SIMS MEASUREMENTS OF Mg ISOTOPES IN THE SOLAR WIND. K. Rieck[1] , A. J. G. Jurewicz[1] , M. Wadhwa[1], D. S. Burnett[2], R. Hervig[1] and R. Wiens[3], [1]ASU (CMS / SESE, Tempe AZ 85287-1404, Amy.Jurewicz@asu.edu), [2]Caltech (GPS, m/c 100-10, Pasadena, CA), [3] LANL (SSA, ISR-1, m/s D-466 Los Alamos, NM).

Introduction: Using Genesis collector materials, we investigate whether or not solar wind (SW) Mg isotopes are fractionated compared to the photospheric composition.

It is well established that SW elemental fractionation relative to the solar photosphere correlates with first ionization potential (FIP). But, FIP is an atomic property and unlikely to produce isotopic fractionation. Other processes have, however, been postulated which may fractionate isotopes; for example, electromagnetic effects associated with acceleration of solar wind from the corona would be mass dependent. "Coulomb Drag", a specific model by Bochsler [1] predicts relatively large fractionations. For Mg, a 26Mg/24Mg depletion of ~20 per mil in solar wind relative to Sun is predicted. Kallenbach et al. [2] based on SOHO / Celias /MTOF spacecraft instrument data show 26Mg depletion consistent with Bochsler.

If we assume that (with the exception of evaporation effects in CAIs) systematic mass dependent fractionations for *non-volatile* elements are small (<~1 per mil / amu) then Mg isotopes can provide a good test for isotopic fractionation between photosphere and solar wind. Terrestrial Mg-isotopic ratios are well known. Thus, deviations of Mg isotopes between solar wind and terrestrial composition are assumed indicative of the solar wind relative to the photosphere.

Originally, we assumed that ICPMS measurements would be required for a good test of Mg isotope fractionation; but, with the -10 to -20 permil per amu of [1], ion probe analyses looked feasible.

Experimental: Analyses are being performed on both amorphous diamond-like carbon collectors (DLC) and silicon collectors (Si) using the ASU Cameca 6f with an O2+ primary beam. No interference from ^{24}MgH was observed for DLC but was significant for Si. Accordingly, for DLC it was adequate to use a lower mass resolving power, sufficient to resolve C_2^+, increasing SW signal over silicon. To further increase signal on both materials, we used a 250µm raster using 60% dynamic transfer optics setting (DTOS).

The solar wind is a constant velocity plasma; our implants are of monoenergetic ions. In both cases there are slight differences in depth distributions. Thus, isotopic ratios were calculated from the sum of the counting rates, ***not*** ratios of isotopes from each cycle. Per profile counting statistics errors are about 6 per mil for both ^{25}Mg/^{24}Mg and ^{26}Mg/^{24}Mg.

Results: We discuss only DLC data here. Fig. 1 shows that distinct solar wind Mg depth profiles are obtained. Instrumental mass fractionation (IMF) was measured with a 2 isotope (24, 26) Mg implant standard, calibrated with ICPMS.

Using the ICPMS measurement of the implant relative to terrestrial standards, the DLC data for sample 60065 define per-mil/amu SW-terrestrial mass fractionations, F, for ^{25}Mg and ^{26}Mg relative to ^{24}Mg. Since mass dependent fractionation is expected, F_{25} is expected to be equal to F_{26}. Fig. 2 shows that, for 8 independent profiles of 60065, excellent reproducibility is obtained for F_{25}. Fig. 3 shows good reproducibility for F_{26}, but surprisingly F_{25} appears lower than F_{26}. Both F values are distinct from 0 (terrestrial) and are in the direction, and of a consistent magnitude as predicted by Bochsler. However, the derived solar wind ^{26}Mg/^{25}Mg agrees with terrestrial to within a few permil.

