THERMAL BEHAVIOR OF PITTED TERRAINS ON VESTA. F. Tosi[1], M.T. Capria[1], M.C. De Sanctis[1], B.W. Denevi[2], D.T. Blewett[2], F. Capaccioni[1], D. Grassi[1], E. Palmer[3], E. Palomba[1], F. Zambon[1], E. Ammannito[1], J.M. Sunshine[4], T.N. Titus[5], M.J. Toplis[6], C.T. Russell[7], C.A. Raymond[8]. [1]INAF-IAPS, Via del Fosso del Cavaliere 100, I-00133 Rome, Italy, federico.tosi@iaps.inaf.it. [2]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA. [3]Planetary Science Institute, Tucson, AZ, USA. [4]University of Maryland at College Park, MD, USA. [5]U.S. Geological Survey, Flagstaff, AZ, USA. [6]Institut de Recherche en Astrophysique et Planétologie (UMR 5277), Toulouse, France. [7]University of California at Los Angeles, Los Angeles, CA, USA. [8]NASA/Jet Propulsion Laboratory and California Institute of Technology, Pasadena, CA, USA.

Introduction: Pitted terrain is characterized by irregular rimless depressions found in and around some impact craters on Vesta, with a distinct morphology not observed on other airless bodies [1]. Similar terrains are associated with numerous martian craters, where pits are thought to form through degassing of volatile-bearing material heated by the impact [1]. The thermal behavior of pitted terrains found on Vesta can be related to physical properties that may provide some information about the origin of those materials. Dawn's Visible and Infrared Mapping Spectrometer (VIR) [2] hyperspectral images can be used to retrieve surface temperatures, with high accuracy (< 1 K) as long as temperatures are greater than ~180 K.

We present temperature maps and spectra of pitted terrain observed by the VIR experiment onboard Dawn in different phases of the mission, which may constrain the composition and provide information on the physical structure of pitted terrain.

Data set and analysis: After the initial Survey (11 through 31 August 2011) and High Altitude Mapping Orbit (HAMO-1, 29 September through 1 November 2011), Dawn spiraled down to its 210-km above mean surface Low Altitude Mapping Orbit (LAMO), which was by far the longest phase of the Vesta mission (12 December 2011 through 30 April 2012). Terrains with a distinct pitted morphology were identified on the basis of Framing Camera (FC) clear-filter images obtained during LAMO. The Dawn spacecraft eventually raised its altitude back to 685 km above mean surface to perform a second High Altitude Mapping Orbit (HAMO-2, 15 June to 25 July 2012).

Here we calculate surface temperatures of pitted terrains on the basis of VIR data acquired especially in the Survey and High Altitude mapping orbits. In the Survey data, VIR obtained resolved images of more than 65% of the surface of Vesta with average spatial resolution of ~0.68 km. In the HAMO-1 and -2 phases, VIR acquired hyperspectral images at a roughly constant pixel resolution of 0.17 km. Even though footprints were mostly non-continuous due to the higher instantaneous speed of the ground tracks, some of the pitted terrain sites (e.g., Marcia, Cornelia, Licinia) were re-observed in greater detail. VIR data acquired in LAMO have much reduced spatial coverage and larger phase angles (resulting in long shadows) with respect to Survey and HAMO data, and as such LAMO data will not be discussed here.

On Vesta, the region of the infrared spectrum beyond ~3.5 μm is dominated by thermal emission from the asteroid's surface, which can be used to determine surface temperature by means of temperature-retrieval algorithms. To calculate surface temperatures, we applied a Bayesian approach to nonlinear inversion [3] based on the Kirchhoff law r_λ=1-ε_λ and the Planck function. Results were compared with those provided by the application of alternative methods (e.g, [4]). In all cases, the minimum retrievable temperature (~180 K) is set by the Noise Equivalent Spectral Radiance (NESR), i.e. the RMS noise of the in-flight measurements expressed in units of spectral radiance. On the other hand, for a given local solar time (LST), the maximum temperature depends on incidence angle and surface properties such as thermal inertia and albedo.

Results: Pitted terrains display distinct thermal properties compared to other terrains on Vesta. They show a significatly reduced thermal emission at infrared wavelengths longward of 4 μm (**Fig. 1**) and have distinct margins in the temperature images, being colder than nearby terrains even though they show similar albedos and are observed at similar solar illumination conditions (**Fig. 2**). Pitted terrains can be >10 K colder than the surroundings, and even colder than bright material deposits found on Vesta, despite their lower albedo. It is worth noting that bright material was in turn found to be significantly colder than dark material deposits observed with same spatial resolution and comparable illumination conditions (**Fig. 2**).

Spectral emissivity profiles retrieved for pitted terrains found in the floors of Marcia and Cornelia reveal prominent differences with respect to other distinct features discovered on Vesta, most notably dark [5] and bright material deposits (**Fig. 3**). This evidence is likely related to a difference in both composition and physical structure of the surface material. The lower temperatures suggest a higher thermal inertia, i.e. a slower response to insolation, which may be due to reduced local porosity (i.e., increased local density) and/or an increase in the local thermal conductivity. This might be caused by rapid degassing of volatile-bearing materials: local cavities at micrometer to centimeter scale gradually disappear, leaving a compact layer. A combination of both density and thermal conductivity may actually be responsible for the observed behavior. This is also supported by the lower albedo of compact material compared to the unconsolidated material widespread on the surface of Vesta.

