A SEARCH FOR HYDROGEN NEAR THE LUNAR TERMINATOR AT LOW LATITUDE.

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Introduction: We investigate the possible signature of hydrogen in the lunar regolith in the near-equatorial region as a function of local time, using the leakage flux of epithermal neutrons from the lunar surface for remote sensing. Sunshine *et al.* [1] and Pieters *et al.* [2] have observed hydration features in reflectance spectroscopy of minerals in regolith near the terminator, determining that the hydration is equivalent to minerals with < 0.5wt% H_2O. Such a concentration of water is consistent with measurement targets for the LEND instrument on LRO. LEND measurements acquired over two years since the start of data collection in July 2009 thus may be sensitive to distinguishing between models for the degree and extent (depth) of hydration in the near-equatorial regolith near the terminator.

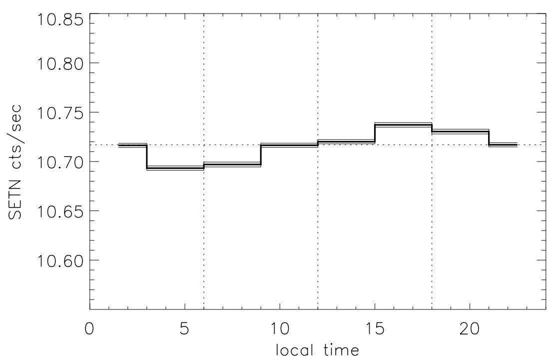
Observed hydration: The hydration features detected in near-infrared spectroscopic mapping are restricted to a broad band near the terminator, with spectra indicating desiccated minerals nearer the subsolar point. No information is available for mineral hydration on the night side, as the Sun is the sole light source for the measured spectroscopy. Surfaces at high latitude are always relatively far from the subsolar point and always relatively near the terminator, but surfaces at low latitude must go through a repeated diurnal cycle of desiccation and hydration in order for hydration features to be restricted to the near-terminator region.

The model proposed by Sunshine *et al.* [1] to explain the isolation of the hydration feature near the terminator is a population of OH radicals or H_2O molecules that is driven off from the sub-Sun surface and adsorbed onto cooler mineral surfaces near the terminator. The source of hydrating ions/molecules could be a steady-state influx from solar wind or meteorite impacts, balanced by escape to space with a transient pile-up near the terminator; or it could be a reservoir of ions/molecules that is essentially fixed in local time as the surface rotates relative to it, successively hydrating and desiccating from the passing regolith. Hydrates that form at the moderately low temperature of the dusk terminator may persist through the extreme cold of the lunar night. As this terrain emerges into sunlight at dawn, it experiences a competition between the sublimation of the hydration preserved overnight and deposition of hydration driven away from the sub-Sun region. This model suggests that the equatorial regolith near the sub-Sun point (local time 12:00) would be most completely desiccated, with hydration developing at the dusk terminator, persisting through the night, and desiccating once more as of a few hours of local time across the dawn terminator and into the day.

The materials observed to undergo the cycle of desiccation-hydration-desiccation are only the surfaces that are directly illuminated by the Sun to yield the measurable diagnostic, a thin layer at the surface of the regolith. It is not possible to determine from the spectroscopy alone whether hydration is limited to this thin layer or extends deeper into the regolith. It is possible that small amounts of water could be adsorbed on buried grains in the loose regolith that would not participate in the hydration cycle and could not be observed by remote optical spectroscopy but may be discernible by techniques that probe the regolith in greater depth.

Investigation by LEND: The Lunar Exploration Neutron Detector (LEND) on the Lunar Reconnaissance Orbiter (LRO) is sensitive to buried hydrogen [3]. Energetic cosmic rays eject neutrons from nuclei within the regolith with a broad spectrum of energy. Neutrons with energy in the epithermal range, roughly 1 eV to 1 MeV [4] are efficiently degraded in energy by collisions with hydrogen nuclei, depleting the epithermal component of the energy spectrum where hydrogen is present. LEND offers a capability to probe the observed hydration-desiccation cycle without depending on solar illumination.

We select LEND data that fall within the low-latitude range of ±45° latitude and bin the data by sub-spacecraft local time. We have tested several binning widths, ranging from fine-grained “5-minute” bins (1.25° longitude, ~38 km width at the equator) up to bins of several hours in width. The fine-grained binning provides access to information on systematic instrument effects that can be calibrated in the analysis, while coarse binning provides sensitivity to the very weak effects consistent with small amounts of hydrogen volatiles (water) in the regolith. Data for this purpose were collected from the beginning of instrument operations in July 2009. All data used for this purpose are accessible from the PDS. As it happens there were few low-latitude measurements before October 2009. This analysis primarily employs the uncollimated STN3 detector of LEND that senses thermal neutron flux omnidirectionally, the uncollimated SETN detector that responds to epithermal neutrons omnidirectionally, and the CSETN "detector" that is actually a combination of the four collimated epithermal neutron detectors (CSETN1, CSETN2, CSETN3, CSETN4).



The binned data suggest a small modulation as a function of local time in the detection rate of epithermal neutrons using the uncollimated omnidirectional detector labeled SETN. The greatest neutron counting rate, and thus the neutron flux least suppressed, is measured at 15–18 hours, immediately preceding the dusk terminator. The lowest neutron counting rate, and thus the neutron flux that is most suppressed, is measured at 3–7 hours local time, straddling the dawn terminator. Assigning the neutron suppression to the presence of H_2O in the regolith, we can determine a small water content in the dawn region. We will evaluate whether the apparent modulation is a systematic error due to phasing of the measurements with topographic features, and the implications of the observed modulation if it actually is due to the presence of a very small quantity of water in the equatorial regolith.

References:

[1] Sunshine, J. M., *et al.* (2009) *Science* **326**, 565–568. [2] Pieters, C. M., *et al.* (2009) *Science* **326**, 568–582. [3] Mitrofanov, I. G., *et al.* (2010) *Space Sci. Rev.* **150**, 183–207. [4] Lawrence, D. J., *et al.* (2010) *Astrobiology* **10**, 183–200.