Evidence for surface volatiles on the Moon and Mercury: A Planetary Comparison

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Introduction: An analysis of lunar polar surface volatiles would be incomplete without comparison to similar thermal environments of the planet Mercury. The Moon and Mercury both have cold, permanently shadowed regions featuring temperatures low enough to preserve water ice and other volatiles. With data from the Lunar Reconnaissance Orbiter (LRO) and MESSENGER missions, we can now begin to make detailed comparisons of surface reflectance data to evaluate evidence of surface polar volatiles on these two solar system bodies.

Background: Both LRO and MESSENGER carried 1064-nm wavelength laser altimeter instruments that provide a unique, zero-phase measurement of surface reflectance. Surfaces measured by the Mercury Laser Altimeter (MLA) showed higher than average surface albedo within some shadowed craters near the North Pole [1]. Modelling surface temperatures with MLA topography, these same areas were found to provide thermally stable environments for surface water ice to survive for geologic time [2]. In addition to the Lunar Orbiter Laser Altimeter (LOLA), LRO also carries a UV spectrometer, LAMP, which can detect surface frosts in polar regions illuminated by the Lyman-Alpha background illumination.

This study: We further develop the study of Paige et al. [2] and apply a similar technique to newly available data from LOLA. In the previous studies for Mercury [1,2] MLA data were unavailable at latitudes northward of 84° (due to the MESSENGER orbit). Since this time, a campaign of off-nadir measurements has extended both MLA topography and reflectance measurements to colder areas nearer to the North Pole. We assert that the presence of a surface volatiles could result in characteristic "bumps" and "dips" in brightness as a function of maximum surface temperature, a *volatility spectrum*.

Results: Figures 1-3 show the volatility temperatures of several volatile materials plotted as vertical lines on top of a point cloud (grey) of all available MLA (Fig 1), LOLA (Fig 2) and LAMP (Fig 3) data as a function of maximum surface temperatures from Diviner and MLA/thermal modeling. Maximum surface temperature controls the abundance of surface ice measured by remote spectroscopy. These comparisons suggest that both the Moon and Mercury may harbor surface volatiles, but that that these volatiles are not the same on the two planets and may have different sources. Understanding these sources has important implications for the delivery and retention of volatiles in the inner solar system.

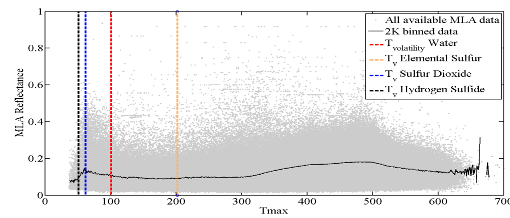

Figure 1: MLA reflectance vs maximum modeled surface temperature [updated models from Paige et al., 2013].

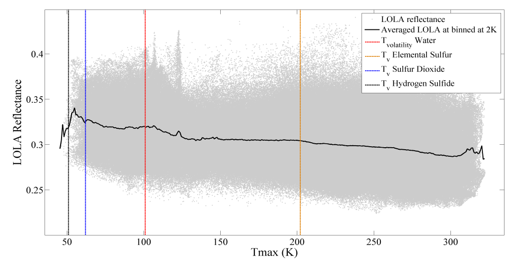

Figure 2: LOLA reflectance vs maximum Diviner measured surface temperature.

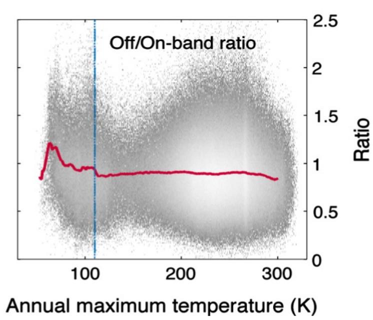

Figure 3: LAMP Off/On-band ratio vs maximum Diviner measured surface temperature from Hayne et al., 2015.

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