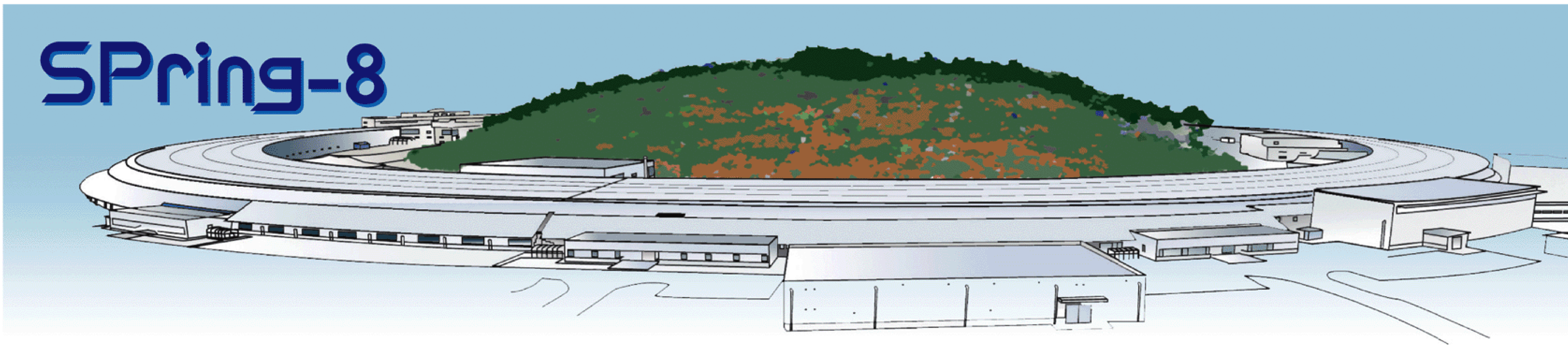

Research on rheological property of Earth's deep interiors using SPring-8

To understand the material transport in the Earth's deep interior, it is necessary to determine the rheological property of its constituent materials. Measurement of the strain and stress in a material is indispensable for examining its rheological property precisely. Professor Tetsuo Irifune, Senior Research Fellow Yu Nishihara at Ehime University and their research group established a stress measurement method for materials under high pressure using a Kawai-type multi-anvil apparatus (SPEED-1500) and two-dimensional monochromatic X-ray diffraction at the High Temperature and High Pressure Research Beamline, BL04B1, of SPring-8 (Figure 1).

Using this technique, a stress-relaxation test of olivine, the most abundant mineral in the upper mantle of the Earth, was carried out under pressures of up to 10 GPa and temperatures of up to 1000 °C (equivalent to the conditions 300 km depth of the Earth). High pressure was applied on the olivine sample using SPEED-1500, and monochromatic X-rays were irradiated onto the sample to obtain a two-dimensional X-ray diffraction pattern on an imaging plate. Polycrystalline olivine from San Carlos, which was sintered beforehand, was used as a sample, and strong uniaxial stress was applied to the sample under high pressure in a mechanically anisotropic cell assembly with strong aluminium oxide (Al_2O_3) pistons. After the sample was pressurized at room temperature, the temperature was increased and maintained at 400, 600, 800, and 1000 °C. Monochromatic X-ray diffraction patterns (Figure 2) and monochromatic X-ray radiographic images were obtained under constant temperatures. Typical exposure time to obtain the diffraction pattern was 20 minutes. Accordingly, sufficient data for the quantitative evaluation of the stress relaxation process were obtained (Figure 3).

However, the plastic strain of the sample under steady-state conditions determined by X-ray radiography was too small to measure. This result indicates that the data obtained from the stress-relaxation test in this study alone are not sufficient to determine the rheological property quantitatively and that the use of high-pressure deformation apparatus, such as deformation-DIA, with the technique established in this study is necessary.

References:

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[2] Yu Nishihara*, Ken-ichi Funakoshi, Yuji Higo, Noriyoshi Tsujino, Takaaki Kawazoe, Tomoaki Kubo, Akira Shimojuku, Hidenori Terasaki, and Norimasa Nishiyama, Stress relaxation experiments of olivine under Earth's deep upper mantle conditions, Physics of the Earth and Planetary Interiors, submitted.

