

**LATITUDE DEPENDENCE OF THE HYDROGEN/WATER CONCENTRATION IN THE LUNAR SURFACE MEASURED BY LRO/LEND.** Timothy A. Livengood<sup>1,2</sup>, Gordon Chin<sup>2</sup>, William Boynton<sup>3</sup>, Timothy P. McClanahan<sup>2</sup>, Jao Jang Su<sup>4</sup>, <sup>1</sup>University of Maryland, College Park, MD (tlivengo@umd.edu), <sup>2</sup>NASA Goddard Space Flight Center, Greenbelt, MD, <sup>3</sup>University of Arizona, Tucson, AZ, <sup>4</sup>Systems Engineering Group, Inc., Columbia, MD.

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 thus 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. 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 to assure consistency with earlier measurements by the Lunar Prospector mission.

Lunar neutrons are sourced from galactic cosmic ray (GCR) interactions with the surface. The hydrogen concentration is deduced from regional deficits in the leakage flux of epithermal neutrons, neutrons at low suprathermal energy for which the cross-section to scatter from hydrogen atoms is high, efficiently moderating the energy into the thermal range and thus depleting the epithermal energy population [2].

In September 2009, remote sensing spectroscopy published from three other spacecraft demonstrated the existence of widespread hydration in the lunar surface, with the concentration increasing at higher latitude [3-5]. 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. It was already known that poleward of  $\sim 79^\circ$  (both N and S), neutron depletion increases steeply, consistent with increasing near-surface water abundance [6]. Outside the polar cap region, we find a consistent slope in decreasing epithermal neutron flux from the equator to  $\sim 79^\circ$  latitude, consistent with a small water abundance in the regolith that increases monotonically towards higher latitude. LEND demonstrates that the globally observed hydration is more than skin deep.

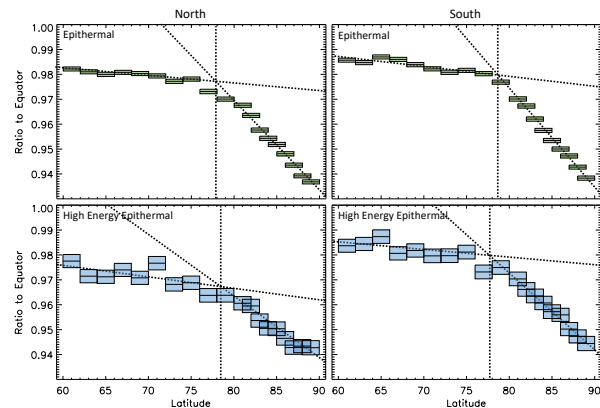


Fig. 1: Neutron leakage flux declines gradually with latitude up to  $79^\circ$ , then declines sharply in the polar regions. North is left, South is on right. Upper plots are for epithermal neutron detector, which probes to a depth of  $\sim 1\text{m}$ ; lower plots are for collimated detectors that have a greater fraction of higher energy epithermal neutrons and probe to  $\sim 0.25\text{m}$  depth, but is influenced (elevated flux) by iron-rich regions such as mare basalts.

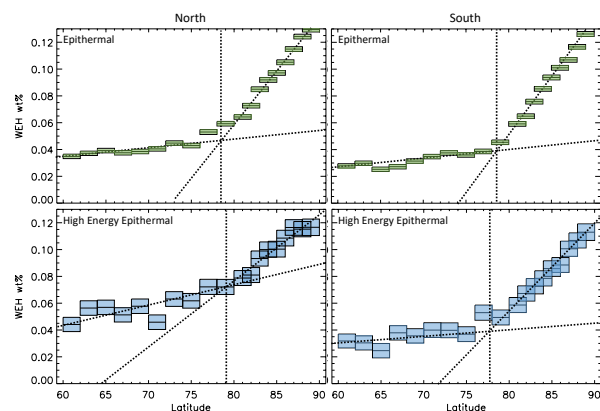


Fig. 2: Inferred water-equivalent hydration fraction (WEH % by mass), differential relative to equatorial band  $\pm 10^\circ$ . Peak water content  $\sim 0.12\text{--}0.13\text{ wt\%}$  at poles, zonally averaged.

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**References:**

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