Correlation between structure and elastic wave velocity of pyrope glass at high pressure

*Naoki Hisano[1], Tatsuya Sakamaki[1], Tomonori Ohashi[1], Ken-ichi Funakoshi[2], Yuji Higo[3], Yuki Shibazaki[4], Akio Suzuki[1]

1. Department of Earth Science, Graduate School of Science, Tohoku University, 2. Comprehensive Research Organization for Science and Society, Neutron Science and Technology Center, 3. Japan Synchrotron Radiation Research Institute, 4. Frontier Research Institute for Interdisciplinary Sciences, Tohoku University

Considering the composition of magma generated in the Earth, magnesium and aluminum are of the same importance as silicon. Nevertheless, a study of melts and glasses of the Mg-Al-silicate composition was limited. Therefore, knowledge of elastic properties of the glass is still poor and its high-pressure behavior is also unknown.
The ratio of non-bridging oxygen (NBO) to tetrahedrally coordinated cation (T), NBO/T, is known as a good indicator of the degree of polymerization and results in different structural changes, especially in intermediate-range ordering structure with pressures. Although fully-polymerized (NBO/T = 0) and depolymerized (NBO/T > 2) melts/glasses have been examined well, the study for an intermediate composition (NBO/T ~ 1) is useful for discussing the behavior of partially molten rocks in the mantle. Here, we have measured elastic wave velocity of Mg-Al silicate glass (pyrope composition: $Mg_3Al_2Si_3O_{12}$, NBO/T = 0.8 at 1 atm) at pressures up to about 13 GPa using ultrasonic technique at beamline BL04B1 of SPring-8. V_P and V_S increased rapidly up to 5 GPa, and then the increase in velocities became smaller between 5 GPa and 13 GPa. In addition, the structure of the glass was measured using the energy-dispersive X-ray diffraction method at beamline NE5C of PF-AR in order to understand the correlation between elastic property and structure. The rapid increase in velocity up to 5 GPa corresponds to the large shrinkage of the intermediate-range ordering in silicate network. Moreover, our results demonstrate that the degree of polymerization is one of the most effective parameter to control the physical properties, structure and their pressure dependence.

Keywords: silicate glass, elastic wave velocity, X-ray diffraction, structure, ultrasonic measurement

