Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36528

Investigations of Nitrogen Cycling in Ancient Subsurface Fluids

SUSAN BEALE[1,2], CHRISTOPHER CHARLES[1,2], TONY MARRONE[3], CORINA ANDREOIU[1,2], TANUJ MAHAJAN[4], OLIVER WARR[4], HAYDEN KLASSEN[2,5] AND NIGEL J. T. SMITH[2]

[1]Simon Fraser University
[2]TRIUMF
[3]McMaster University
[4]University of Ottawa
[5]University of Toronto

Worldwide isolated subsurface fracture systems at-depth contain hypersaline brines possessing distinct isotopic signatures, indicating a unique evolution from meteoric waters. Radiolysis may be one possible mechanism driving brine evolution, induced by the long-term natural radioactive decay of U, Th, and K in the surrounding host rock. N_2 often represents a significant dissolved gas component in these brines and is an essential nutrient for life that is cycled by different biological and abiotic processes. Although gamma radiolysis of N_2 in pure water solutions has been shown to produce species including nitrate, nitrite, and ammonium, the potential role of radiolysis in N_2 cycling within hypersaline brines remains poorly understood.

To better understand how radiation influences the production of nitrogen-bearing compounds, we discuss results on the radiolytic production of NO_2^-, NO_3^-, and NH_4^+ in pure water containing different concentrations of dissolved N_2 gas, after exposure to alpha, beta and gamma emitters. A 370 TBq ^{60}Co source (gamma energies 1.17 MeV, 1.33 MeV) was used to irradiate water samples with increasing pressures of N_2 in the headspace of the vials. This was done to quantify the detection limits of NO_2^-, NO_3^-, and NH_4^+ and the amount of dissolved N_2 necessary to generate these species. A separate 10 MBq ^{60}Co source was used to explore the effects of time and dose rate on production. Further irradiations were also performed by injecting 35 MBq aliquots of ^{212}Pb into similarly prepared water + N_2 samples, depositing alpha particles (6.2 MeV, 8.9 MeV) and beta radiation (end point energies; 569.9keV, 2.2 MeV, 4.9 MeV). This work aims to better understand how nitrogen-bearing species are generated in isolated subsurface environments, that may help constrain the role of radiolysis in N_2 cycling in deep subsurface fracture fluids on Earth, and other moons or exoplanets containing subsurface waters.