The 507th Geodynamics Seminar

Shear localization in peridotites and the occurrence of intermediate earthquakes

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The subduction zone produces a major fraction of the Earth's seismic activity. The mechanisms of intermediate-depth (> 40 km depth) and deep-focus (> 300 km) earthquakes are fundamentally different from those of shallow (≤ 40 km) earthquakes. This is because the frictional strength of silicate rocks is proportional to the confining pressure and it exceeds the upper limit of the stress level in the upper mantle (< 300 MPa: Obata and Karato, 1995) at pressures higher than 1 GPa (~30 km depth). The failure strength of silicate rocks is much higher than 300 MPa at upper mantle pressures due to the positive pressure dependence of the strength (Masuda et al., 1987). Therefore, the cause of intraslab seismicity at intermediate depths have been attributed to dehydration of serpentinite (i.e., the dehydration embrittlement model: e.g., Peakock, 2001) because the water released during dehydration reaction of serpentinite reduces the effective confining pressure. The dehydration embrittlement model is now widely accepted, because the location of the double seismic zone in the subducting Pacific slab corresponds to the main dehydration field in the pressure-temperature diagram of the hydrous peridotite (Omori et al., 2002). Even though effects of hydrous minerals on stable/unstable slip have been investigated by many of recent experimental studies (e.g., Okazaki et al., 2016), effects of aqueous fluid have not been fully studied.

To investigate the role of aqueous fluid on intraslab earthquakes, I conducted uniaxial deformation experiments on water-saturated dunite and harzburgite at pressures 1-3 GPa and temperatures 860-1250 K with a constant displacement rate using a deformation-DIA apparatus. Pressure, stress, and strain were measured in situ by using x-ray diffraction patterns and radiographs. AEs were monitored continuously using six sensors, and three-dimensional AE hypocenter location was determined. At temperatures lower than 1060 K, formation of throughgoing faults was observed in water-saturated dunite (at stress > 1.7 GPa and strain rate > 2 x 10^{-5} s^{-1}). In contrast, faulting was observed at lower stress (< 0.5 GPa) in water-saturated harzburgite. AE hypocenters were located around the faulted samples though those were rarely located in the sample (i.e., aseismic faulting). This result suggests that aseismic semi-brittle flow may mimic silent ductile flow under water-saturated conditions in slabs.

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