REAL-TIME DIFFUSIVE LOSSES OF LIGHT NOBLE GASES FROM GENESIS ALUMINUM COLLECTORS. J.C. Mabry[1], A.P. Meshik[1], C.M. Hohenberg[1], and D.S. Burnett[2]. [1]Washington University, Physics Department, St. Louis, MO, 63130. E-mail: jcmabry@wustl.edu [2]California Institute of Technology, 1201 California Blvd., Pasadena, CA, 91125.

Introduction: The Genesis mission returned samples of solar wind (SW) collected over 2 years at the L1 point for earth-based laboratory measurements. The main goal of the mission is to obtain accurate, high precision isotopic measurements of trace elements in the SW [1]. Since there are several processes and effects that can alter the laboratory measured value from the true SW value, it is worth trying to quantify these effects. In this work we have looked at the light noble gases: helium, neon, and argon, but these results will have implications for other elements as well.

First, isotopic fractionation can occur if the processes which accelerate the SW away from the sun are mass-dependent (e.g. Coulomb drag [2]). It has been uncertain how large this effect might be. In an effort to quantify this effect, Genesis collected samples of SW from different flow regimes (slow, fast, CME). Our measurements of these different regimes have tightly constrained the possible isotopic fractionation of neon and argon [3].

Second, there are implantation effects. It is known that implantation at constant velocity results in mass fractionation with depth [4]. Heavier isotopes have higher energy, and thus a larger range. The effect of this is that if all of the gas is not recovered during the measurement, the measured isotopic ratios will be altered from their source values. Surface erosion (such as surface damage of Genesis collectors and sputtering of lunar regolithic material) will make the measured ratios heavier than the source, while incomplete degassing of the sample will make the measured ratios lighter.

And third, thermally activated diffusion can alter the initial depth profiles and cause losses of shallowly implanted species, both of which cause preferential loss of the light isotopes. We have conducted a real-time diffusion experiment to determine the diffusion parameters of the Genesis collector materials and to quantify the changes in the measured ratios due to diffusive losses.

Experimental Method: We baked individual pieces of two different Genesis collectors - polished aluminum and aluminum on sapphire (AloS) - at six temperatures between 160 ˚C and 360 ˚C (with a reference group left at room temperature) for 322 days. All pieces were kept under vacuum on the same manifold (see Figure 1) and temperatures were set by PID controllers which maintain temperatures to 0.2%.

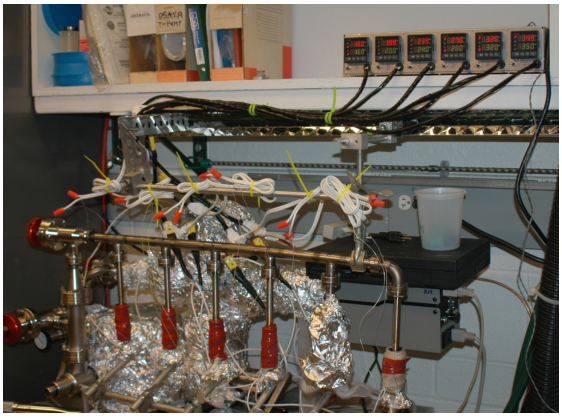
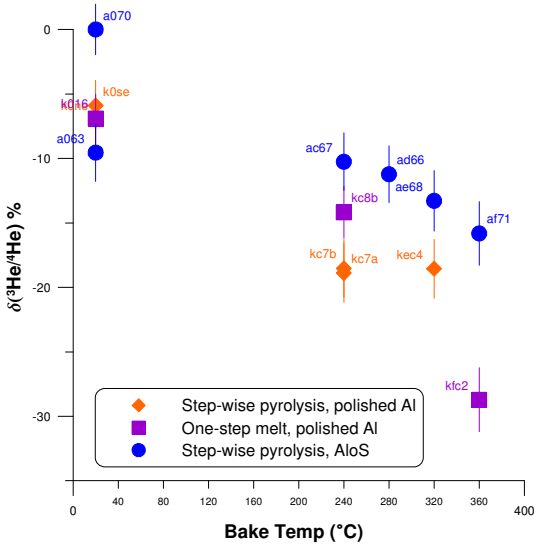


Figure 1: Manifold where Genesis samples were baked for 322 days. Each finger contained 2 pieces of polished Al and 1 piece of AloS.

Then we performed step-wise pyrolysis (200 to 850 ˚C, 45 minute steps) to extract the gas from these samples, measuring the light noble gases released from each step. We analyzed He and Ne together in one mass spectrometer, and cryogenically separated Ar for analysis in a second mass spectrometer.

Initial Results: The purpose of this work is to quantify the effect that diffusive losses of light noble gases from the Genesis collector materials have on the measured ratios. The bulk ratio plots below (Figure 2) show that the measured ratios become heavier with higher diffusive losses as lighter species are preferentially lost. The He isotopic ratio and He/Ne ratio are the most effected. The Ne and Ar isotopes (not shown) do not show losses beyond statistical variations.



