Reassessment of bond correction for in situ ultrasonic interferometry on elastic wave velocity measurement under high pressure and high temperature

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It is very important to clarify the elastic properties of minerals and rocks under high pressure and high temperature in understanding the geophysics and geochemistry, mineralogy of the Earth's interior. There are several methods for elastic wave velocity measurement under high pressure and high temperature. Among them, simultaneous in situ synchrotron X-ray techniques and ultrasonic interferometry experiments combined with Kawai type multi anvil apparatus (referred to below as **in situ ultrasonic method**) have advantage because of reliable temperature control using thermocouple. In particular, the method enables us to measure simultaneously P and S wave velocities and lattice parameters (i.e. density) under same P-T conditions (Higo et al., 2018).
On **in situ ultrasonic method**, the elastic wave velocity is calculated from the sample length divided by travel time through the sample. The travel time is obtained using the acoustic wave property which reflects from different acoustic impedance. The sample length is obtained using X-ray radiography image. As the buffer rod and baking material, ceramic materials are often selected owing to relative acoustic impedance difference and the stability. As silicate minerals are used as the sample in our experiments, a bond material (e. g. Au foil) is required at both ends of sample to clarify its area and the acoustic matching. However, the bond material causes travel time perturbation by reverberation of the acoustic wave inside the bond. Thus, it is necessary to correct the phase shift of the bond effects. The bond correction (e. g. McSkimin, 1950) has been studied to various materials (Davies and O'Connell (1977)). The previous studies of **in situ ultrasonic method** have often adopted the theoretical model to correct the bond effects by Niesler and Jackson (1989) (e. g. Li and Zhang (2005), Chantel et al. (2012)). On the other hand, Spetzler et al., (1993) suggested another model developed by different idea.
We compared two type of the theoretical models, Niesler and Jackson (1989) and Spetzler et al. (1993), to correct the bond effects. The phase shift occurred by multiple reflection inside bond was calculated based on the reported data (Niesler, 1986). The plus-minus sign of the phase shift and frequency dispersion were compared. As the result, we propose a new model which is more reasonable for **in situ ultrasonic method** by investigating pressure and temperature dependence of the model. The change of seismic velocities is less than 1.6% per 100 km depth in the Earth's lower mantle region, therefore our results show that the bond correction is indispensable for **in situ ultrasonic method**.

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