Density of the $Fe_{70}S_{30}$ liquid at high pressure: constraints from the Clapeyron-Clausius relation

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Density of Fe-S liquid is important physical properties to understand the dynamics of the Earth and planetary cores. Density measurements of liquid are, however, difficult at high pressures, and the equations of state of Fe-S liquids are still under debate. To fix the constraint on the liquid density at high pressure is useful to evaluate the equation of state for the Fe-S liquid. In this study, we determined the density of the eutectic liquid of the Fe-FeS system at 15GPa using the Clapeyron-Clausius relation with densities of subsolidus phases (Urakawa et al, 2018).

The eutectic temperature of the Fe-FeS binary system decreases up to 14 GPa and increases with pressure above 14 GPa. The slope of eutectic melting curve is related to the density change upon a fusion at the eutectic point via the Clapeyron-Clausius equation. We can yield constraints on density of Fe-S eutectic liquid just above the eutectic temperature at the invariant point from the densities of the eutectic solid mixtures of Fe + FeS and Fe + Fe_3S_2, because liquid density is higher and lower than those of Fe + FeS and Fe + Fe_3S_2, respectively, around 14 GPa.

Recently, we determine the crystal structure of the $(Fe,Ni)_3S_2$ solid solutions by in-situ observation using synchrotron radiation. We evaluate the density of Fe_3S_2 at the eutectic point and calculated the densities of the eutectic solid mixtures. Then, we can set the constraint on the density of the $Fe_{70}S_{30}$ liquid to 6.93 ±0.08 g/cm^3 at 15 GPa and 1200 K. This is a fairly strict constraint, especially for a lower bound without any assumptions. We also discuss the equations of state of the Fe-S liquid in the presentation.

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