HYDRATION OF LUNAR REGOLITH AT LOCAL SUNRISE: ANALYSIS.

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Summary: The CRaTER instrument on LRO has detected the signature of hydrated lunar regolith at the local dawn sector of the Moon, using a new type of horizon-viewing observation in 2015 and 2016. The yield of ~100 MeV lunar albedo protons at dawn is larger than that of the dusk sector. The simplest explanation is that hydrogen (whether atomic or in a molecule like H_2O) is more abundant on the lunar surface near sunrise than at sunset, and that grazing-incidence galactic cosmic rays (GCRs) and upwelling secondary neutrons scatter the free protons off/out of the regolith via forward-scattering knock-on collisions, thus enhancing the number of albedo protons per incident GCR.

Data: CRaTER is normally oriented vertically, with one end of the telescope facing the Moon and the other end pointed at the zenith. During periods when the polar orbit of LRO passed over the longitudes of Oceanus Procellarum, LRO was rotated to point CRaTER's field of view towards the lunar horizon. (Fig. 1) We collected a total of 65 hours of horizon-viewing data over this mare-rich region of the Moon.

Data reduction: To accurately calculate the yield of lunar albedo protons at different local times, we carefully subtract the background signal in the instrument, as well as account for systematic variations in the actual or measured GCR flux. We use all six detectors in CRaTER to distinguish albedo protons from GCR protons, and then fit an exponential function to the background LET spectrum in one detector in order to isolate and count the protons. (Fig. 2) We also detect and account for a small difference in the dawn vs. dusk flux of incident GCRs due to streaming along interplanetary magnetic field lines. [details in Schwadron et al. 2017]

Implications: The size of the dawn yield enhancement suggests that a significant population of hydrogen or hydrogen-bearing molecules are mobile over the surface of the Moon. Schwadron et al. [2016] found a 1% high-latitude enhancement in the nadir-viewing proton yield using CRaTER, and concluded that the small signal required ~1% H by mass (~10% H_2O equivalent) at depths of 10-20 cm in the regolith, which is on the high side of the range found by other studies. The dawn grazing-angle enhancement seen here suggests a portion of the global H population is concentrated on a small dawn sector of the Moon; this is supported by Schorghofer's [2014] model of mobile lunar H2O which predicts a dawn H_2O regolith concentration that is orders of magnitude larger than that just prior to sunset.

References:

Schorghofer, N. (2014), GRL, 41, 4888-4893, doi: 10.1002/2014GL060820.

Schwadron, N., et al. (2016), Icarus, 273, 25-35, doi: 10.1016/j.icarus.2015.12.003

Schwadron N., et al. (2017), in prep.

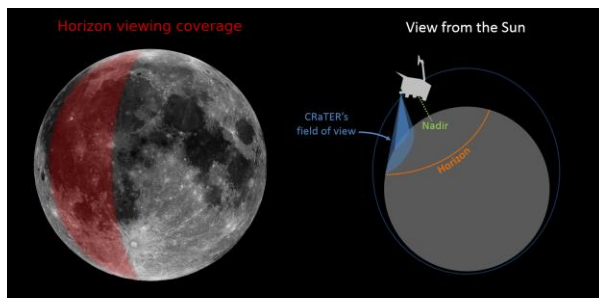

Figure 1. *Left*: The longitudes of the horizon observations are shown in red. *Right*: Illustrative diagram of LRO/CRaTER orientation during horizon observation.

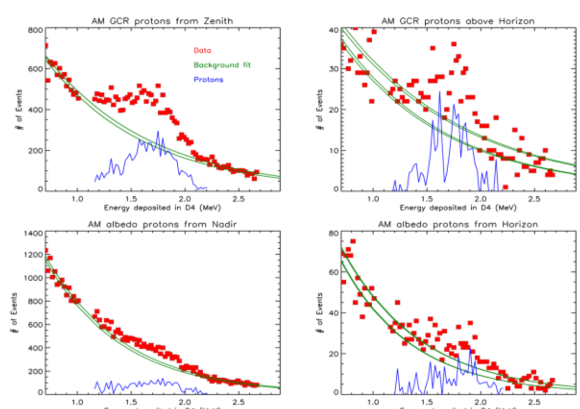

Figure 2. LET spectra (red points), background fits (green lines) and proton-only LET spectra (blue) for the AM data in this study.