Semi-brittle flow in dunite and harzburgite at upper mantle pressures

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The mechanism of intraslab earthquakes (> 40 km depth) is fundamentally different from those of shallower ones. This is because the frictional strength is much higher and fracture process associates ductile flow (i.e., semi-brittle flow) at deeper parts. 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). The cause of intraslab seismicity at intermediate depths has been attributed to breakdown of hydrous minerals such as serpentinite (e.g., Ferrand et al., 2017) and lawsonite (Okazaki et al., 2016) because it causes unstable fault slip or shear localization. However, the role of aqueous fluid in fracturing at high pressures is still unclear.

To evaluate the effect of water on semi-brittle behavior of dunite and harzburgite, we conducted in-situ uniaxial deformation experiments on as-is/water-saturated dunite and harzburgite at pressures 1-3 GPa and temperatures 670-1250 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. Radiographs were taken at each several minutes in most of deformation experiments, though radiographs were continuously taken (each 5 seconds) during a deformation run (at 2 GPa and 860 K). Acoustic emissions (AEs) were also recorded continuously on six sensors, and three-dimensional AE source location were determined.

Formation of throughgoing faults was observed in water-saturated dunite and harzburgite at 860 K and lower temperatures. Fault slip rate is between 3E-5 and 4E-4 s^{-1} which are comparable to the background strain rate just before a faulting (1E-5 and 3E-4 s^{-1}), showing that shear localization is ineffective under water-saturated conditions. Addition of the aqueous fluid resulted in the reduction in the number of AE events in the faulted sample (i.e., aseismic faulting). A high time-resolution strain monitoring revealed that fault slip rate fluctuate within several ten seconds (i.e., stick-slip phenomena). Because the high time-resolution strain monitoring is a preliminary experiment, the relationship between stick-slip phenomena and aqueous fluid is unclear. We will investigate that point in near future.

Keywords: water, semi-brittle flow, faulting

