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Measured and calculated effect of water on P-wave velocities of peridotites

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Understanding the effect of water on P- (Vp) and S-wave (Vs) velocities of rocks gives important constraints to clarify the structure and state of seismic low velocity anomaly in subduction zone. Ito (1990) experimentally determined Vp and Vs for serpentine-dominant peridotite, and obtained linear relationship between velocity decrement and water content, and demonstrated significant decrease in Vp and/or Vs (more than 20 %). The measurements by Ito (1990) were conducted for the rock samples with relatively high water content. As the seismic tomographical profile in upper mantle region beneath active arcs suggest relatively smaller amounts of water content, laboratory measurements of Vp and Vs is required for the upper mantle peridotites with smaller amount of water. Here we report laboratory measurements of Vp in serpentine-bearing wehrlite (0.2 wt.% H2O), serpentinized dunite (4.1 wt.% H2O), chlorite-bearing websterite (1.4 wt.% H2O) and dunite (0.6 wt.% H2O) up to 1000 C at 1 GPa. High-pressure experiments were performed with a piston-cylinder apparatus. Vp was measured with the pulse reflection method and determined with 0.7% uncertainties. Details of our ultrasonic Vp measurement are described in Kono et al. (2004). Vp during heating shows a sudden decrease at dehydration temperature of serpentine and/or chlorite. In contrast, during cooling Vp shows a linear increase to the room temperature. The run products contain dehydration reaction products of serpentine or chlorite, and therefore the sudden decrease in Vp during heating is attributed to dehydration reaction of serpentine or chlorite. In addition, no evidence of back-reaction such as hydration reaction of olivine was identified in the run products. In order to understand the effect of water on Vp, we calculated Vp of anhydrous assemblage with the method of Hacker and Abers (2004), and evaluate the change of Vp (Vp/Vp0) caused by presence of water. The Vp/Vp0 at 900 C and 1 GPa are 0.988 for the wehrlite, 0.988 for the dunite, 0.977 for the websterite, and 0.850 for the serpentinized dunite. Combining the present data with those given by Ito (1990), we examine relationship between Vp/Vp0 and water content. The effect of water on Vp/Vp0 is relatively small (smaller than -0.02 /wt.%) for the rocks with relatively small water content (0.2-1.4 wt.%). Vp/Vp0 increases to -0.09 /wt.% in the rocks with higher water contents than 4.1 wt.%. To discuss the differences in dVp/Vp0/dH2O in terms of wetness, we calculated Vp/Vp0 as a function of volume fraction of water with the method of Takei (1998; 2002). Our Vp/Vp0 results for 0.2-1.4 wt.% H2O content (0.003-0.038 in volume fraction) are comparable to the calculated values for the wetness of 0.15. Although Yoshino et al. (2005) shows a well-fitted relationship between wetness and volume fraction of liquid with the constant fitting parameter 'A'. In this study, nearly constant value of wetness is obtained for rocks with variable volume fractions of water, which well explain our Vp/Vp0 results for rocks with relatively low water. In contrast, the Vp/Vp0 for rocks with 4.1 wt.% H2O (0.105 in volume fraction) corresponds to higher wetness (0.50-0.55). The discontinuous change in Vp/Vp0 at around 1.4-4.1 wt.% with increasing water content might reflect difference in the relationship between wetness and volume fraction of water.