THE GENESIS MISSION: THE EFFECTS OF SOLAR WIND CONDITIONS ON THE DEPOSITION AND INTERPRETATION OF THE GENESIS SAMPLES

D.B. Reisenfeld[1], R.C. Wiens[2], B.L. Barraclough[2], J.T. Steinberg[2], C. DeKoning[2], J. Raines[3], T. H. Zurbuchen[3], D.S. Burnett[4], [1]Department of Physics & Astronomy, University of Montana (MS 1080 32 Campus Dr., Missoula, MT 59812), [2]Space & Atmospheric Sciences, Los Alamos National Laboratory (MS D466, Los Alamos, NM 87545), [3]Atmospheric, Oceanic, and Space Sciences, University of Michigan (2455 Hayward St. Ann Arbor, MI 48109), [4]Geology & Planetary Sciences, Caltech (MS 100-23, Pasadena, CA 91125)

Introduction: The NASA Genesis mission collected solar wind on ultrapure materials between November 30, 2001 and April 1, 2004. The samples were returned to Earth September 8, 2004. Despite the hard landing that resulted from a failure of the avionics box to deploy the parachute, many samples were returned in a condition that should permit achievment of the primary science goals of the mission. Analyses of these samples should give a far better understanding of the solar isotopic composition [1]. Further, the photospheric composition is thought to be representative of the solar nebula with a few exceptions, so that the Genesis mission will provide a baseline for the average solar nebula composition with which to compare present-day compositions of planets, meteorites, and asteroids.

The Genesis samples are affected by the solar and solar-wind conditions under which they were collected. Solar wind is fractionated from the photosphere by the forces that accelerate the ions off of the Sun. Elemental fractionation is significant; isotopic fractionation is more ambiguous. Elemental fractionation appears to be ordered by both the *solar wind speed* and by the *first ionization potential* (FIP) of the elements [e..g. 2,3]. Fractionation also differs within material expelled from the Sun as coronal mass ejections (CMEs). In order to better understand solar wind fractionation, it was necessary for Genesis to collect samples from different solar wind regimes.

For this reason, plasma ion and electron spectrometers continuously monitored the solar wind proton density, velocity, temperature, the alpha/proton ratio, and angular distribution of suprathermal electrons, and used these parameters to distinguish between the solar-wind regimes during collection. In addition, the Advance Composition Explorer (ACE) spacecraft was monitoring the solar-wind conditions from the L1 orbit at the same time. Here we report on the application of this information to understanding the deposition and analysis of the Genesis solar wind samples.

Solar-Wind Regimes: Genesis collected solar wind samples sorted into three regimes: interstream (IS), coronal hole (CH), and coronal mass ejection (CME), in addition to a set of collectors that were continuously exposed to the solar wind. The interstream, or slow (< 500 km/s), solar wind is the dominant regime encountered in the ecliptic. It is consistently fractionated based on FIP, with elements having FIPs below 10 eV enhanced by a factor of about four relative to high-FIP elements. Coronal hole material is characterized by high velocity (500-800 km/s) and a relatively low FIP fractionation of around 2, with a consistent alpha/proton ratio of ~0.043. The Ulysses mission showed that CH is the dominant regime over the solar poles, particularly during the low-activity portion of the solar cycle [4]. CMEs are characterized by strong and often uneven enrichments of heavy elements, including alpha/proton ratios often > 10%.

Table 1. Genesis and ACE Elemental Fluences

	Genesis Sample Fluence (cm^{-2})	ACE-derived Fluence (cm^{-2})	$X_{Genesis}/X_{ACE}$
Proton	1.90E+16[a]	--	--
He	9.80E+14[b]	9.94E+14	0.99
Ne	1.43E+12[c]	2.49E+12[g]	0.57
Mg	2.18E+12[d]	1.84E+12	1.18
Ar	2.05E+10[e]	--	--
Fe	2.09E+12[f]	1.45E+12	1.44

Uncertainties of ~ ±20% in both Genesis and ACE fluences
[a] From ion montitor
[b] Average of Minnesota and Washington University groups
[c] Average of Minnesota and Washington University groups
[d] Caltech group
[e] Minnesota group
[f] Caltech group
[g] Suspect: ACE value about x2 too high compared to Ulysses

Comparison of Elemental Abundances Between Genesis Samples and On-Orbit Detectors: Abundance ratios of He/H were measured with the Genesis Ion Monitor. In addition, the ACE Solar Wind Ion Composition (SWICS) instrument measures abundances of a number of heavy elements in the solar wind, including He, C, N, O, Ne, Mg, Si, and Fe. We have made use of these data to compare elemental fluences determined from sample analysis to composition measured in space (Table 1). The Genesis fluences are in good agreement with on-orbit measurements for those samples for which we have preliminary analyses. As ground-based analysis techniques continue to be refined, we expect the accuracy of abundances derived from the sample analyses to eventually surpass on-orbit measurements.

