The 446th Geodynamics Seminar

Intermediate-depth earthquakes can be caused by localized heating in dehydrated antigorite shear zones

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Abstract

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). Furthermore, brittle fracture associating dilatancy is difficult at high pressures. The fracture 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). 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, I conducted uniaxial deformation experiments on anhydrous dunite and wet harzburgite 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, samples tend to develop throughgoing faults. 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 usually higher than 1 at the primary phase and it decreased to < 1 just before a mainshock. At temperatures higher than 1100 degC, AEs were hardly recorded (i.e., ductile flow). I will report the details of the localized heating, which is the cause of faulting in deforming samples at high pressures.

詳細は当センターホームページ: http://www.grc.ehime-u.ac.jp/をご覧ください
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