EVALUATION OF TIME VARIABILITY OF WATER FROST IN THE SOUTH POLE PERMANENTLY SHADED REGIONS USING THE LRO LYMAN ALPHA MAPPING PROJECT (LAMP).

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Introduction: The Permanently Shaded Regions (PSR) of the Moon are of great interest due to their ability to retain volatiles longer than areas exposed to sunlight. Of particular interest is the water content of the PSR's. Several methods have been used to estimate the water content of the Lunar PSR's, including visible albedo [1,2], radar [3], neutrons [4], and ultraviolet albedo [5]. Figure 1 illustrates the surface water content determined using the Lunar Reconnaisance Orbiter (LRO) Lyman Alpha Mapping Project (LAMP) ultraviolet spectrograph [5,6] for four PSR's in the south polar region of the Moon. The water content ranges from 0.3% in Shoemaker to as much as 2.0% in Shackleton [5].

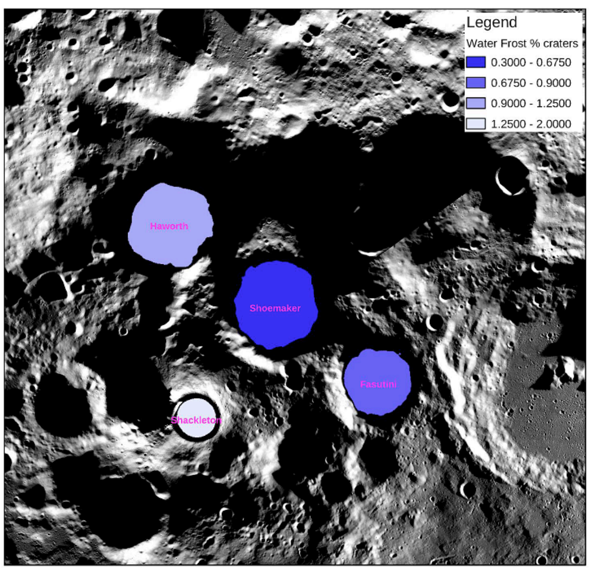

Figure 1: LRO Wide Angle Camera (WAC) composite of the Lunar south pole with LAMP surface water content estimates [5] overlaid on four PSR's.

Interestingly, the water content of Shoemaker estimated by the Lunar Epithermal Neutron Detector (LEND) suggests possible evidence of a large concentration of subsurface water ice [7] compared to the other PSR's. It has been suggested that surface frost prevents neutron detectors from identifying subsurface deposits [8]. Because LAMP is only able to detect surface frost in the top ~50-100 nmthe lack of surface frost at Shoemaker might allow LEND to see a stronger subsurface deposit signature there [5]. Water content at Shackleton has been studied by several instruments with a lack of consistency between measurements (see Table 1). Clearly more work is needed to determine water content in PSR's.

Table 1: Estimates for water content in Shackleton crater determined by a variety of methods.

Method	% H_2O	Ref.
Visible albedo (Kaguya)	< 7.5 %	**[1]**
Radar (Mini-RF)	< 10 %	**[3]**
UV albedo	2 %	**[5]**
Neutrons (LEND & LP)	~ 0.7 %	**[4]**
1064 nm albedo (LOLA)	20% or decreased space weathering	**[2]**

Seasonal variability: Illumination conditions at the south pole are unique. The PSRs receive no direct light at any time, but sunlit peaks on the crater rims demonstrate significant seasonal variability [9]. Reflected light from these sunlit peaks have been found to illuminate the PSR of Shackleton crater enough to allow visible images of the crater's interior during part of the year [1]. We investigate whether reflected sunlight leads to variability in the surface water frost of PSRs in the south polar region.

LRO's nominal mission began in September 2009 and more than 30 months of LAMP measurements are now available to evaluate surface water frost in Lunar PSR's. Figure 2 illustrates the Lyman-α brightness (photons/cm^2/s/sr) of the south polar PSR's that was measured at night during the month of January, 2010. Although the data do not provide full spatial coverage due to limitations imposed by solar illumination and the thermal state of the instrument, sufficient information is available to estimate the surface water content for individual months. We use this to evaluate the water content as a function of time according the methods outlined in [5] to determine if any seasonal effects are evident.

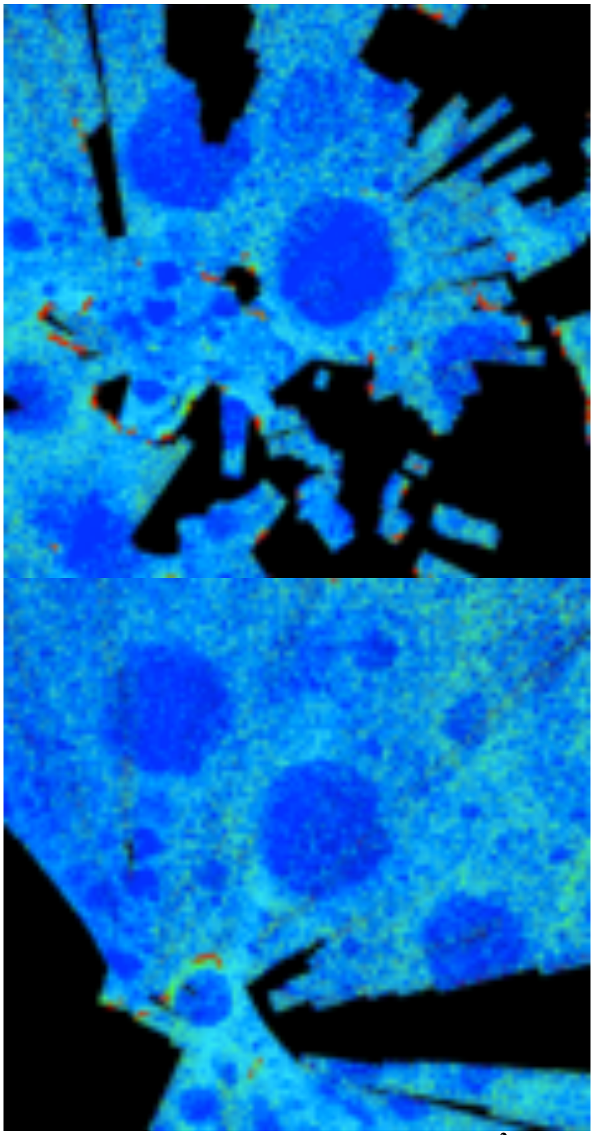

Figure 2: Lyman-α brightness (photons/cm^2/s/sr) of the south polar PSR's as measured by LAMP during January, 2010 (top) and March 2010 (bottom). Red peaks are known sunlit peaks that we exclude from the analysis.

References: [1] Haruyama J. et al., (2008) *Science, 322,* 938–939. [2] Zuber M. T. et al. (2012) *Nature, 486,* 378–381. [3] Thomson, B. J. et al. (2012) *GRL, 39*, L14201. [4] Miller R. S. et al. (2012) *JGR, 117*, E11007. [5] Gladstone, G. R. et al. (2012) *JGR, 117*, E00H04. [6] Gladstone, G. R. et al. (2009) *SSR, 150*, 161–181. [7] Mitrofanov, I. G. et al. (2010) *Science, 330*, 483–486. [8] Lawrence, D. J. et al. (2011) *JGR, 116*, E01002. [9] Bussey, D. B. J. et al. (2010) *Icarus, 208*, 558-564.