

## The Nitrogen Budget of Earth

BEN W JOHNSON\*<sup>1</sup> AND COLIN GOLDBLATT<sup>1</sup>

<sup>1</sup>Department of Earth and Ocean Sciences, University of Victoria, Victoria, BC.

(\*bwjohnso@uvic.ca and czg@uvic.ca)

We calculate a new nitrogen budget for the Earth. Our estimate for the solid Earth (crust and mantle, minus the core) is between  $8.3\text{-}13.5 \times 10^{18}$  kg N. This is 2-3 times the atmospheric mass of  $4 \times 10^{18}$  kg, though there is potential for the mantle to sequester a substantially higher amount [1].

Our estimate is based on a thorough literature compilation, and represents the most comprehensive N budget of which we are aware. Significantly, we find that nearly an atmosphere's worth of N ( $3.2 \times 10^{18}$  kg) is contained in the continental crust, with a substantial amount in the lower crust, suggesting continents may act as a long-term sink for N. In addition, at least 2-3 atmosphere's worth is contained in the mantle.

Determining the current distribution of N on Earth is important, since many aspects of its long-term cycling between the surface and deeper Earth remain unresolved.

Surface N has clearly been subducted and cycled through the mantle, as revealed by correlation between  $\text{N}_2$  and  $^{40}\text{Ar}$  in mid-ocean ridge basalts [2]. In contrast,  $\text{N}_2$  does not correlate with primordial  $^{36}\text{Ar}$ , strengthening the case for a surficial origin. The timing, rate, and magnitude of N movement to the deeper Earth is somewhat constrained for modern subduction zones [3] [4], but fluxes in the past and the amount of N retained in the mantle in are more enigmatic.

N sequestration into the solid Earth has a direct impact on atmospheric evolution. It is possible that the atmosphere during the Archean contained up to 2-3x the present mass of N [5] [6], though other evidence suggests the N content has been constant since that time [7].

[1] Li *et al* (2013) *EPSL* **377** 311-323 [2] Marty (1995) *Nature* **377** 326-329 [3] Elkins *et al* (2006) *Geochimica et Cosmo.* **70** 5215-5235 [4] Mitchell *et al* (2010) *G<sup>3</sup>* **11** 24 pp. [5] Goldblatt *et al* (2009) *Nature Geoscience* **2** 891-896. [6] Nishizawa *et al* (2007) *EPSL* **254** 332-344 [7] Marty *et al* (2013) *Science* **342** 101-104