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Elasticity and equation of state of sodium silicate glass

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The structure and physical properties of melt are important to understand the Earth's mantle. However, it is difficult to conduct the experiments of melt at high pressure and high temperature because of the technical challenge. The glass is important for analog material of melt because the glass structure is similar to the melt structure. To investigate the physical properties of glass is one of the most plausible approaches to understand the structure and density changes of melt under high pressure. It is important for melt to understand the glass which contains SiO_2 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.
In this study, we conducted the elastic velocity measurements of $Na_2Si_4O_9$ glass , which is a binary system of SiO_2-Na_2O glass, under high pressures up to 50 GPa using Brillouin scattering with diamond anvil cell.
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 35GPa, 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 $Na_2Si_4O_9$ 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 33GPa, 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.

Keywords: elastic velocity, Brillouin scattering, $Na_2Si_4O_9$ glass