Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24301

Constraining the terrestrial nitrogen cycle: advances from high-resolution $^{15}N^{15}N$ measurements

JABRANE LABIDI[1] AND EDWARD D. YOUNG[2]

[1]Institut de Physique du Globe de Paris
[2]University of California, Los Angeles
Presenting Author: labidi@ipgp.fr

Nitrogen in Earth's mantle may be surface-derived. Signatures inherited from Earth's accretion and differentiation would have been erased by billions of years of volatile subduction. Constraining d^{15}N and $N_2/^3He$ ratios of various mantle sources may help quantifying nitrogen subduction. We present $^{15}N^{15}N$ data on hydrothermal gases offering a window into plume and arc regions, where fresh glasses are often absent. Measurements of $^{15}N^{15}N$ in natural samples are done with a high-resolution gaseous source mass spectrometer at UCLA. Data allows tracing the provenance of nitrogen in gas mixtures. The approach is based on the finding that modern atmospheric N_2 has an enrichment in $^{15}N^{15}N$ of nearly 20‰ relative to any other source of N_2. This is particularly useful to unambiguously constrain the amounts of contaminant-air in hydrothermal gases.

Some of our most important findings include that air is ubiquitous in hydrothermal gases, even when venting temperatures are close to volcanic gases. We have also found that the d^{15}N tracer can be deceiving to identify air. Isotope fractionation of atmospheric nitrogen occurs within hydrothermal systems, resulting in negative d^{15}N values similar to estimates for mantle values, yet with $^{15}N^{15}N$ values that preclude a mantle origin. The $^{15}N^{15}N$ data bring constraints on the deep N cycle. We find that the true d^{15}N of volcanic components is positive in arcs, consistent with the contribution of subducted nitrogen. The d^{15}N of hydrothermal nitrogen of a plume system is near-zero. This is not consistent with substantial amounts of recycled N in the plume source.

Our conclusions rely on the assumption that $^{15}N^{15}N$ enrichments in atmospheric gases are not reset in hydrothermal samples. Although preliminary data on natural samples appear to confirm the hypothesis, experiments will have to be designed to determine the rates of $^{15}N^{15}N$ re-ordering in nature. Another potential outlook is the application of the $^{15}N^{15}N$ systematic to samples of ancient atmosphere, trapped in fluid inclusions. Determining the rates of $^{15}N^{15}N$ resetting in those fluid inclusions will be critical for attempts at constraining the composition of ancient air.