Sink/float experiment for the 7 GPa near-solidus melt of a primitive mantle peridotite

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Density is one of the essential physical properties that control behavior and transport of silicate magmas interior of the Earth and other planets. Silicate magmas that have lower density than surrounding mantle peridotite can ascend in the mantle and subsequently form crust. On the other hand, silicate magmas that have higher density than surrounding mantle peridotite can sink down in the mantle and subsequently form some regions that are enriched in melt components. Therefore, density of silicate magmas have significant influence on the silicate differentiation of rocky planets. Kondo et al. (2016) determined major element composition of the near-solidus melt of an primitive mantle peridotite at 7 GPa as an missing Early Enriched Reservoir (EER), a melt component which was generated in the Hadean (4.6-4.0 Ga) and has low $^{142}Nd/^{144}Nd$ ratio to compensate the difference in $^{142}Nd/^{144}Nd$ ratio between the present accessible silicate Earth (ASE) and the chondritic uniform reservoir (CHUR). Kondo et al. (2016) calculated the density of the EER from its major element composition, and concluded that the missing EER had lower density than the surrounding mantle peridotite and that the EER probably ascended in the mantle, formed an early crust, and then lost by some impact collision. There is, however, uncertainty in the calculation of melt density, and it is preable to measure experimentally the density of the EER. In this study, we determined the density of the EER (the 7 GPa near-solidus melt of a primitive mantle peridotite) by performing sink/float experiments.

In our sink/float experiments at high pressure and high temperature, we faced technical problems such as different behavior between old and new $LaCrO_3$ heaters during heating and reactions between the melt, capsule, and the density marker. We improved these technical problems and succeeded to determine the melt density. The sink/float experiments were performed at 1850 °C, higher temperature than the solidus temperature of 1750 °C that was determined in Kondo et al. (2016), in order to melt the starting material completely. At the load of 226 ton, the density marker (Fo90 olivine) floated in the melt, and this result suggests that the melt has higher density than the Fo90 olivine at the load of 226 ton. On the other hand, the Fo90 olivine sunk in the melt at the load of 186 ton, suggesting that the density of the melt is lower than the Fo90 olivine at that pressure. After pressure calibration, it was revealed that the densities of the melt and Fo90 olivine meet at 5-6 GPa at 1850 °C. Then, we corrected the temperature effect on the melt density and estimated the density of the 7 GPa near-solidus melt at 1750 °C. As the result, the 7 GPa near-solidus melt at 1750 °C probably has higher density than the PREM (Preliminary Reference Earth Model). Thus, our result suggests the possibility that the EER generated as the near-solidus melt of a primitive mantle peridotite at 7 GPa had higher density than the surrounding mantle and has been hidden in deep mantle interior.

Keywords: near-solidus melt, Sink/float experiment, density

