

Equation of State of CaSiO₃-perovskite determined by in situ X-ray observations up to 40GPa

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CaSiO₃-perovskite (CaPv) is one of the major minerals in the earth's deep mantle. Thus, it is important to determine the thermoelastic parameters of CaPv for understanding the mineral constitutions in the earth's lower mantle. Because CaPv is known to be unquenchable to the ambient conditions, the mineral physics studies related to CaPv have been very limited up to data. In this study, we conducted in situ X-ray observations to determine the thermoelastic parameters of CaPv at pressures up to 40GPa.

High temperature and pressure experiments were conducted with SPEED-1500 and SPEED-MKII installed at BL04B1, SPring-8. We used sintered diamond anvils (L=14mm) as second-stage anvils, and to obtain the P-V-T data set at pressures up to 40GPa.

The starting material was used wollastonite (CaSiO₃), which was mixed with a gold powder (20:1 wt%) for pressure measurement. Pressure was estimated from the equation of state of gold reported by Anderson et al. (1989).

The sample was pressurized up to the target pressure under the room temperature, and then CaPv was synthesized at 1473K for about 1 hour. After the formation of pure CaPv, the P-V-T data were acquired at every 200K upon decreasing temperature to the room temperature.

The experiments were conducted at 10-40GPa and 300-1473K under the stable conditions of CaPv.

The obtained P-V-T data at the room temperature were fitted by Birch-Murnaghan equation of state, and then the bulk modulus, its pressure derivative, and the unit cell volume of CaPv were determined as $K_{300,0}=223(6)$ GPa, $dK_0/dP=5.3(6)$, and $V_0=45.57(3)$ Å³. We also analyzed the P-V-T data at high temperature to 1473K under pressure, and determined thermal expansion coefficient at the ambient condition and the temperature derivative of the bulk modulus, $\alpha_0=2.52(7)*10^{-5}$ K⁻¹, $\beta_0=1.02(8)*10^{-5}$ K⁻², and $(dK_0/dT)_P=-0.034(1)$ GPa/K.

From the present thermoelastic parameters, we calculated the density changes of CaPv in the mantle transition region and the upper part of the lower mantle, assuming a geotherm by Brown & Shankrand (1981). The results show that the density of CaPv at the top of the lower mantle is 4.4 g/cm³, which is larger than those in the PREM by about 0.1 g/cm³.