

Melting experiments in the system $\text{MgSiO}_3\text{-SiO}_2$ at 13 GPa

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Melting behavior of silicates is essentially important to assess the chemical differentiation in a deep magma ocean in an early stage of the Earth. Therefore, melting relations of the system MgO-SiO_2 have been extensively studied since a pioneer work by Bowen and Anderson [1]. Furthermore, many scenarios of chemical differentiation in the deep magma ocean has been proposed based on the results of high pressure melting experiments (e.g. [2]). However, almost all of these works have been carried out on limited range of compositions from MgO to MgSiO_3 , assuming that the bulk mantle composition is peridotitic or close to that derived from CI chondrite. Recently, enstatite chondrite (E-chondrite) has been favored as the source material of bulk earth [3], because the isotope systematics of the Earth and Moon are nearly identical to those of E-chondrite over O, N, Mo, Re, Os, and Cr. In E-chondrite, the silicate composition is characterized by $\text{SiO}_2/(\text{SiO}_2+\text{MgO}) = 0.53 \sim 0.58$ (molar ratio: $\text{SiO}_2[\text{M}]$) [4], which is substantially higher than that of the peridotitic mantle (~ 0.43).

In order to understand the mantle differentiation in the E-chondrite earth model, it is indispensable to clarify the melting relations in the system $\text{MgSiO}_3\text{-SiO}_2$ at high pressures. Moreover, it also enables us to constrain the chemical composition of the crust formed in the early Earth. Nevertheless, there have been only limited works on the melting behavior of the system $\text{MgSiO}_3\text{-SiO}_2$ under high pressures. Information regarding phase relations in the system has been so far limited to 5 GPa based on the experiments using the multi anvil apparatus (MAA) [5], Using a diamond anvil cell (DAC), on the other hand, melting experiments on the system MgO-SiO_2 were carried out at pressures from 24 to 139 GPa in phase equilibrium studies in order to determine eutectic melting curves and examine eutectic compositions [6, 7]. Compared with DAC, MAA has remarkable advantages of larger sample volume under stable and homogenous temperature conditions (e.g. [8]). In this study, therefore, we are precisely determining the melting relations in the system $\text{MgSiO}_3\text{-SiO}_2$ at pressures between 5 and 25 GPa using the Kawai-type multi anvil apparatus; we would present the results obtained at 13 GPa in the presentation.

In the system $\text{MgSiO}_3\text{-SiO}_2$, $\text{SiO}_2[\text{M}]$ values of eutectic point were 0.56 (1620 °C) [9] and 0.60 (1920 °C) [5] at 1 and 5 GPa, respectively, showing increase of $\text{SiO}_2[\text{M}]$ with increasing temperature and pressure. In this study at 13 GPa, eutectic composition was 0.60 of $\text{SiO}_2[\text{M}]$ at 2300 °C, which is same as that at 5 GPa and showing systematic increase in eutectic temperature with increase of pressure. If source material of Earth is enstatite chondrite, therefore, composition of melts formed at magma ocean (up to ~ 3000 °C and ~ 30 GPa) in the early Earth show chemical homogeneity to ~ 400 km depth from the surface.

In this study, we also examined temperature effect on the experimental pressure up to 2500 °C based on the phase boundary between stishovite-coesite (SiO_2), showing that the pressure at 2500 °C was almost 3 GPa higher than that at room temperature. We conclude that this difference is caused by thermal expansion of specimens in the cell during heating.

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