Should we consider nitrgoen a lithohpile element? A combined isotopic, petrological and cosmochemical evaluation

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Goldschmidt recognized four broad categories of the elements: atmophile, lithophile, chalcophile, and siderophile. This classification is based on empirical observations for meteorites and Earth's major geochemical reservoirs: the mantle/crust, and the hydrosphere/atmosphere (the rest inferred to be in the core). Because molecular N is unreactive the behaviour of N has traditionally been grouped with the noble gases [1]. Here I utlizise recent datasets to ask the question: Should we group N as a lithohpile element in terms of the bulk silicate Earth (BSE)?

Firstly, stable isotope data suggest N recycling extends into the lower mantle [2-3], implying a storage mechanism for N in the deep Earth to explain the crust-mantle flux-imbalance [4]. Secondly, N can behave like an atmophile, lithophile, or siderophile element depending upon its redox state, and recent theoretical [5] and experimental [6] data show that ammonic N should dominate over molecular N in the mantle. Thirdly, when balancing the mantle N budget using N/Ar constraints relative to chondrites, N appears to be the most depleted volatile element [1]. However C is more siderophile that N [7], so one would presume more C partitioned into the core relative to N, meaning N should be more enriched than C in the BSE (relative to chondrites). If one recalculates the BSE N-abundance based solely on the storage capacity of the upper mantle [8] it is apparent that the upper mantle alone can host enough N to give the BSE a chondritic C/N ratio, and would make the BSE the largest N reservoir. Therefore it appears that the bulk of Earth's N is most-likely stored in the mantle (where $NH4^+$ substitutes for K^+ [9]). Ergo, the bulk of N appears to be stored as a lithophile element, and only in the upper-most sections of the Earth is N actually a volatile (atmophile) element.

1- Marty, 2012, EPSL; 2- Palot et al., 2013, EPSL; 3- Dauphas & Marty, Science; 4- Busigny et al., 2003, EPSL; 5- Mikhail & Sverjensky, 2014, Nature Geoscience; 6- Li and Keppler, 2014, GCA; 7- Zhang & Yin, 2013, PNAS; 8- Li et al., 2013, EPSL; 9- Watenpaul et al., 2010, Chem.Geol