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Study of rock deformation mechanism using neutron diffraction technique and AE signal measurement

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Acoustic emission (AE) is defined as a transient elastic wave generated by the rapid release of energy within a material. Crack initiation and slipping generated inside rock materials are all detectable with the measurement of AE signals, and therefore such measurement helps to research the underlying mechanism of macroscopic deformation. On the other hand, strain gauge is commonly used to measure strain in rock. In recent years, diffraction techniques for investigating strain in engineering materials have been developed. Strain measurements using diffraction technique are based on Bragg's law. Strain value can be estimated from the changes of lattice parameter.

Accumulation of macro strain in rock samples is generally caused by lattice strain as well as grain boundary shearing and pore collapse generated inside the rock, which would be detectable as AE events. Therefore, simultaneous using of neutron diffraction technique and AE signal measurements should provide us with new insight into rock deformation and fracturing mechanism. In order to study deformation mechanism of geological materials under uni-axial compression, neutron diffraction patterns and AE signal have been measured simultaneously.

Berea sandstone and calcarenite are used as a specimen. Main composed mineral of Berea sandstone is quartz (SiO_2), and that of calcarenite is calcite ($CaCO_3$) with minor apatite. Berea sandstone was compressed uniaxially up to 35.6 MPa with two-cycle compression. Calcite was compressed until the specimen fractured at 16.4 MPa. Lattice strain measurements using neutron diffraction technique were performed at the Engineering Materials Diffractometer "TAKUMI" in J-PARC/MLF. The diffractometer have been designed to investigate the stress-strain state of engineering materials (e.g. steel) using a pulsed neutron beam. Macroscopic strain was recorded using a strain gauge attached to the rock specimen surface. AE signal measurements were conducted using USB AE NODE (PHYSICAL ACOUSTIC CORP.) with a miniature AE sensor (Micro30) attached to a compression jig.

Macroscopic strain of both rock materials was greater than lattice strain. Inside rock specimens, mineral grain slip and pore collapse might be generated under compression. These changes would induce macroscopic deformation of the rock specimens. In addition, AE signals which might be derived from these changes in the internal structure of the rock specimens were detected. Parameters of AE signals might be a function of the amount of grain-boundary shear and/or the degree of resistance to deformation. And the frequency characteristics of AE signals depend on rock type. This difference between rock types might be related to the deformation mechanism of the rock specimens.

Keywords: neutron diffraction, lattice strain, AE, uxi-axial compression, rock deformation