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Dehydration kinetics of Antigorite by in situ high-temperature IR microspectroscopy

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Previous studies suggested that the dehydration processes of hydrous minerals such as serpentinite play a key role in a generating mechanism of earthquakes in the subducting slabs. These studies indicate that the reaction of released water from serpentinite with subducting slab is thought to be the cause of intra-slab earthquakes. The volume change caused by reaction and the rate of the reaction products are likely to associate with the earthquake generation mechanism. However, the dehydration process and kinetics of serpentinite are still controversial, thus we here in report the dehydration kinetics of serpentinite.

In previous works, the dehydration kinetics of serpentinite was mainly studied by X-ray diffraction analysis which mainly focused on a change of crystal structure and not for states of water (ex. Inoue et al., 2009). Tokiwai and Nakashima (2010) studied the dehydration kinetics of muscovite by using in situ high-temperature IR microspectroscopy which enables to distinguish the water species. Therefore, we investigated the state of the water in serpentinite and determine the dehydration kinetics by using in situ high-temperature IR microspectroscopy.

Serpentinite samples which consist of antigorite were collected from Nomo peninsula in Nagasaki prefecture. Dehydration experiments of antigorite were conducted by using a fourier transform infrared (FT-IR) microscope in Osaka University, temperature set at 650-750 degrees C and atmospheric pressure under Ar stream which flow rate is 60ml/min.

In the case of antigorite of this study, the spectrum at room temperature shows a relatively sharp band at around 3450-3510 cm^{-1} (peak1), around 3570-3595 cm^{-1} (peak2) and around 3655-3660 cm^{-1} (peak3). Serna et al. (1979) reported that peak1 and peak2 correspond to OH with substitution of Al for Si, and peak3 corresponds to Mg-OH bond, respectively. To describe quantitatively the OH decrease, we measured integral intensity (absorbance) from 3200 to 3900 cm^{-1} . And we also applied a Gaussian function to the absorption band in order to split into the three OH elements and analyze each peak with diffusion equation.

Experimental results show that each peak has different dehydration kinetics and activation energy. The diffusion coefficient approximated by diffusion equation indicates that the peak3 is higher than peak1 and 2. And the activation energy calculated from the temperature show that the peak3 is lower than that of peak1 and peak2. These results suggested that OH associated with Mg tends to dehydrate easily than that associated with Al. In addition we have conducted the heating and cooling experiments of antigorite by the same in situ high-temperature IR microspectroscopy. The results show that the dehydration of Mg-OH (peak3) caused earlier than OH related to Al (peak1 and 2) by about 50 degrees C. These results agree with the data of Bromiley and Pawley (2003) which reports that the presence of even small amount of Al can stabilize antigorite to about some degrees higher temperature.

Keywords: serpentine, dehydration kinetics, diffusion, in situ IR microspectroscopy