Fate of Nitrogen during core-mantle separation

DAMANVEER S. GREWAL*[1], RAJDEEP DASGUPTA[1], GELU COSTIN[1], KYUSEI TSUNO[1], YUAN LI[2], ALEXANDRA K. HOLMES[1]

[1]Department of Earth, Environmental and Planetary Sciences, Rice University, 6100 Main Street, MS 126, Houston TX, 77005, USA.

[2]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, 510460, China

*correspondence: dsg10@rice.edu

Nitrogen (N) is the sixth most abundant element in the Solar System, but it is severely depleted in the bulk silicate reservoirs (atmosphere + crust +mantle) of rocky bodies in the Inner Solar System. Nitrogen depletion, especially in Bulk Silicate Earth (BSE), has been directly linked to the volatile nature of nitrogen, however, delivery of N during core-mantle equilibration in rocky bodies can also play an important part in setting up present-day N budgets of their bulk silicate reservoirs. However, alloy-silicate partitioning of N is known over a limited range of conditions [1,2].To better understand the fate of N during different modes of rocky body accretion and differentiation in inner Solar System, a systematic experimental effort to explore a wider parameter space is needed.

Here we present several sets of experiments to constrain the partition coefficient of N between alloy and silicate ($D_N^{alloy/silicate}$) as a function of P (1-7 GPa), T (1500-2200 °C), fO_2(ΔIW~-4.5–0), silicate melt composition (NBO/T–0.5-2.5), and S (0-30 wt.%) and Si (0-3 wt.%) contents of the alloy. The experiments were performed using piston cylinder and multi-anvil apparatus under graphite saturated conditions. N in quenched metal and silicate was measured using EPMA and C-O-H-N speciation in silicate glasses was studied using spectroscopy. Our experimental results show that N becomes siderophile with increase in P, fO_2, and NBO/T, and with decrease in T, and S and Si contents of the alloy. Our calculations predict that N delivery via either volatile-depleted, reduced bodies and/or volatile-rich, oxidized bodies during the entire span of accretion of rocky bodies can deliver substantial amounts of N in their silicate reservoirs, therefore, either they were built up of hitherto unknown extremely N-poor material, or, the silicate reservoirs were left essentially N-free in their early, violent history followed by late stage delivery of N via either smaller, undifferentiated bodies or larger, differentiated planetary embryo(s).

[1] Roskosz et al. (2013), GCA 121, 15–28. [2] Dalou et al. 151 (2017), EPSL 458, 141–151.