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The effect of sulfur on carbon solubility and partitioning in the alloy-silicate systems: Implications for core-mantle fractionation of carbon and sulfur during accretion of Earth

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Abstract

Constraining the carbon (C) fractionation between the silicate magma ocean and core-forming alloy liquid during early differentiation of Earth and terrestrial planets is required to determine the origin and present-day distribution of C between planetary reservoirs such as exosphere, mantle and core [1]. Experiments on the metal-silicate partitioning of C have shown that preferential fractionation of C into the alloy liquid would have left the bulk silicate Earth (BSE) devoid of C [2-4]. It has been recently proposed that merger of a sulfur (S)-rich differentiated body into the proto-Earth could have supplied almost the entire C budget of the present-day BSE [5]. However, systematic experimental data at high pressures on the effect of S on C solubility in alloy liquid and the effect of S on partitioning of C between Fe-rich alloy liquid and silicate melt are not fully known. We have performed multi-anvil experiments at 6–13 GPa and 1800–2000 □C to examine the effects of S and Ni on the solubility limit of carbon in Fe-rich alloy liquid and simultaneous determination of C and S partitioning between alloy liquid and silicate melt. The composition of alloy liquid, including carbon, was determined using EPMA. Major elements and volatiles (C and H2O) in the silicate glass were obtained using EPMA and SIMS, respectively. The obtained data were used to quantify the effect of S on the distribution of C between the silicate magma ocean and core-forming alloy liquid of Mars-sized impacting body. A simple two-stage equilibrium core formation model was tested to determine whether the merger of an S-rich impacting body to a volatile-depleted proto-Earth can satisfy C and S contents as well as C/S ratio of the BSE [6].

[1] Dasgupta (2013) RiMG. [2] Dasgupta et al. (2013) GCA. [3] Chi et al. (2014) GCA. [4] Li et al. (2015) EPSL [5] Li et al. (2016) Nature Geo [6] Hirschmann (2016) Am Mineral.

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