Melting relations in the $MgO-MgSiO_3$ system under the lower mantle conditions

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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, 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). 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.
The experiments were performed up to 115 GPa using a CO_2 laser heated diamond anvil cell. The quenched 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 liquidus phase were determined on the basis of chemical and textual analyses of sample cross sections. Our experimental results show that the eutectic composition is Si/Mg molar ratio of ~0.76 at around 35 GPa and it decreases with increasing pressure below 45 GPa. Above 45 GPa, it becomes relatively constant at about 0.64-0.65 Si/Mg molar ratio. Additionally, the eutectic composition was described by thermodynamic calculation under the whole lower mantle conditions. We obtained the Si/Mg molar ratio of ~0.64 at the base of the mantle. The liquidus phase changes from MgO-periclase to $MgSiO_3$ -bridgmanite at around 35 GPa in the Fe-free simplified pyrolite composition (~0.7 Si/Mg molar ratio). In the other model rock composition such as chondrite (~0.84 Si/Mg molar ratio), $MgSiO_3$-bridgmanite becomes the liquidus phase in the entire lower mantle. Thus $MgSiO_3$-bridgmanite should be the dominant phase to crystallize from a deep global magma ocean in the lower mantle.

