Metal-siliacte partitioning of carbon in a shallow magma ocean: Implications for the distribution of carbon in the Earth during core formation

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Elucidating the distribution of carbon in the Earth during core formation is important for understanding both of mass and composition of the early Earth’s atmosphere, and perhaps the composition of the Earth’s core. However, the distribution of carbon in the Earth during core-mantle differentiation has not been understood well. Previous studies have conducted high-pressure experiments on liquid metal-silicate partitioning of carbon and found that carbon is highly siderophile (iron loving) [e.g., 1, 2]. However, carbon abundance in the current Earth’s mantle is much more abundant than prediction based on experiments [e.g., 1, 2]. In order to explain this discrepancy, the late accretion of sulfur-rich planetesimals has been proposed because carbon is thought to be expelled to mantle if planetesimals had sulfur-rich core [3]. However, this hypothesis is based on experiments for the solubility of carbon in metal and silicate phases using a graphite capsule. Because the activity coefficient is not a constant, depending on molar concentration, the solubility ratio of carbon between metal and silicate may not be equal to metal-silicate partition coefficient of carbon. Given that bulk Earth is not saturated with carbon, it is necessary to perform experiments at undersaturated conditions.
In this study, we conducted high-pressure experiments on liquid metal-silicate partitioning of carbon using a boron nitride capsule and multi-anvil apparatus at 8 GPa and 1923-2123 K. Carbon in quenched metallic liquid and silicate liquid were analyzed by electron probe micro-analyzer and secondary ion mass spectrometry, respectively. The preliminary experimental results show that carbon may not be highly siderophile than previously thought. Although additional experiments are required, preliminary experimental results suggest that the late accretion of sulfur-rich planetesimals, such as a Mercury-like impactor, might not be necessary to explain the current abundance of carbon in the Earth’s mantle.

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