HiRISE CHARACTERIZATION OF THERMOPHYSICAL UNITS AT ACIDALIA PLANITIA, MARS.

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Introduction: The thermophysical properties of a surface (albedo, thermal inertia) are determined by physical attributes (e.g., particle size, rock/bedrock exposure, degree of induration) relevant to understanding the surface's geological nature. As part of an ongoing effort to characterize in detail the global thermophysical units previously identified in Mars [1, 2, 3], we report results regarding a region of Acidalia Planitia. This region includes the largest outcrop (~1x10^6 km^2, the area of Egypt) of thermophysical unit F on the planet. Unit F has the highest thermal inertia values and low albedo; it has been interpreted as a surface dominated by rocks, bedrock, and duricrust [3] (fig. 1). Understanding the nature of the large unit F region at Acidalia may shed light on past and present processes active in the northern lowlands.

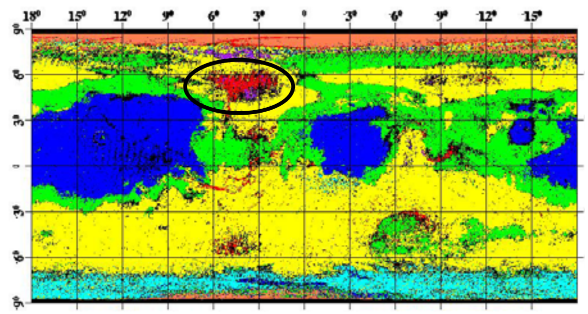

Figure 1. Global thermophysical units [3]. Black ellipse indicates Acidalia study region. Unit A (blue): bright unconsolidated fines. B (yellow): sand, rocks, and bedrock; some duricrust. C (green): duricrust, some sand, rocks and bedrock. D (cyan): low density mantle or dark dust. E (purple): as B, but little or not fines. F (red): rocks, bedrock, and duricrust. G (orange): very bright, thin dust deposits and polar ice.

Methods and Results: MOLA, MOC, and HiRISE data have been analyzed together with TES-derived thermal inertia values to investigate the surface expression of the thermophysical units present in Acidalia.

Slopes and morphology of the study region do not differ (at MOLA scale) from those of surrounding areas in the Northern plains (fig. 2). At more detailed scale (MOC, HiRISE) we observe a strong correlation between presence or absence of mantle terrain [4] and thermophysical unit type. Mantle terrain has characteristic subdued topography and uniform albedo; it has been interpreted as ice-cemented aeolian materials deposited during high-obliquity periods. Current obliquity conditions would have rendered these deposits unstable, hence their degradation (dissection) [4]. In the Acidalia study region dissected/mantle areas correspond predominantly to unit B (sand, rocks/bedrock, some duricrust); mantle-free areas to unit F (fig. 3). Latitude does not seem to explain this observation: we find mantle-free unit F areas at the same and higher latitudes as mantle terrain in unit B.

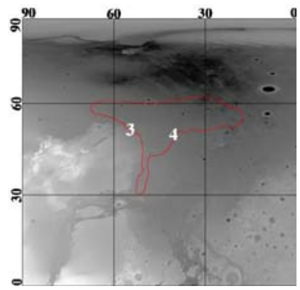

Figure 2. MOLA topographic data; lighter gray levels indicate higher elevation. Red contour indicates unit F at Acidalia. Labels show location of subsequent figures.

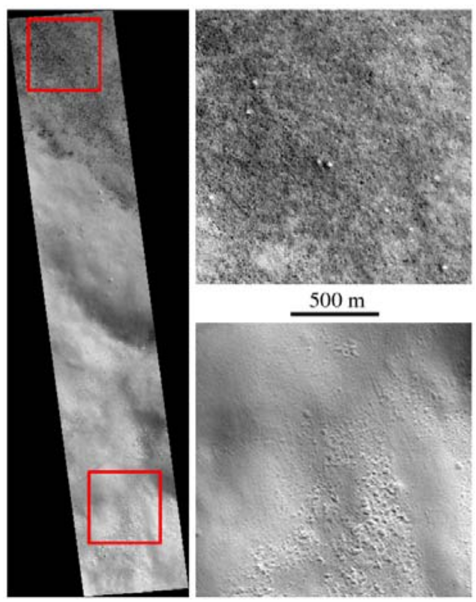

Figure 3. MOC M0307028 [5] showing gradual transition between materials of thermophysical unit F (top) and B (bottom). Illumination is from lower left.

A survey of the MOC narrow angle images covering unit F in the study region shows plains peppered with boulders and locally criss-crossed by dark dust devil tracks. The latter is indicative of a thin veneer of light-colored particles covering darker materials. Lack of aeolian features such as dunes and ripples indicate lack of loose materials movable by wind (at least 100-

200 µm in size) and/or lack of winds of sufficient strength to move such materials. HiRISE reveals that the boulders are rather sparse, angular, and range in size between 1m (~minimum resolvable) and 6 m across. The mostly flat inter-crater surface presents a dense network of low, arcuate ridges (fig. 4).

