IMPROVED LUNAR HYDROGEN COMPOSITIONS BY REDUCING THE EFFECTS OF Sm and Gd CONCENTRATION ON LUNAR PROSPECTOR EPITHERMAL NEUTRON DATA.  J. J. Gillis-Davis1,  
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Introduction: Accurate determinations of hydrogen abundance at the lunar poles has importance for investigating the distribution of excess deposits of hydrogen and calculating equivalent weight percent water [1]. Thus far, however, equatorial hydrogen deposits have been overlooked and potential errors on equatorial hydrogen deposits ignored. Johnson et al. [2] suggest that the moderate correlation between mean hydrogen contents measured in Apollo and Luna samples and the epithermal* neutron counts at the landing site is likely due to the effects of Rare Earth Elements (REEs). Incomplete removal of the effect of Sm and Gd on epithermal neutron count rates have the potential for influencing hydrogen compositions. Hence, decorrelating the effects of REEs on Lunar Prospector epithermal neutron has the potential to improve the accuracy of hydrogen concentrations in lunar equatorial regions. Detrending the correlation between epithermal data and REE composition would also account for regional disparities between Lunar Prospector and Clementine estimates of TiO2 [3,4].

Background: Neutrons are generated on the lunar surface by galactic cosmic rays. Fast neutrons are produced first and then scatter down to lower energies through elastic and inelastic collisions. The rate of energy loss is determined mostly by hydrogen, because it has a mass equal to that of a neutron and has a large crosssection for elastic scattering at epithermal energies. In addition, the rate of neutron absorption is determined mostly by the relative abundance of Fe, Ti, Gd, and Sm. If the rates of production and absorption are fixed, the intensity of the neutron flux spectrum at intermediate energies is proportional to the rate of energy loss through collisions from the fast energy range (<700 keV) to the thermal energy range (<0.3 eV). The more hydrogen present, the faster the rate of energy loss, which is observed in a reduced epithermal neutron flux (500-0.3 eV). However, the measured flux of the epithermal neutron is marginally, but measurably, sensitive to elemental composition other than hydrogen. In the past this sensitivity has been minimized by subtracting a small fraction of the thermal flux from the epithermal flux, which has been done by normalizing the number of fast neutron produced in each galactic cosmic ray induced nuclear cascade or by relating a quantity epithermal* to a monotonic relation with thermal neutrons [1].

Discussion: The hydrogen distribution map (Fig 1) shows that equatorial hydrogen deposits contain approximately 180-200 ppm hydrogen, similar in concentration to the polar deposits. An observed correlation between hydrogen distribution map with the thorium distribution map indicates that the effects of Sm and Gd are not properly being accounted for in the epithermal neutron spectrum. In addition, principal component analyses of the two data sets reveal a linear trend between Th composition and epithermal count data. Using this linear trend we are able reduce the effects of Sm and Gd on the epithermal neutron data.

newepis = epi + (578.26 – Th * -3.7+580.65) (1)

Equation 1 shows the regression algorithm used to define the epithermal-thorium trend. Adjustment of the epithermal neutron flux is only done for areas with greater than 1.5 ppm thorium. Lunar Prospector thorium data is used as a proxy for Sm and Gd, assuming that to first order that Th, Sm, and Gd are present in KREEP-like proportions. Thus, areas low in thorium are also low in Sm and Gd and have little affect on the epithermal spectrum.

Results: The hydrogen map produced by the decorrelated epithermal counts – termed newepis – shows little correlation with areas that contain elevated thorium concentrations (Fig 2). In addition, hydrogen concentrations in the equatorial regions are more similar to hydrogen concentration determined for Apollo and Luna soil samples. While the effects of Sm and Gd are removed and the concentrations in better agreement to the lunar samples, there still exists a moderate correlation between mean hydrogen contents measured in Apollo and Luna samples, which suggests that further analyses of the data are warranted and could improve hydrogen and titanium concentration determined using Lunar Prospector neutron data.

Fig 1. Hydrogen distribution map of the Moon [1], centered on the nearside, projected in simplecylindrical, with a resolution of 0.5 degrees (15 km) at the equator. Note the correlation of enriched hydrogen in areas that are rich in thorium (e.g. Fra Mauro Formation and Northern rim of the Imbrium Basin). Areas of immature regolith (e.g., Tycho, Hayn, and basalt within Mare Orientale) exhibit low Hydrogen values because they have been exposed to the solar wind for a shorter period of time.

Fig 2. Improved hydrogen distribution map. Hydrogen values are decoupled from areas of high Th content.