ANALYSIS OF TEMPERATURE MAPS OF SELECTED DAWN DATA OVER THE SURFACE OF VESTA. F. Tosi[1], M.T. Capria[1], M.C. De Sanctis[1], E. Palomba[1], D. Grassi[1], F. Capaccioni[1], E. Ammannito[1], J.-Ph. Combe[2], J.M. Sunshine[3], T.B. McCord[2], J.-Y. Li[3], T.N. Titus[4], C.T. Russell[5], C.A. Raymond[6], D.W. Mittlefehldt[7], M.J. Toplis[8], O. Forni[8], M.V. Sykes[9]. [1]INAF-IAPS, Via del Fosso del Cavaliere 100, I-00133 Rome, Italy, federico.tosi@ifsi-roma.inaf.it. [2]Bear Fight Institute, 22, Fiddler's Road, P.O. Box 667, Winthrop, WA, 98862, USA. [3]Department of Astronomy, University of Maryland at College Park, MD 20742-2421, USA. [4]Astrogeology Science Center, U.S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ 86001, USA. [5]Institute of Geophysics and Planetary Physics, University of California at Los Angeles, 3845 Slichter Hall, 603 Charles E. Young Drive, East, Los Angeles, CA 90095-1567, USA. [6]NASA/Jet Propulsion Laboratory and California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA. [7]NASA Johnson Space Center, 2101 NASA Parkway Houston, TX 77058, USA. [8]Institut de Recherche en Astrophysique et Planétologie (UMR 5277), Observatoire Midi-Pyrénées, 31400, Toulouse, France. [9]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719, USA.

Introduction: The thermal behavior of areas of unusual albedo at the surface of 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) [1] hyperspectral cubes can be used to retrieve surface temperatures. Due to instrumental constraints, high accuracy is obtained only if temperatures are greater than ~180 K. Bright and dark surface materials on Vesta are currently investigated by the Dawn team [e.g., 2 and 3 respectively].

Here we present temperature maps of several local-scale features that were observed by Dawn under different illumination conditions and different local solar times.

Data set and analysis: During the Dawn's Approach and Survey mission phases of the mission (23 July through 29 August 2011), VIR obtained resolved images of Vesta with spatial resolution spanning from 1.31 km to 0.68 km. More than 65% of the surface, from the South Pole up to ~40°N, was observed under different illumination conditions and local solar elevations. Based on this datasets, several unusual features were identified on the surface: 1) high-albedo (bright) and low-albedo (dark) material deposits (**Fig. 1**), 2) spectrally distinct ejecta, 3) regions showing fine-grained materials. A database of such features was prepared on the basis of remote sensing data acquired in the Survey phase.

The subsequent High-Altitude Mapping Orbit (HAMO) phase (30 September through 31 October 2011), allowed Dawn's remote sensing instruments to investigate Vesta's surface features in greater detail. In this phase, VIR acquired IR data at a roughly constant pixel resolution of 0.17 km. Compared to the Survey phase, the HAMO spatial coverage was significantly reduced due to operational constraints, and footprints were mostly discontinuous due to the higher instantaneous speed of the ground tracks. Nevertheless, some of the unusual dark and bright peculiar features were re-observed by VIR (**Figs. 2, 3**).

A Low-Altitude Mapping Orbit (LAMO) phase began in December 2011, which will result in the best spatial resolution of data obtained by Dawn's remote sensing instruments. However, LAMO data have much reduced spatial coverage and a larger phase angle (resulting in long shadows) with respect to Survey and HAMO. In LAMO, VIR data are expected to be acquired no earlier than mid-January 2012. It is also of note that in LAMO, the Gamma-Ray and Neutron Detector (GRaND) is the prime instrument onboard Dawn. As such, during LAMO VIR data are collected under less optimal conditions than in earlier phases of the mission.

On Vesta, the region of the infrared spectrum beyond ~3.5 μm is dominated by the thermal emission of 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 [4] based on the Kirchhoff law and the Planck function, and whose results were compared with those provided by the application of alternative methods (e.g, [5]). 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. The NESR is a function of several instrumental parameters (e.g., cutoff sensitivity and temperature of the optics). It is important to note that ~180 K is just the lower limit of sensitivity of VIR in retrieving temperatures, and is not related to any physical temperature on the night side of Vesta: temperatures below 180 K can actually be evaluated by VIR, but with larger formal errors at lower temperature. On the other hand, for a given local solar time, the maximum temperature depends on some surface properties, such as density, thermal conductivity, and specific heat, which in turn provide the surface thermal inertia.

