THERMAL INERTIA ANALYSIS OF THE MARTIAN GLOBE, SOUTH POLAR REGION, AND PAST LANDING SITES.

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Introduction: We present new results from the analysis of thermal inertia as derived from Thermal Emission Spectrometer (TES) data throughout the primary mapping mission of the Mars Global Surveyor (MGS) [1,2]. Global analysis of thermal inertia together with albedo confirms the presence of three previously identified major surface units [2], and further delineates several smaller regions with distinct characteristics. Most notably, a fourth unit of low thermal inertia and low-to-intermediate albedo dominates the region poleward of 65ºS. We also performed a detailed analysis of thermal inertia over the Pathfinder and Viking landing sites, providing an important link between surface characteristics observed *in situ* and those derived from remote-sensing data.

Background: Thermal inertia is the key surface property controlling diurnal temperature variations and is dependent on the particle size, degree of induration, rock abundance, and exposure of bedrock within the top few centimeters of the subsurface. It is defined as the combination of thermal conductivity k, density ρ, and heat capacity C of the surface layer such that:

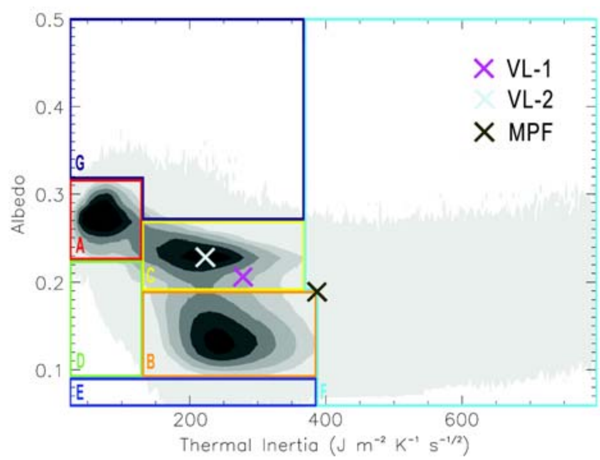
$$I \equiv \sqrt{k\rho C} \; .$$

Thermal inertia is a measure of the subsurface's ability to store heat during the day and to re-radiate it during the night. We report all thermal inertia values in units of J m^{-2} K^{-1} $s^{-1/2}$.

Unconsolidated fines (i.e., dust) will have low values of thermal inertia, indurated dust (duricrust) and sand-sized particles will have intermediate values, and rocks and exposed bedrock will have high values. In the context of MGS observations, the thermal inertia of any given location on the martian surface is generally controlled by a variable mixture of such materials on the scale of the TES observations (approximately 3 x 6 km). By considering thermal inertia together with other observed surface properties, one can gain insight into the physical characteristics of the surface and the geological processes which have affected it.

Methodology: We used global maps of thermal inertia and albedo from *Mellon et al* (2001), MOLA elevation, MOC images, and Viking MDIM 2.0 in our global, regional, and local analyses. The thermal inertia map was derived from nighttime (approximately 2 AM local time) thermal bolometer observations of surface temperature gathered during TES orbits 1583-11254, covering over one Mars year (L_s 103º to 360º + 0º to 152º) [1,2]. The mapping process employed filters to eliminate observations from periods of high water-ice-cloud and atmospheric-dust opacity and completely excludes orbits 4199-5410, due to the 1999 global dust storms. Map overlays and two-dimensional histograms between the various datasets at each analysis scale are used to delineate areas with common features and to assign mapping units.

Globe and South Polar Region: Previous analyses [1,2] of MGS-TES derived thermal inertia identified three regions of distinct albedo and thermal inertia (Units A, B, and C in Figures 1 and 2). These have been interpreted as surfaces dominated by (A) unconsolidated fines; (B) courser-grained sediments, rocks, bedrock exposures, and some duricrust; and (C) duricrust with some rocks and/or bedrock exposures.



Here, we further subdivide the thermal inertia-albedo parameter space into regions of (D) low thermal inertia and low-to-intermediate albedo; (E) very low albedo; (F) very high thermal inertia; and (G) very high albedo (see Figure 1). Figure 2 provides a global map of these units, showing their areal distribution. Unit D exhibits distinct low-thermal-inertia boundaries, making it unique from higher thermal inertia Units B and C. Unit D dominates the region south of about 65ºS. While the low thermal inertia of this unit corresponds to that of Unit A and is similarly indicative of a fine-grained, unconsolidated surface, its significantly lower albedo suggests that it either is compositionally distinct or has been altered by a darkening process, perhaps one related to its polar location.

Other regions of interest include those of very low albedo delineated by Unit E (Acidalia: 40-80ºN, 20-

