SHALLOWLY-BURIED HYDROGENATION IN THE LUNAR REGOLITH: REFINING LATITUDE AND LOCAL TIME TRENDS.
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Summary: Now that the CRaTER instrument on LRO has tentatively detected excess hydrogen or hydrogen-bearing molecules in the lunar regolith both near the dawn terminator [1] and near the poles [2], we are exploring multiple avenues to better quantify the degree of lunar hydrogenation in the top 10 cm of regolith as a function of latitude and time of day.

Expanding horizon-viewing coverage: Horizon-viewing observations by CRaTER are particularly sensitive to forward-scattering knock-on collisions of galactic cosmic rays (GCRs) with hydrogen in the upper few cm of soil, as detailed in the abstract of de Wet et al. in this meeting [3], and as illustrated in Figure 1. Schwadron et al. [1] used our first horizon-viewing data from 2015 to show that the yield of ~100 MeV lunar albedo protons is twice as great at local lunar sunrise than at sunset, suggesting an enhanced abundance of hydrogenation in the cool pre-sunrise lunar regolith compared to the warmer regolith at sunset.

In addition to making use of untapped horizon data from 2016 and 2017, we are also planning horizon-viewing observations over all lunar night-time hours in 2018 to test whether this hydrogenation gradually builds up during the lunar night, or whether it occurs in a pre-sunrise "standing wave" as hypothesized by Schorghofer [4]. The former case would suggest that there is an efficient method of transporting and trapping hydrogen to the entire night-side hemisphere of the Moon, while the latter case would suggest that the dawn hydrogen enhancement is mostly a manifestation of a localized diffusion "wind" from the warm side of the dawn terminator to the cold side.

Improved data analysis of the latitude trend: Schwadron et al. [2] used an early form of collimated CRaTER data analysis [5] to create a course plot of the lunar albedo proton yield vs. latitude, and found a ~1% enhancement of the yield near the poles compared to the equator, suggesting a polar hydrogen enhancement in the top 10 cm of regolith. The sparse horizon data used in the subsequent sunrise/sunset study [1] inspired a new and improved collimated data reduction technique which we will use to improve the resolution and signal-to-noise ratio of the albedo proton latitude trend. This will help to bridge the hydrogen latitude trends seen by other instruments at the surface (< 1 mm) and at depth (~50 cm) [6].

New uncollimated data analysis: We have made a potential breakthrough in lunar albedo proton mapping that could *improve our counting statistics by two orders of magnitude.* While refining a technique for automatically detecting solar energetic particle events in CRaTER data, we found a weighted sum of the ratios of the total particle detection rates from multiple CRaTER detectors that is essentially unaffected by the variable background GCR flux, or by other factors which have complicated our previous lunar albedo proton studies. This weighted sum is nonetheless sensitive to 14-50 MeV lunar albedo protons, which are more abundant than the ~100 MeV protons investigated in the collimated data. We will present any preliminary albedo proton mapping results from this brand-new method.

References: [1] Schwadron N., et al. (2017), PSS, [2] Schwadron, N., et al. (2016), Icarus, 273, 25-35, [3] de Wet, W. et al. (2018, this meeting), [4] Schorghofer, N. (2014), GRL, 41, 4888-4893, [5] Wilson, J.K., et al. (2012), JGR, 117, E00H23, [6] Jordan, A.P., et al. (2018, this meeting)

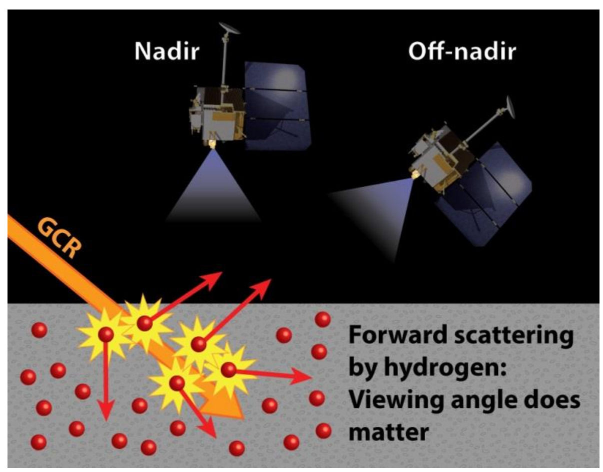

Figure 1. The orientation of CRaTER's field of view relative to the lunar horizon affects CRaTER's sensitivity to the products of forward-scattering (knock-on) collisions of GCRs with hydrogen atoms in the lunar regolith.