ANALYSIS OF PHOTOMETRIC PROPERTIES OF THE VESTAN SURFACE MATERIALS. F. Capaccioni[1], Jian-Yang Li[2], M.C. De Sanctis[1], E. Ammannito[1], M.T. Capria[1], F. Carraro[1], S. Fonte[1], A. Frigeri[1], G. Magni[1], E. Palomba[1], A. Longobardo[1], F.Tosi[1], F. Zambon[1], B. Buratti[3], S.E. Schröder[4], M.D. Hicks[3], V. Reddy[4], A. Nathues[4], M. Hoffman[4], B.W. Denevi[5], L. Jorda[6], S. Mottola[7], C. Pieters[8], C.A. Raymond[3], M.V. Sykes[9], E. Palmer[9], C.T. Russell[10], T. Titus[11], T. Roatsch[7], N. Mastrodemos[3].
[1]INAF-IAPS, Via del Fosso del Cavaliere 100, I-00133 Rome, Italy, fabrizio.capaccioni@iasf-roma.inaf.it, [2]University of Maryland, College Park, MD, USA, [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [4]Institute for Solar System Research, Max-Planck,Katlenburg-Lindau, Germany, [5]Johns Hopkins University Applied Physics Laboratory, MD, USA, [6]Laboratoire d'Astrophysique de Marseille, France, [7]DLR, Inst. of Planetary Research, Berlin, Germany, [8]Brown University, Planetary Geosciences Group, RI, USA, [9]Planetary Science Institute, AZ, USA, [10]UCLA, Institute of Geophysics, CA, USA, [11]US Geological Survey, Astrogeology Science Center.

Introduction: Since July 2011 the VIR imaging spectrometer onboard DAWN is acquiring hyperspectral imaging data of the surface of the asteroid Vesta. Photometric correction of these data is essential for the correct interpretation of the observed spectra. An almost straightforward approach, consisting of the evaluation of the photometric properties at all VIR wavelengths (864 bands in the range 0.25-5.0µm) using Hapke's model, is being carried out [1].
However, to gain deeper insight on the physical and spectral properties of the surface materials we consider it worthwhile to analyze the photometric behaviour of some of the spectral descriptors derived from the VIR data [2].
The adoption of spectral descriptors (bands depth, bands centers, spectral slopes, etc.) is a very effective method that allows reduction of the dimensionality of the spectral data without losing the relevant information contained in the spectra. This approach has been adopted very successfully in the analysis of spectra of the icy satellites of Saturn obtained by the VIMS instrument on board Cassini [3].
We shall describe the behaviour and variability of the band depth, band shapes, spectral slopes, band ratios and band centers as a function of the illumination conditions. This will complement the Hapke modeling for the spectrophotometric correction, and it will allows to provide quantitative estimates of mineral abundance and regolith grain size.

VIR data: VIR acquired data during Approach, Survey and HAMO, (LAMO data are underway at moment of writing this abstract) phases, obtained a good coverage of the surface (> 65%). Data of high quality, from 0.2 to 5 µm, have been acquired for a total of about 8.5 million spectra in 864 spectral channels. The VIR pixel resolution ranged from 1.3 km (Approach phase) to 0.18-0.15 km (HAMO). The coverage obtained permits a quasi-global view of Vesta's. There are several instances in the full set of data where the same region is observed under diverse illumination conditions. In particular the near equatorial region has been extensively covered during the approach and Survey orbits. We have preliminarily analyzed two regions repeatedly observed during the Survey phase. Figures 1 and 2 show the footprints of the data cubes of the regions taken into account. The average spatial resolution for each pixel is 680±20m for all the cubes. The red cross in both images gives the geographic reference.

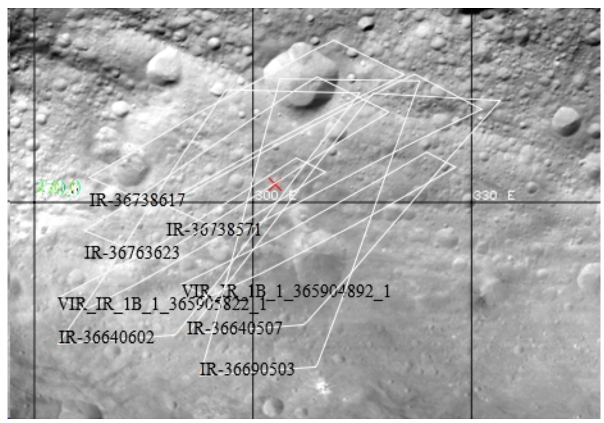

Figure 1. Area 1; the cubes used in this analysis are outlined in white. The red cross is located at latitude 2N and Longitude303.

