Technical developments on acoustic emissions monitoring under the upper mantle conditions

*Tomohiro Ohuchi[1], Xinglin Lei[2], Yuji Higo[3], Yoshinori Tange[3], Tetsuo Irifune[1,4]

1.Geodynamics Research Center, Ehime University, 2.National Institute of Advanced Industrial Science and Technology, 3.Japan Synchrotron Radiation Research Institute, 4.Earth-Life Science Institute, Tokyo Institute of Technology

The subduction zone produces a major fraction of the Earth’s seismic activity. Intermediate-depth earthquakes within the subducting slab form a double seismic zone. 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). The causes of intermediate-depth and deep-focus earthquakes have been attributed to dehydration of hydrous minerals (e.g., Peacock, 2001) and anticrack faulting during the phase transformation of olivine (e.g., Green et al., 1992), respectively. To understand the mechanisms of failure of rocks under the upper mantle conditions, experimental techniques on acoustic emission (AE) monitoring have been adopted to multianvil apparatuses or Griggs apparatuses.
Green et al. (1992) conducted AE monitoring by using a Griggs apparatus combined with an AE sensor. Dobson et al. (2002, 2004) and Jung et al. (2006) adopted 2 or 4 AE sensors to a multianvil apparatus. However, the three-dimensional location of AE hypocentres have not been determined in the experiments because of not enough number of sensors used in the experiments, even though determination of the location of AE hypocenter is critical in the judgement of brittle failure of the sample surrounded by the solid pressure medium. De Ronde et al. (2007) adopted 8 AE sensors to a multianvil apparatus and they succeeded to determine the position of AE sources. Recently, Gasc et al. (2011) succeeded to develop an experimental setup that allows determining the position of AE source by using DIA-type multianvil apparatus combined with 6 AE sensors. Schubnel et al. (2013) adopted the experimental setup reported by Gasc et al. (2011) to a D-DIA apparatus installed at a synchrotron facility, and they succeeded to measure strain and stress of the sample and AE signals. We have developed an experimental setup that is optimized for the determination of the location of AE hypocentres in a synchrotron D-DIA apparatus.
Similar to Schubnel et al. (2013), we developed an AE monitoring system optimized for a D-DIA apparatus installed at BL04B1, SPring-8. One of big difference between previous systems and our system is the use of the MA 6-6 system (Nishiyama et al., 2008). In our system, the AE sensors were pasted to the backside of the second-stage anvils. Use of the second-stage anvil as a wave guide enables us to shorten the distance between the sample and the AE sensors, namely, attenuation of AE waveforms is reduced. Another advantage of our system is the large-volume cell assembly (sample diameter: 3mm; length: 4mm). Because the error on the hypocenter location is usually a couple of millimeter (e.g., Gasc et al., 2011), use of a sample having a large volume is critical when we judge whether a hypocenter locates inside of the sample or not. We succeeded to conduct experiments on AE monitoring during the deformation of olivine aggregates at pressures 1-3 GPa and temperatures 600-1100 degC. 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. We will report some the details of experimental results, and we will consider further improvements on the system.

Keywords: acoustic emission, D-DIA, earthquake

