

Elastic property and structure of pyrope glass at high pressure

*Naoki Hisano¹, Tatsuya Sakamaki¹, Tomonori Ohashi¹, Ken-ichi Funakoshi², Yuji Higo³, Yuki Shibazaki⁴, Akio Suzuki¹

1. Department of Earth Science, Graduate School of Science, Tohoku University, 2. Neutron Science & Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3. Japan Synchrotron Radiation Research Institute, 4. International Center for Young Scientists, National Institute for Materials Science

Structural properties of magma are closely correlated to their physical, chemical, and thermal properties. One of approaches for obtaining insights of magmas is an examination of silicate glasses. Aluminum is one of the major elements in the Earth and an important element for controlling the silicate network in melts and glasses because Al^{3+} behaves as an intermediate species in the silicate melts. Aluminum cation can act as either a network former or a modifier, depending on the composition. In the case of a fully-polymerized melt, such as jadeite and albite composition, all TO_4 tetrahedra (where T represents cations, such as Si, Al, etc.) are interconnected via oxygen anions, forming a three-dimensional network structure. Compositional differences are generally considered in terms of variety of alkaline (e.g., Na^+) and alkaline-earth (e.g., Mg^{2+} , Ca^{2+}) cations in the melts. These cations are called network modifiers and tend to cut Si-O-Si bonds between a SiO_4 tetrahedron and the adjacent ones. In addition to aluminum cation, other network modifiers also affect the melt behavior. A Mg-aluminosilicate, pyrope ($\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}$) is an important mineral of mantle because of its abundance in the Earth's upper mantle. Change in the slope of melting curve of pyrope around 7-10 GPa has been reported, and pressure-induced Al-coordination change was suggested. Although investigations of structure and elasticity of Mg-aluminosilicate glasses and pyrope-composition glasses have been conducted at ambient pressure, those observations at high pressures are still poor.

Here, we have measured sound velocities of pyrope glass at pressures up to 12.9 GPa using ultrasonic technique at BL04B1 of SPring-8. Longitudinal and transverse wave velocities decreased up to 5.6 GPa, and then the velocities started to increase with pressure. Pressure dependence of elastic moduli and Poisson's ratio of the glass also changed around 7-8 GPa. The structural determination of the glass was conducted based on the energy-dispersive X-ray diffraction method at beamline NE5C of PF-AR in order to understand the mechanism of changes in microscopic physical properties in terms of macroscopic structural evolution. The characteristic shrinkage of the intermediate-range ordering in silicate network was observed around 7 GPa. We could find some correlation between elastic properties and structure. Detailed discussion will be shown in the meeting.

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