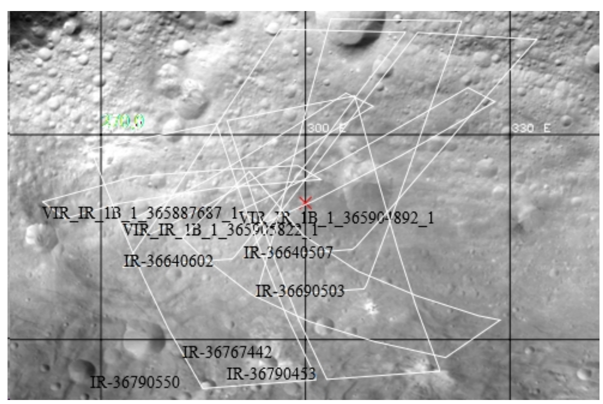

Figure 2. Area 2; the cubes used in this analysis are outlined in white. The red cross is located at latitude 10S and Longitude300.

Data Analysis. We show here a first analysis performed on the depth variation of the pyroxene Band II absorption (2µm), which along with the Band I (0.9 µm), is ubiquitously found in all spectra across the surface of Vesta. We have evaluated the band depth for the various cubes and plotted its value as a function of the phase angle.

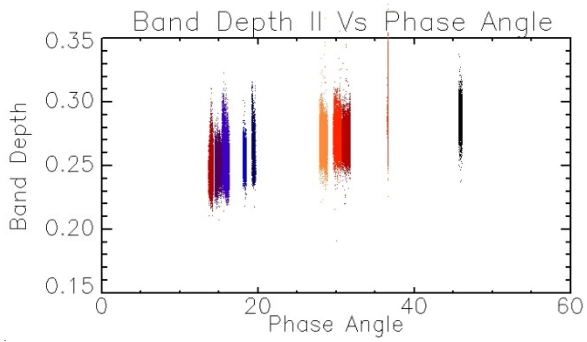

Figure 3. Band Depth plotted as a function of the phase angle. Each color represents a single cube of those reported in figures 1 and 2.

In figure 3 we show how the band depth varies with phase for all the cubes in figure 1 and 2. We note a fairly large dispersion of the band depth values for a single phase angle, and this is essentially due to topography, as the phase angle is derived for each pixel without taking into account local topographic variations, and the variation in grain size and/or pyroxene abundance within the observed areas.

There is a clear increase in the band depth with the increase in phase; a linear fit of the mean band depth versus the mean phase angle for each cube, gives a linear correlation coefficient of 0.98, an intercept of 0.217 and a slope 0.00120 ± 7.e-5 deg^{-1}.

The plot of the Band II depth as a function of the incidence angle (Figure 4) or emission angle (not shown here) does not show any clear correlation. The band depth seems to depend solely on the phase angle. The VIR result is confirmed by the analysis of the depth of Band I as inferred from color images taken by the Framing Camera onboard Dawn [4].

Discussion: In general, absorption band depth and band shapes should show a dependence on the illumination conditions. This is true in particular for airless bodies with relatively high albedo, for which the multiple scattering contribution is relevant [5, 6,7]. Deep within the band, the absorption coefficient reaches its maximum value reducing the chance for a photon to be multiply scattered through several grains; as we move towards the wings of the absorption band the contribution of multiple scattering becomes larger and larger. As a consequence, observations performed at small incidence and emission angles should show a deeper band depth relative to the same regions observed at larger phase angles. This has been recently observed on meteorites samples measured in the laboratory [8,9]. It must be recalled that the absorption band depth is mainly determined by grain size and by mineral abundance. However, this would imply that local variation of the grain size of the regolith or of the pyroxene abundance in the soil would contribute to the dispersion of the band depth values rather than to any trend with phase.

The present VIR results shown in figure 3 however, seem to tell us a different story. A deeper understanding of this effect will come with the study of the behaviour of the depth of pyroxene Band I (0.9 µm); we shall also identify other occurrences of multiple observations to possibly extend the phase coverage, within the limitation imposed by the variation of the spatial resolutions combining data from different mission phases.

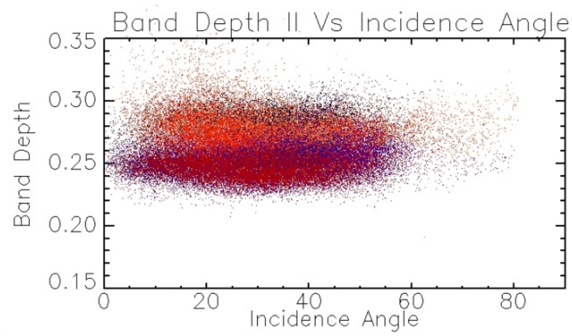

Figure 4. Band Depth as a function of the incidence angle. The color code is the same as in figure 3.

Acknowledgement: The contribution of the Italian team is funded by the Italian Space Agency (ASI).

References: [1] Li et. al (2012), *LPS XLIII*. [2] Filacchione et al, (2011), DPS-EPSC. [3] Filacchione et al. (2007), *Icarus*, *186*,259-290. [4] Schroeder et al, (2011), DPS-EPSC. [5] Hapke (1993),Theory of Reflectance and emittance spectroscopy, Cambridge. [6] Veverka et al (1978), *Icarus*, *34*,406-414. [7] Buratti and Veverka, (1985) *Icarus*, *64*, 320-328. [8] Beck et al (2011), *Icarus*, *216*,560-571. [9] Reddy et al. (2012), *Icarus*, *217*, 153-168.