The core-mantle partitioning of nitrogen in carbon-undersaturated ultramafic systems

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In addition to its highly volatile character, segregation into the metallic core could have played a primary role in explaining the depletion of nitrogen (N) in the Bulk Silicate Earth (BSE) and similar reservoirs of other rocky bodies in the inner Solar System. As N is shown to have either siderophile (metal-loving) or lithophile (silicate-loving) character depending on the fO_2 of the accreting material, therefore it can act as a powerful tracer to track the fO_2-dependent volatile accretion history of rocky bodies. Previous high *P-T* experimental studies have shown that at fO_2>~IW–2.5, N acts as a siderophile element, while it acts as a lithophile element at fO_2<~IW–2.5. However, all high *P-T* experiments on $D_N^{alloy/silicate}$ that have been published till date were conducted under graphite saturated conditions for basaltic to andesitic melt compositions primarily to quench silicate glasses necessary to determine equilibrium N content in the silicate melt. Terrestrial magma oceans are presumed to be C-undersaturated with ultramafic silicate melt compositions, but the inability to quench glass for such compositions has been an outstanding issue in the high *P-T* experimental community.

Here we present experiments where we were able to quench large silicate glass pools for experiments conducted in MgO capsules. $D_N^{alloy/silicate}$ was constrained as a function of temperature (*T*=1600-2000 °C), oxygen fugacity (fO_2= IW-7 to -2) and (NBO/T=1.5-3.5) at a fixed *P* (3 GPa). N in the quenched metal and silicate products was measured by EPMA. In contrast to previous studies, our experimental results show that N remains siderophile at even more reducing conditions (≥ IW-4) primarily due to lower C content in the alloy relative to graphite saturated conditions, which allows enhanced dissolution of N in the alloy melt. Our calculations predict that for core formation conditions applicable for Earth, N could act as a siderophile element across the entire fO_2 range; therefore, segregation of N into the core could be more important than previously thought in explaining the N depletion in the BSE. Also, metallic cores are likely larger inventory of N for a wide range of rocky bodies than previously realized.