FIP Fractionation: Ultimately, we wish to determine photospheric abundances from the Genesis samples. However, since the particle fluences in the samples reflect solar wind abundances, we need a model to link Genesis fluences to photospheric abundance. To help us develop such a model, we make use of ACE/SWICS data. In particular, we look at the fractionation of the elements detected by ACE relative to photospheric values [6], both as a function of FIP and solar wind regime. Figure 1 shows ACE/SWICS abundances vs. FIP for CH flow, as determined by the Genesis solar wind regime algorithm. Also shown are abundances measured by the Ulysses spacecraft in 1991-1996 [3]. Agreement between ACE and Ulysses is very good, which demonstrates that (a) the FIP fractionation in the solar wind is stable with time, and (b) the Genesis regime selection algorithm successfully differentiated between IS and CS flows.

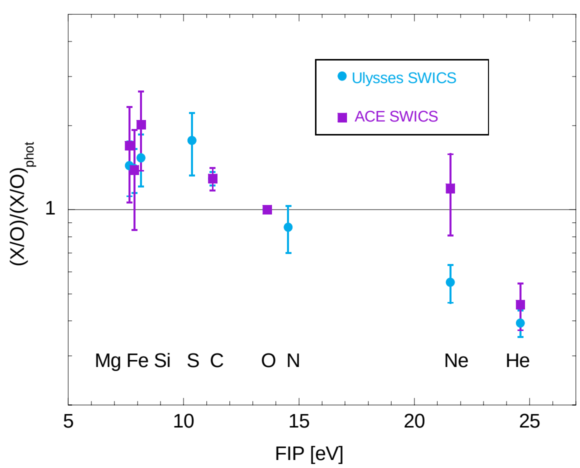

Figure 1. Comparison of ACE and Ulysses FIP fractionation relative to photosphere. ACE composition data sorted based on Genesis solar wind regime algorithm.

Genesis Abundances vs. FIP: We report FIP fractionation for certain elements based on analysis of the bulk (undifferentiated) solar wind samples. Figure 2 shows the Genesis bulk sample abundances of Mg, Fe, Ne, and Ar relative to helium compared to photospheric values, plotted as a function of FIP. Also shown are these ratios, where available, from the Apollo samples, ACE and Ulysses. Within the error bars, there is significant overlap between measurements, although disagreement exists. Ultimately, the Genesis sample analysis will give us the best determinantion of elemental and isotopic abundances in the solar wind to date. Thus the samples, in particular the regime-specific samples, will allow for the best determination of the nature of FIP fractionation in the solar wind.

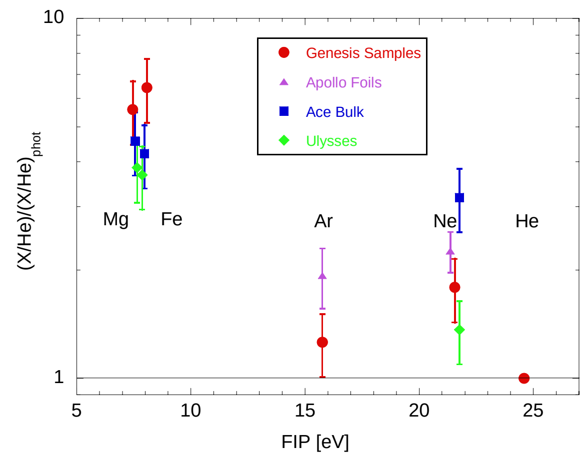

Figure 2. Comparison of FIP fractionation relative to photosphere, based on abundances fromGenesis samples, Apollo foils, ACE and Ulysses, for the bulk solar wind. Abundances are relative to helium.

References: [1] Burnett D.S. et al. (2003) *Spa. Sci. Rev. 105*, 509-534. [2] Neugebauer M. (1991) *Science 252*, 404-409. [3] Bochsler P. (2000) *Rev. Geophys. 38*, 247-266. [4] McComas D.J. et al. (2002) *Geophys. Res. Lett. 29*, 1314-1317. [5] Barraclough B.L. et al (2003) *Spa. Sci. Rev. 105*, 627-660. [6] Asplund M., Grevesse N., and Sauval A.J. (2005) The Solar Chemical Composition, in *Cosmic Abundances as Records of Stellar Evolution and Nucleosynthesis, ASP Conference Series, Vol. XXX*, F.N. Bash, T.G. Barnes, eds., in press.