LAYERED MORPHOLOGY OF THE LATITUDE-DEPENDENT MANTLE: A POTENTIAL LATE-AMAZONIAN PALEOCLIMATE SIGNAL. S. C. Schon[1], J. W. Head[1] and R. E. Milliken[2] [1]Dept. of Geological Sciences, Brown University, Providence, RI, 02912 USA; samuel_schon@brown.edu. [2]Jet Propulsion Lab, 4800 Oak Grove Dr., Pasadena, CA 91001 USA.

Introduction: Recent high-resolution imaging has confirmed earlier observations of latitude-dependent mantling deposits whose emplacement may be controlled by obliquity-driven climate changes. Systematic latitudinal variation in surface roughness was observed using MOLA data [1]. Within the mid- to high- latitude region of both hemispheres, higher latitude terrains were found to be smoother at short baselines. Using Mars Orbiter Camera (MOC) images, [2,3,4] presented morphological observations of young surface textures ranging from smooth and continuous to highly degraded, viscous flow features, and gullies which they interpreted as consistent with the recent emplacement of ice-cemented loess undergoing desiccation/degradation. Observational [5], theoretical [6,7], and experimental [8] studies support the stability of near-surface ground ice in this latitude regime. Gamma-ray spectroscopy results also document abundant hydrogen [9,10]. Stratigraphic analysis of layering within mantle deposits is a means of assessing formation hypotheses such as vapor diffusion (e.g., [11]) and airfall deposition that may be correlative with geologically recent obliquity perturbations (Figure 1) [12].

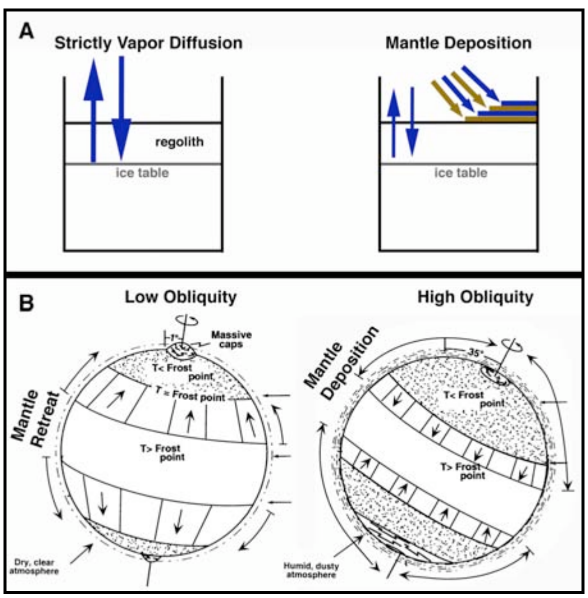

Figure 1: A) Schematic illustrating the difference between strictly vapor diffusion (left) and obliquity-driven surface emplacement of mantling materials (right). **B)** High obliquity expands the zone of mantle stability and mobilizes volatiles from higher latitude reservoirs for mantle deposition.

Observations: Layering within the mantle is observed symmetrically within the mid-latitudes of both hemispheres, but outcrops are more numerous in the southern hemisphere where the topographic variability of the basement more frequently generates favorable slopes with orientations that expose layering. Generally, mantle surface texture varies from smooth and continuous at higher latitudes to discontinuous, sublimation pitted, degraded mantle textures at lower mid-latitudes.

Latitude bands. Layering outcrops are concentrated in the transitional zone between these textures (~35°-40°); most MOC and HiRISE images in which layering was observed individually contain both smooth and degraded mantle textures. The global MOC catalog of ~13,000 images compiled by [3] contains 101 southern hemisphere images interpreted as mantle layering outcrops located between 28.9°S and 49.44°S with a median of 37.9°S ($\bar{x}$=37.9°S). This latitudinal range is commensurate with a band of strong slope asymmetry attributed to obliquity-controlled insolation geometry that favored downslope movement on pole-facing slopes [13] as well as the occurrence of young gullies [14]. HiRISE images between 20°S and 50°S were also analyzed: 42 of 210 images contained evidence of mantle layering with a median of 37.9°S ($\bar{x}$=37.8°S).[1]

Slope and Orientation. Mantled craters, valleys, and scarps are common in this subset because of their association with slopes that are advantageous for observing layering in cross-section. Smooth mantle textures are observed preferentially on equator-facing slopes, while degraded mantle textures exhibit a preference for pole-facing slopes. Asymmetrically mantled craters illustrate this phenomenon and are common in the latitudinal band between smooth and degraded textures where layering is most commonly observed: smooth mantle morphology dominates the equator-facing interior wall, while the pole-facing interior wall is degraded (Figure 2).

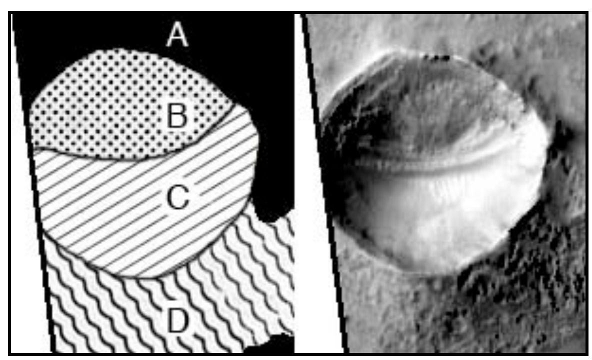

Figure 2: This portion of MOC M0402834 (40.5°S, 190.4°W) illustrates asymmetric mantle textures associated with a (~340m) crater: **A)** Smooth equator-facing crater rim, **B)** Degraded pole-facing crater interior; **C)** Smooth equator-facing crater interior, **D)** Degraded pole-facing crater rim.

