Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23354

On the challenges of tracing the origin of nitrogen on Earth, Moon, and Mars - *S. Epstein Science Innovation Medal Lecture*

EVELYN FÜRI

CRPG (CNRS-UL)

Presenting Author: evelyn.furi@univ-lorraine.fr

Light elements (H, C, N) were essential for the emergence of life on Earth. Nonetheless, the origin of these ‘volatiles’ on the terrestrial planets remains debated. NASA's Genesis mission permitted to measure the N isotopic composition of the solar wind, and to demonstrate that the protosolar nebula was highly depleted in ^{15}N compared to the reference $^{15}N/^{14}N$ ratio, that of Earth's atmosphere. In parallel, laboratory analyses of terrestrial and extraterrestrial samples, together with spectroscopic observations, revealed that all Solar System objects (expect for the atmospheres of the giant planets) are enriched in ^{15}N by several tens to hundreds of percent compared to the solar signature. Given the outstanding $^{15}N/^{14}N$ variability across the Solar System – recognized, in part, by Samuel Epstein and his colleagues through their work on carbonaceous chondrites – the $^{15}N/^{14}N$ ratio is commonly used as a tracer of the source(s) of N trapped in the interior and at the surface of planetary bodies.

Resolving the complex volatile mixtures in extraterrestrial samples into constituent components and identifying the primordial N isotopic signature of planetary reservoirs remains a challenge. Only coupled N–noble gas analyses by static noble gas mass spectrometry permit to quantify solar wind–derived and cosmogenic components. This approach also provides constraints on the cosmic ray exposure age of meteorites or samples returned by space missions which, in turn, is key for correcting measured $^{15}N/^{14}N$ ratios for the cosmogenic ^{15}N contribution. In contrast, *in situ* analyses by secondary ion mass spectrometry are key for targeting melt inclusions for N analyses, and for deriving pre-eruptive N concentrations and isotopic ratios in planetary reservoirs sampled by achondrites. Experimental studies provide complementary but fundamental insights on how planetary processes (e.g., differentiation, degassing) may have modified the initial isotopic signature of N accreted by Earth and other planetary bodies. Ultimately, combining N isotope datasets for terrestrial volcanic rocks, chondritic and differentiated meteorites, samples brought back to Earth by space missions as well as synthetic samples is key to deciphering the volatile accretion history of our planet, Moon, and Mars.