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Deformation experiments of serpentinite using gas apparatus: Implication for slow earthquakes in subduction zone

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Slow earthquakes (e.g. slow slip events, very low frequency earthquakes and non-volcanic tremors) have been detected in southwest (SW) Japan. Most slow earthquakes in the subduction zone of SW Japan occur with the depth range from 35 to 45 km (Obara, 2002), where is slightly deeper than seismogenic zone of Nankai megathrust earthquake. In these depths of SW Japan, low velocity anomaly and high Poisson's ratio have been reported, and it suggest that the corner of mantle wedge are locally serpentinized, where the subducted Philippine Sea plate is dehydrated (Tsuji et al., 2008, Kamiya and Kobayashi, 2000). In addition, the effective normal stress at source region of tremor in SW Japan is an order of 100kPa (Nakata et al. 2008), which indicates that tremor source regions in SW Japan maintains high pore fluid pressure. To compare the strength of olivine, serpentine is week material and behaves semi-brittle deformation at shallower depth, thus, it is considered that serpentine prevents from generating earthquakes. In summary, the region of slow earthquakes activity involves areas of (1) presence of serpentine, (2) high pore fluid pressure zone and (3) semi-brittle deformation.

This study focuses on the deformation behavior of serpentine under high pore pressure and hydrothermal conditions. Experiments were conducted using the high-temperature and high-pressure gas confining medium apparatus at Hiroshima University. Stating material was used highly dense and isotopic antigorite serpentinite from Nishisonogi metamorphic belts, Nagasaki, Japan, which porosity is about 0.2 to 0.3 %. We performed preliminary deformation experiments at confining pressure of Pc = 10 MPa, pore pressure of Pp = 0 MPa under room temperature. The sample shows brittle failure at differential stress of 500MPa and axial strain of 0.02. The residual stress was almost 0MPa. In another run, at Pc = 200 MPa, Pp = 190 MPa and temperature of 400 C, shows brittle failure at 340 MPa at axial strain of 0.016. The residual stress was 280 MPa. The stress-weakening rate of the former experiment was up to 1200MPa/s, whereas the stress-weakening rate of the experiment under hydrothermal condition was 2.7 MPa/s. These preliminary data indicates that the high pore pressure plays important role one the failure strength of serpentinites, and we will report more results on the mechanical data of serpentinite under high pore pressure and hydrothermal conditions.

Keywords: serpentinite, subduction zone, deformation experiment, slow earthquake, brittle-ductile transition, high pore pressure