Albedo-Temperature Correlations in Lunar Polar Craters

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Introduction: MESSENGER observations of the polar regions of Mercury have revealed strong correlations between normal surface albedo and temperature [1-2] that have been interpreted as strong evidence for the presence of thermally stable surface and subsurface water ice. The LOLA instrument on LRO [3] has obtained an analogous set of normal albedo measurements on the Moon at a wavelength of 1.064 µm [4] that can be interpreted with the aid of surface temperature measurements obtained by the LRO Diviner Lunar Radiometer instrument [5].

Approach: Polar stereographic maps of all calibrated LOLA normal reflectance observations and Diviner annual maximum Channel 8 brightness temperatures obtained poleward of 70° latitude were binned at a resolution of 0.5 km and cross correlated. To reduce the potential effects of "geological" albedo variations, the cross correlations were limited to the interiors of ~400 quasi-circular impact craters with diameters ranging from 10 to 100 km. LOLA normal reflectances within each crater were binned in increments of 10K and then normalized to a value of 1.0 at a bin centered at 255K. The resulting relative variations in normal reflectance as a function of temperature were then averaged for all craters.

Results: Figure 1 shows the average temperature-correlated reflectance variation within all north polar and south polar craters. A strong and consistent trend of increasing albedo with decreasing temperature is evident. Relative albedoes increase by ~8% as temperatures decrease from 350K to 75K in both polar regions. Large error bars are observed at temperatures lower than 75K because the coldest regions occupy a small fraction of the available area, particularly in the north.

Interpretation: The observed ~8% increase in albedo with decreasing temperature must be the result of phenomena that are presently active on the lunar surface. Candidate processes include:

1. *Space Weathering* - Exposed regolith surfaces on the moon darken over time due the formation of nanophase iron and agglutinates [6]. The rates of both darkening processes may be diminished in low temperature regions as colder surfaces receive less sun exposure, and are less prone to melting.
2. *Opposition Effect* - Lunar soil reflectance increases markedly at zero phase angle due to the combined effects of shadow hiding and coherent backscatter [7]. Colder temperatures may affect soil packing geometry or density of soils to alter their backscatter characteristics to produce the observed albedo trends.
3. *Volatiles* - The presence of increasing concentrations of bright surface water ice or other volatiles with decreasing temperatures has been observed on Mercury, and may also be occurring on the moon. The ice may be preferentially concentrated in small regions at textural scales below the spatial resolution of the present study.

We expect to narrow our interpretations through further analysis and consideration of additional data.

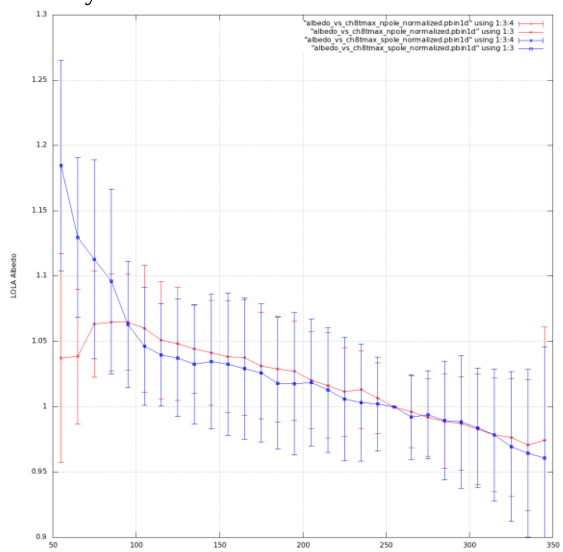

Figure 1. Correlation of relative LOLA albedo with Diviner Channel 8 annual maximum temperatures within ~400 impact craters in the lunar north (red) and south (blue) polar regions.

References: [1] Neumann et al., Science 339, 296-300, 2013. [2] Paige et. al., Science 339, 300-303, 2013; [3] Smith et al., Space Sci. Rev. 150, 209-241, 2010; [4] Lucey et al., JGR *in preparation*, 2013; [5] Sefton-Nash et al, NLSI Volatiles Workshop, 2013; [6] Hapke JGR 106, 10,039-10,073, 2001; [7] Hapke, Theory of Reflectance and Emittance Spectroscopy, Cambridge Univ. Press, 1993.