In-situ X-ray observations of the olivine-spinel transformation under shear deformation: preliminary results on the reaction-induced weakening

*Tomoaki Kubo[1], Moriyama Kazuya[1], Yuichiro Mori[1], Masahiro Imamura[1], Sanae Koizumi[2], Yu Nishihara[3], Akio Suzuki[4], Yuji Higo[5]

1. Kyushu Univ., 2. ERI, 3. GRC Ehime Univ., 4. Tohoku Univ., 5. JASRI

It has been suggested that high-pressure transformations cause rheological weakening and large deformation of subducting slabs in mantle transition zone (MTZ) . However, there have been few direct experimental evidences so far largely because of the difficulties in quantitative deformation experiments under such conitions. Here we report preliminary results on the olivine-spinel transformation experiments under shear deformation upto MTZ pressures. D-111 (DT-cup) type high-pressure deformation apparatus was newly used for this purpose combined with high-energy synchrotron mono X-rays (50-60 keV) at Photon Factory (PFAR NE7 beamline), which enables in-situ observations of interactions between transformation and creep behaviors. Sintered Mg_2SiO_4 forsterite was first deformed at 15-25 GPa at 600˚C in shear, and subsequently heated to higher temperatures (~0.2˚C/s) to cause the olivine-spinel transformation under shear deformation. The transformation started at much lower temperatures under shear deformation (~900-1100˚C depending on the overpressure from the phase boundary) compared to that without deformation (~1400˚C), suggesting that the shear deformation enhances the olivine-spinel transition rate. The shear strain rate in the sample monitored by X-ray radiography was ~3-4 x 10^{-6} (s^{-1}) at 600˚C, and increased up to ~2-3 x 10^{-4} (s^{-1}) with ramping temperatures even keeping the anvil displacement rate constant (200 micron/h). We observed that the shear weakening does not occur at the same temperature, but reflects on the initiation of the olivine transition. Also, the weakening effects become significant at larger overpressures (and low T). This implies that the weakening of the shear zone induced by the grain-size reduction due to the olivine-spinel transition, however further evidences from microstructural observations are necessary. We plan to install 8-ch acoustic emission measurement system attached with D-111 apparatus to capture the transformation-induced shear instabitiy. Results of D-DIA shear deformation study on the olivine-spinel transition in Fe_2SiO_4 will also be presented and compared with those of the D-111 study in Mg_2SiO_4 .