Results: Some bright terrains have an overall albedo in the visible as much as 40% brighter than surrounding areas. Data from the IR channel of VIR show that bright regions generally correspond to regions with lower thermal emission, i.e. lower temperature, while dark regions correspond to areas with higher thermal emission, i.e. higher temperature (**Fig. 4**). This behavior confirms that many of the dark appearance in the VIS mainly reflects albedo variations. In particular, it is shown that during maximum daily insolation, dark features in the equatorial region may rise to temperatures greater than 270 K. However, individual features may show different thermal behaviours, as a result of their different composition and/or structure (e.g, average grain size of the surface regolith, porosity, etc.).

To complement the temperature and near-infrared emissivity derived from the infrared spectra, thermal inertia and other thermal properties can be calculated by theoretical models which solve the heat equation for airless bodies, as well as modeling the distribution of temperatures due to surface roughness [6].

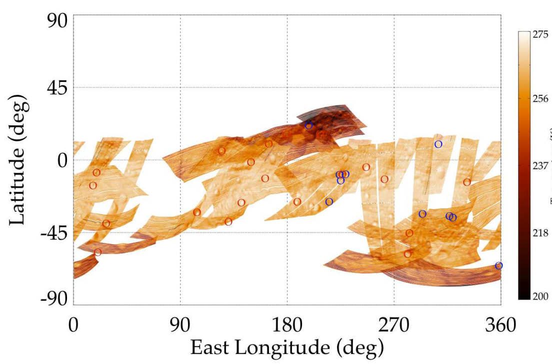

Fig. 1. Temperature map (simple cylindrical projection) of selected regions of Vesta where bright features (blue circles) and dark features (red circles) occur. VIR data acquired in the Approach and Survey phase (spatial resolution 1.3-0.7 km) are represented here.

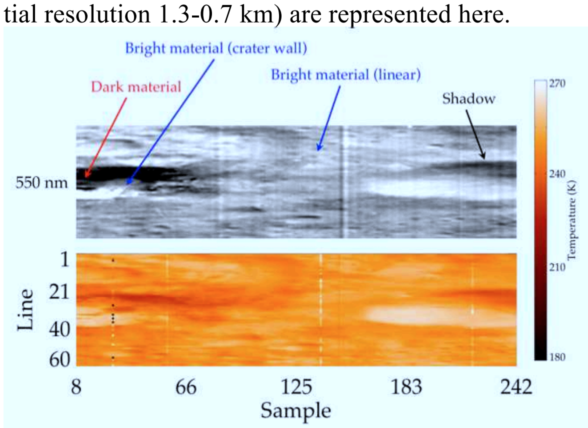

Fig. 2. Example of HAMO data acquired by VIR (cube 371813008). In this case, the upper panel represents a small equatorial region exhibiting both dark and bright materials, as seen at the visible wavelength of 550 nm (pixel resolution 0.17 km). In the lower panel, the temperature image of the same area is provided for comparison.

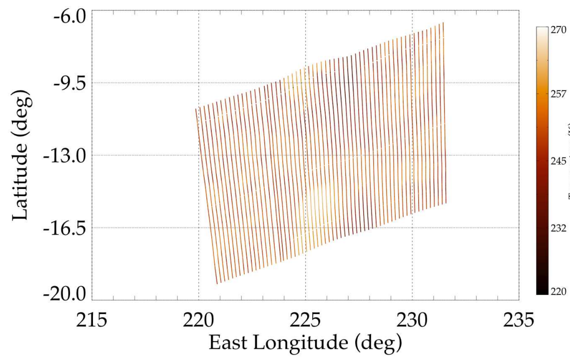

Fig. 3. Temperature map of the same region shown in **Fig. 2**, projected in simple cylindrical coordinates. Individual footprints (lines) appear to be disconnected from each other as a consequence of the instantaneous speed of the ground tracks.

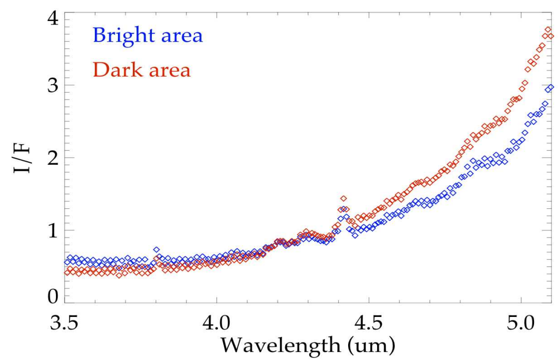

Fig. 2. Example of thermal emission of a bright (blue) and dark (red) material deposit on the surface of Vesta. The infrared specta of a dark and bright features as measured by VIR are revealed in the 3.5-5.1 μm spectral range. Dark features exhibit a higher thermal emission, which reflects in a higher surface temperature with respect to the other terrains.

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