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Structural change of hydrous sodium silicate glass under high pressure using Brillouin and Raman spectroscopies

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The structure and physical properties of silicate melt are important to understand the Earth's mantle. However, it is technically difficult to conduct experiments of the melt at high pressure and high temperature. The glass is important for analog materials of the melt and one of the plausible approaches to understand its structure and density changes. It is important for melt to understand the glass which contains SiO2 as a basic component of melt. Elastic velocities of glass consist of the bulk modulus, shear modulus and density. Elastic velocities enable us to discuss the structure and density changes of melt. Brillouin scattering with DAC enables us to discuss about the glass structure and density changes under high pressure indirectly based on pressure effect on trend elastic velocities. Additionally, water owes its importance to the dramatic influence which it exerts even at very low concentrations on variety of physical properties. In this study, we measured the elastic velocity of Na2Si4O9 glass, which is a binary system of SiO2-Na2O glass, under high pressures up to 50 GPa based on Brillouin scattering together with diamond anvil cell. The other starting material is hydrous Na2Si4O9 glass. I synthesized it based on hydrothermal experiment. I observed the sample using a polarization microscope and analyzed it using FT-IR to estimate the content of water in the sample. I ovserved the peak derived from Si-O bond of the glass using Raman spectroscopy. To expect the structure and density changes of the hydrous glass based on the elastic velocities, I measured hydrous Na2Si4O9 glass elastic velocity up to 50 GPa based on Brillouin scattering together with a diamond anvil cell at SPring-8. We observed the apparent elastic velocity profile change around 35 GPa. Below 35 GPa, the relatively steeper gradient (Vp; dV/dP=0.11, Vs;dV/dP=0.043) of the elastic velocity profile was observed. Above 35 GPa, the relatively gentle gradient (Vp; dV/dP=0.05, Vs; dV/dP=0.024) was observed. Based on these results, the relatively steeper gradient suggests that the structure of Na2Si4O9 glass changes from 10 to 35 GPa. This tendency is consistent with the result of previous Raman spectroscopy (Wolf et al., 1990) which shows that the coordination number of silica changes from 4 to 6 between 20 and 33 GPa and above 33 GPa, the coordination number of silica is constant of 6 coordination. Density vs. pressure relationship was also calculated from 35 to 50 GPa based on the observed values of Vp and Vs. The relationship possibly helps to construct the precise equation of state of sodium silicate glass under high pressure, although it requires quantitative values of glass density of ambient conditions. The measurement of elastic sound velocities using Brillouin scattering could be one of the most favorable approaches to understand the structure and density changes of glass. Combined measurement with the other spectroscopic methods like Raman scattering or X-ray diffraction and absorption would leads farther understanding of density and structure change of glass. We will present about details of the result and discussion of hydrous glass experiments.

Keywords: glass, melt, structural change, Brillouin scattering, Raman spectroscopy