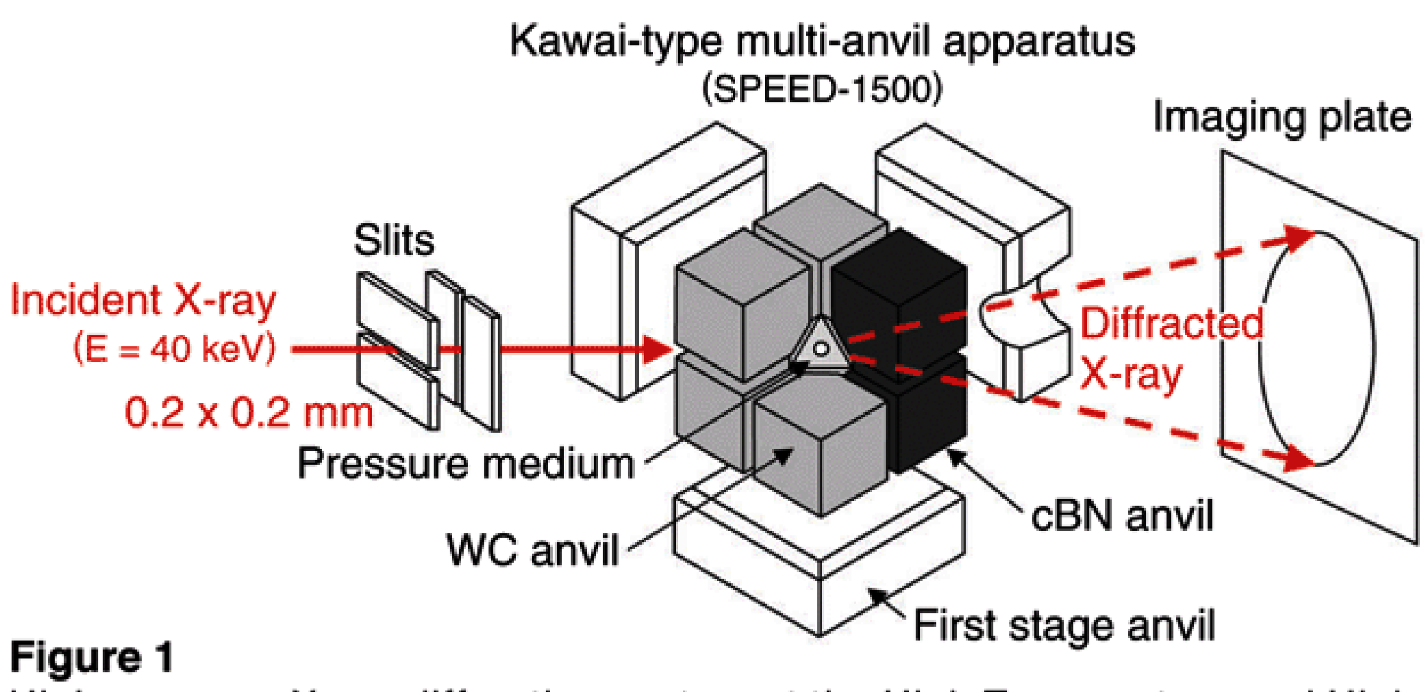

Figure 1
High pressure X-ray diffraction system at the High Temperature and High Pressure Research Beamline, BL04B1, of SPring-8: Two cBN anvils were used.