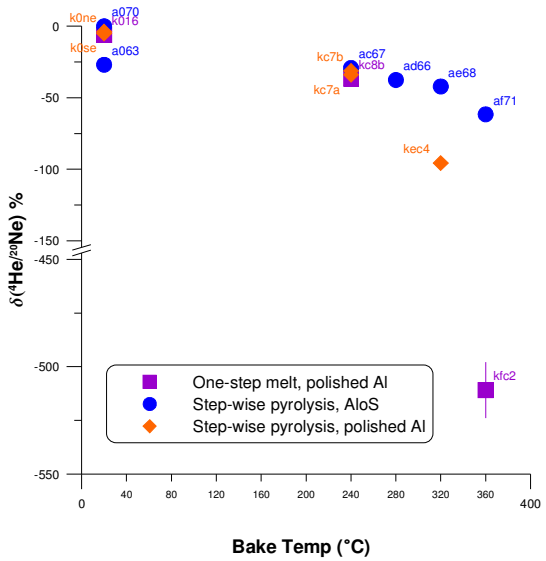


Figure 2: Bulk (total of all step-wise pyrolysis steps) ratios (^{3}He/^{4}He and ^{4}He/^{20}Ne) normalized to reference unbaked AloS sample (a70). Labels denote individual samples. X-axis refers to the baking temperature the sample was held at for the 322-day diffusion experiment, not the step-wise pyrolysis temperature. Error bars are 1σ statistical uncertainties.

For AloS, ^{3}He/^{4}He varies from 10 to 15% heavier compared to the reference sample; and for polished Al from 10 to 20% heavier. The ^{4}He/^{20}Ne for AloS varies from 30 to 60% heavier compared to the reference sample; and for polished Al from 30 to over 500% heavier. Also, overall the polished Al ratios are heavier than the AloS ratios implying that the polished Al collector is not as retentive as the AloS.

Scratches and abrasions on the surface of the sample may also contribute to the change in measured ratios since it is clear from the profiles (Figure 4) that heavier species are implanted deeper than lighter species. This may explain why of the two reference room temperature AloS samples measured (Figure 3), the one that appears more scratched (a63) has heavier measured ratios.

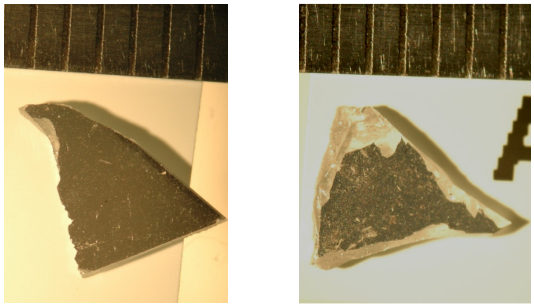


Figure 3: Unbaked AloS reference samples. A63 (right) is considerably more scratched than A70 (left) and gives consistently heavier measured ratios.

The predicted undistrubed release profiles should be lighter near the surface and become heavier with depth (shown in Figure 4 as simulated by TRIM [5]), because all solar wind species are traveling at the same velocity, and therefore the heavier species will be implanted deeper. As seen in Figure 4, heating the samples alters the profile, flattening it and leading to a heavier ratio overall.

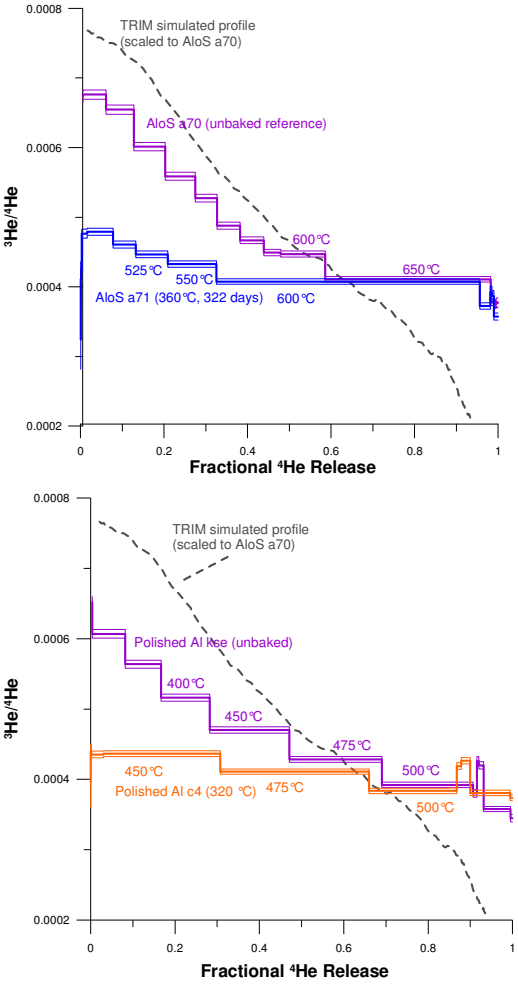


Figure 4: Helium release profiles for AloS (top) and polished Al (bottom) compared to the simulated depth profile given by TRIM code [5]. Each horizontal bar represents the measured ratio of a pyrolysis step, with the temperature of some of the larger steps labeled on the plot. Error bars are 1σ statistical uncertainties.

References:

[1] Burnett D. S. et al. (2003) *Space Sci. Rev., 105*, 509. [2] Geiss J. et al. (1970) *Solar Physics, 12,* 458. [3] Meshik A. P. et al. (2007) *Science, 318,* 433. [4] Grimberg A. et al. (2006) *Science, 314,* 1133. [5] http://www.srim.org.

Additional Information: This work was supported, in part, by NASA grants NNJO4HI17G & NAG5-12885. Thanks to the entire Genesis team for making this work possible.