Nitrogen Isotopes as Astrobiological Indicators: The Role of Animal Behavior

Erik Melchiorre and Becky TayIn
California State University

Nitrogen isotope values of terrestrial minerals have been used successfully to identify biogenic vs. abiotic nitrate sources, and even specific environments and animal behavior patterns. Copper nitrate (Gerhardite) from Queensland, Australia has been linked by isotopic signature to nitrate accumulation and isotopic enrichment by termites. Various copper nitrate minerals from other mining districts have nitrogen isotope values that suggest nitrate sourced from bat guano. Other nitrogen-bearing minerals have been shown to have inherited their nitrogen isotope values from coal, following underground coal fires. Halophilic Archaea from hypersaline Searles Valley, CA have been shown to have a remarkably enriched nitrogen isotope value (+45 per mil). All of these studies have shown that social behavior and metabolic processes of life can produce nitrogen fixation, concentration, and enrichment that has been preserved in the mineralogical record. Even the destruction of this record (e.g. coal fires) produces a distinct biological signature recorded by secondary minerals. Perhaps most significantly, terrestrial systems seem to record that the more extreme an environment is, the more pronounced the nitrogen fractionation produced by organisms. Extreme environments are the most likely home of early life on Earth, as well as life on other solar system bodies. Thus, the search for life in the solar system should be aided by these nitrogen isotope studies as: 1) Potential exploration targets for metal nitrates in the solar system can be easily identified with existing gravity and magnetics data, and 2) Extremophile chemosynthetic organisms living within these metal deposits should produce a highly fractionated (many 10's of per mil greater than atmospheric) nitrogen isotope signal in the resulting minerals. Both of these factors should result in a smaller and lower-cost mission with an enhanced probability of success.