Commonly crater walls are too steep and altered (e.g., gullies, slumps, viscous flow features) to be conducive to mantle stratigraphic exposure, but pole-facing slopes from raised crater rims are frequently observed locations for

[1] Stereo pairs are considered a single observation for statistical purposes.

outcrops of layered mantle units; characteristic mantle textures are shown in Figure 3. Insolation control of preserved mantle texture is highlighted by observations where a pole-facing, steep slope is dominated by degraded texture, but benches of much gentler slope have smooth mantle texture (e.g., PSP_002317_1445; 35°S, 195°E) [15].

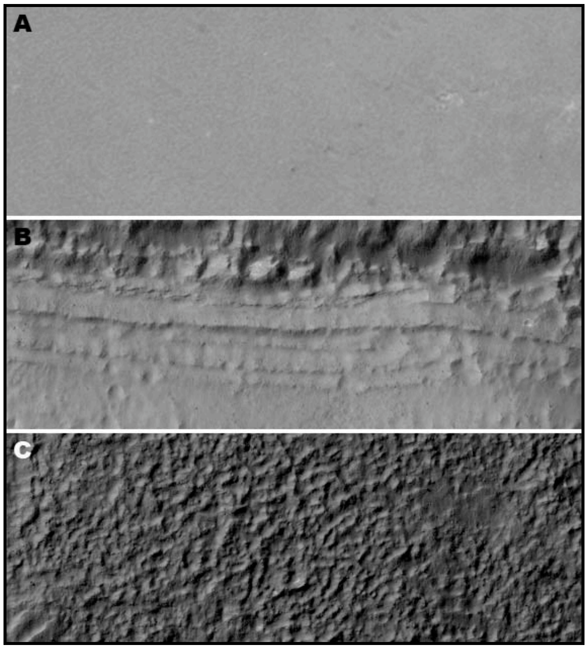

Figure 3: Characteristic mantle textures from HiRISE observation PSP_001507_1400 (39.6°S, 343.8°E), all frames are 284.5m across, north is to the top, and illumination is from the upper left. **A)** Smooth mantle texture, commonly observed on equator-facing slopes and at higher latitudes **B)** outcrop of mantle stratigraphy, note raised layers interpreted as resistant lags **C)** degraded mantle texture, commonly observed on pole-facing slopes and at lower latitudes.

Layer Morphology. Individual layers are interpreted to be of relatively uniform and consistent thickness (on the order of several to ten meters). Cross-bedding relationships are not observed and correlation of layered units is possible within a single observation when surface features and outcrop geometries are similar (e.g., M1900888, PSP_001507_1400). Therefore, layers are interpreted to be of wide aerial extent. Approximately tripartite layering with homogeneous lithologic facies (degraded textures) is the most common style of layering observed in outcrop. However, finer layering is observed on more gentle slopes where ≥8 individual layers are sometimes distinguishable (Figure 4). These homogeneous units are discernable by slight variations in texture and albedo near the limit of resolution in MOC data. Within the sequence, smooth textured lower albedo surfaces separate higher albedo, raised relief, blocky and segmented surfaces. These blocky segments are interpreted as semi-consolidated dust-rich lag deposits that may represent boundaries of depositional events. These lags are thought to be more resistant and provide the strength to support greater relief than intervening units, which are interpreted as the sublimated remnants of the most initially ice-rich layers.

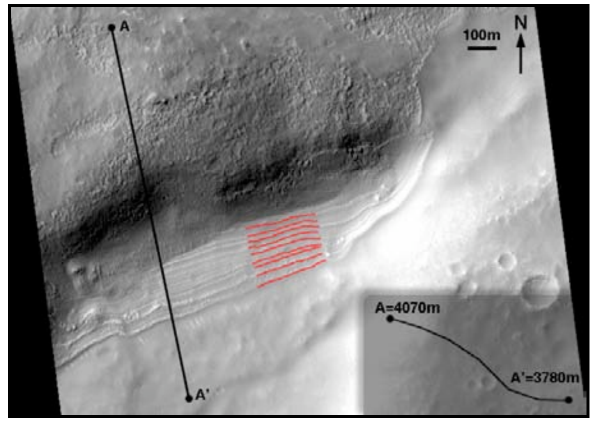

Figure 4: This portion of MOC M0204329 (38.01°S, 113.59°W) contains an outcrop of fine mantle layering associated with a gentle pole-facing slope.

Implications: Layered mantle outcrops provide genetic evidence of syndepositional layering interpreted to be the result of cyclical deposition of an ice-rich eolian dust material (loess), which is inconsistent with a strictly vapor diffusion model of high latitude terrain softening. Individual units are hypothesized to represent short-duration geologically recent obliquity excursions. In this model, excursions from the current mean obliquity lead to the mobilization of volatiles that are deposited in mid-latitude regions. This deposition is expected to be most ice-rich initially then become increasingly dust-rich, leading to a reverse grading pattern in these units. Therefore, one smooth texture low albedo unit and one blocky high albedo unit together could be the result of one obliquity excursion, but more work remains to explore the relationship between obliquity variation and mantle stratigraphy.

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