

**CHARACTERISTICS OF INTRACRATER THERMAL ANOMALIES IN SOUTHWESTERN MARGARITIFER TERRA.** M. L. McDowell<sup>1</sup> and V. E. Hamilton<sup>1</sup>, <sup>1</sup>Hawai'i Institute of Geophysics and Planology, University of Hawai'i, 1680 East-West Rd, Honolulu, HI, 96822, mcdowell@hawaii.edu.

**Introduction:** An investigation of nighttime thermal infrared images recorded by the Thermal Emission Imaging System (THEMIS) onboard Mars Odyssey reveals numerous craters in the region of southwestern Margaritifer Terra, Mars with anomalously warm floor deposits relative to the surrounding materials (Figure 1a, b). These deposits differ from classic intracrater deposits, e.g. [1], in that they appear to be coherent units rather than aeolian sand deposits. We have analyzed the spectral, thermal, topographic, and geomorphic characteristics of these anomalous deposits using THEMIS, Mars Global Surveyor Thermal Emission Spectrometer (TES), Mars Orbiter Laser Altimeter (MOLA), and Mars Orbiter Camera (MOC) data to understand their composition and origin.

**Background:** Margaritifer Terra is centered at 4.9°S, 335°E [2]. The study area discussed here is in the southwestern quadrant and is part of the heavily cratered Noachian plateau sequence [3]. The anomalous intracrater deposits are observed throughout the area in craters of various sizes (15 to 66 km).

Nighttime temperatures primarily represent the thermophysical properties of the top 10's of cm of the surface [4, 5]. A relatively high nighttime temperature indicates a material that has a higher thermal inertia, absorbing and emitting heat more slowly, than neighboring lower temperature materials. Thermal inertia variations commonly can be linked to differences in particle size, with larger particles having greater thermal inertia [4-7]. The global thermal inertia values determined by [5] fall into two modes centered at 70-80 and 240-250 J m<sup>-2</sup> K<sup>-1</sup> s<sup>-1/2</sup> and indicate that the bulk of the planet's surface materials correspond to clay/very fine silt and medium sand sized particles, respectively [6,8]. Sufficiently high values of thermal inertia (e.g. >2200 J m<sup>-2</sup> K<sup>-1</sup> s<sup>-1/2</sup>) could indicate outcrops of bedrock on the Martian surface [9], places where thermal infrared spectral signatures are commonly strongest. The warm crater floor deposits in southwestern Margaritifer Terra may be an effect of larger particle size and therefore make excellent targets for seeking out compositionally distinct materials.

**Approach:** To obtain a better understanding of the formation of the warm intracrater deposits we are performing surveys of their thermophysical properties, albedo, short wavelength emissivity, composition, geomorphology, and elevation.

*Evaluation of compositional differences.* THEMIS daytime infrared calibrated radiance images were used

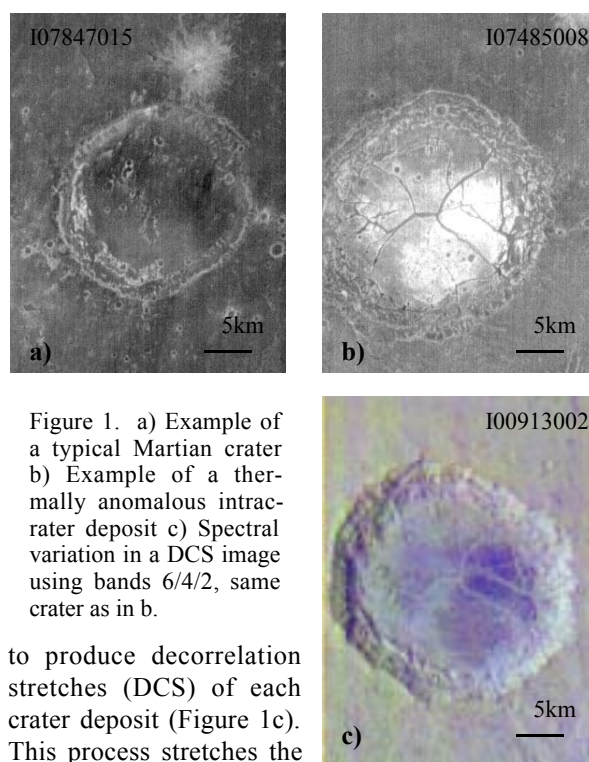


Figure 1. a) Example of a typical Martian crater b) Example of a thermally anomalous intracrater deposit c) Spectral variation in a DCS image using bands 6/4/2, same crater as in b.

to produce decorrelation stretches (DCS) of each crater deposit (Figure 1c). This process stretches the component band images by redefining the coordinate system in a way that enhances variation, and then combines three of these band images to make a false color image [10]. Multiple DCS images were created for each crater using the 6/4/2, 8/6/4, and 9/7/5 THEMIS spectral band combinations for the red, green, and blue colors in each image. A visual analysis of the decorrelation stretches was used to determine which crater deposits, if any, exhibit spectral variation from their immediate surroundings.

*Analysis of thermophysical characteristics.* For each crater deposit, we produced nighttime brightness temperature images and recorded the maximum, minimum, and mean temperatures for the anomalous deposit and a representative area outside each crater. TES nighttime bolometric thermal inertias are recorded also for each deposit and a representative area outside the crater. These data are subdivided into four groups to account for seasonal variations:  $L_s = 0-90^\circ$ ,  $90-180^\circ$ ,  $180-270^\circ$ , and  $270-360^\circ$ .

