RELATIVE ABUNDANCES OF HEAVY NOBLE GASES FROM THE POLISHED ALUMINUM SOLAR WIND COLLECTOR ON GENESIS.

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Introduction: Previous elemental ratios of light solar noble gases were determined from the SWC Experiments on Apollo [1] with collection time ranging from 77 minutes (July 1969) to 45 hours (April 1972). These exposures were too short to collect measurable amounts of less abundant heavy noble gases and contamination with fractionated solar wind-rich dust remained a problem. However, the 853 days exposure of Genesis solar wind collectors give us a good platform to measure the abundances of the heavy noble gases and refine those of the light. Here we report the current status of our Ar-Kr-Xe analysis of solar wind captured by Polished Aluminum Collector (PAC).

Experimental: PAC was selected for these measurements for several reasons. First, it's large area, critical for precision of the low-abundance heavy noble gases and, following the mission, is the *only* unbroken Genesis solar wind collector of significant area available. Second, our earlier experiments with Al and Si films deposited on sapphire revealed that most of the noble gas blank is associated with the interface between the coating and sapphire, and not within the film itself. The solid Al alloy of the PAC has extremely low volume-correlated noble gases. However, in contrast to these expectations, high Xe blanks were found, accompanied by unknown contaminants (possibly organic) at specific isotopes. We first attributed this contamination to a residue of fatty acids contained in the paste used to polish the surface of the PAC (which served as a thermal shield for the battery compartment). However, analyses of non-flight coupons of this material, polished using the same paste, did not demonstrate the same level of contamination nor Xe blank. Apparently the problem originates from the large amounts of solar wind hydrogen and helium implanted in the PAC. Hydrogen reacts with the active getter material, sintered in an inert atmosphere during manufacter, and the internal surfaces of the sample system, which may contain traces of the electropolishing solution and lubricants, releasing otherwise dormant noble gases and contaminants. Although the exact sources of hydrocarbon contamination and elevated Xe and Kr blanks are yet to be determined, the installation of a Pd-filter to remove hydrogen before it reacts with getters has allowed us significantly reduce the contamination and blank problems.

Results: We have analyzed three areas of the PAC: $3.5\,cm^2$, $0.34\,cm^2$ and $0.16\,cm^2$ using UV-laser ablation with incrementally increased power density delivered to the PAC surface. Figure 1 demonstrates the ability of this technique to retrieve implanted solar Ar from different depths and to separate it from surface-correlated terrestrial Ar. In the two intermediate extraction steps the $^{40}Ar/^{36}Ar$ ratio is 1.3 and 1.4, the purest solar Ar we yet observed (the solar ratio is <1, while the terrestrial ratio = 296).
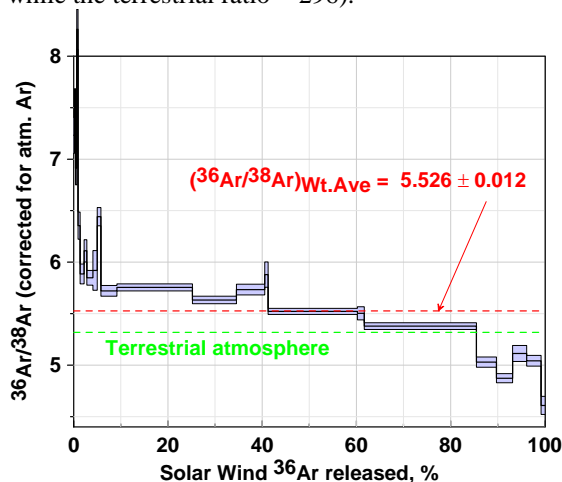

Fig. 1. $^{36}Ar/^{38}Ar$ corrected for atmospheric Ar (assuming solar $^{40}Ar = 0$) as a function of fractional solar ^{36}Ar released. Similar depth dependant isotope fractionation was previously observed for He and Ne and consistent with ion implantation at constant velocities.

Figure 1 demonstrates that the isotopic composition varies with depth, in agreement with the implantation of constant velocity ions. The bulk $^{36}Ar/^{38}Ar$ ratio = 5.526 ± 0.012, calculated from weighted average of all extraction steps, is higher than the value of 5.501 ± 0.005 reported earlier for the Al-on-sapphire collectors [2]. Two reasons can cause elevation of this ratio in gases extracted from the PAC: (1) Heating the collector during laser extraction can partially degas regions adjacent to rastered area, preferentially releasing the lighter isotope and (2) Incomplete degassing of PAC by the laser, which will be checked by total pyrolysis. In contrast to laser removal of the Al film on the Al on Sapphire (AloS) collector, where the film is totally vaporized by the laser, laser rastering of solid Al, an excellent thermal conductor, takes a longer time and requires far more power, much of which heats the bulk collector material.

