

Nitrogen isotopic variations in the early Solar System recorded by pallasites

JULIE GAMBLIN, DR. EVELYN FÜRI, PHD, BÉATRICE
LUAIS AND LAURENT ZIMMERMANN

Université de Lorraine, CNRS, CRPG

Understanding the distribution and evolution of N in the protoplanetary disk is key to explaining the development of habitable conditions on Earth. Iron meteorites, which are core fragments of the earliest-formed planetesimals [1], serve as a valuable tool for this purpose, as their $\delta^{15}\text{N}$ values closely reflect those of their parent bodies [2]. These meteorites exhibit distinct $\delta^{15}\text{N}$ values between the so-called non-carbonaceous (NC) and carbonaceous (CC) irons, whose parent bodies formed in the inner and outer Solar System, respectively [2–3]. This indicates the existence of two isotopically distinct N reservoirs at the very beginning of Solar System history [4]. In this study, we investigate the N isotopic composition of pallasites, whose Main Group may be genetically linked to IIIAB iron meteorites [5], to provide new insights into N isotopic variations within the protoplanetary disk.

Pallasites are stony-iron meteorites composed of nearly equal proportions of Fe-Ni metal and silicate (olivine $\pm$ pyroxene). For the first time, coupled analyses of N, Ne, and Ar isotopes were performed in pure metal fragments and olivine separates of thirteen pallasites – eight from the Main Group (NC reservoir), two pyroxene-rich pallasites (NC reservoir), two from the Eagle Station group (CC reservoir), and one ungrouped pallasite (Milton, CC reservoir) – as well as in the metal of five IIIAB iron meteorites. Gases were extracted using CO_2 laser heating, and analyzed at CRPG with a Noblesse–HR noble gas mass spectrometer. While noble gases and N in olivine are predominantly cosmogenic, the metal of pallasites records $\delta^{15}\text{N}$ variations within the protoplanetary disk. The metal of pallasites associated with the CC reservoir is ^{15}N -enriched by $\sim 15\text{‰}$ compared to those associated with the NC reservoir, but ^{15}N -depleted compared to CC-type iron meteorites. These new $\delta^{15}\text{N}$ measurements in pallasites, along with $\delta^{15}\text{N}$ values of iron meteorites, serve as a new key to decoding the spatio-temporal history of N in the early Solar System.

References: [1] Spitzer et al. (2021) EPSL; [2] Grewal et al. (2022) GCA; [3] Kruijer et al. (2019) Nature Astronomy; [4] Grewal et al. (2025) GCA; [5] Wasson and Choi (2003) GCA.