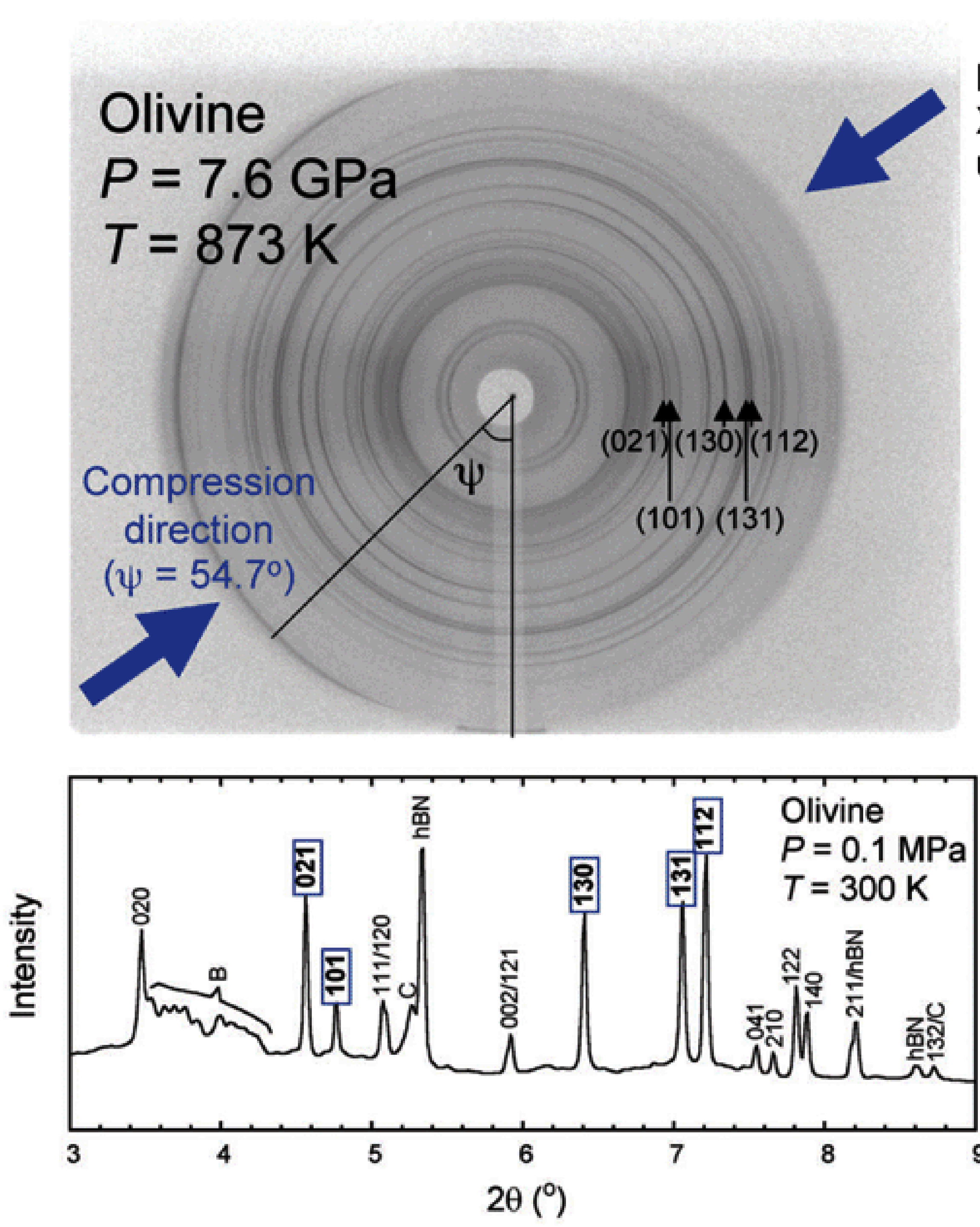

Figure 2
X-ray diffraction pattern: Five intense peaks were used for stress and pressure analyses.

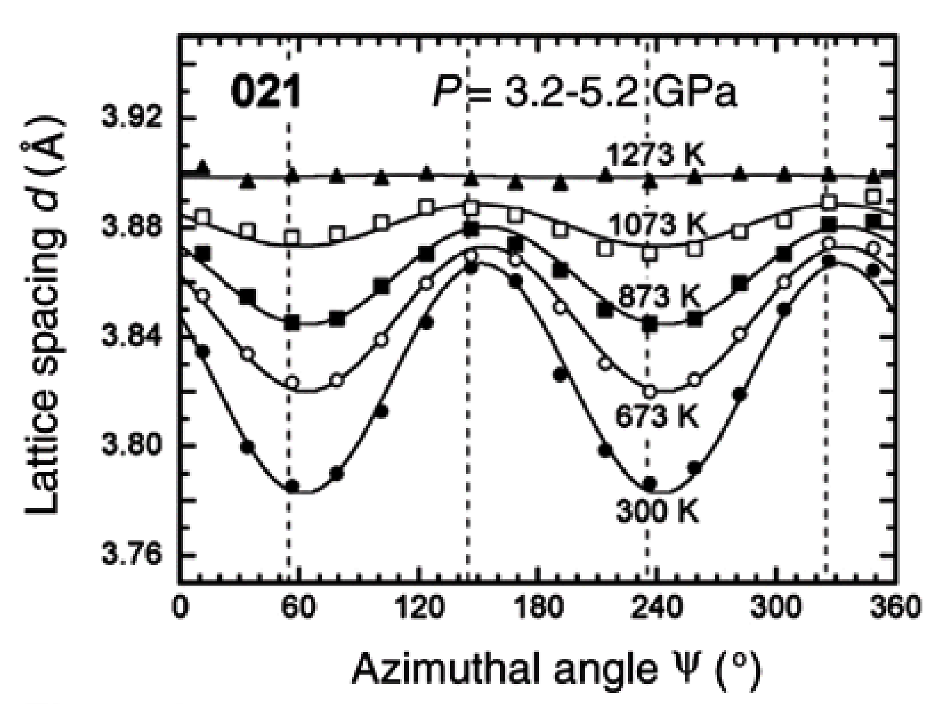

Figure 3
Lattice strain: Lattice strain decreased with increasing temperature (relaxation of stress). Broken lines show compression (54.7° and 234.7°) and dilatation (144.7° and 324.7°) directions.