The effects of carbon concentration and silicate melt structure on the metal-silicate partitioning of carbon in a shallow magma ocean

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Abundance and speciation of carbon in planetary mantle affect volcanic activity, physical properies (e.g., solidus temperature) of mantle minerals, and the chemical composition of planetary atmospheres. Thus, elicidating the distribution and chemical speciation of carbon in terrestrial planets provides important clues to understand the chemical evolution and habitability of planets. Previous studies have conducted high-pressure experiments on liquid metal-silicate partitioning of carbon and found that carbon is highly siderophile [e.g., 1-3]. This result indicates the carbon-depleted planetary mantle after the core formation. However, the carbon abundance in the current Earth’ s mantle is much more abundant than prediction based on experiments [e.g., 1-3]. In order to explain this discrepancy, the late accretion of carbon-rich bodies has been invoked [e.g., 1-3]. However, this explanation is *ad-hoc*, and previous experimental studies have used a graphite capsule, which causes carbon-saturated conditions. Given that bulk Earth is not saturated with carbon and the activity coefficient varies with the concentration of target element, it is necessary to perform experiments at carbon-undersaturated conditions.
In this study, we conducted high-pressure experiments on liquid metal-silicate partitioning of carbon using a SiO2 capsule and multi-anvil apparatus at 2 GPa and 1923 K. The starting materials were prepared from mixtures of metallic Fe and Ni, and oxide. For silicate compositions, we used two types of compositions: EH-type enstatite chondrite and mid-ocean ridge basalt. 0.2 wt% of carbon was added to these starting materials as Na_2CO_3. Carbon in quenched metallic liquid and silicate liquid were analyzed by electron probe micro-analyzer and secondary ion mass spectrometry, respectively. Chemical species of volatiles and the melt structure of quenched silicate glasses were analyzed by Raman spectroscopy. The experimental results show that the metal-silicate partition coefficient of carbon at carbon-undersaturated conditions is lower than that reported using a graphite capsule. Raman spectroscopic analyses show the presence of CH species and amorphous carbon in silicate and that the carbon abundance in silicate liquids increases with increasing non-bridging oxygen. These results suggest that the metal-silicate partitioning behavior of carbon depedns both on carbon concentration and silicate melt structure. In this talk, we will also discuss the application of experimental results to the Earth.

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