

**THERMAL PROPERTIES OF SAND FROM TES AND THEMIS: DO MARTIAN DUNES MAKE A GOOD CONTROL FOR THERMAL INERTIA CALCULATIONS?** L. K. Fenton and R. L. Fergason, Arizona State University, Mail Code 1404, Tempe, AZ, 85287, [lkfenton@asu.edu](mailto:lkfenton@asu.edu), [Robin.Fergason@asu.edu](mailto:Robin.Fergason@asu.edu).

**Introduction:** Thermal inertia is a measure of a material's thermal response to the diurnal heating cycle. Loose, fine-grained sediments lose heat rapidly after sunset, leading to low thermal inertia values. Increasingly consolidated sediments and coarser-grained materials (i.e., sand, gravel, boulders, and bedrock) lead to successively weaker diurnal extrema from higher heat retention and therefore they produce progressively higher thermal inertia values. In ideal situations where all other factors are accounted for, thermal inertia can be used to estimate the average grain size of a particulate surface material.

Dune fields are composed of well-sorted unconsolidated particulates of a known grain size, making them ideal targets for verification of thermal models. In some sense, dune fields may be regarded as "ground truth" for thermal inertia calculations, because their thermal properties are well constrained. Because of this predictability, the thermal inertia of martian dunes has been studied since the first thermal models were produced for Mars, e.g., [1], [2]. In particular, the Proctor Crater dune field of the Helluspontus area in Noachis Terra has been used as a basis for comparison between different models [3] and between different dune fields [4].

Thermal data from TES and THEMIS provide a much higher resolution view of the surface of Mars. With these data sets, we look once again at the thermal properties of the Proctor Crater dune field in Noachis Terra (see Figure 1a). We find that there are thermal variations present within the dune field. Some variations correspond to exposed underlying surfaces in the interdunes, but others occur even in areas of complete sand cover. We put forth a hypothesis that may explain the observed thermal variations within the dune sand. We then discuss the potential implications of using dune sand as a control for thermal inertia studies, given the observed range of thermal properties.

**Results:** Because thermal inertias are derived from nighttime surface temperatures, we use THEMIS IR surface brightness temperatures as a proxy for thermal inertia for much of this work. Figure 1b shows three overlapping nighttime THEMIS IR images that pass over the Proctor Crater dune field. Yellows and reds correspond to higher DN values (warmer temperatures) and blues and violets correspond to lower DN values (cooler temperatures). Although each image was obtained at a different time during the martian summer, leading to seasonal differences in surface

temperatures, an offset has been set here to make the images appear to have the same range of surface temperatures – this offset makes qualitative comparisons between images simpler, although it has no quantitative value.

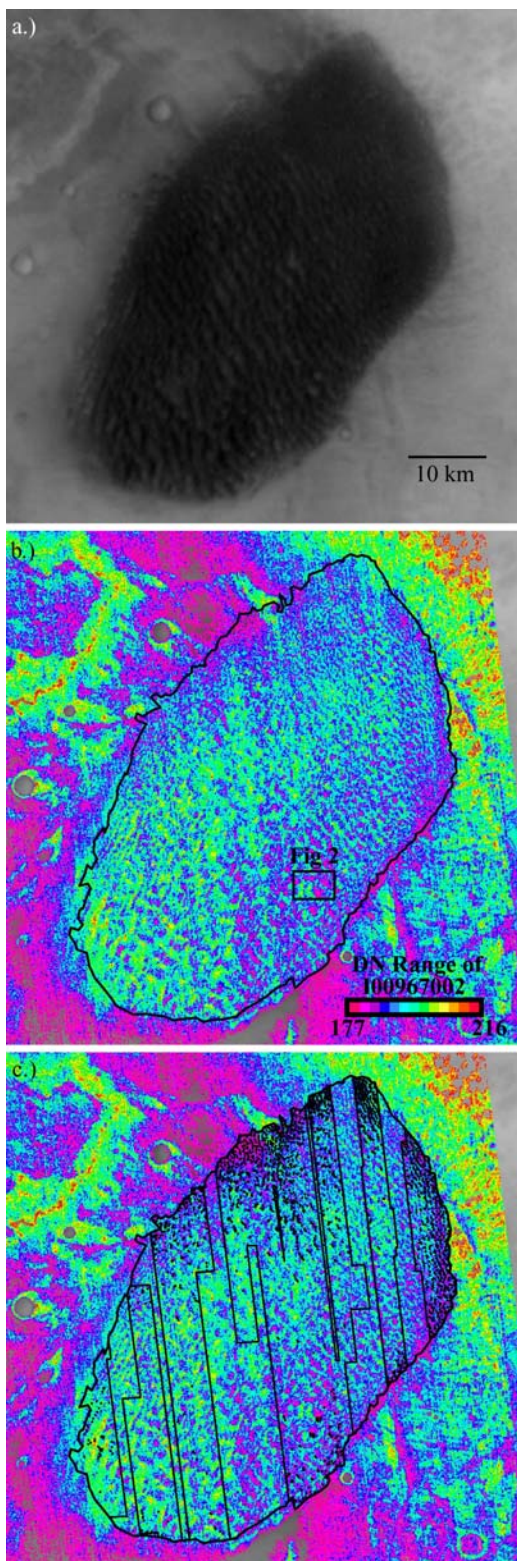
The temperatures within the dune field follow a striking pattern. The many very straight, almost vertical lines in the images are caused by uncorrected streaks in the THEMIS data set, and they may be considered artifacts in the images. The remaining pattern appears to follow the trend of dune ridges that are visible in Figure 1a. In general, higher temperatures correspond to dune crests and lower temperatures correspond to dune troughs and interdunes. Table 1 shows that in two THEMIS images, the mean temperatures of the dune ridges are 2.3 – 2.5 K higher than those of the low-lying areas.

