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Strain Measurements of Rock samples using Neutron diffraction at J-PARC/TAKUMI

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A high-intensity proton accelerator facility named J-PARC (Japan Proton Accelerator Research Complex) has been constructed at Tokai in Japan. Various experiments are being performed using the globally highest intensity pulsed neutron beam at MLF (Material and Life Science Experimental Facility) in J-PARC. The Engineering Materials Diffractometer "TAKUMI", which was constructed at BL19 in MLF, was designed to research the stress of engineering materials. The first neutron beam was extracted in 2008, and user-operation commenced in 2009. Measurements of residual strain in superconductive materials, in situ neutron diffraction under tensile test and high-pressure neutron experiments have been performed at "TAKUMI".

Strain measurements using neutron diffraction are based on Bragg's law. Tensile or compressive stress causes change in lattice spacing, which results in peak shift of Bragg peak. Strain value can be derived from this peak shift value. Since neutron penetrate materials more than X-rays, the strain inside the material could be obtained nondestructively using neutron diffraction technique. While the stress measurements using diffraction technique has been focused mostly on metals, the application to geological materials was examined. The aim of this study is to develop neutron diffraction technique applicable to the geological materials. High intensity neutron beam at J-PARC has potential to provide strain distribution of inner area of bulk rock specimen. In situ strain measurements on specimens under compression or heating condition will provide us a new insight into rock fracturing mechanism. In addition, the residual strain in rock samples, which is hard to measure by conventional methods, could be obtained using neutron diffraction technique.

Measurements of residual strain in a rock sample and in situ strain measurement on specimens under uniaxial compression have been performed at "TAKUMI". The residual strains in a quartz vein from the Sambagawa metamorphic terrain of the Nagatoro area in the Kanto Mountains, Japan, were measured. Various rock samples (e.g. Berea sandstone) were cored (14.6 mm diameter and ca. 40 mm length) and examined by neutron beam under uniaxial compression loading. These cored rock samples were compressed approximately by 80 MPa. The strain values were measured by both strain gauge and the change of the lattice parameter.

In spite of the long neutron path length (ca. 40 mm) and small gauge volume (2 x 2 x 2 mm), sufficient neutron diffraction patterns could be obtained. This indicates that the strain distribution in rocks is nondestructively measurable using "TAKUMI". Measurements of residual strain in a quartz vein revealed that the anisotropy of strain value in respect to the direction. In the in situ strain measurements experiment, discrepancy was found in values obtained by strain gauge and quartz lattice spacing. In this presentation, we will report the methods of strain measurements of rock samples at "TAKUMI" and these results.

Keywords: Neutron diffraction, strain measurement, rock deformation