The 455th Geodynamics Seminar

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

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Abstract

Melting relations have important implications for chemical evolution of the Earth. Knowledge of the melting phase relation in the lower mantle is a key to understand the crystallization process from the global magma ocean and the nature of the ultra-low velocity zones (ULVZ). 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), the melting experiments at higher pressures are still limited. Only a few model rock compositions, such as peridotite and mid-oceanic ridge basalt (MORB), were studied under the core-mantle boundary (CMB) conditions using a laser-heated diamond anvil cell (LHDAC) (e.g. Fiquet et al. 2010; Andrault et al. 2014). The difference of the bulk chemical compositions in the model mantle has a large effect on the melting behavior such as the appearance of liquidus phases and the degree of melting (e.g. Inoue 1994; Boukaré et al. 2015). The melting phase diagrams as a function of the composition are fundamental to understand the melting relation of the lower mantle. For melting relations in a binary system MgO-$MgSiO_3$, which is a major component in the lower mantle, melting experiments have been performed up to only 26 GPa (e.g. Liebske and Frost 2012). Here we carried out melting experiments in the MgO-$MgSiO_3$ system up to 110 GPa by LHDAC experiments. 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 phases were determined on the basis of chemical and textual analyses of sample cross sections. Our results show that the eutectic composition is Si/Mg molar ratio of ~0.76 at around 30 GPa and it decreases with increasing pressure below 40 GPa. Above 40 GPa, it becomes relatively constant at about 0.65 Si/Mg molar ratio. The liquidus phase changes from MgO-periclase to $MgSiO_3$-bridgmanite at around 30 GPa in the Fe-free simplified pyrolite composition (~0.7 Si/Mg molar ratio). In the model rock compositions of the lower mantle such as pyrolite and chondrite (~0.84 Si/Mg molar ratio), which have high SiO_2 ratios compared with the eutectic composition, $MgSiO_3$-bridgmanite segregation should have occurred over the wide pressure range under the deep mantle. This phenomenon may lead to produce the bridgmanite-rich lower mantle during the cooling from the magma ocean. Additionally, the generated melt could have the MgO-rich composition with ~0.65 Si/Mg molar ratio at the base of the mantle, which should indicate the partial melt Si/Mg composition in the ultralow velocity zones (ULVZ).

詳細は当センターホームページ: http://www.grc.ehime-u.ac.jp/をご覧ください
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