The 489th Geodynamics Seminar

Liquid metal-silicate partitioning of carbon in a shallow hydrous magma ocean: Implications for the distribution of carbon in the Earth during core formation

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Abstract

Elucidating the distribution of carbon in the Earth during core formation is important for understanding early Earth's atmosphere mass and composition, 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) (i.e., Metal-silicate partition coefficients > 500) (e.g., Dasgupta et al., 2013; Chi et al., 2014). However, carbon abundance in the current Earth's mantle (i.e., 35-115 ppm) (Rosenthal et al., 2015) is much more abundant than prediction based on experiments (i.e., < 1 ppm) (e.g., Li et al., 2016). 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 (Li et al., 2016). However, this hypothesis is based on experiments for the solubility of carbon in metal and silicate phases using a graphite capsule. Because the activity of carbon in both metal and silicate phases would depend on its 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, may not be necessary to explain the current abundance of carbon in the Earth's mantle.

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