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PVT equation of state of lawsonite

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1 Introduction

Lawsonite [$CaAl_2Si_2O_7(OH)_2 \cdot H_2O$] is a common hydrous phase in metabasalts and metagreywackes, and is believed to be the last hydrous phase in the mid ocean ridge basalts (MORB) system in subduction zones. The previous experimental results in CaO-Al_2O_3-SiO_2-H_2O system (CASH) have revealed that lawsonite can be stable up to 10 GPa and 1230 K, which allows it to retain the water to the depth of ~300 km in the descending slab. Thus lawsonite can be a very important water carrier into the deep mantle. Several experiments have already been conducted under high pressure and high temperature to clarify the compressibility of lawsonite [1-3], but the reported values of the bulk modulus show a large discrepancy ([1] 96 GPa; [2] 191 GPa, etc). Here we conducted in situ X-ray diffraction experiments of lawsonite under high pressures and high temperatures to determine the equation of state under high pressure and high temperature.

2 Experiment

The starting "lawsonite" sample was synthesized at 10 GPa and 1273K for 10 hours by a Kawai-type multi anvil apparatus installed in GRC, Ehime University. High-pressure and high temperature in situ X-ray experiments were conducted at the AR-NE5C beam line of PF-AR in KEK, Tsukuba, Japan. The 6-6 type compression method was used [4]. The TEL of the second stage anvils made by WC was 4 mm. After obtaining the diffraction patterns at ambient condition, the cell was first compressed to a desired load, and then heated to a temperature within the stability region to release the deviatoric stress. After collecting the diffraction patterns for both sample and pressure standard, the temperature decreased at 100 K interval to collect the diffraction patterns. The generated pressure values were calculated from the equation of state (EoS) of NaCl [5].

3 Results and Discussion

Figure 1 shows the pressure and temperature conditions where we collected the data. The obtained diffraction patterns were fitted by the program XRayAna, using at least 14 sharp diffraction peaks to calculate the lattice parameters.

Figure 2 shows the pressure-volume-temperature (P-V-T) dataset, and the data were fitted by using 3rd order Birch-Murnaghan equation of state. The bulk modulus of lawsonite has second order dependence on temperature. Thus fitting the high temperature data yielding: V_0 = 674.3(4) $Å^3$, K_0 = 128.7(15) GPa, $\partial K_{T,0}/\partial T$ = -0.047(8) GPa K^{-1}, $(\partial^2 K_{T,0})/(\partial T^2)$ = 0.028(6) 10^{-3} GPa K^{-2}, and α = 3.1(3) 10^{-5} K^{-1}. K_0' was fixed to 4. The present dataset was less scattering than the previous studies. Using those parameters one can calculate the density and the decomposition boundaries of lawsonite under high pressure and high temperature. This work is now submitted to an international journal [6].

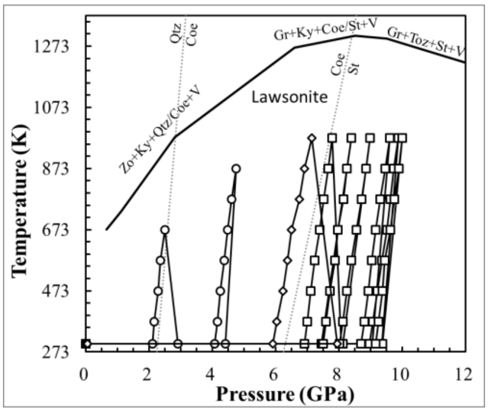

Figure 1 The pressure-temperature pathways for the in situ experiments.

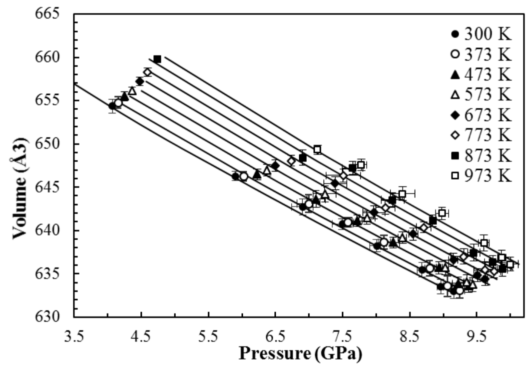

Figure 2 Compressibility of Lawsonite with 3rd order Birch-Murnanham fitting at temperatures of 300, 373, 473, 573, 673, 773, 873 and 973 K, respectively.

References

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