The TES thermal inertia values for unit F in the Acidalia study region range mostly between 400 and 600 tiu (J m^{-2} K^{-1} $s^{-1/2}$), locally reaching values around 800; the scarce boulders observed do not justify such high values. To investigate the nature of the inter-boulder surface, rock abundance was measured in HiRISE images and the thermal inertia of a putative fine-grained component of the surface was derived as described in [6, 7]. Our calculations utilize conservative values to avoid the overestimation of the fine component inertia. The particle size of the fine-grained component was then determined [8, 9] (table 1). The results indicate that medium-to-coarse sand and gravel are required to justify the thermal inertia of this region; duricrust deposits could also explain such high values.

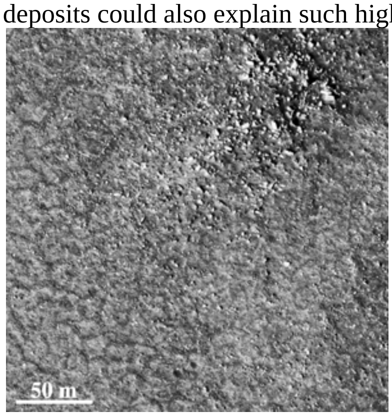

Figure 4. Subset of HiRISE PSP_001745_2295 showing unit F surface in detail.

Table 1

HiRISE Scene	TES TI (tiu)	Rock Abundance	Fine Component TI (tiu)	Fine Component Size
PSP_001481_2410	630	0.05	600	>few µm fine gravel
PSP_001745_2295	365	0.11	300	900 µm coarse sand
PSP_001785_2330	480	0.3	250	400 µm medium sand
N/A Unit F at Acidalia	500	0.127 [10]	420	~4 µm very fine gravel

The absence of finer-sized materials could be explained by wind removal. This hypothesis is supported by NASA Ames Mars GCM simulations which show the highest value of surface wind stress on the planet in the region of Acidalia Planitia and along the southern rim of Hellas Basin (fig. 5).

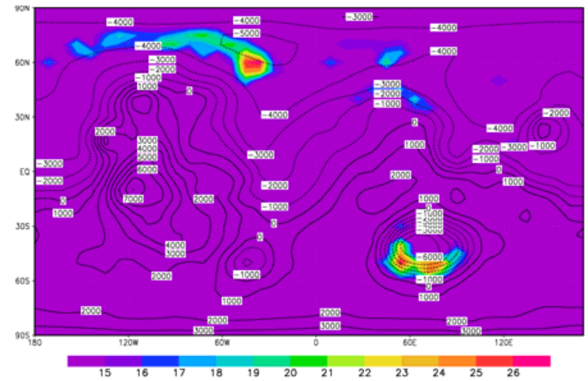

Figure 5. Maximum annual wind stress (mN). Topographic contours are shown in black.

Discussion: The elevated thermal inertia of unit F can be explained by scattered boulders on sand and gravel and/or on duricrust. Vertical layering (e.g., loose particles on bedrock or on duricrust) could also explain fine component thermal inertia values over 400 tiu. Spectral evidence supporting the presence of duricrust in this region is absent: sulfates, the most likely cementing agent, or hydrated phases have not been identified in the OMEGA or CRISM spectral datasets thus far [11, 12]. Previous analysis of TES spectral data have identified Acidalia as andesitic [13] or, alternatively, weathered basalt [14]. This region is spectrally (and, hence, compositionally) more diverse than the planet's average, as shown by its anomalously high TES Spectral Variance Index, locally 4 stdv over the average [15]. This would not be consistent with a spectrally homogeneous duricrust cover.

Lacking finer-sized materials could have been removed by wind. Mantle terrain, absent in unit F but observed in unit B nearby, could have been ablated by wind. Systematic removal of dust deposited during global storms is consistent with localized wind patterns in Acidalia. GCM results indicate a global wind stress maximum in Acidalia, resulting from the juxtaposition of strong winds associated with the northern hemisphere winter storm track and the higher densities associated with lower topography.

References: [1] Mellon et al. (2000) *Icarus*, 148, 437-455. [2] Putzig et al., (2005) *Icarus*, 173, 325-341. [3] Putzig (2006) *PhD Dissertation*. [4] Mustard et al. (2001) *Nature*, 412, 411-413. [5] www.msss.com/moc_gallery. [6] Golombek and Rapp (1997) JGR, 102, E2, 4117-4129. [7] Golombek et al. (2003) *JGR*, 108, E12, 8086. [8] Presley and Christensen (1997) *JGR*, 102, 6551-6566. [9] Jakosky (1986) *Icarus*, 66, 117-124. [10] Christensen (1986) *Icarus*, 68, 217-238. [11] Bibring et al. (2006) *Science* 312, 400-404. [12] Pelkey et al. (2007) JGR, 112, E08S14. [13] Bandfield et al. (2000) *Science*, 287, 1626-1630. [14] Wyatt and McSween (2002) *Nature*, 263-266. [15] Martínez-Alonso et al. (2006) *JGR*, 111, E01004.