NEW ANALYSES OF HELIUM, NEON, AND ARGON IN ALUMINUM FOILS OF THE APOLLO SOLAR WIND COMPOSITION EXPERIMENT. N. Vogel[1], H. Baur[1], P. Bochsler[2], F. Bühler[2], A. Grimberg[2] and R. Wieler[1], [1]ETH Zurich, Earth Sciences, CH-8092 Zurich, Switzerland, vogel@erdw.ethz.ch; [2]University of Bern, Physikalisches Institut, Sidlerstrasse 5, CH-3012 Bern, Switzerland.

Introduction: The Solar Wind Composition experiment (SWC) determined the elemental abundances and isotopic compositions of He, Ne, and Ar in Al (and Pt) foils exposed to the SW on the lunar surface during the Apollo missions [1, 2]. These data can now be compared with those obtained by the Genesis mission [3-6]. Both missions collected SW a few years after the activity maximum of their respective solar cycle (Fig. 1). The various SWC foils collected SW only during hours to days and therefore contain much less noble gas than the Genesis bulk SW targets, which were exposed for about 2.3 years. However, SWC foils were exposed during five different time intervals over a period of 3 years and might thus reveal short-term compositional differences averaged out in Genesis targets. In fact, SWC data indicate a correlated variability between ^{3}He/^{4}He and ^{4}He/^{20}Ne [2] (Fig. 2).

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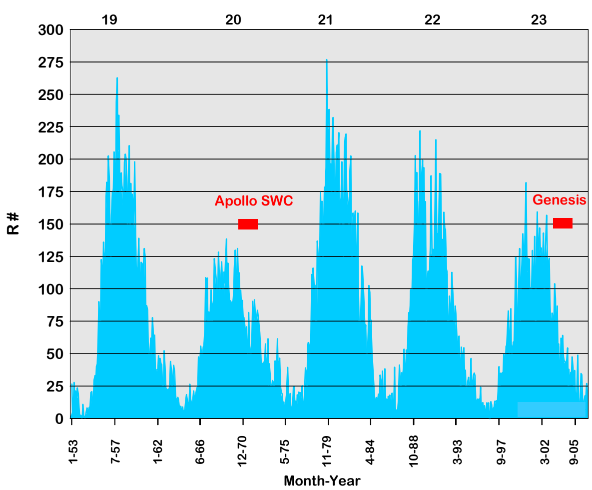

Fig. 1: SWC and Genesis collected solar wind in similar parts of their respective solar cycles. The histogram shows monthly averages of NSO/SP sunspot numbers. Solar cycles numbered on top abscissa.

In general, the mean SW noble gas composition determined in Bern with SWC foils agrees well with the composition deduced in Zurich with Genesis targets. However, a minor but potentially important difference appears to exist, as discussed below. In order to test whether this difference is real, we reanalyse samples from SWC foils in the same laboratory at ETH Zurich where also many of the Genesis noble gas analyses are being carried out. A second objective of this work is to attempt to obtain improved precision compared to what was attainable 40 years ago, by applying modern analytical techniques.

Experimental Methods: For the first series of analyses, we chose the Apollo 15 SWC Al-foil, exposed in July 1971 in Mare Imbrium for 41 hours to SW ions with a speed range of 380-510 km/s and a He-flux of (17.7+-2.5)*10^6/(cm^{2}s) [2]. To minimize potential contamination by lunar dust, foil pieces to be analysed are from the uppermost part of the exposed foil, close to positions of the pieces originally analysed. Foil pieces are cleaned ultrasonically and examined microscopically to control for dust contamination. A first set of data was obtained by melting foil by an infrared laser. Future analyses are mainly to be obtained by UV laser ablation of foils with the system also used for the Genesis targets [3]. A first data point obtained with this technique is discussed below. UV laser ablation yields low blanks from the targets themselves, because only very small amounts of material are degassed. He and Ne are collected from areas of ~0.5 cm^2 size, yielding ^{4}He and ^{20}Ne amounts of about 2.5x10^{-8} cm^{3}STP and 5x10^{-11} cm^{3}STP, respectively. He and Ne material blanks are on the order of a few permil and a few percent, respectively, of the expected He and Ne amounts in the Apollo 15 foil samples.

