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Elastic wave velocity measurement of natural serpentinite up to 8 GPa

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Recent seismological studies have demonstrated low velocity and high Poisson's ratio anomaly in subduction zones, which has been believed to represent the existence of serpentinite. In contrast, some experimental studies have reported P-wave (Vp) and/or S-wave (Vs) velocities of serpentinite to clarify the existence of serpentinite in these regions. However, these experiments were limited to relatively low pressure conditions (up to 1 GPa), although we need Vp and Vs data under higher pressures of subduction zone (~1 to 5 GPa). Here we measured Vp and Vs of low-temperature type (mixture of chrysotile and lizardite) and high-temperature type (antigorite) serpentinite at pressures up to 8GPa and room temperature.
High-pressure experiments were carried out using Kawai-type multianvil apparatus. We measured Vp and Vs by using ultrasonic technique. The Vp of the high-T type serpentinite increases with increasing pressure to 4 GPa, but it decreases with increasing pressure at 4-6 GPa. The Vp again increases with increasing pressure at higher than 6 GPa. The Vs slightly increases with increasing pressure to 2 GPa, while it decreases with increasing pressure at 2-7 GPa. The Vp of the low-T type serpentinite also increases with increasing pressure below 4 GPa, while the pressure dependence becomes gentle at pressures higher than 4 GPa. The Vs value is almost constant or slightly decreases with increasing pressure at 3-7 GPa. In order to compare our Vp and Vs results with those of previous studies, we estimated the Vp and Vs at 0 GPa by extrapolating the experimental results obtained at high pressure. We observed Vp=6.70 km/s and Vs=3.96 km/s for the high-T type, which are close to those of Bezacier et al.(2009) determined by the Brillouin scattering techniques at ambient condition (Vp=6.76 km/s, Vs=3.83 km/s). In contrast, the present results of Vp=5.08 km/s and Vs=3.26 km/s for the low-T type are markedly higher than those of previous studies (e.g., Vp=4.3 km/s and Vs=2.1 km/s: Christensen, 1966). However, recent first principle calculation by Mookherjee and Stixrude (2009) reported high Vp and Vs of lizardite of 6.36 km/s and 3.63 km/s, respectively, which are relatively close to those of antigorite. Our Vp and Vs results locate between those of the first principle calculation for lizardite and previous ultrasonic measurement of natural low-T type serpentinite. Because natural rock samples consist not only of lizardite but also of chrysotile, the variations of Vp and Vs of low-T type serpentinites may be attributed to variations of the amount of chrysotile in the rock samples, and chrysotile would have significantly lower Vp and Vs than antigorite and lizardite.

Keywords: serpentine, elastic wave velocity