LATITUDE DEPENDENCE OF THE HYDROGEN/WATER CONCENTRATION IN THE LUNAR SURFACE MEASURED BY LRO/LEND. T. A. Livengood[1,2], and G. Chin[2], W. V. Boynton[3], T. P. McClanahan[2], and J. J. Su[4]. [1]Astronomy Dept, U of MD, College Park, MD, tlivengo@umd.edu; [2]NASA Goddard Space Flight Center; [3]LPL, UAz; [4] Systems Engineering Group, Columbia, MD.

Introduction: The Lunar Exploration Neutron Detector (LEND) has operated at the Moon since July 2009 to measure the concentration of hydrogen in the upper meter of the lunar surface [1]. Neutron remote sensing operates regardless of illumination and functions in both day and night and within permanently shadowed regions (PSRs) to assess the concentration of hydrogen and thus, water, in the lunar surface [2,3]. LEND was supplied to the Lunar Reconnaissance Orbiter (LRO) mission by the Russian Space Research Institute. The primary goal for LEND was to map the spatial distribution of hydrogen in the polar regions, but LEND operates everywhere over the Moon.

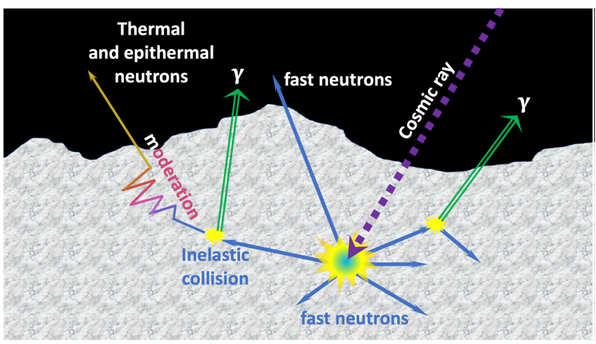

Fig. 1: Lunar neutrons come from Galactic Cosmic Ray (GCR) "illumination", probing ~1m depth. Fast neutrons produced at depth are moderated by collisions with regolith atoms. Hydrogen efficiently moderates moderate-energy "epithermal" neutrons into the thermal energy range, creating a local deficit in epithermal flux from regions with enriched hydrogen.

In September 2009, remote sensing spectroscopy published from multiple other spacecraft demonstrated the existence of widespread hydration in the lunar surface, with the concentration increasing at higher latitude [4,5,6]. Optical/near-infrared spectroscopy does not constrain the depth into the surface of the hydration and thus the total water abundance.

We present the variation with latitude of epithermal neutron flux measured by LEND, using the ratio of flux relative to contemporaneous measurements near the equator to calibrate for variable sensitivity in the neutron detectors as well as natural variability in GCR flux [7]. It was already known that poleward of ~75° (both N and S), neutron depletion increases steeply, consistent with increasing near-surface water abundance. Outside the polar cap region, we find a consistent slope in decreasing epithermal neutron flux from the equator to ~75° latitude, consistent with a small water abundance in the regolith that increases monotonically towards higher latitude [8]. LEND demonstrates that the globally observed hydration is more than skin deep.

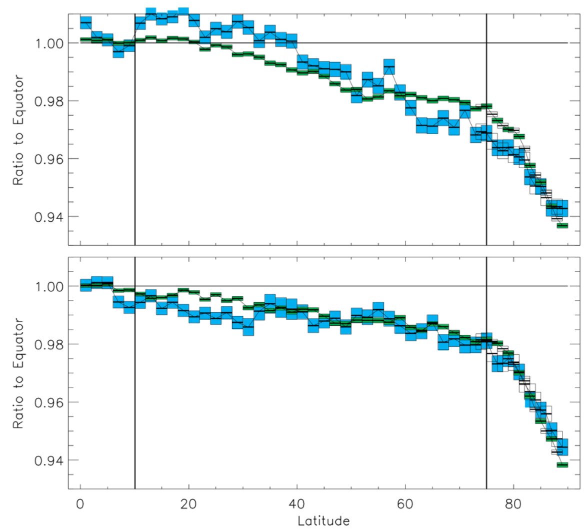

Fig. 2: Meridional profile of declining neutron flux. The decline in neutron leakage flux with latitude is similar in both north (top) and south (bottom) hemispheres, in epithermal (green) and high-energy epithermal (blue) neutrons. Population statistics on bins of 2° latitude result in the mean suppression at each latitude, with uncertainty from standard error of the mean.

Zonally averaged meridional profiles of neutron flux suppression in the southern hemisphere measured in epithermal and higher-energy epithermal neutrons match more closely than in the north, where the maria influence the higher-energy neutron flux at certain latitudes (mid-latitude) and longitudes. In both hemispheres, suppression in a polar cap region starting at ~75° latitude increases more steeply toward the pole, indicating greater surficial water content with increasing latitude.

Water content averaged within 2° of each pole is 0.126–0.129 wt% WEH [8]. The south pole features a few large PSRs within the 88°-90° region, while the north pole does not, yet flux suppression and zonal average water content for these regions is nearly identical.

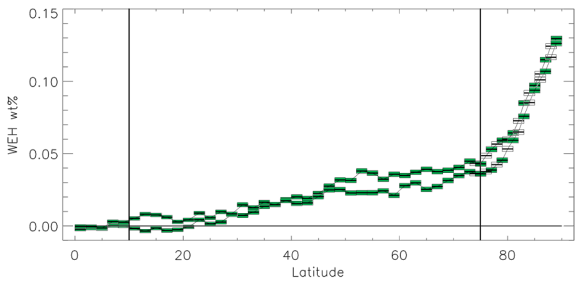

Fig. 3: Meridional profile of surficial water, north and south hemispheres together. Surficial hydrogen content, evaluated as water-equivalent hydrogen percentage by weight (WEH wt%) is inversely proportional to the neutron flux suppression (Fig. 2) for the small quantities found here.

Conclusion: Surficial hydrogen as WEH wt% is shown to be present at all latitudes outside the ±10° equatorial band. Water at the equator is not disproved or even tested – by using the equator as a reference, the relative neutron suppression can detect only the differential water content at other latitudes. However, the zonal average abundance within the upper meter that is sensed is consistent with quantities deduced from NIR spectroscopy.

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