higher than that on the dry experiments, on the other hand, shear modulus is almost unchanged. These effect of pore water in elastic constants causes the difference of elastic wave velocity between dry and wet experiment. Our results on the wet experiments correspond with the relationship between velocity and porosity reported by Domenico (1984) that velocity decreases with increasing porosity.

The estimate of serpentinization using the new relationship between serpentinizaiton and *P*-wave velocity based on our experimental results decreases with increasing the saturated pores in serpentinite. If the saturated pores exist 10 % in serpentinite formed at outer-rise regions, it is possible that the previous studies approximately 5 % overestimate serpentinization.

Keywords: serpentinite, elastic wave velocity, pore water, outer-rise region