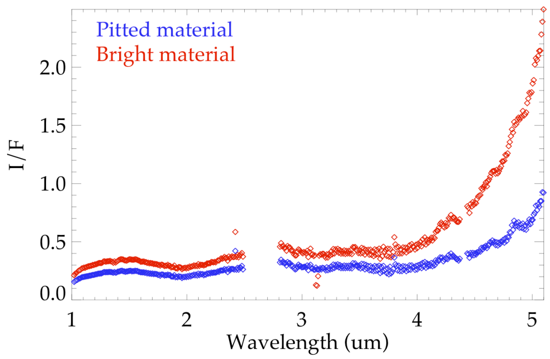

Fig. 1. Spectral comparison based on VIR infrared data between pitted terrain in crater Marcia (blue curve) and very bright material in nearby crater Calpurnia (red curve). Pitted terrain shows lower albedo and a significantly reduced thermal emission compared to very bright material, even under similar solar illumination and local solar time.

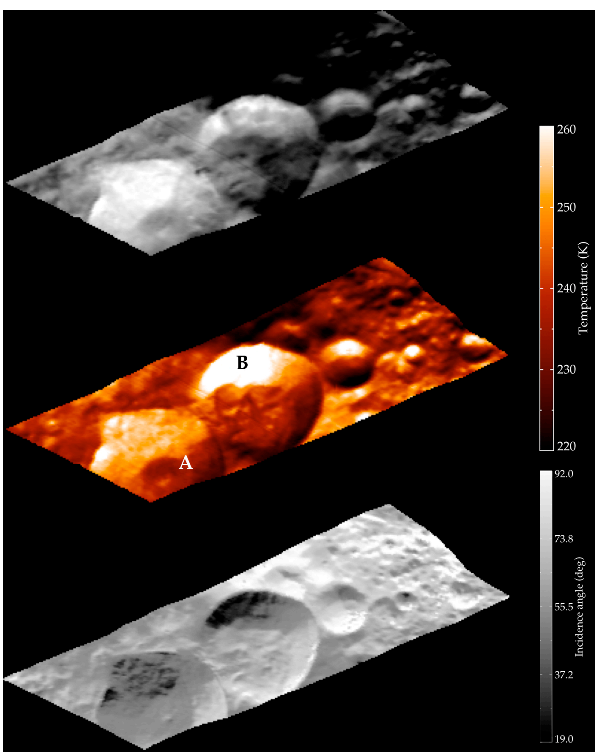

Fig. 2. Simple cylindrical projection of a portion of Marcia crater, observed by VIR (cube: 366641356_1) during the Survey phase (680 m/pixel). The upper panel shows the region as seen at the near-infrared wavelength of 1.4 µm. The middle panel shows a temperature map of the same area, as derived from VIR spectra using the method described in [3] at wavelengths greater than 4 µm, where thermal emission becomes increasingly relevant. The bottom panel shows the local solar incidence angle measured from the surface normal to a detailed shape model. Materials illuminated at high incidence angles are generally colder than materials at low incidence angles. The spectrally distinct material associated with Marcia's floor (point A), observed at 10.4 h LST, is ~10 K colder than the rest of the crater where illumination conditions are similar, and similar to slightly lower in temperature as compared with Marcia's ejecta blanket. The average surface temperature in the crater's floor where the pitted material is located is 234 K, compared with the average temperature of 241 K found in the floor of the nearby crater Calpurnia observed at 11.0 LST and the temperature of ~260 K found in the northern wall of Calpurnia (point B) observed at 11.1 h LST.

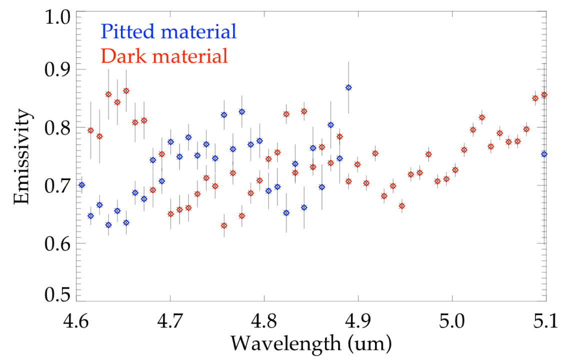

Fig. 3. Comparison of spectral emissivities, retrieved from VIR infrared data, between pitted terrain in the floor of Cornelia (blue dots) and dark material found in the wall of the same crater (red dots). The interval 4.9-5.1 µm is not usable for pitted material due to the superposition of solar reflectance and thermal emission, which yields no information on the emissivity. The two profiles reveal an anti-correlation at wavelengths shorter than 4.9 µm, which may be related to a difference in composition.

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