Discussion: Unfortunately, the high Mg fluences we chose for accurate ICPMS measurements produced large SIMS dead-time corrections for ^{24}Mg on the standard. Instantaneous counting rates can be much higher than those measured when the beam is rastered; DTOS added further complications, as did changing primary current between sample and standard. The semiconductor industry rarely makes isotopic measurements, so the combination of problems is almost unique to Genesis samples. At the peak of the profile the correction to ^{24}Mg is 60 permil; for the integral it is 40 permil. The corrections to isotope ratios are essentially the same. Our correction procedures should have sufficient accuracy, although they are approximate. Measured ratios favored the light isotope; IMF corrections were -10 to -20 permil/amu. Ideally standards and samples should be measured under the same analytical conditions. This was not possible here. A factor of 20 higher primary ion current was required, even though all other conditions held constant. Therefore, some of our data-reduction techniques are problematic. A solution, which we are currently pursuing, is to standardize an implant with lower counts so that conditions can be kept identical between standard and flight sample.

Conclusions: The results, if true, would be of major importance; however at present systematic errors cannot be ruled out. The problem is possibly with us, not the Sun. Because the ^{26}Mg / ^{25}Mg is terrestrial, a problem with the deadtime correction is suggested.

However, the 26Mg / 24Mg depletion is significant unless we have underestimated dead time corrections by 50%, which seems large. Alternatively, small inhomogeneities in the implant Mg isotopic composition are possible. The good news is that sensitivity and precision of solar wind Mg isotopic data are good, for both DLC and Si. The problems with implant standards can be fixed. Work has begun with a different 2 isotope implant using equal amounts of ^{25}Mg and ^{26}Mg at equal fluences making deadtime corrections negligible. These Mg fluences are a factor of 3 lower, reducing the difference with flight samples, but still enabling good ICPMS measurements.

References: [1] Bochsler P (2000) *Rev.Geophys. 38,* 247-266, [2] Kallenbach R et al. (1998) *Space Sci. Rev. 85*, 357-370.

Acknowledgements: This work supported by Genesis mission funds, including JPL sub-contract #1354958. Special thanks to L. Williams, K. Franzreb, and P. Williams for their help and extremely useful discussions.

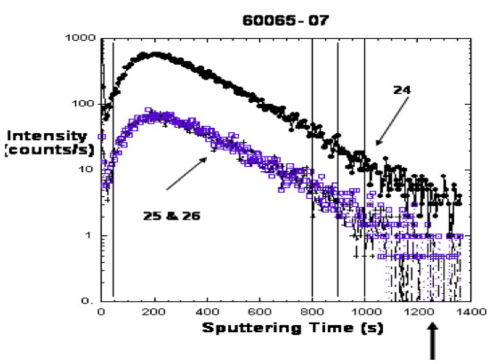

Figure 1. Profile from DLC Sample 60065. *In this profile, SW signal at the peak is ~90cps for ^{25}Mg, ^{26}Mg, demonstrating we have adequate sensitivity.*

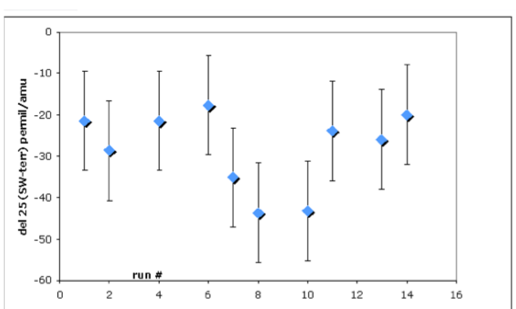

Figure 2. SW 25Mg measurements in DLC vs. run number. *These data are consistent at the +- 2 sigma level.*

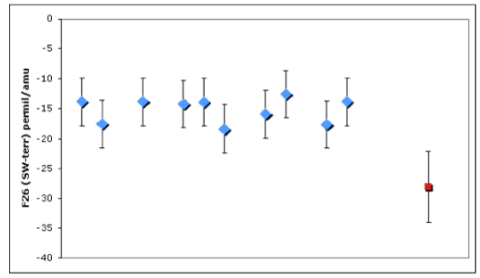

Figure 3. SW 26Mg measurements vs. run number. *Averages consistent, but don't agree with 25Mg.*