Melting relations in the MgO-$MgSiO_3$ system and the effect of other elements in the lower mantle

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Melting mechanism has important implication for chemical evolution of the Earth. Knowledge of the melting phase relation in the lower mantle is a key to understand the chemical differentiation in the early Earth and the nature of the ultralow-velocity zones (ULVZs) 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. [1]), the melting experiments at higher pressures are still limited. Only in a few model rock 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. [2][3]). Since chemical heterogeneity of both major elements and minor ones should have a large effect on the melting behavior, the melting phase diagrams as a function of composition are fundamental to understand the detail of the early melting history of the Earth and the nature of the ULVZs. In this study, we determined the melting relations in the MgO-$MgSiO_3$ system, which is a major component in the lower mantle, and the effect of other elements (e.g. Ca, Al and H_2O) under the lower mantle condition using a LHDAC. A CO_2 laser heating system was used to heat the sample directly. The eutectic compositions and the liquidus phases were determined on the basis of chemical and textural analysis of the quenched samples. In the MgO-$MgSiO_3$ system, the eutectic composition at 30 GPa is about 44 mol% SiO_2 and it becomes about 40 mol% SiO_2 at 50 GPa. Above 50 GPa, it is predicted to become relatively constant, consistent with the previous result [4]. The effect of H_2O was also examined, and showed the significant effect compared to major elements.

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

[1] Ito et al. (2004) Phy. Earth Planet. Inter. 143-144, 397-406. [2] Fiquet et al. (2010) Science 329, 1516-1518. [3] Andrault et al. (2014) Science 344, 892-895. [4] Liebske and Frost (2012) Earth Planet. Sci. Lett. 345-348, 159-170