THE FORMATION OF MOLECULAR HYDROGEN FROM WATER ICE IN THE LUNAR REGOLITH BY ENERGETIC CHARGED PARTICLES. A. P. Jordan[1], T. J. Stubbs[2], C. J. Joyce[1], N.A. Schwadron[1], H. E. Spence[1], J. K. Wilson[1], [1]EOS Space Science Center, University of New Hampshire, Durham, NH, [2]NASA Goddard Space Flight Center, Greenbelt, MD.

Introduction: On 9 October 2009, the Lunar Crater Observation and Sensing Satellite (LCROSS) mission impacted a spent Centaur rocket into the permanently shadowed region (PSR) within Cabeus crater and detected water vapor and ice, as well as other volatiles, in the ejecta plume [1]. The Lyman Alpha Mapping Project (LAMP), a far ultraviolet (FUV) imaging spectrograph onboard the Lunar Reconnaissance Orbiter (LRO), observed this plume as FUV emissions from the fluorescence of sunlight by molecular hydrogen (H_2) and other constituents [2]. Energetic charged particles, such as galactic cosmic rays (GCRs) and solar energetic particles (SEPs), can dissociate the molecules in water ice to form H_2 [3]. We examine how much H_2 can be formed by these types of particle radiation interacting with water ice sequestered in the regolith within PSRs, and we determine whether it can account for the H_2 observed by LAMP [Jordan et al., submitted to *J. Geophys. Res.*, 2013].

Space Radiation Environment: We use LRO CRaTER (Cosmic Ray Telescope for the Effects of Radiation) [4] and the OMNI data set [5] to estimate the historical GCR and SEP radiation doses. A previous study showed the GCR dose rate to be 0.02 eV/(molecule·Myr) [6]. We find the SEP dose rate to be about or 0.24 eV/(molecule·Myr) (Figure 1).

GCRs and SEPs can penetrate below the regolith's surface. To estimate their penetration, we use the National Institute of Standard's Stopping-Power and Range Tables for Protons (PSTAR) [7]. Most GCRs will affect ice to a depth of ~36 cm, whereas SEP protons detected by CRaTER penetrate to ~0.2 cm.

These penetration depths affect the amount of time a given layer of the regolith can be exposed to the incident particles. Meteoritic impacts overturn and mix the regolith in a process called gardening [8]. The rate of gardening enables us to estimate the time a given layer is, on average, exposed to GCRs and SEPs. The longer the gardening time is, the longer the exposure time. This exposure time, combined with the penetration depth of the particles and the average dose rate, gives us the dose received by water molecules above the gardening depth. For GCRs, the total dose is 9.2 eV/molecule, and for SEPs it is 0.55 eV/molecule.

These doses enable us to estimate how much H_2 GCRs and SEPs have created in PSRs. Based on laboratory experiments [9-11], we estimate that the G-value (the number of H_2 molecules formed per 100 eV of radiation deposited per water molecule) lies between 0.1 and 0.7. Therefore we expect at least 1-7% of the original water molecules have converted in H_2 (Figure 2).

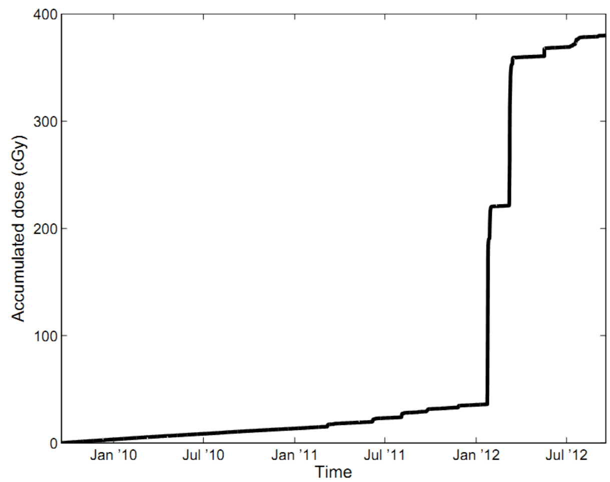

Figure 1: Accumulated dose calculated from CRaTER data during 18 September 2009 to 18 September 2012. Each step occurs during an SEP event. The accumulated dose is 380 cGy, or 0.24 eV/(molecule·Myr).

Conclusion: We find that GCRs and SEPs can convert at least 1-7% of the original water molecules into H_2. This accounts for 1-11% of the ratio of H_2 to H_2O molecules found when combining the results of the LCROSS and LAMP observations of the Centaur's impact plume.

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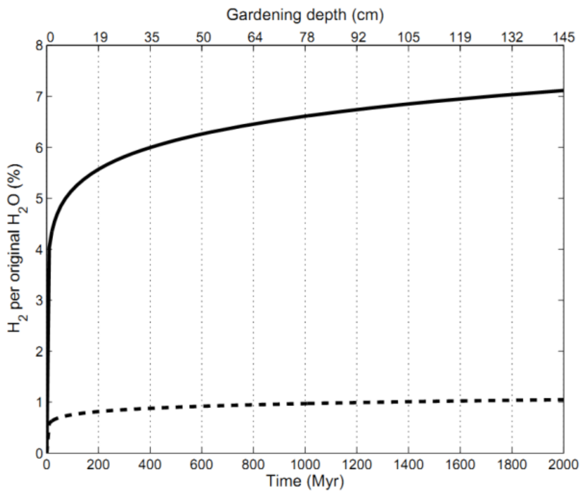

Figure 2: The number (as a percentage) of H_2 molecules created by GCRs and SEPs with respect to the original number of water molecules as a function of gardening time (lower axis) and depth (upper axis). The dashed line shows the percentage if G = 0.1, and the solid line if G = 0.7.