沈み込むスラブ内条件下におけるカンラン石多結晶体の脆性 - 塑性流動
Semibrittle flow of olivine aggregates under the conditions of subducting slab

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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 (< 600 MPa: Obata and Karato, 1995) at pressures higher than 1 GPa (~30 km depth). Furthermore, brittle fracture associating dilatancy is difficult at high pressures. The fracture strength of silicate rocks is much higher than 600 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). However, a recent experimental study using the techniques of acoustic emission (AE) monitoring and in-situ x-ray diffraction showed that antigorite-rich serpentinite samples produced no detectable AEs in the samples in the course of their dehydration. Another explanation for the origin of intermediate-depth earthquakes is the hypothesis of a periodic shear-heating mechanism (Kelemen & Hirth, 2007). The occurrence of ultramafic pseudotachylite in natural peridotite shear zones supports the validity of the shear-heating mechanism. The hypothesis of a periodic shear-heating mechanism explains the origin of seismicity in the dry upper mantle.
To investigate the origin of intraslab earthquakes at intermediate depths, we conducted uniaxial deformation experiments on anhydrous dunite at pressures 1-3 GPa and temperatures 600-1100 degC 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 radiographies. AEs were also recorded continuously on six sensors, and three-dimensional AE source location were determined.
At temperatures lower than 950 degC, dunite samples tend to develop throughgoing faults. In the regions away from faults, formation of subgrain boundaries and recrystallized grains are frequently observed, showing the dislocation-creep controlled flow. Flow strength was higher than 1 GPa, and a sudden stress drop (1-2 GPa) associated with faulting was observed. AEs were recorded during sampled deformation at strains higher than 1E-4 s^{-1} and at temperatures below 1000 degC. The b-value was in the range of 1.2-4.3 at the primary phase and it decreased to < 1 just before a mainshock. The b-value tends to be higher at higher temperatures. At temperatures higher than 1100 degC, AEs were hardly recorded (i.e., ductile flow). Our results suggests that the brittle-ductile flow may play an important role in the seismicity in the subducting slabs.

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