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Application of X-ray absorption technique to 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 magmatic process in planetary interior. However, because of experimental difficulties, the density of magma at high pressure is poorly known. Recently, we have applied X-ray absorption technique to measure density of silicate melts at high-pressure, using synchrotron X-ray and a multi-anvil apparatus.

When X-ray is transmitted to the sample, the intensity of the transmitted X-ray (I) is expressed as $I = I_0$ exp(-$\mu\rho t$), where I_0 is the intensity of incident X-ray, μ is the mass absorption coefficient, ρ is the density of the sample, and t is the thickness of the sample. If t and μ are known, we can determine the density of the sample by measuring I and I_0. In this study, we used a single crystalline diamond cylinder as a sample capsule. Diamond is thought to be elastically deformed, so that even at high pressure sample thickness t can be evaluated. Due to very low X-ray absorption of diamond, it possible to measure the absorption profile (I/I_0) of silicate melt with small absorption coefficient.

High-pressure X-ray absorption experiments were conducted by using a DIA-type cubic anvil apparatus and a highly brilliant monochromatic X-ray at BL22XU of SPring-8, Japan. We used glasses with the compositions both of the MORB and of the Fe-bearing sodium disilicate for starting materials. Densities of glasses, crystalline solids, and melts were determined up to 5 GPa and 1873 K. This method can yield a series of density data at high pressures and temperatures. Therefore we can evaluate important thermophysical properties of silicate melts, such as density difference with melting and bulk modulus.