

Dehydration and the equation of state of chlorite under pressure and high temperature

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Introduction

Water in hydrous minerals has been transported to deep Earth's interior by subducting slab, which dehydrate at certain pressure and temperature. The existence of deep Earth's water affects the physical properties of Earth's mantle minerals, such as melting point, viscosity, elastic velocity, and so on. Therefore it is important to study the effect of water for the subducting slab materials. Serpentine ((Mg,Fe)₆Si₄O₁₀(OH)₈) is major hydrous mineral in subducting slab, and chlorite ((Mg,Fe,Al)₆(Si,Al)₄O₁₀(OH)₈) should be also important hydrous mineral in the subducting slab because Al is included in slab materials. In this study, the dehydration reactions of chlorite were determined by time-resolved X-ray diffraction analysis under high pressure and temperature using MAX80, PF-AR, KEK. In addition, P-V-T experiments of chlorite have also been conducted under HPHT.

Experimental

Natural chlorite was used as a starting material. We tried to use h-BN and NaCl sleeves to release the deviatoric stress. Temperature was measured by W-Re thermocouple, and pressure was calculated by equation of state of NaCl proposed by [1]. Experiments were conducted up to ~10 GPa in the truncated edge length of 4 mm on WC anvil. The diffraction data of sample and pressure standard were collected alternatively for 300 seconds each at intervals of 100°C with decreasing temperature to release the deviatoric stress.

Results and discussion

We found that chlorite was quickly dehydrated to forsterite + pyrope + fluid within 1 hour at 3 - 7 GPa when across the phase equilibrium boundary. On the other hand, the kinetic boundary was observed above 7 GPa because of low temperature phase equilibrium boundary, and the dehydration product was Mg-sursassite mineral assembly (Fig. 1). The dehydration boundary in the present study is consistent with previous phase equilibrium boundary by quench experiment. This means that, chlorite become to equilibrium state rapidly when slab cross the dehydration boundary below 7 GPa.

The room temperature P-V data (Fig. 2) below 7 GPa have been fit to the Birch-Murnaghan equation of state, yielding $V_{0,300\text{K}} = 711.9(5) \text{ \AA}^3$, $K_{0,300\text{K}} = 78.7(14) \text{ GPa}$, when pressure derivative K' was fixed to 4.0. The present K_0 value is agreement with the previous studies of 75 ~ 80 GPa, which were obtained by DAC up to 7.7 GPa at room temperature. However the compression curve looks

like change around 4 GPa, so the analyses using the data below and above 4 GPa were also conducted. We obtained $K_{0,300\text{K}} = 86.9(21) \text{ GPa}$ below 4 GPa, and $K_{0,300\text{K}} = 64.5(8) \text{ GPa}$ above 4 GPa respectively. This result shows that the high pressure phase transition occurred through the volume softening behavior at around 4 GPa. The high temperature Birch-Murnaghan equation of state using the data below 4 GPa, yielded $V_{0,300\text{K}} = 710.3(3) \text{ \AA}^3$, $K_{0,300\text{K}} = 85.8(21) \text{ GPa}$, $\alpha_0 = 2.3(3) \times 10^{-5}/\text{K}$, $dK/dT = -0.0132(82) \text{ GPa/K}$, which was consistent with the previous study below 4 GPa.

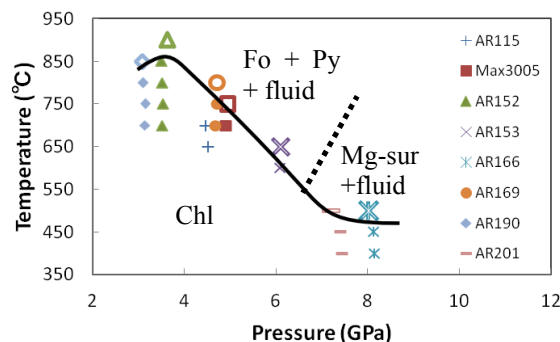


Fig.1 Stability of chlorite (Chl). Fo: Forsterite, En: enstatite, Mg-sur: Mg-sursassite

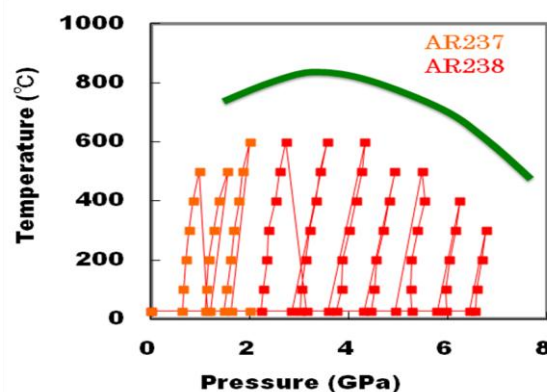


Fig.2 P- T path for the EoS determination of chlorite.

References

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