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Flow behaviors and AE activities during syndeformational antigorite dehydration at high pressures

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Intermediate-depth earthquakes are seismic activities in Wadati-Benioff zone at depths from 60 km to 300 km, where subducting plates deform plastically rather than brittle failure. To understand the shear instability mechanisms above ~2 GPa, there have been some acoustic emission (AE) measurements with multi-anvil apparatus (e.g., Jung et al., 2009; Gasc et al., 2011). However in previous studies, the relationships among dehydration, plastic flow and shear instability were unclear because quantitative flow data, reaction kinetics, and AE activities could not be obtained simultaneously. To conduct quantitative and simultaneous measurements of these processes, we have carried out syndeformational antigorite dehydration experiments at high pressure.

High-pressure deformation experiments were conducted at 1-8 GPa, 300-1050 K, and strain rates of 3.4-7.4 x 10-5 s-1 in pure shear using a 1500-ton uniaxial press (SPEED Mk. II) with a D-DIA type guide block installed at BL-04B1, SPring-8. 50 keV monochromatic X-ray were used to measure reaction kinetics and stress-strain data. To monitor shear instabilities by detecting AEs, six piezoelectric devices were positioned between first and second stage anvils of MA 6-6 type system. AE waveforms were recorded in trigger mode using six-channel 8-bit digital oscilloscopes at a sampling rate of 50 MHz, and were analyzed to determine 3D AE source location and AE magnitude. We used three kinds of starting materials (1.7 mm in diameter and 2.7 mm in length) of polycrystalline antigorite (Atg) , fine-grained forsterite (Fo) polycrystal, and two-phase mixtures of Atg and San Carlos olivine (10%, 30%, and 50%Atg). The starting sample was first compressed at room temperature, then heated at constant load, and finally deformed with constant strain-rate mode. In some experiments, dehydration occurred during heating or deformation. Microstructures of recovered samples were preliminarily observed by optical microscopy.

Many AE events of relatively large amplitude were observed from Fo sample during cold compression stage at lower than 2 GPa. In contrast, almost no AEs were observed from Atg and 10-50% Atg samples during cold compression and heating stages. Optical microscopic observations of recovered Atg samples from each stage revealed that some faults are generated during cold compression stage, and fault slipping occurred during the heating stage. Creep behaviors of Atg samples during the deformation stage indicate that flow stress reached steady state at the sample strain of more than 10%, and no stress drops were observed until the final strain of 30-40%. These flow behaviors and flow strengths are almost similar to the previous study (Hilairet et al., 2007). Few AEs were recorded and additional faults were not observed from recovered sample during the deformation stage. We observed dehydration of Atg and 10-50% Atg samples when increasing temperature from 673K to 1000K during deformation, however we did not observe AEs during the syndeformational dehydration stage. Faults were absent in fully dehydrated samples. Although more detailed microstructural observations are needed, these results suggest that syndeformational dehydration do not enhance shear instability of antigorite in pure shear at high pressure .