This work utilizes our Nu-Instruments multicollecor Noblesse mass spectrometer which, after several modifications, is capable of measuring Ar, Kr and Xe isotopes simultaneouisly in a single run. Therefore, Ar can be used as a tracer for solar wind Kr and Xe. Figure 2 shows ^{84}Kr and solar ^{36}Ar released from two relatively small areas (0.34 and 0.16 cm^2). The spread of experimental point is not due counting statistics, but to the differences in the implantation profiles of Ar and Kr.
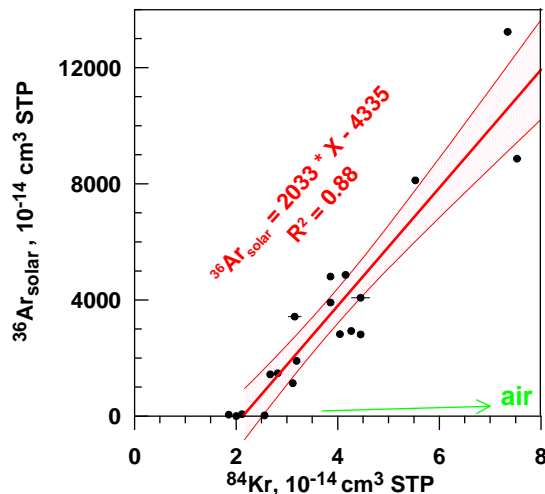

Fig. 2. Solar wind ^{36}Ar and ^{84}Kr from stepped power UV laser rasters of 0.34 cm^2 and 0.16 cm^2 areas of the PAC. Differences in implantation depths contribute to the spread from linear.

Since heavier ions penetrate deeper, the Ar/Kr ratio decreases with depth, becoming quite low near the end of the range as apparent in high depth resolution extractions. Figure 2 shows the two areas (0.34 cm^2 and 0.16 cm$^{2)}$ extracted with fewer extraction steps, represent thicker layers, making the depth effect for Ar and Kr implantation depths less apparent. The slope of the correlation line suggests the incoming solar wind elemental ratio ^{36}Ar/^{84}Kr of 2033. At the present it is hard to estimate the uncertainty of this value since the nature of this error is not statistical, and differences in the implantation profiles for Ar and Kr can skew the results. Only when Ar and Kr is measured in a single raster from AloS, or pyrolysis from the PAC, will we get a good value for the Ar/Kr ratio and evaluate models for solar wind fractionaton. But even this prelimenary ^{36}Ar/^{84}Kr of ~2030 points out to possible problems in recently proposed model [3] which requires about 1/3 of this value.

Due to the relatively small difference in energies, the Kr and Xe implantation profiles are more similar,

resulting in less departure from linear, for ^{84}Kr and ^{132}Xe (Figure 3). Here, the spread of the data points from linear are more comparable with statistical uncertanties, yielding a solar wind ^{84}Kr/^{132}Xe ratio of 9.55 ± 0.16 (statistical errors only). However, despite the good correlation between ^{84}Kr and ^{132}Xe, the observed ratio must still be considered an upper limit. Unlike the case of Ar, it difficult evaluate the actual blank contributions which may be understated and, given the atmospheric value (^{84}Kr/^{132}Xe)$_{atm}$ = 27.7, we conclude that solar wind ^{84}Kr/^{132}Xe ≤ 9.71.
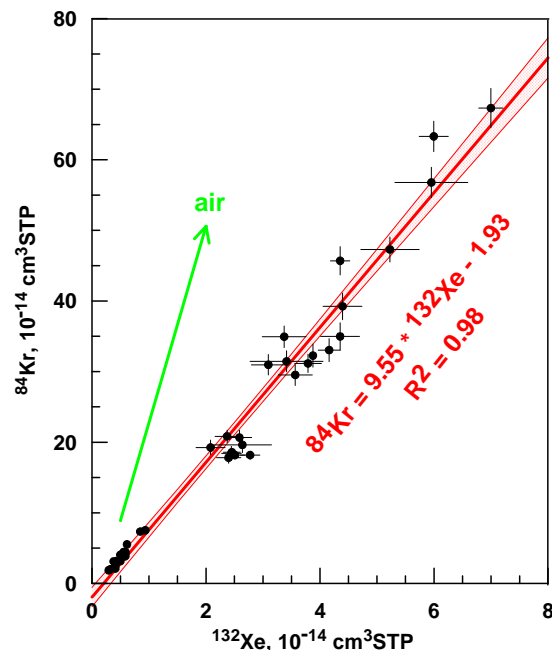

Fig. 3. ^{84}Kr and ^{132}Xe released from three different areas of PAC combined as a single plot.

We are working on retrieving isotopic ratios for Xe and Kr in analyses we already did, but multiple, and isotope-specific, blank corrections make this difficult. Therefore we will try to analyze heavy noble gases from AloS collectors in a single step laser extraction, which will not require complex blank corrections.

References: [1] J. Geiss at al (2004) *Space Sci. Rev.* **110**, 307-335. [2] A. Meshik et al. (2007) *Science,* **318,** 433-437. [3] M. Asplund, N. Grevesse and N. Sauval (2005) *ASP* Conf. series **336**, 25 [astro-ph/0410214].