Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.30315

Probing Extraterrestrial Nitrogen: Partial Fluorescence Yield N-XANES Spectroscopy of Carbonaceous Chondrites and Xenolithic Clasts

YOKO KEBUKAWA[1], HIROKI SUGA[2], MASANORI SUZUKI[3], MINORI OGINO[3], MICHAEL E. ZOLENSKY[4] AND YOSHIO TAKAHASHI[5]

[1]Institute of Science Tokyo
[2]Japan Synchrotron Radiation Research Institute (JASRI)
[3]Yokohama National University
[4]NASA Johnson Space Center
[5]The University of Tokyo

Carbonaceous chondrites, derived from primitive asteroids, contain a diverse range of organic compounds, including nitrogen-bearing species that may have contributed to the prebiotic chemistry of early Earth. While soluble organic matter (SOM) and insoluble organic matter (IOM) are typically analyzed separately, direct analysis methods for nitrogen-bearing compounds remain limited due to their low abundance. In this study, we employed partial fluorescence yield X-ray absorption spectra of nitrogen *K*-edge spectroscopy at SPring-8 to investigate nitrogen speciation in various carbonaceous chondrites and xenolithic clasts in ordinary chondrites.

Our analysis identified three primary nitrogen peaks: (A) 398.7 eV (pyridinic nitrogen), (B) 399.7 eV (pyridinic nitrogen and/or nitriles), and (C) 400.8 eV (pyrrolic nitrogen, amines, amides, and/or ammonium salts). The Zag C1 clast exhibited a particularly strong peak at 400.8 eV, suggesting an enrichment of labile nitrogen species, a trend also observed in the Tarda and Tagish Lake meteorites. The nitrogen chemistry of these meteorites suggests an origin in the outer solar system, consistent with D/P-type asteroids. In contrast, CI chondrites, despite their potential cometary origins, exhibited weaker peak intensities at 400.8 eV, possibly due to terrestrial alteration over time. Comparative analysis of IOM from selected meteorites (Orgueil, Murchison, and Tagish Lake) demonstrated that acid demineralization modifies nitrogen species, with a notable decrease in peaks at 399.7 eV and 400.8 eV, indicating the loss of acid-labile moieties.

These findings provide new insights into the nitrogen chemistry of carbonaceous chondrites, shedding light on the nature and alteration of extraterrestrial organic matter. This study demonstrates the efficacy of fluorescence yield N-XANES spectroscopy for high-sensitivity nitrogen analysis in chondritic materials, facilitating further research into the origins and evolution of extraterrestrial organic matter.