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Dehydration kinetics of serpentine under high pressure and high temperature

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Introduction

Many hydrous phases should exist in the subduction zone, and serpentine is a main hydrous phase in the hydrous peridotite layer of the descending slab. Antigorite (Atg) is one of the polymorph of serpentine, and it has been studied for stability field and phase relation. As the result, it has been clarified that the dehydration of Atg brings free water into the mantle wedge and promotes partial melting. Above ~5 GPa, the breakdown of Atg produces phase A ($Mg_7Si_2H_6O_{14}$; 11.8 wt% H_2O), and the subducting slab is able to transport water to deep mantle. However, the subducting slab is considered to be very low temperature, and the dehydration of Atg should occur at very low temperature. This indicates that the kinetic effect should be important for the dehydration of Atg in the Earth's interiors.

In this study, time-resolved dehydration experiments of Atg were conducted by in situ X-ray diffraction using the high-pressure apparatus "MAX80" at KEK to evaluate the dehydration rate of Atg.

Experimental

Natural Atg was used as a starting material, and sealed by rare metal lids plus diamond sleeve, which enabled us to get high quality of diffraction because of high X-ray transparency of diamond [1]. Temperature was measured by W-Re thermocouple, and pressure was calculated by equation of state of NaCl proposed by [2]. Experiments were conducted between 3 and 9 GPa and up to 1000ºC. Time-resolved X-ray diffraction was measured at intervals of 50ºC from 500ºC with checking diffraction change. The collected diffraction data was fitted by Avrami equation [3] to inspect the reaction mechanism.

Results and discussion

In all experiments, Atg was quickly dehydrated to enstatite (En) + forsterite (Fo) + fluid within 2 hours at 650ºC below ~6 GPa. Result of Avrami fitting and SEM observation of the partially dehydrated sample indicates that nucleation rate is quite high for En, but low for Fo. The values of n of En and Fo for Avrami fitting were about 1, and 2.5, respectively (Fig. 1). This indicates that the crystallizations of En and Fo are governed by growth-controlling and nucleation-controlling mechanism, respectively. This result should be related with the fact that the fluid formed in this condition is enriched in MgO-component.

Talc was formed above ~6 GPa with breakdown of Atg, which have not reported in previous phase equilibrium experiments [e.g. 4]. This talc may be metastably formed, and may disappear for long duration. In spite of this possibility, the formation of talc should be important because amount of water transported into deep mantle should be change comparing with previous estimate.

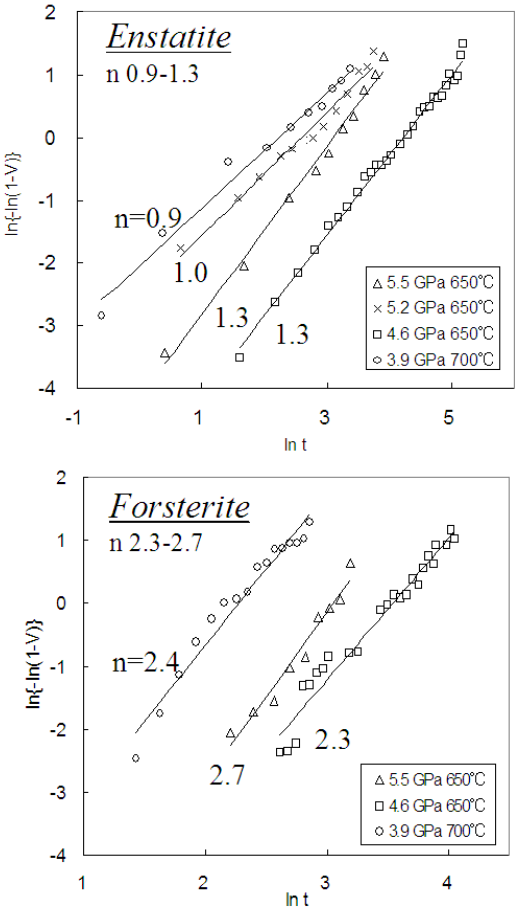

Fig.1 Time dependence of the integrated intensity (I) of the diffraction peaks ($ln(t)$ vs. $ln\{-ln(1-V)\}$) for enstatite and forsterite. $V=I/I_{max}$, where I_{max} is the intensity at the end of the reaction. The n value, which reflects the reaction mechanisms, can be obtained from the slope of the line using the Avrami equation.

References

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