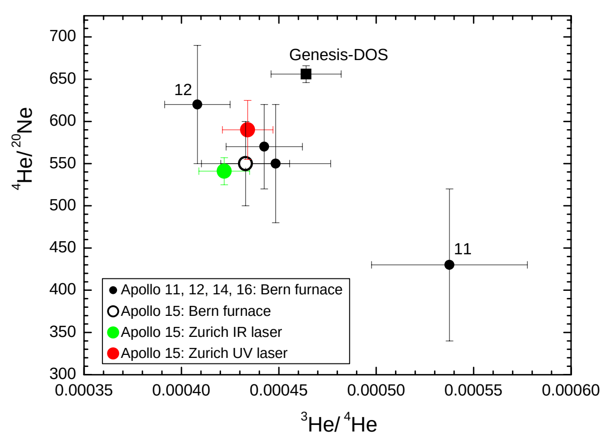

Fig. 2: ^{4}He/^{20}Ne in SWC foils is inversely correlated with ^{3}He/^{4}He (only the extreme data points from Apollo 11 & 12 are labelled). The original data were obtained by noble gas extraction in a furnace [1, 2] and are shown in black symbols. The preliminary new data from Apollo 15 obtained in this work are shown in green (average of 3 samples extracted by IR laser) and red (one sample extracted by UV laser). Uncertainties are 2σ. Also shown is the average from 11 Genesis DOS targets [3].

Preliminary results: So far, three pieces of Apollo 15 foil, each a few cm^2 in size, were analysed by IR laser extraction. Two pieces (~0.5 cm^2 each) were analysed by UV laser ablation. Fig. 2 shows the average of the IR-laser data and one of the two data points obtained by UV-laser extraction. As explained below, Ar isotopic data indicate that this sample suffered little or no contamination by lunar dust, whereas the other UV-laser sample was contaminated. The main observation from Fig. 2 is that the new data agree within uncertainties with the original Apollo 15 average obtained in Bern, although some contamination of our IR-laser foils cannot be excluded. In particular, the elemental ratio $^{4}He/^{20}Ne$ is in good agreement in all data sets.

Fig. 2 also shows a basically good agreement of the He isotopic composition in all three data sets. On the other hand, the new analyses in Zürich all yielded preliminary $^{20}Ne/^{22}Ne$ ratios at the low end of the range of 13.7±0.35 originally reported for the Apollo 15 foil [2]. The two UV-laser foils also yielded precise $^{36}Ar/^{38}Ar$ ratios of the trapped solar wind component, thanks to the very low blank of the laser extraction system and the fact that ^{40}Ar can be used for blank correction of the other two Ar isotopes (assuming atmospheric isotopic composition of the blank). UV-laser sample 2 yields a blank-corrected $^{36}Ar/^{38}Ar$ ratio of 5.47±0.11, within uncertainty identical to the solar wind value measured by Genesis [3, 5], whereas UV-laser sample 1 has a ratio closer to atmospheric composition. UV-laser sample 2 also yields a similar ^{36}Ar SW fluence as the Apollo 15 average reported by [7], whereas UV-laser sample 1 contains a substantially higher ^{36}Ar concentration. We therefore conclude that the latter was contaminated by lunar dust, despite an identical cleaning procedure used for both samples. We therefore disregard UV-laser sample 1.

Discussion: Fig. 2 shows that the ratios $^{3}He/^{4}He$ and $^{4}He/^{20}Ne$ observed in the various SWC foils inversely correlate with each other [2, 8]. Note that all data points shown in this figure have been corrected for backscatter losses of He [2, 3]. The correlation has been explained by variably efficient Coulomb drag of heavier species by protons in the corona, an effect which is expected to affect both elemental and isotopic ratios [8]. Also shown is the Genesis Bulk SW data point obtained from DOS targets [3]. DOS (Diamond-like Carbon on Si) is particularly well suited to determine the composition of light noble gases, because of its low diffusivity for He and the low required corrections for backscatter losses due to the very low atomic mass of carbon [3]. The DOS point falls above and/or to the right of a best fit line defined by the original SWC data by about 10%, not only significantly outside the limits of uncertainty of each individual SWC data point but also inconsistent with the average solar wind composition from all SWC foils. A major motivation for the present experiments is to explain this discrepancy. It cannot be due to stochastic short-term fluctuations of the solar wind composition as recorded by the SWC foils relative to a longer term average represented by the Genesis sample. Experiments with simultaneously irradiated Al and DOS (among other target materials) showed that the adopted relative trapping efficiencies are correct [9]. The deviation can therefore not be explained by imprecise corrections for backscattering. The preliminary new data presented here also make it unlikely that a discrepancy in the calibration of noble gas concentrations in Bern 40 years ago and in Zürich at present may explain the discrepancy, since original and newly analysed elemental ratios $^{4}He/^{20}Ne$ in the Apollo 15 foil agree closely with each other. More work will be required, however, before we may decide whether a real difference exists in the average composition of the SW sampled by Genesis and SWC, respectively. If this should turn out to be the case, one possibility to be investigated in more detail is the contribution of Coronal Mass Ejections (CMEs) which are generally known to contain some enrichments of ^{4}He to the fluence collected by Genesis [10].

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