Semi-brittle behavior of lawsonite in high pressure deformation experiments

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One of the cause for intermediate-depth earthquakes (50-300 km) in subducting slabs has been proposed to be the dehydration embrittlement (e. g., Raleigh and Paterson, 1965) because there are many kinds of hydrous minerals in a subducting slab and hypocenter distribution coincides with the dehydration boundary determined by high pressure experiments (e.g., Hacker et al., 2003). Many experimental studies on antigorite have been conducted, but a few previous works about dehydration embrittlement of lawsonite-bearing rocks experimentally. Lawsonite, $CaAl_2Si_2O_7(OH)_2H_2O$, is a hydrous mineral which contains 11 wt% water in its structure as both water molecules and a hydroxy group (Cmodi and Zanazzi, 1996). Lawsonite is one of the candidates for dehydration embrittlement in cold subducting slabs, however previous works have apparently contradictory results. Okazaki and Hirth (2006) showed that lawsonite dehydration induced unstable fault slip based on deformation experiments of pure lawsonite using Griggs-type deformation apparatus at 1 GPa. On the other hand, Incel et al. (2017) also investigated the deformation properties of lawsonite and glaucophane mixture at 1.5 to 3.0 GPa using deformation-DIA apparatus. They insisted that there is no evidence for a straightforward relation to the dehydration of lawsonite and the brittle failure of samples. So, we have conducted the deformation experiments of lawsonite under the cold slab conditions in order to clarify the deformation property of lawsonite and understand the relationship between dehydration and brittle failure.

Experiments were carried out using Deformation-Cubic Anvil Press (D-CAP) installed at KEK PF AR-NE7A beamline. Pure lawsonite powder (~ 98%) was used as starting materials. Deformation experiments were carried out at a pressure of ~ 6 GPa and temperatures of 300 ~ 800 ˚C. The temperature was increased at the same time as deformation started. During deformation stages, strain, stress and transformation rate were measured for in-situ using a monochromatic X-ray beam with an energy of 60 keV.

Results of deformation experiment with temperature ramping indicate that unstable fault slip did not occur during dehydration of lawsonite. Instead, we find that deformation was localized and weakening occurred within the stability field of lawsonite. We will discuss the deformation property of lawsonite (mechanical data and microstructures) and the possibility of the candidate for dehydration embrittlement in cold subducting slabs.

Keywords: dehydration embrittlement, Lawsonite, intermediate-depth earthquakes

