THE GENESIS SOLAR WIND CONCENTRATOR TARGET: MASS FRACTIONATION CHARACTERISED BY NE ISOTOPES. V. S. Heber[1], R. C. Wiens[2], D. B. Reisenfeld[3], J. H. Allton[4], H. Baur[1], D. S. Burnett[5], C. T. Olinger[2], U. Wiechert[6] and R. Wieler[1]; [1]Isotope Geology and Mineral Resources, ETH, 8092 Zürich, Switzerland, heber@erdw.ethz.ch; [2]LANL, Space & Atmospheric Science, Los Alamos, NM 87544, USA; [3]Physics and Astronomy, University of Montana, Missoula, MT 59812 USA; [4]JSC, 2101 NASA Parkway, Houston , TX 77058, USA; [5]CalTech, JPL, Pasadena, CA 91109 USA; [6]AG Geochemie, FU Berlin, 12249 Berlin, Germany

Introduction: The solar wind concentrator on board the Genesis spacecraft was designed to provide a sample of increased concentration of solar wind (SW) atoms [1-3]. This allows high precision analyses of the isotopic composition of SW O and N in the laboratory. The SW is a proxy for the composition of sun and primordial solar nebula and is therefore fundamental to understand the observed differences in the O isotopic composition between different solar system bodies and different phases of primitive meteorites.

The concentrator was an electrostatic mirror, designed to concentrate the fluence by a factor of 20 on average [3]. Incoming ions with mass/charge ratios of 2.0-3.6 (4-28amu) were accelerated and focused onto the concentrator target. This concentration process resulted in an instrumental mass fractionation varying as function of the radial position at the concentrator target. The performance of the concentrator was simulated using angular -, charge state -, and velocity distributions of the solar wind actually measured during the Genesis mission.

The aim of our work is to verify the post-flight simulation by direct measurement of the mass fractionation on the target. Here we report Ne concentrations and isotopic composition measured along 2 arms of the gold cross of the concentrator target and compare measured concentration factors and mass fractionation with the post-flight simulation.

Experimental: Ne concentration and isotope composition were analysed on two arms, 9 (60009.2) and 12 (60009.1) of the gold cross used to mount the single concentrator targets onto a base plate. Ne was released from single spots (~100μm in diameter) ablated by a UV laser. Both arms were extensively sampled at up to 12 positions about equally distributed along the arms. Several measurements were done at each radial position. The three innermost data points of arm 9 are rejected (in brackets in Fig. 1) since an incomplete ablation cannot be excluded caused by partly shadowing of the UV beam by the sampleholder. Ne was analysed with a very sensitive mass spectrometer equipped with a molecular drag pump that almost quantitatively conveys the gas into the ion source [4]. All samples were very slightly corrected by a blank measured on flight-spare material with identical ablation conditions.

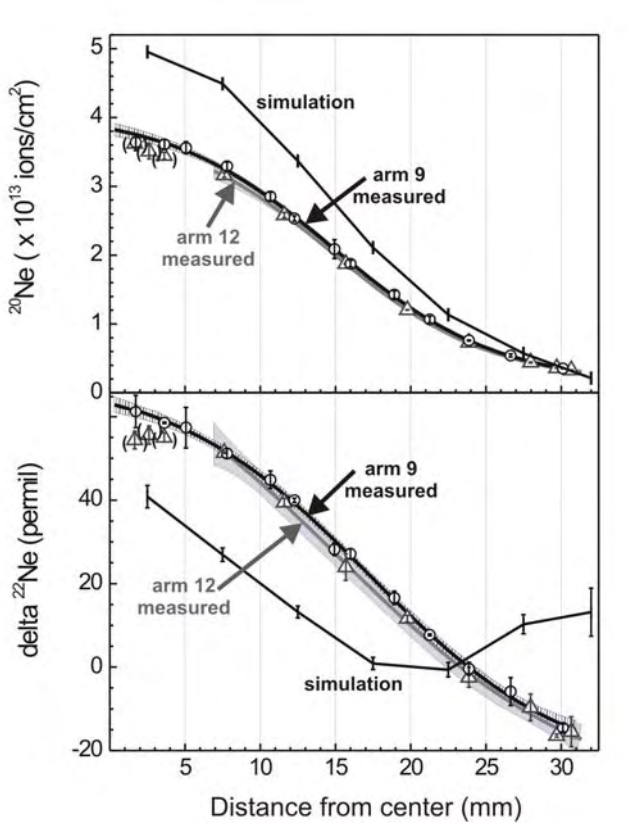

Fig. 1. Comparison of the Ne concentration (upper panel) and isotopic composition data (lower panel) obtained from arm 12 (black circles, black fit line), arm 9 (grey triangles, grey fit line), and simulation (vertical dashes connected by a black line). The data are plotted as function of the radial distance from the centre of the concentrator target. Uncertainties are given as 2-σ errors of the mean for the measured data points and as 1-σ statistical uncertainties for the modelled data. Measured data have been fitted by sigmoid functions (error weighted for concentrations, unweighted for the δ^{22}Ne; 95% confidence bands for the fits are given). The innermost 3 data points of arm 9 are not considered (see text).

