Experimental investigation into the cause of a high attenuation zone of the lunar seismic waves: A possible partialy molten layer at the lowest lunar mantle

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Existence of a partially molten layer at the lunar core mantle boundary is suggested by recent seismic studies. It is important to study experimentally the chemical and physical condition at the boundary. However, the chemical compositions of the lunar mantle are still poorly understood. There is a long-standing hypothesis that dense Ti-rich cumulate minerals were crystallized from the lunar magma ocean at shallow depth (~100 km) at the final stage of the lunar formation history. Furthermore, those minerals subsequently sank deep into the moon because of gravitational instability. Convective mixing of the late and early cumulates could result in a hybrid lunar mantle.
In this study, high temperature (1200 - 1500˚C) and high pressure (4 - 5 GPa) experiments are conducted to investigate the solidus of the lunar lowermost mantle which could be composed of the mixture of the late and early cumulates. The composition of the late cumulate suggested by Elkins-Tanton et al. (2011) was selected in this study. The solidus temperatures were determined to 1225 ±10˚C at 4 GPa and to 1275 ±25˚C at 5 GPa, defining a slope for the solidus of 5 ˚C/ kbar. Based on the solidus temperatures determined in this study, melting temperature at lunar core- mantle boundary (approximately 4 - 5 GPa) can be extrapolated as 1225-1275 ˚C, which is also lower than previous studies (e.g. Van Orman and Grove, 2000; Thacker et al., 2009).
Because the lower limit temperature at lunar core-mantle boundary (e.g. Flourish and Nakamura, 2009), which was estimated by terrestrial heat flow and seismic studies, has been reported to be higher than the solidus of the later cumulates determined in this study. Therefore, later cumulate could be a strong candidate for component of partial molten layer at lunar core- mantle boundary.

Keywords: core-mantle boundary, low-velocity zone, partial melt

