SOLAR WIND IMPLANTATION INTO LUNAR REGOLITH: H RETENTION IN A SURFACE WITH DEFECTS.

W. M. Farrell [1,3], D. M. Hurley [2,3], M. I. Zimmerman [2,3], [1.] NASA/Goddard Space Flight Center, Greenbelt, MD, [2.] Johns Hopkins University/Applied Physics Laboratory, Laurel, MD, [3.] NASA's Solar System Exploration Research Virtual Institute, NASA/Ames Research Center, Moffett Field, CA

Abstract: Solar wind protons are implanted directly into the top 100 nanometers of the lunar surface, but can either quickly diffuse out of the surface or be retained, depending upon surface temperature and the activation energy, U, at the implantation site. The activation energy defines the diffusive mobility of the H in the crystal, with a high energy value indicative of a location with a trapping, vacancy-type defect [1, 2].

In this work, we explore the distribution of activation energies upon implantation and the associated H-retention times; this for comparison with recent observation of OH on the lunar surface.

We apply a Monte Carlo approach: for simulated solar wind protons, we assume at implantation that they have a distribution of activation energies, U, with a central peak, U_c and width, U_w. We then derive the diffusion time and count the fraction retained for long periods in the near-surface (those 'loitering' in the surface with diffusion times > 10^5 sec).

We find that that surfaces characterized with a distribution with predominantly large activation energy values (U > 1 eV) will retain implanted Hs for long times. Surfaces with the distribution predominantly at small values (U < 0.2 eV) will quickly diffuse away implanted Hs. However, surfaces with a large portion of activation energies in a mid-range between 0.3 eV < U < 0.9 eV will tend to be H-retentive in cool conditions but transform into H-emissive surfaces when warmed (as when the surface rotates into local noon). **These mid-range activation energies give rise to a diurnal effect with a clear minimum in retained Hs at local noon, similar to recent reports [3].**

The adjacent figure shows 240000 proton implantations having a distribution of activation energies with a width in the distribution of ~0.3 eV. The associated diffusion times (or retention times) is shown in panel b. Note that most of the H's quickly diffuse out of the surface (to possibly be observed as a neutral H emission [4]). However, some small fraction loiters for long periods of time (> 10^5 s). These long-lasting H implantations are found at the cool dawn and dusk terminators (panel c) and are likely candidates for OH formation.

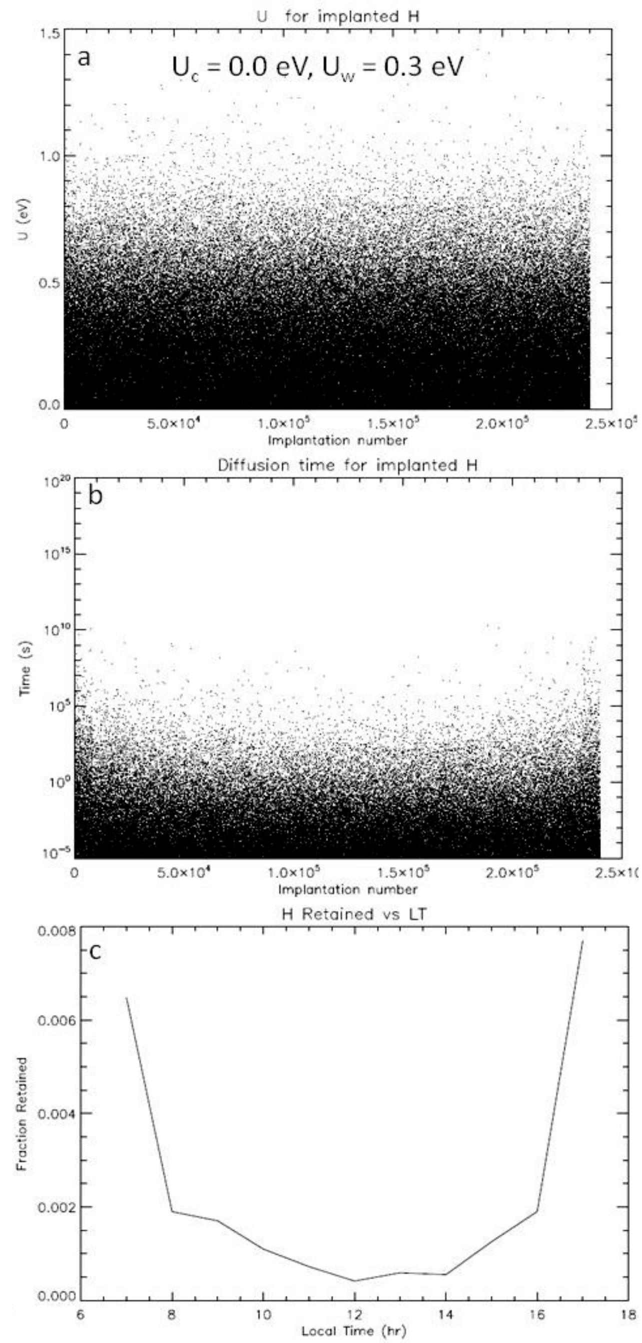

Figure 1: (a) U values and (b) diffusion times for a set of implantations having a distribution with width of 0.3 eV. Panel (c) shows the associated fraction of H's retained for long times (> 10^5 s) as a function of Local Time.

References: [1] Starukhina, L.V (2001J. Geophys. Res.-Planets 106, 14701–14710, [2] Starukhina, L.V.(2006) Adv. Space Res. 37, 50–58, [3] Sunshine, J.M., et al. (2009), Science, 326, 565, [4] McComas, D. J., et al. (2009),Geophys.Res.Lett.,36,L12104,doi:10.1029/2009GL038794.