**Table 1.** Temperature differences within the dune field

THEMIS IR	Low-lying Areas		Dune Ridges	
	$\Delta$ DN	Mean $T_B$	$\Delta$ DN	Mean $T_B$
100967002	177-186	194.1 K	195-210	196.7 K
101304006	141-150	185.4 K	159-174	187.7 K

The narrow angle MOC images of the dune field have the resolution to determine which surface features correspond to which set of temperatures. Figure 2a shows one narrow angle image crossing the dune field and Figure 2b shows the corresponding THEMIS IR region (the region is indicated in Fig. 1b). The lowest temperatures correspond to interdune areas, but some regions of low temperature correspond to sand-covered low-lying areas. To test the distribution of each type of low temperature area, all interdune areas were marked on MOC narrow angle images crossing the dune field. These areas are shown as black dots in Fig. 1c. Most of the interdunes are located near the edges of the dune field in these images. In the center of the dune field, cooler areas correspond to sand-filled troughs between dunes, rather than interdunes exposing the underlying surface.

**Discussion:** The lower temperatures from the interdunes indicate an exposed surface with a lower thermal inertia than that of the dune sand. However, the lower temperatures from the sand-covered troughs between dunes are more difficult to explain. Figure 2 shows that these troughs have a higher albedo than the sand on the dune ridges. The combination of higher albedo and lower thermal inertia is consistent with



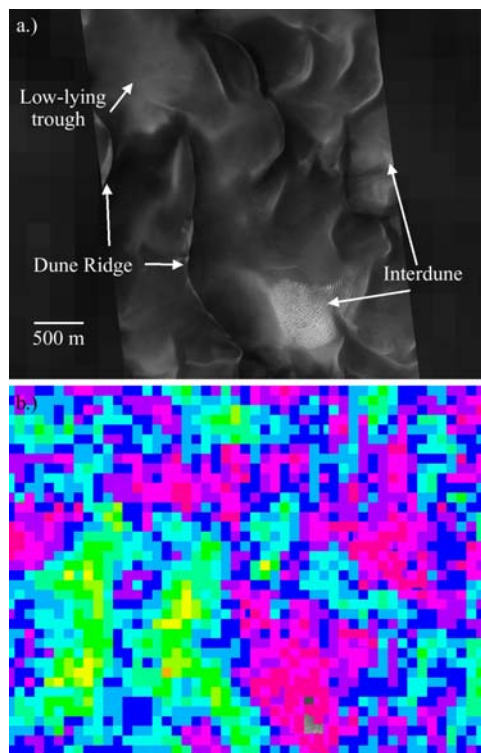
**Figure 1.** a.) Proctor Crater dunes, b.) THEMIS IR images 100967002, I01304006, and I01329005, offset to produce DN ranges similar to that of 100967002, c.) dots represent interdunes in MOC narrow angle images.

dust. The idea proposed here is that the dune troughs have accumulated a small amount of dust. Terrestrial dunes that are partially active tend to show activity—mainly at dune crests; a similar process could be acting here in which the dune ridges are active enough to clear off annual dust fallout, but the dune troughs are not active enough to keep up with the dune ridges.

TES thermal inertias across the Proctor Crater dune field indicate a mean value of  $277 \pm 17 \text{ J m}^{-2} \text{ s}^{-0.5} \text{ K}^{-1}$  [5]. Assuming the low-lying areas can be represented by a linear mixture of  $2 \mu\text{m}$  dust grains ( $68 \text{ J m}^{-2} \text{ s}^{-0.5} \text{ K}^{-1}$  at 5 mbar [6]) and 1 mm sand grains ( $300 \text{ J m}^{-2} \text{ s}^{-0.5} \text{ K}^{-1}$  at 5 mbar [6]), the surface can be described as an areal mixture of 90% sand and 10% dust.

If the lower thermal inertias in the low-lying areas are indeed due to the presence of accumulated dust, then these areas may depress the average thermal inertia of the dune field by up to  $20\text{-}25 \text{ J m}^{-2} \text{ s}^{-0.5} \text{ K}^{-1}$ , so a closer look into sand thermal inertia is required for its use as a control in future studies.

**References:** [1] Christensen P. R. (1983) *Icarus*, 56, 496-518. [2] Edgett, K. S. and Christensen, P. R. (1991), *JGR*, 96, 22,765-22,776. [3] Edgett, K. S. and Christensen, P. R. (1994), *JGR*, 99, 1997-2018. [4] Herkenhoff, K. E. and Vasavada, A. R. (1999), *JGR*, 104, 16,487-16,500. [5] Fenton, L. K. et al. (2003) *JGR*, 108, doi:10.1029/2002JE002015. [6] Presley, M. and Christensen, P. R. (1997), *JGR*, 102, 6551-6566.



**Figure 2.** Closer view of a region within the dune field (marked in Fig. 1b). a.) MOC NA E13-01254, b.) corresponding THEMIS DN's: warmer temperatures occur on dune crests and cooler temperatures occur both in interdunes and low-lying sand-covered troughs between dunes.