In situ density measurement of silicate melts at high pressure

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Density of silicate melt at high pressure is one of the most important properties to understand magma migration in the planetary interior. However, because of experimental difficulties, the density of magma at high pressure is poorly known. Katayama et al. (1996) recently developed a new in situ density measurement method for metallic melts, based on the density dependency of X-ray absorption in the sample. In this study, we tried to measure the density of basaltic melt by this absorption method.

When X-ray is transmitted to the sample, the intensity of the transmitted X-ray beam (I) is expressed as follows; I= I0 exp(-udt), where I0 is the intensity of incident X-ray beam, u is the mass absorption coefficient, d is the density of the sample, and t is the thickness of the sample. If t and u are known, we can determine the density of the sample by measuring I0 and I. This is the principle of the absorption method for density measurement.

In this study, in order to determine t, we used a single crystalline diamond cylinder as a sample capsule, which shows less absorbed and less deformed. So t (thickness of the sample at the point x) is expressed as follows; t = 2*(R2-x2)1/2, R is the inner radius of cylinder, and x is a distance from the center of the capsule.

Experiments were made at the beamline (BL22XU) of Spring-8. For generation of high pressure and high temperature, we used DIA-type cubic anvil apparatus (SMAP180) there. We used tungsten carbide anvils with the edge-length of 6 mm. The energy of monochromatic X-ray beam was 25 keV and the beam size was reduced to 0.1*0.1 mm2 by 2 slits. Starting material was a glass with the MORB composition (SiO2-Al2O3-FeO-MgO-CaO-Na2O). We measured the density from 3 to 5 GPa at temperatures from 300 K to 1873K.

When the sample glass was heated at high pressure (3 GPa or 5GPa) from 300 K to 873 K, the density increased by 20 %, which may be due to the structural relaxation of the glass. Further heating to 1073K, the glass crystallized to become denser. When the sample was melted at 1873 K, the density beame lighter. Details of the results and discussion will be reported. This method is suitable for measurement of the density of silicate melts at high pressure.