The 530th Geodynamics Seminar

A raman spectroscopic study on carbon in a magma ocean during the core formation of terrestrial planets

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Carbon, volatile and highly siderophile element, in the silicate part of terrestrial planets was thought to be highly depleted due to the high-temperature conditions and core-mantle differentiation during the formation of terrestrial planets [e.g., Dasgupta et al., 2013; Hirschmann, 2016; Li et al., 2016]. However, recent observations have shown the presence of unexpected amounts of carbon on planetary surface and mantles [e.g., Rosenthal et al., 2015; Wetzel et al., 2015; Peplowski et al., 2016]. Thus, the origin of carbon in the silicate part of terrestrial planets is puzzling and not well understood.

Core-mantle partitioning of carbon during the formation of terrestrial planets is a key process for controlling the distribution of carbon in the planet. Previous experimental studies [e.g., Dasgupta et al., 2013; Li et al., 2016] have used basaltic starting materials and a graphite capsule, which causes carbon-saturated conditions. However, the bulk Earth and other terrestrial planets are likely to be neither basaltic nor saturated with carbon. Nevertheless, the effects of carbon concentration and silicate composition on the metal-silicate partitioning of carbon are not constrained.

In this study, we conducted high-pressure experiments on liquid metal-silicate partitioning of carbon at 0.2 wt% carbon concentration and 2 GPa using a SiO2 capsule. Raman spectroscopic analyses show the presence of amorphous carbon and C-H species in quenched silicate glass equilibrated with metallic iron. Other carbon species, such as carbonyl and carbonate, were not observed. Raman spectroscopic analyses on the structure of quenched silicate glass suggest that the abundance of these reduced carbon species increases with the number of non-bridging oxygen in silicate. Because the numbers of non-bridging oxygen for chondritic and peridotitic compositions are higher than those of basaltic compositions, these results indicate that the abundance of carbon partitioned to planetary mantles may have been underestimated in previous studies. In this seminar, I will also discuss the implications of experimental results for terrestrial planets, such as Moon, Mercury, and Earth.

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