CONSTRAINTS ON THE ORIGIN OF NITROGEN ISOTOPE VARIATIONS IN PLANETARY OBJECTS FROM SINGLE GRAIN ANALYSIS OF LUNA 24 SOILS.

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Introduction: The recent Genesis findings revealed that modern solar wind (SW) nitrogen has an isotopically light composition ($\delta^{15}N_{SW} \approx$ -407 ‰ [1]), indistinguishable from the isotope signatures of Jupiter's atmosphere [2] and of osbornite in a CAI [3]. These results indicate that the N isotope ratio in the Sun's outer convective zone has not varied significantly over time, and is representative of the protosolar nebula composition. However, the terrestrial planets, primitive meteorites, micrometeorites, interplanetary dust particles (IDPs), and comets are all enriched in ^{15}N compared to the solar value [1, 4, and references therein]. While some of these enrichments may result from atmospheric processes (e.g., Mars and Titan), a contribution of ^{15}N-rich components is needed for primitive objects as well as planetary interiors.

The $\delta^{15}N$ value of N trapped in the lunar regolith varies by ~300 ‰ and correlates with the $^{40}Ar/^{36}Ar$ ratio, which represents an index of the 'antiquity' of lunar regolith [5], i.e., the time in the past when the soil was exposed at the Moon's surface (Fig. 1). In light of the Genesis findings, the secular $\delta^{15}N$ variations of Apollo soils can only be explained by changes in the mixing proportions between SW-derived N and isotopically heavier non-solar N sources [6-9]. Thus, the lunar regolith constitutes a unique archive to identify and possibly quantify past planetary contributions to the surfaces of the terrestrial planets almost over the entire history of the solar system.

In this study, we use the approach of single grain analysis to re-evaluate the origin of N in Luna 24 soils. Our new N-Ar data, together with previous results from the Apollo sites, allow us to place limits on the proportion of solar and non-solar N trapped in lunar regolith, as well as on the flux of planetary material to the Moon's surface.

Experimental: Luna 24 drill core samples 24092.4, 24143.4, 24156.2 and 24192.4 were selected for this study. The samples were dry-sieved, and between 4 and 10 single breccia clasts, as well as 12 agglutinates, were selected under a binocular microscope from the 200-370 μm or 300-900 μm size fractions. Nitrogen and argon abundances and isotope compositions were determined by CO_2 laser extraction-static mass spectrometry analysis.

Results: Single Luna 24 grains have $\delta^{15}N$ values between -107.3 and +123.3 ‰ relative to air (Fig. 1). The N isotope signatures, corrected for cosmogenic ^{15}N, are consistent with binary mixing between SW N and a non-solar N component with a $\delta^{15}N$ value of +100 to +150 ‰. The planetary component is best represented by micrometeorites and IDPs, which dominate the current flux of extraterrestrial matter on Earth. In constrast, a possible cometary contribution to the lunar N inventory appears to be ≤ 8 to 12 %, assuming a $\delta^{15}N$ value of +1000 ‰ for comets [10].

Implications: Based on the proportions of solar to planetary N in Luna and Apollo samples, we estimate the recent flux of planetary material to be (2.2 to 5.7) × 10^3 tons yr^{-1} at the Moon's surface, which, scaled to Earth, is comparable to the terrestrial cosmic dust flux. However, the secular decrease of the $\delta^{15}N$ values of Apollo samples with increasing antiquity is consistent with a lower contribution of planetary N earlier in the history of the Moon, assuming a constant SW N flux.

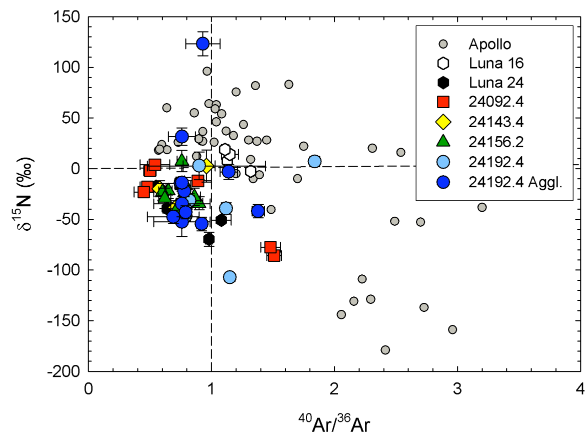

Fig. 1: Measured nitrogen isotope compositions, $\delta^{15}N$ (where $\delta^{15}N = [(^{15}N/^{14}N)_{sample}/(^{15}N/^{14}N)_{air} - 1] \times 1000$, in ‰), versus $^{40}Ar/^{36}Ar$ ratios of single breccia clasts and agglutinates from four different Luna 24 drill core sections, as well as of bulk Luna 16 and 24 samples [4] and Apollo soils (e.g., [1]).

References: [1] Marty et al. (2011) *Science, 332*, 1533-1536. [2] Owen et al. (2001) *ApJ, 553*, L77-L79. [3] Meibom et al. (2007) *ApJ,* 656, L33-L36. [4] Marty et al. (2010) *GCA, 74*, 340-355. [5] Eugster et al. (2001) *Meteoritics & Planet. Sci., 36*, 1097-1115. [6] Wieler *et al.* (1999) *EPSL, 167*, 47-60. [7] Hashizume et al. (2000) *Science, 290*, 1142-1145. [8] Hashizume et al. (2002) *EPSL, 202*, 201-216. [9] Assonov et al. (2002) *Meteoritics & Planet. Sci., 37*, 27-48. [10] Bockelée-Morvan et al. (2008) *ApJ, 679*, L49-L52.