Materials Science

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Equation of State of Antigorite at High Pressure and Temperature

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Introduction

Antigorite plays key roles in subduction zone processes including transport of water and seismogenesis. The equation of state (EoS) of antigorite is critical for understanding of its stability field and for interpretation of seismological observations. Although a few compression tests have been conducted at room temperature, EoS is still poorly understood at high temperatures. We have investigated EoS of antigorite by in-situ synchrotron X-ray powder diffraction.

Experimental

Measurements were conducted at a beamline NE5C of Photon Factory-Advanced Ring. The sample was a natural antigorite ($(Mg_{5.67}Fe_{0.04})Si_4O_{10}(OH)_{7.82}$) collected from Inner Mongolia, China. It was finely ground and mixed with NaCl, and pressurized in a multi-anvil type high-pressure apparatus (MAX80). Measurements were made at pressures of 0.5~5 GPa and temperatures of 100~400 ºC. The pressure was estimated from the compression of NaCl. Diffraction peaks of antigorite were indexed with the aid of indices reported by Capitani and Mellini (2004). Lattice parameters A, b, c and β were estimated by the least square method.

Results

Isothermal Compression

The compression in the c-axis dominates the isothermal compression in bulk. Fig.1 shows lattice parameters at temperature of 300 ºC as a function of pressure. The lattice parameters are normalized by the values at pressure of 0 GPa, which are obtained by fitting linear (A and b) or 2nd-order (c) equations to data.

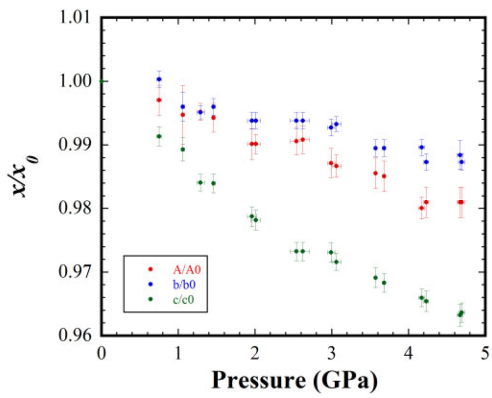

Fig.1 Normalized lattice parameters at T=300 ºC.

The compressibility in the c-axis is larger than those in the a- and b-axes by a factor of ~3. This is consistent with the previous study [1]. The linear compressibility in the c-axis significantly increases with increasing temperature ($(6\pm3)\times10^{-15}$ $Pa^{-1}K^{-1}$), while those in a- and b-axes are almost independent of temperature. The isothermal bulk modulus is estimated to be 60 GPa at room temperature, which is close to the previously reported values [1].

Isobaric Expansion

The linear expansivity is estimated from lattice parameters at a given pressure and temperature of 100, 200, 300, 400 ºC, which are calculated by using the fitted equations. Fig.2 shows the linear expansivity as a function of pressure. The expansivity in the c-axis is the largest and largely decreases with increasing pressure, while that in the b-axis the smallest and almost independent of pressure. No significant difference can be seen between axes at the pressure of 5 GPa.

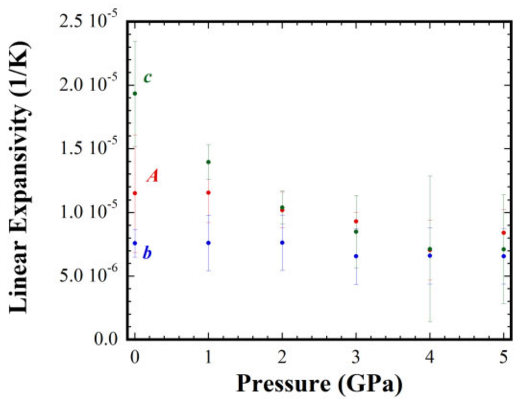

Fig.2 Linear expansivities as a function of pressure.

The volumetric thermal expansivity is calculated to be $(3.8\pm0.6)\times10^{-1}$ K^{-1} at P=0 GPa, which is consistent with the previous estimation [2]. Our estimation clearly shows that the expansivity decreases with increasing pressure.

References

[1] N. Hilairet et al., Geophys. Res. Lett. 33, doi:10.1029/2005GL024728 (2006).
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