In Fig. 1 the ^{20}Ne concentrations and the Ne isotopic composition are presented as mean values at each radial position. Reproducibilities are calculated as 2-σ error of the mean. These uncertainties vary between

0.2-5‰ and are on average 1.8‰ for the $^{20}Ne/^{22}Ne$ ratio. Thus, the uncertainties of the measured isotope ratios are in the range of the intended accuracy of the O isotope analyses.

Results: The measured ^{20}Ne concentrations of both gold cross arms agree within their 95% confidence limits along the entire radius of the concentrator target (Fig. 1), suggesting a radially symmetric concentration process. The modelled ^{20}Ne concentrations are based on concentration factors obtained from simulation of Ne implantation into Au multiplied by the ^{20}Ne fluences ($1.21\pm0.01\times10^{12}$atoms/cm^2) measured in a diamond-like carbon (DOS) target from the passive Genesis bulk collector. Measured and modelled data show monotonically increasing ^{20}Ne concentrations from edge to centre of the concentrator target by a factor of 10, but they differ in their absolute concentrations by ~30%. According to the simulation, concentration factors >40 were expected at the centre of the target, whereas the measured data revealed maximum concentration factors of only 30.

The implanted SW Ne isotopes are fractionated as function of the radial position on the concentrator target. At the edge of the target, Ne is slightly enriched in the light isotope ($^{20}Ne/^{22}Ne$: 14.05) relative to bulk SW Ne. Towards the centre, Ne monotonically becomes heavier with a $^{20}Ne/^{22}Ne$ ratio of ~13.04 at the centre of the target. In Fig. 1 (lower panel) this variation is shown as the ‰-deviation of the measured from a standard $^{22}Ne/^{20}Ne$ ratio (preliminary SW $^{22}Ne/^{20}Ne$: 0.07227, measured in a DOS target of the bulk collector in our laboratory). Using a lower or higher standard value would shift the fractionation curve along the y-axis without changing the total extent of fractionation. The isotope fractionation curves obtained from both arms are indistinguishable within their uncertainties, showing again a radially symmetric operation of the concentrator. The comparison of measured and modelled isotope fractionation curves shows that both have similar slopes at 0-17mm reflecting an increasing heavier isotopic composition towards the centre of the target. However they are offset relative to each other. The measured absolute fractionation is about 20% larger than the modelled one. At 17-31mm measured and modelled fractionation curves show very different trends. Whereas the former continuously decreases towards the edge, the latter attains a minimum around 20mm. The measured target-wide instrumental mass fractionation along the radius is thus considerable higher (3.8%/amu) than the modelled one (2.1%/amu).

Discussion: The Ne data obtained here are encouraging, as they prove that the concentrator performed essentially as expected. However, in order to be able to appropriately correct the mass fractionation of eventual O data, the differences between measured and modelled Ne concentrations and – especially – isotopic compositions need to be understood. We are currently investigating possible reasons for the differences between both types of data. One concern is the spatial resolution of the used simulation model. This will be improved in future as a newer version of the simulation software became available. Another concern has been that the concentrator might become misaligned during operation in space, leading to a somewhat different behaviour than modelled. The hard landing prevented remapping the concentrator. However, the similarity of the data obtained from 2 arms of the gold cross is promising that grid shapes remained unchanged. Also, pre- and post-flight simulations showed that in particular the isotopic composition as function of the radial position is very sensitive to solar wind velocity - and the angular distribution. Especially the latter needs a careful re-examination since it strongly influences the slope of the mass fractionation curve. A potential problem may be the substantial backscatter loss of Ne from the high atomic mass element Au, which amount to 30-40% for the prevailing range of angles of incidence of 40-60° [5]. Additionally, the actual gold cross has a rough surface, which might have resulted in even larger backscatter losses. We will study this possibility by implantation experiments carried out on identical spare flight materials. Depending on the outcome of these experiments, it may be strongly advisable also to analyse Ne in some of the "real" concentrator targets, since they have a much lower atomic mass than Au and hence require much lower backscatter loss corrections.

Summary: Measured Ne concentrations and isotopic composition data show that the Genesis SW concentrator worked essentially as designed and support a radially symmetric operation of the concentrator. Future work will concentrate on the understanding of the fractionation to eliminate the remaining differences in concentration and isotopic composition of measured and modelled data.

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References: [1] Burnett D.S. et al. (2003) Space Sci. Rev 105 509-534; [2] Nordholt J.E. et al (2003) Space Sci. Rev 105 561-599; [3] Wiens R.C. et al (2003) Space Sci. Rev 105 601-625; [4] Baur H. (1999) EOS Transactions, Suppl. F1118. [5] Ziegler J.F. (2004) Nucl. Inst. Meth. Phys. Res. 219/220 1027-1036.