Hydrogen Distribution From Lunar Prospector Epithermal Neutron Data: Correlations With Impact Craters And Landing Site Samples. J.R. Johnson[1], S. Maurice[2], W. Feldman[3], D. Lawrence[3], P. Lucey[4], and T. Swindle[5], [1]U.S.G.S., Flagstaff, AZ 86001 (jrjohnson@usgs.gov), [2]Observatoire Midi-Pyrénées, Toulouse, France, [3]Los Alamos National Laboratory, NM, [4]Hawaii Institute of Geophysics and Planetology, Honolulu, [5]Lunar and Planetary Lab, University of Arizona, Tucson.

Introduction. Initial studies of neutron spectrometer (NS) data returned by Lunar Prospector (LP) concentrated on the discovery of enhanced hydrogen abundances near both lunar poles [1-2]. However, the non-polar NS data exhibit intriguing patterns that appear spatially correlated with surface features such as young impact craters (e.g., Tycho). We investigated correlations between the observed variations in epithermal neutron counts and impact crater regions of variable age [3] to test the hypothesis that the youngest crater materials have the lowest hydrogen contents because of their relative lack of exposure to the solar wind. We also performed a first-order calibration between epithermal neutron counts at Apollo landing sites and the mean hydrogen content and soil maturity measurements of Apollo samples. We used this calibration with Clementine maturity and iron abundance maps to construct an estimated hydrogen distribution map.

Correlation with craters. The LP epithermal neutron counting rates are inversely proportional to hydrogen content [1-2,4-5]. "Epithermal*" data have been corrected using the LP thermal neutron data for the effects of compositional variations between mare and highlands (mainly Ti, Fe) and for rare-earth elements (REEs). Highest epithermal* counts outside the polar regions often appear to correlate with large, young impact craters, although there are also mare regions with high values (e.g., Orientale). Using a GIS database we calculated the average epithermal* counts of the crater and continuous ejecta regions (2.3 x crater diameter) of Copernican craters >20 km diameter classified as "Old", "Intermediate", and "Young" using the Clementine-derived optical maturity (OMAT)-based age classification system of [3]. The "Young" class was supplemented with high albedo, high OMAT Copernican craters from [6] that are located at latitudes higher than appropriate for the OMAT algorithm [7; **Figure 1**]. A representative group of Eratosthenian craters larger than 20 km also were acquired from [6]. The results (**Figure 2**) show that the mean epithermal* count for each class decreases with increasing age until saturation is reached near the Old/Eratosthenian boundary. This is consistent with the idea that the immaturity of the regolith in these cratered regions results in a dearth of solar wind-implanted hydrogen.

Correlation with landing site soils. The correlation between the epithermal* neutron counts for the Apollo landing sites and average landing site soil hydrogen abundances is relatively poor [8]. To compensate for differences in exposure age, we computed a mean Is/FeO value for the soils from each landing site [10-11] and divided that into the corresponding mean hydrogen content for each site [9]. Then we used the J. Adams lunar soil sample spectral library and computed the OMAT parameter [7] for each soil for which there were hydrogen and Is/FeO measurements. We then obtained a mean OMAT value for each landing site based on the sample spectra and multiplied the result by the Hydrogen/(Is/FeO) values for each landing site. The quantity OMAT*Hydrogen/(Is/FeO) correlates very well with epithermal* counts for the landing sites (r = -0.949) (**Figure 3**). We also made an attempt to apply this correlation to the epithermal* and Clementine FeO and OMAT maps to estimate global hydrogen content (not shown here). A comparison of hydrogen abundances calculated for each landing site location from such a global map compares favorably to the mean hydrogen content measured in lunar soils for all sites except Apollo 16 and 17 (**Figure 4**).

Conclusions. Observations regarding correlations of epithermal* neutron counts with hydrogen content, maturity, and geologic features will be important in understanding the distribution, migration, and retentivity of the solar wind-implanted volatiles in the lunar regolith. The epithermal* data suggest that ejecta from young impacts is depleted in hydrogen relative to older impact materials. Correlations between landing site epithermal* counts and hydrogen content in soil samples are improved by using soil maturity indices. However, preliminary global hydrogen distribution maps created with such correlation functions are only moderately successful in reproducing measured hydrogen contents.