*Evaluation of dust cover.* Historically, in addition to thermal inertia, albedo has been used as a proxy for dust cover. [11] developed a dust cover index (DCI) to compliment albedo as a means of evaluating surface

character. Spectral effects of particle size variation are most prominent at higher wavenumbers, so the DCI is determined by the average emissivity from 1350 to 1400  $\text{cm}^{-1}$  and represents the relative mean particle size of the uppermost surface [11]. In addition to recording albedo, we have also recorded the DCI value for each crater thermal anomaly and a representative area outside each crater.

**Preliminary Results and Discussion:** Although our survey is not yet complete, there are some constraints we can place on the properties of these interesting intracrater deposits.

*Compositional Differences.* Of the intracrater thermal anomalies analyzed to date, five show color variations in at least one of the decorrelation stretched images, indicating possible differences in composition between the deposits and their surroundings. The observed DCS image variations are not restricted to a particular band combination, suggesting that there may be compositional variations among the deposits.

*Thermophysical Characteristics.* Without consideration of season, the thermally anomalous deposits show average nighttime temperatures in the range of 182 to 213 K (with  $\sigma$ 's of 2.2 to 5.6), with maximum temperatures as great as 223 K. In contrast, the mean and maximum temperatures for the areas outside of the craters are between 171 and 204 K (with  $\sigma$ 's of 0.9 to 3.0) and 184 and 213 K, respectively. This results in average temperatures 5 to 18 K greater for the thermally anomalous deposits than the surrounding areas. Both the deposit and the adjacent area exhibit slightly higher temperatures during southern summer.

The five craters with clear spectral variations in the DCS images have average thermal inertia values in the range of 220 to 396  $\text{J m}^{-2} \text{K}^{-1} \text{s}^{1/2}$ , in the high inertia/low albedo mode of the inertia vs. albedo classification identified by [5]. However, it is important to note that this is the average of all values collected throughout an area that contains the deposit, crater, and an amount of space outside of the crater. Therefore, this average may not accurately reflect the thermal inertia of the deposit, which is likely nearer to the maximum values of 470-800  $\text{J m}^{-2} \text{K}^{-1} \text{s}^{1/2}$  retrieved in each area. These maximum thermal inertia values suggest a mean particle size at least as coarse as pebbles (4-16 mm) [6,8]. Another alternative was offered by [5], who examined an intracrater deposit at 28S, 334W with inertias greater than 480 and suggested that thermal inertias above 400 indicate induration or are a mixture of exposed bedrock and loose grains.

*Topography.* The thermally anomalous materials are always at a lower elevation than the surface adjacent to the crater, as expected for typical Martian craters [12]. Mean elevation values for the deposits vary

from -491 m to -3103 m. This range of values suggests that these deposits likely were not produced in the same event, or perhaps even by the same process.

*Dust cover.* Mean Lambert albedo values for each of the five craters (including a small area of the immediately surrounding plain), vary by season between 0.12 and 0.16. The average TES short wavelength depth values for the craters are between 0.969 and 0.972, placing all the craters within the dust-free surface class ( $>0.962$ ) on the Dust Cover Index [11]. Based on these albedo and DCI values, we should have no trouble utilizing TES and THEMIS spectral data to determine the composition(s) of the anomalous intracrater deposit materials.

**Conclusions:** Our investigation of intracrater deposits in southwestern Margaritifer Terra has shown that many have anomalously high nighttime temperatures, with maximum temperatures reaching up to 223 K and mean temperatures ranging from 5 to 18 K greater than the surface adjacent to the crater. The deposits are present at various elevations, suggesting that multiple events and/or processes may be responsible for their formation. To date, five craters have been identified that appear to exhibit spectral variation. Their low dust cover makes them good sites for analysis of TES spectra. High maximum thermal inertia values suggest the deposits are composed of very coarse grained or indurated materials. The combination of visible, thermophysical, and mineralogical identification will aid us in interpreting the origin of these materials.

**Ongoing Work:** The next steps in this research include expanding the albedo, short wavelength depth, and thermal inertia surveys to the entire set of craters, identifying the composition of the anomalous materials through deconvolution of TES spectra, and examining available THEMIS VIS and MOC images of the deposits in the five craters. We also will establish the spatial extent of these thermally anomalous deposits to determine if they are confined to craters within a geologically discrete region.

**References:** [1] Christensen, P. R. (1983) *Icarus*, 56, 496-518. [2] International Astronomical Union: Gazetteer of Planetary Nomenclature. [3] 1:15M Global Geologic Map. [4] Kieffer et al. (1977) *JGR*, 82, 4249-4291. [5] Mellon M. T. et al. (2000) *Icarus*, 148, 437-455. [6] Presley M. A. and Christensen P. R. (1997) *JGR*, 102, 6551-6566. [7] Christensen P. R. (1982) *JGR*, 87, 9985-9998. [8] Fenton L. K. and Bandfield J. L. (2003) *JGR*, 108. [9] Rogers D. et al (2003) *LPSXXXIV*, Abstract #2082. [10] Kahle A. B. et al (1993) in *Remote geochemical analysis: elemental and mineralogical composition*, 99-120. [11] Ruff S. W. and Christensen P. R. (2002) *JGR*, 107. [12] Strom R. G. et al (1992) in *Mars*, 383-423.