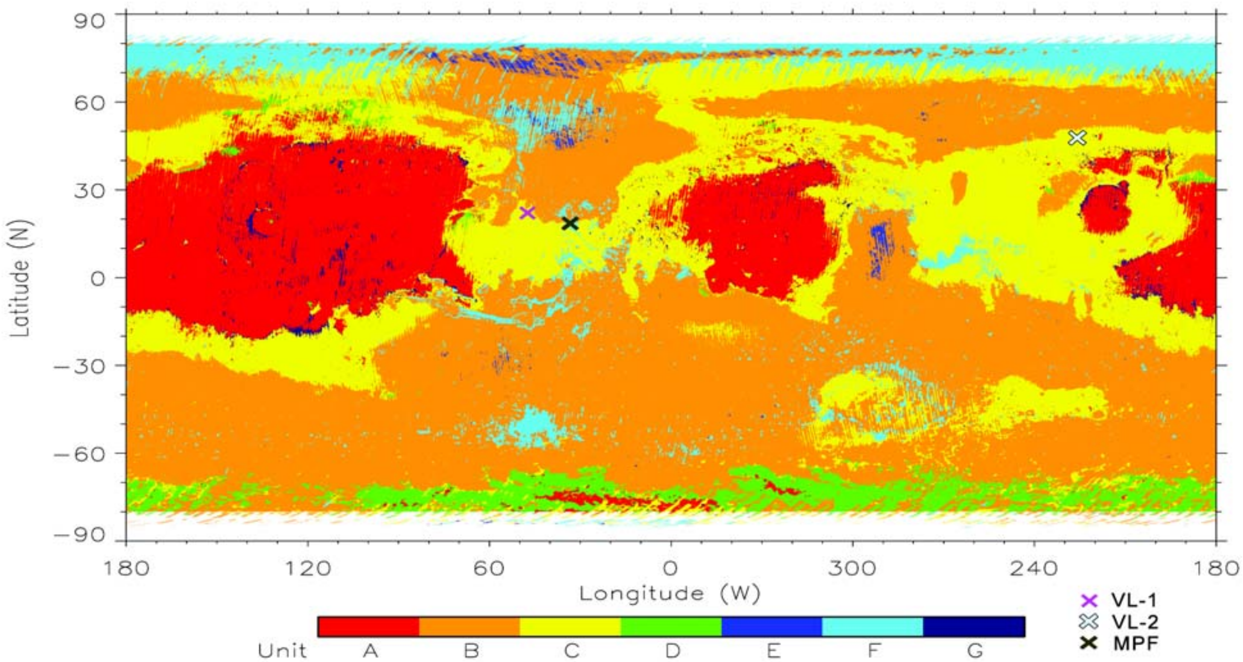


Figure 0: Global map of thermal inertia-albedo units for Mars. Units letters correspond to those in Figure 1.

80ºW; Syrtis Major: 0-20ºN, 285-295ºW) and those of very high thermal inertia delineated by Unit F (Acidalia: 40-60ºN, 25-55ºW; Valles Marineris and outflow channels: 15ºS-30ºN, 25-80ºW; Argyre: 45-55ºS, 40-60ºW; Isidis: 0-15ºN, 305-315ºW; Hellas: 30-60ºN, 270-310ºW; however, much of Unit F poleward of 70ºN can be attributed to uncompensated atmospheric effects [1]). The Unit E regions have thermal inertias similar to and are generally surrounded by Unit B, and it is reasonable to expect them to have similar physical properties. One possible interpretation is that these areas are unusually free of dust relative to Unit B, but are otherwise of the same general composition. The Unit F regions are likely to contain high rock abundances and/or exposed bedrock at the surface, given their high values of thermal inertia. See Table 1 for a summary of unit boundaries and their interpretation.

Unit	*Inertia*	*Albedo*	*Interpretation*
A	Low (24-130)	High (0.23-0.32)	Unconsolidated fines (high albedo)
B	High (130-386)	Low (0.09-0.19)	Course grains, rocks, bedrock, some duricrust
C	High (130-368)	Med. (0.19-0.27)	Duricrust, some rocks and/or bedrock
D	Low (24-130)	Low-Med. (0.09-0.23)	Unconsolidated fines (low albedo)
E	Low to High (24-386)	Very Low (< 0.09)	As Unit B, but little or no unconsolidated fines?
F	Very High (>386)	All	High rock abundance and/or bedrock

Table 1: Unit bounds and possible interpretation.

Past Landing Sites: The Viking and Pathfinder landers provided *in situ* data on the physical properties of the martian surface in three locations, all of which exhibited varying quantities of unconsolidated dust, duricrust, rocks, and bedrock exposures [3,4,5]. This information provides a reference for interpretation of remote-sensing data. We analyzed MGS derived thermal inertia, albedo, and elevation data co-registered to Viking MDIM 2.0 over the landing sites and found a good correspondence between the *in situ* observations of physical surface characteristics and those inferred from the orbiter data. Both Viking sites are well within the bounds of Unit C, whereas the Pathfinder site falls within Unit F near the boundary of Units B and C (Figure 1). This is in keeping with the observed rock abundances (see Table 2) and the higher degree of induration at the Pathfinder site [6].

Site	*Inertia*	*Albedo*	*Unit*	*Rocks*
VL-1*	283	0.22	C	6%
VL-2	234	0.24	C	14%
MPF	387	0.19	F	16%

Table 2: MGS thermal inertia and albedo, their associated Unit, and observed rock abundances [3,4,5] for the Mars landing sites. *VL-1 location corrected in 1999 [7].

References: [1] Mellon *et al* (2001) *LPSC XXXIII*. [2] Mellon *et al* (2000) *Icarus* 148. [3] Christensen & Moore (1992) in *Mars*, Kieffer et al, eds., U. of Az. [4] Golembek & Rapp (1997) *JGR* 102. [5] Golembek et al (1999) *JGR* 104, 8585-8594. [6] Moore *et al* (1999) *JGR* 104. [7] Parker & Kirk (1999) *LPSC XXX*.