Origin of nitrogen in lunar basalts

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The discovery of H-bearing species in various lunar samples [1] has revealed that at least some parts of the Moon's interior contain a significant amount of 'water'. Current lunar volatile evolution models argue for extensive devolatilization of the Moon-forming material, suggesting that the influx of chondritic matter provided water to the lunar magma ocean (LMO) after the Moon-forming impact [2]. Accordingly, the Moon is also expected to have aquired a substantial amount of chondritic-like nitrogen (N).

In order to improve our understanding of the origin of N trapped in lunar basalts, and of the abundance and isotopic composition of N in the Moon's interior, we have investigated coupled N and noble gas (Ne-Ar) signatures of (n=21) bulk fragments and mineral separates of lunar rocks (10 mare basalts, 1 highland breccia, 1 anorthosite) by step-wise CO_2 laser-extraction, static-mass spectrometry analysis. Noble gases are employed to identify samples affected by 'exogenic' (atmospheric, solar, planetary) N contributions, and to assess the extent of cosmic ray exposure. Solar-gas-free mare basalts with small proportions of cosmogenic ^{15}N record $\delta^{15}N$ values of ~0 to +27 ‰. These values best represent the isotopic composition of indigenous lunar N, and agree with previous findings [e.g., 3-5]. We conclude that lunar N is isotopically heavier than N in Earth's primordial mantle ($\delta^{15}N_{mantle}$ = <-40 to -5 ‰ [6]), inconsistent with a transfer of N from the proto-Earth to the Moon-forming material. Instead, these data can be explained by a post-giant-impact volatile accretion scenario whereby the LMO trapped a few ppm N from the assimilation of carbonaceous chondrites ($\delta^{15}N_{CC,mean}$ = +20 ± 20 ‰ [7]), and the reducing conditions during magma ocean crystallisation favored the incorporation of N into mafic minerals [8]. Thus, the mare basalt source region(s) acquired a large amount of N, whereas the anorthositic crust remained N-free.

[1] Robinson and Taylor (2014) *Nat. Geosci.* **7**, 401-408. [2] Füri et al. (2014) *Icarus* **229**, 109-120. [3] Becker et al. (1976) *Proc. Lunar Sci. Conf.* **7**, 441-458. [4] Mathew and Marti (2001) *EPSL* **184**, 659-669. [5] Mortimer et al. (2015) *Icarus*, in press. [6] Cartigny and Marty (2013) *Elements* **9**, 359-366. [7] Li et al. (2013) *EPSL* **377-378**, 311-323. [8] Kerridge (1985) *GCA* **49**, 1707-1714.