Elastic wave velocity of Al-bearing anhydrous bridgmanites under high pressure and high temperature

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Bridgmanite (Brg), the endmember formula is $MgSiO_3$, is considered to be a major constituent mineral in the Earth's lower mantle, and the most abundant mineral in the Earth. Al is one of the abundant elements in the Earth's interior, and in case of the pyrolite composition, almost Al in lower mantle can be incorporated in Brg in anhydrous condition (e.g. Irifune et al., 1994). Zhang and Weidner (1999) reported that the bulk moduli of Al bearing Brg (Al-Brg) (Al 0.1 pfu, O=3) is more than 10% smaller than that of Mg-endmember Brg (Mg-Brg). Moreover, hydrous Al-Brg was experimentally synthesized (Inoue et al.,2014), although Brg is considered as anhydrous mineral so far. Therefore, it is very important to clarify the physico-chemical properties of Al-Brg in understanding dynamics of the Earth's interior.
Our recent knowledge suggests that there are three types of Al substitution mechanisms, Tschermak and oxygen vacancy substitutions and hydrous substitution. In this study, we focused on anhydrous Al-Brg, because the anhydrous type, pure Tschermak and oxygen vacancy substitutions Brg, has not been reported so far in low Al content, when we checked the previous reported compositions carefully (e.g. Irifune et al, 1996; Kubo and Akaogi, 2000). The previous studies have used powder samples as the starting materials, so we considered that chemical compositions of Al-Brg were shifted to hydrous type by partial hydration by absorbed water.
The high pressure synthesis experiments were conducted at 28 GPa and 1600-1700℃ for 1hour using a Kawai-type multi-anvil apparatus. Glass rods were used as the starting materials to eliminate the absorbed water on the sample surface. Moreover, the glass rods were enclosed in a metal capsule to prevent the water incorporation from the surrounding cell assembly. In addition, all parts of the cell assembly were dried just before the synthesis experiments. As the results, we could synthesize the pure Tschermak and oxygen vacancy substitutions Brg, and obtained almost single phase and large volume of Al-Brg for the elastic wave velocity measurement using the ultrasonic interferometry. The elastic wave velocity measurements under high pressure and high temperature were conducted at BL04B1 in SPring-8 using Kawai-type multi-anvil apparatus (SPEED-1500). We investigated the elastic wave velocity of the Tschermak type (Al 0.1 pfu, O=3) and the oxygen vacancy type (Al 0.025 pfu, total cation of 2). Date acquisitions were carried out at pressures up to ~30 GPa and temperatures up to 1100 K. These results show that the V_P is slower than that of Mg-Brg, whereas the V_S is almost same of that one. We confirmed the effect of Al substitution for elastic wave velocity at the uppermost lower mantle pressure.

Reference

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