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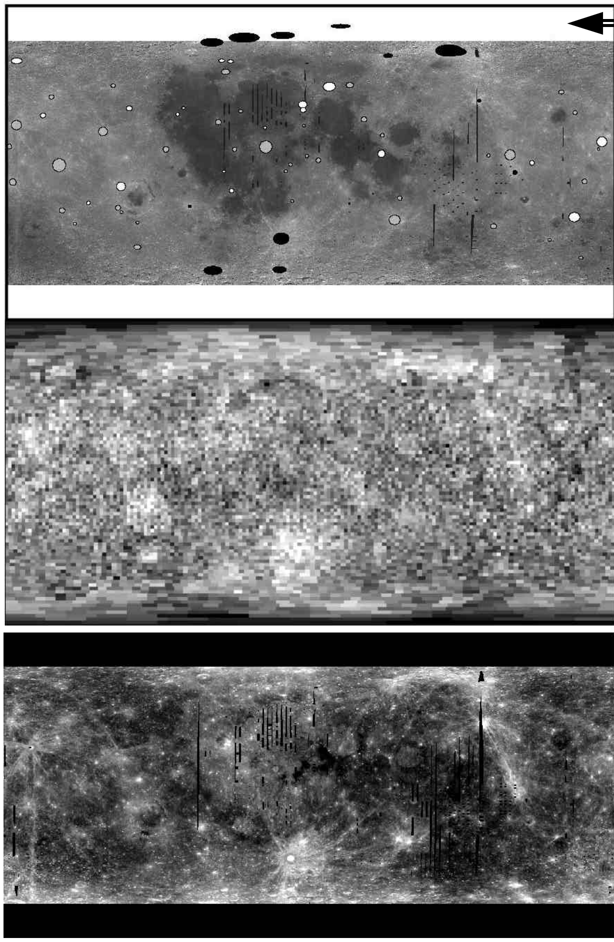


Figure 1. (*top*) Clementine 750 nm map (70S to 70N) with Copernican impact crater locations and continuous ejecta diameters shown. Relative age classification of [3] used, where white craters are "Old", gray are "Intermediate", and black are "Young"; (*middle*) LP epithermal* neutron map [5] where white pixels represent highest counts and black the lowest; (*bottom*) optical maturity (OMAT) image derived from Clementine data using the method of [7].

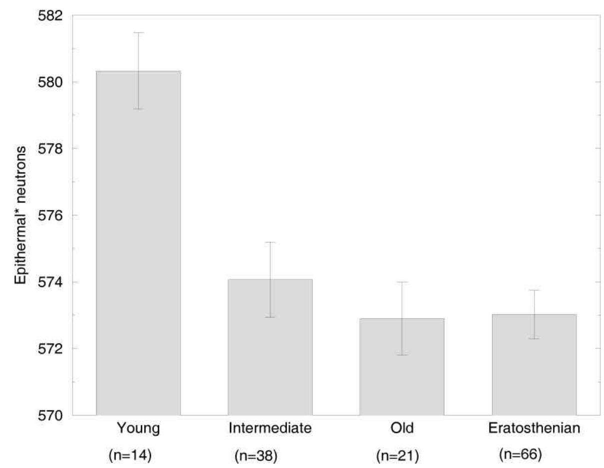
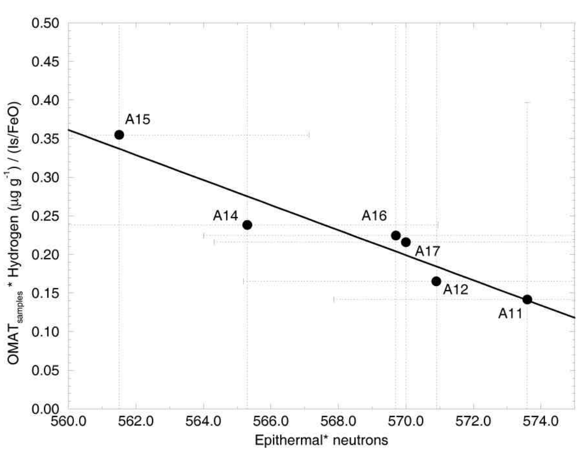


Figure 2. Comparison of average epithermal* neutron counts for continuous ejecta regions of Copernican Young, Intermediate, and Old impact craters [3], and Eratosthenian [6] craters. A decrease in epithermal* counts (increase in hydrogen content) with age is observed. Number of craters *n* shown along with uncertainty of the mean (standard deviation/$(n)^{1/2}$).



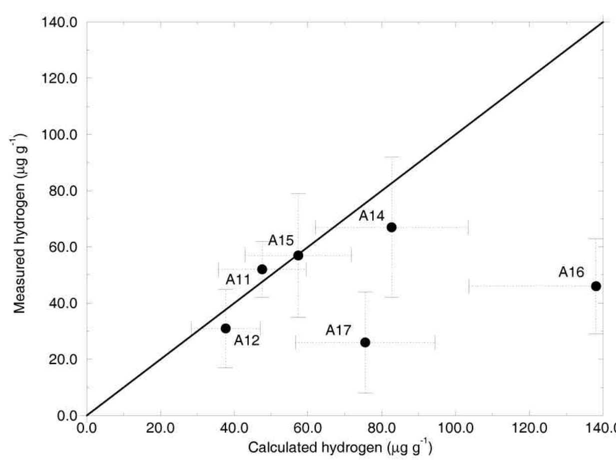


Figure 3. Mean Apollo landing site epithermal* neutron counts (± 1%) compared to the mean hydrogen content of landing site samples divided by their mean Is/FeO values [11] and multiplied by their mean optical maturity (OMAT) value derived from laboratory reflectance spectra of sample soils (± uncertainty of the mean shown). Correlation coefficient of linear fit is –0.949.

Figure 4. Comparison of hydrogen abundances extracted for each landing site location from the estimated global hydrogen distribution map compared to mean hydrogen content in lunar soils. Most points fall near 1:1 correlation line with the exception of Apollo 16 and 17 data.