SOLAR WIND NITROGEN IN GENESIS GOLD-ON-SAPPHIRE (AuOS) COLLECTORS.

R. O. Pepin[1], R. H. Becker[1], and D. J. Schlutter[1], [1]School of Physics and Astronomy, University of Minnesota, 116 Church St. S. E., Minneapolis, MN 55455, USA. E-mail: pepin001@umn.edu.

Introduction: Nearly four decades of experimental studies have failed to agree on an isotopic composition for solar wind (SW) nitrogen implanted in lunar regolith grains. Estimates of $\delta^{15}N$ range from > +200 ‰ [1] to < -250 ‰ [2]. Its actual value is crucial, not only for untangling component mixtures in the lunar system but also in elucidating the sources and isotopic evolution of N in other solar system objects, where $\delta^{15}N$ spans >1000 ‰. Determining N composition in the contemporary SW was thus a high priority objective of the Genesis mission. Here we report measurements of SW-$\delta^{15}N$ in N extracted from Genesis AuOS collectors.

Technique: N and light noble gases were released from the AuOS gold film by amalgamation at ~30ºC. Fig. 1 illustrates the process. The Hg-Au amalgam is liquid; subsequent removal of Hg vapor by cryopumping at -80ºC results in the deposition of tiny spheres and rivulets of recondensed gold on the sapphire substrate (visible in Fig. 1B at higher magnification).

Blanks and Extraction Efficiency: A great advantage of low-T amalgamation is that it does not release N contaminants which are mobilized by high-T extraction techniques. AuOS blanks for N are consequently lower by factors of thousands (Fig. 2). That this is not due to inefficient N_2 extraction is shown in Fig. 2 by

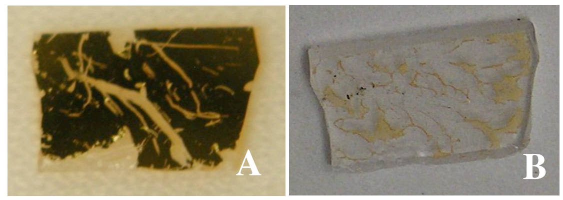

Fig. 1. A small (< 1cm^2) scratched AuOS flight sample (**A**) before and (**B**) after amalgamation by exposure to mercury vapor in a high vacuum reaction chamber at room temperature. Dust contaminants (dark specks in (**B**)) are not attacked by Hg vapor.

reasonably high amalgamation recoveries (average of ~60-65%) of $^{15}N_2$ implanted at SW energies in gold

