Dehydration Kinetics and Mechanism of Serpentine (Chrysotile) at High Pressure and Temperature

Takuma Hayakawa[1]; Takumi Kato[1]; Tomoaki Kubo[1]

[1] Kyushu Univ.

1. Introduction

Water cycling between the inner part of the earth and the surface is the most important problem in the earth science. The peridotite in the slab partly altered by water formed hydrous serpentine minerals. It has been proposed that serpentine mainly contributes to water transportation to the deeper mantle. The purpose of this study is revealing dehydration kinetics and mechanisms of chrysotile serpentine to consider conservation ability of H2O.

2. Experimental methods

Chrysotile in natural serpentinite collected at Horoman Hokkaido was used as starting material. MAX90 (Kyusyu university) for quench experiments and MAX3rd (KEK-PF, BL14C)and SPEED1500 (Spring-8, BL04B1) for in situ X-ray diffraction experiments were utilized as high pressure apparatus. In both experiments, graphite capsules were used as heater. In several runs, samples were annealed at 673K before the target temperature. Recovered samples were identified by powder X-ray diffraction and observed by SEM.

3. Results

At 3.6 GPa and 833K-973K, firstly chrysotile started decomposition to talc and forsterite, and finally reacted to form forsterite and enstatite. This reaction character resembles reported antigorite dehydration reaction. In quench experiments at 3.6 GPa, the time series samples were obtained at 833K and 973K. At 833K, even after two hours heating, chrysotile remained and enstatite did not crystallize, while at 973K, almost complete decomposition is achieved in 30 minutes.

In X-ray in situ experiments, temperature was kept at 873K and 973K, respectively. At 873K and 3.6 GPa, enstatite started crystallizing after about 15 minutes. Arriving at 973K (3.7 GPa), enstatite started growth instantly. These experiments showed the accordance with the results of quench experiments.

Observations by SEM revealed chrysotile decomposed along grain boundaries to forsterite and talc. These analyses also showed very small enstatite crystallized from the region of firstly decomposed phases.

4. Discussions

Talc firstly crystallized with decomposition of chrysotile and finally disappeared with generation of enstatite at constant temperature. This facts show talc is metastable product. Decomposition speed of annealed samples was slower than that of non-annealed ones. These facts are thought annealing removed the strain energy of grain boundaries of chrysotile and nucleations of decomposition products were inhibited.

5. Implications

In the conditions of most cold slab, metastable talc may subduct to deeper part of the earth without reaction to forsterite and enstatite and transport the water to DHMS.