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Melting relations in the $MgO-MgSiO_3$ system under the lower mantle conditions using a CO_2 laser heated diamond anvil cell

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Abstract

Seismological observations of the ultralow-velocity zones (ULVZs) suggest the presence of partial melts above the core-mantle boundary (CMB). Knowledge of the melting relations in the lower mantle is a key to understand the chemical differentiation at the base of the mantle. While melting relations of mantle materials at relatively low pressure (below 30 GPa) have been extensively studied using a multi-anvil apparatus (e.g. Ito *et al.*, 2004 *Phy. Earth Planet. Inter.*), the melting experiments at higher pressures are still limited. Only in a few model compositions, such as peridotite and mid-oceanic ridge basalt (MORB), the experiments were conducted under the CMB conditions using a laser-heated diamond anvil cell (LHDAC) (e.g. Fiquet *et al.*, 2010 *Science,* Andrault *et al.*, 2014 *Science*). Since chemical heterogeneity of both major elements (Mg, Si, Fe, Al...) and minor ones (e.g. alkalis and volatiles) should have a large effect on the melting behavior, the melting phase diagrams as a function of composition are fundamental to understand the nature of the ULVZs. For melting relations in a binary system $MgO-MgSiO_3$, which is a major component in the lower mantle, the experiment up to only 26 GPa was performed (Liebske and Frost, 2012 *Earth Planet. Sci. Lett.*). So, further studies at higher pressure corresponding to the deep lower mantle condition are required. In this study, we have determined the melting relations in the $MgO-MgSiO_3$ system above 30 GPa using a LHDAC. Glasses of several different compositions were used as the starting materials. A CO_2 laser heating system was used to heat the sample directly. The recovered samples were polished and analyzed by a dualbeam focused ion beam (FIB) and a field emission scanning electron microscope (FE-SEM), respectively. The eutectic compositions and the liquidus phases were determined on the basis of chemical and textural analysis of the quenched samples. Our results show that the eutectic composition at 30 GPa is about 44 mol% SiO_2 and it becomes about 40 mol% at 50 GPa. Above 50 GPa, it is predicted to become relatively constant, consistent with the previous result by Liebske and Frost (2012). From these results, MgO-rich melt layer may be generated by partial melting of the bulk mantle, such as pyrolite composition (i.e. 42 mol% SiO_2), at the base of the mantle.

The present result should provide basic information for better understanding on the melting relations at deep mantle conditions.

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