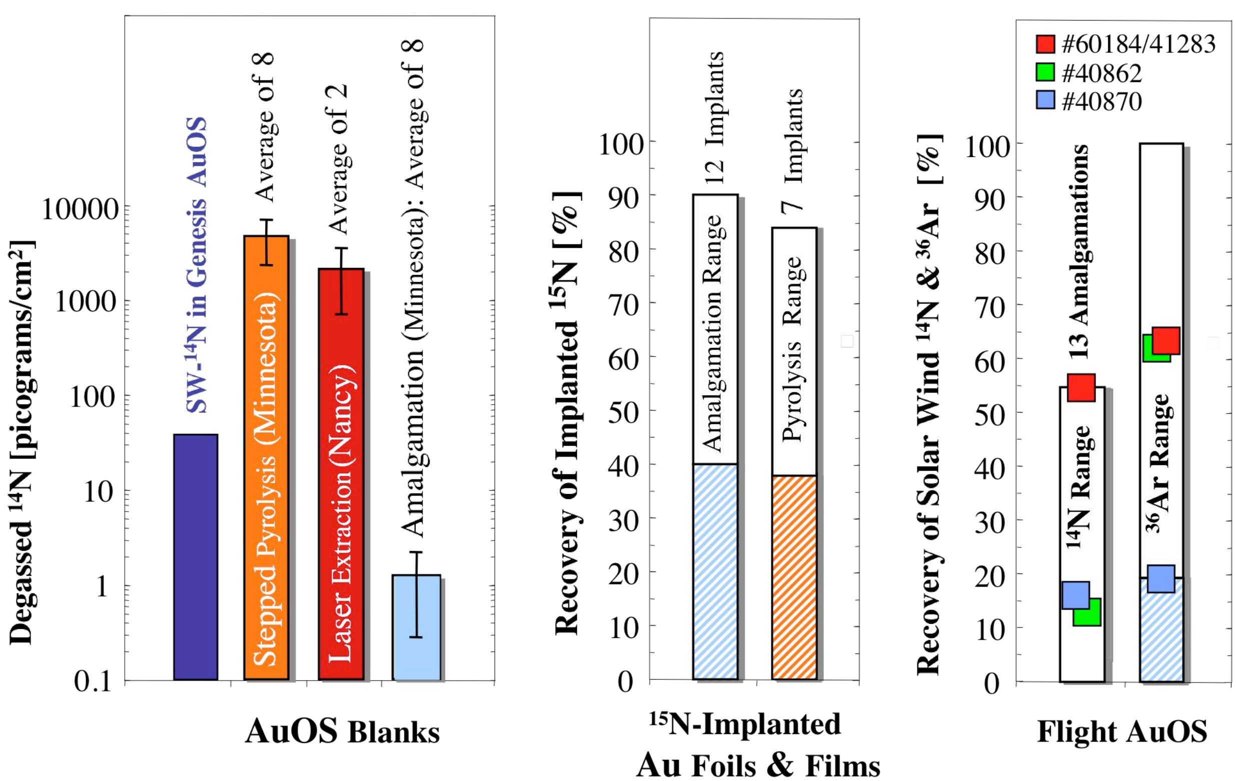

Fig. 2. Ranges of blank, implant, and flight sample analytic data measured on gold collector materials at Minnesota. Laser extraction blanks from [3]. SW-^{14}N (left panel) is the expected measured value (without backscatter correction) in Genesis AuOS.

films and foils in the laboratory. If the AuOS were the sole blank contributor, it would produce only ~3% of the expected SW-N in 1 cm^2 of flight AuOS, compared to >95% for pyrolytic extraction. However there is an additional system blank determined by replicating the amalgamation procedure while keeping the sample at ~125ºC (we have found that gold above ~100ºC is not attacked by Hg vapor). This procedural blank can be several times the AuOS blanks.

Nitrogen Yields from Flight Samples: To date we have analyzed 13 AuOS flight samples. Throughout this investigation we have been troubled by anomalously low yields of N compared to amounts expected from pre-flight estimates of SW-N fluence (Fig. 2, right panel). Of the 13 samples, several were at or near blank levels. In others the combination of low yields and comparatively high blanks prevented useful constraints on the SW-N composition. However 3 of the 13, identified and plotted in Fig. 2, yielded unambiguous and consistent SW-δ^{15}N values near +325 ‰, although with varying uncertainties (see below).

There are at least two possibilities for low SW-N recovery: speciation of N with other SW–implanted elements (e.g. H or C) such that it is not released from the gold as the N_2 molecule we measure; or, variable diffusive loss of N from the gold collector material in space. For the first, all we can say at present is that mass-spectrometric searches for N species other than N_2 have been negative; however, depending on their volatilities, there is a chance that they never reached the spectrometer. On the second, we do have evidence in our stepwise pyrolytic extractions from ^{15}N-implanted gold that substantial N evolution occurs at surprisingly low temperatures. In one case 20% of the total implanted ^{15}N was released at 290ºC, and a further 20% at 500ºC, both in 20 second heating steps. We are designing experiments to properly measure implanted N (and noble gas) diffusion coefficients in gold as functions of temperature.

