Evaluation of Enstatite chondrite model based on melting relations in the system $MgSiO_3$-SiO_2

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Enstatite chondrite (E-chondrite) has been recommended as the source material of bulk Earth [e.g. 1] because the isotope compositions of the Earth, Moon and E-chondrite are indistinguishable over O, N, Mo, Ru, Os, Cr, and Ti. On the other hand, the melting relations of the system MgO-SiO_2 as a representative of the mantle have been extensively studied since a pioneering work by Bowen and Anderson [2]. However, almost all of these works have been carried out on the compositions ranging from MgO to $MgSiO_3$ because the bulk mantle composition has been assumed to be peridotitic or close to that derived from CI chondrite. Their molar ratios of SiO_2/(SiO_2+MgO) (which is denoted by X_{Si} hereafter) are 0.43 to 0.48, which are depleted in Si compared with that in E-chondrite (X_{Si} = 0.55). In order to understand the mantle differentiation in the E-chondrite model, it is indispensable to clarify the melting relations in the system $MgSiO_3$-SiO_2 at high pressures. Nevertheless, there have been limited works on the melting behavior of the system $MgSiO_3$-SiO_2 under high pressures. Therefore, recently we determined the melting relations in the system $MgSiO_3$-SiO_2 at 13.5 GPa which displays eutectic melting with the eutectic point located at X_{Si} = 0.61 and at 2350 ±50 ℃ [3].
The available eutectic compositions in the system $MgSiO_3$-SiO_2 experimentally determined from 1 to 128 GPa indicate that the X_{Si} of the melts produced from E-chondrite source materials are around 0.6, significantly higher than the current upper mantle, 0.43. To evaluate the E-chondrite model, taking into account the incorporation of Si into the core during core formation in a magma ocean, we estimated the range of Si content in the core assuming an E-chondrite model. Our results showed that Si content in the core would be between 2.7 to 8.6 wt.%, which is within the range of 2 to 9 wt.% Si in the core as predicted by metal-silicate element partitioning [7-9]. On the other hand, through determining the P wave velocity of liquid Fe–Si at the core–mantle boundary conditions based on inelastic X-ray scattering measurements in a laser-heated DAC, the estimated upper limit of silicon concentration in the outer core to be <1.9 wt.% [10]. Considering with the core density deficit and higher Si content in the core predicted by the metal-silicate element partitioning, Nakajima et al. [10] suggested that the present-day liquid outer core was depleted in silicon after crystallizing SiO_2 (and $MgSiO_3$) through the history of the Earth. Thus, our results indicate that the E-chondrite model could explain the bulk Earth composition if the Si depletion in the core has operated through Earth' s history.

References

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