Results: Measured SW-δ^{15}N in the 3 AuOS flight samples identified in Fig. 2 are plotted in Fig. 3 using the same color code. Total N amounts released from the 3 samples (areas ~1.2-1.5 cm^2) ranged from ~10 to 40 pg/cm^2. The most precise δ^{15}N of +322 ± 17 ‰ (red square) is from the sample with by far the highest SW-N yield (~55%) and a blank of ~20%. Green designates a sample with ~12% N yield, 44% blank, and measured SW-δ^{15}N = +315 ± 40 ‰. The blue measurement has 16% N yield, 85% blank, and SW-δ^{15}N = +355 +85/-50 ‰. The high blank in this case derives from the presence of a hot (~1000ºC) Pt filament in the extraction system, added in an attempt to convert any possibly speciated N compounds to N_2. It worked well, but not in revealing evidence for speciated SW-N; instead it converted contaminant organic N to N_2. Despite the high blank it was possible to extract a SW-δ^{15}N value, albeit with substantial uncertainties, because the large amounts of evolved N permitted relatively high precision in measured isotope ratios.

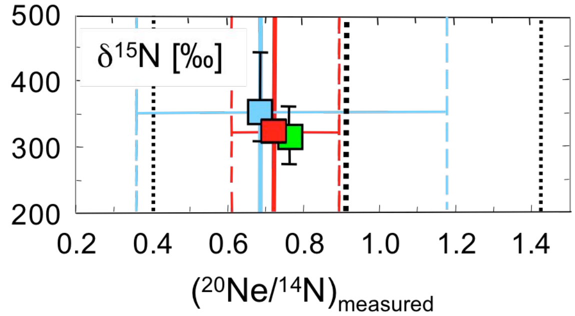

Fig. 3. Amalgamation-extracted N and Ne from AuOS samples. Vertical lines indicate estimates and uncertainties for the SW-^{20}Ne/^{14}N ratio from the amalgamation data (colored) and spacecraft measurements (black) [4]. $\delta^{15}N = 1000\,[(^{15}N/^{14}N)_{SW}/(^{15}N/^{14}N)_{air} - 1]$.

Yields for SW-^{14}N and ^{36}Ar shown by the red symbols in Fig. 2 (right panel) agree within error, implying little loss or at least little fractionating loss of these two elements. This permits an estimate of the SW-^{36}Ar/^{14}N fluence ratio. Combined with the SW-^{20}Ne/^{36}Ar ratio measured in Genesis samples (~53 from Minnesota analyses, in agreement with [5]), this yields the SW-^{20}Ne/^{14}N ratio = 0.72 +0.18/-0.11 shown by the vertical red lines in Fig. 3. The blue measurements give a similar but less precise value. Both are within the uncertainties of spacecraft measurements of the ratio [4]. In cases where the ^{14}N yield is much lower than the ^{36}Ar yield (e.g., the green sample in Fig. 2), SW-N isotopic fractionation if N loss is governed by Fick's Law diffusion should be relatively small, ~35 ‰ or less.

Conclusions: The directly measured SW-δ^{15}N reported here agrees with previous inferences from lunar studies that recent SW-N is isotopically heavy [1, 6-8]. It stands in sharp contrast to another Genesis study that reports SW-δ^{15}N to be negative by hundreds of ‰ [9].

References: [1] Becker R. H. and Pepin R. O. (1994) *Meteoritics, 29,* 724-738. [2] Hashizume K. et al. (2000) *Science, 290,* 1142-1145. [3] Marty B. et al. (2007) *LPS XXXVIII,* Abstract #1704. [4] Reisenfeld D., personal communication. [5] Mabry J. C. (2007) *LPS XXXVIII,* Abstract #2412. [6] Becker R. H. et al. (1976) *Proc. 7th Lunar Sci. Conf.,* 441-458. [7] Norris S. J. et al. (1983) *Proc. 14th Lunar Planet. Sci. Conf.,* B200-B210. [8] Kim J. S. et al. (1995) *Nature, 375,* 383-385. [9] Marty B. (2008) Oral presentation at 71st Meteoritical Society Meeting, Matsue, Japan.