SPATIAL DISTRIBUTION OF THE ABSORPTION BAND AT 1.2 µm ON THE SURFACE OF CERES

F. G. Carrozzzo[1], Maria Cristina De Sanctis[1], Marco Ferrari[1], Andrea Raponi[1], Mauro Ciarniello[1], Eleonora Ammannito[2], F. Tosi[1]
[1]INAF-IAPS,via fosso del cavaliere 100, 00133 Roma Italy (giacomo.carrozzo@inaf.it), [2]Agenzia Spaziale Italiana, viale del politecnico, 00133 Roma Italy

Introduction: In 2015 NASA's Dawn mission, equipped with a Visible and Infrared Spectrometer (VIR) [1], two Framing Cameras (FC1 and FC2) [2], and a Gamma Ray and Neutron Detector (GRaND) [3], orbited Ceres, mapping its surface in great detail.

The data acquired by the different instruments revealed a surface composed mainly of opaque materials, ammoniated phyllosilicates, carbonates, water ice, and salts [4]. Their abundance and spatial distribution has been mapped in the near infrared spectral domain [i.e. 4,5] by using the data acquire by VIR imaging spectometer. In this work we study the distribution at global scale of the 1.2 µm absorption on the surface of Ceres, as resulting from the combination of data from the two spectral channel of the VIR imaging spectrometer: the VIS channel, working in the visible wavelengths between 0.26-1.07 µm and the NIR channel, operating in the near infrared between 1.02-5.1 µm. The 1.2 µm absorption, indeed, extend across the two instrument channels.

Method: To study the 1 µm spectral range, we have implemented an automatic method to co-register the data from VIR and NIR channels, where they overlap on the surface. After the spatial co-registration, a residual difference in the I/F at 1 µm between the two channels can still remain due to the difference in the Point Spread Function (PSF) and residual photometric effects. To avoid this problem, each VIS spectrum is rescaled to the value of the I/F at ~1 µm of the corresponding NIR spectrum. The exact wavelength at which the two VIR channels are matched, inside the overlapping range between 0.92–1.8 µm, is selected for each spectrum on the basis of the best match. The difference between the VIS and NIR reflectance at ~1 µm (ΔR) is usually 1-2% and only about 1% of data show a $\Delta R>10\%$. The spectra with the largest mismatch between the two channels are located along relatively sharp surface feauters, such as crater walls, where the influence of PSF and shadowing effects are expected to be larger. In this study the few data with $\Delta R>10\%$ are discarded. The maps have global longitudinal coverage, latitudinal coverage from 66°S to 66°N, and a spatial resolution of ~1.86 km/pixel at the equator.

Each spectrum of the surface is the result of a mixture of different minerals, and the resulting spectral reflectance properties are a complex combination of the spectra of each mineral end-member. Several studies have shown that it is possible to explore Ceres mineralogical diversity utilizing specific spectral parameters [4,5].

In order to extract compositional information from the spectra, we have introduced some spectral indices (i. e. band centers, band depths, integrated areas, etc.) and studied the correlations between them all over the VIR data set. Global maps of the 1 µm signature on Ceres have been derived from various spectral indices.

Results: A better understanding of the spatial distribution and the content of the different mineral phases can thus be obtained by investigating the spectral characteristics of the 1.2 µm band. In fig.1, band depth at 1.2 µm (BD1000) is reported with the band deth at 3.07 µm (BD3100) and the level of reflectance at 1.2 µm (R1200) for comparison.

In general, the VIR spectrum of Ceres is dominated by a broad absorption at about 1.2 µm (fig.2). It is mostly uniform across the surface, but some differences can be seen in the map of the band

parameters, like the band depth. Variation in the band depth could be due to various factors, such as relative abundance and grain size of the present minerals. However, the spectral properties of the 1 µm band have been related to other spectral parameters in the NIR domain where mineralogy is known. For example, the attribution of the 3.07 µm band to ammonia-bearing species [4] show that this mineral phase has high values broadly where are low values of 1 µm band. Also, the 1.2 µm band intensity is roughly anticorrelated to the reflectance, suggesting that the ”dark” material is the dominat phase hosting the 1 µm band.
Further analysis on the 1.2 µm intensity, shape, center and overall distribution can shed light on the minerals responsible for such absorption on Ceres.

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References: [1] De Sanctis et al. (2011) Space Sci. Rev. 163, 329–369. [2] Sierks et al. (2011) Space Science Reviews 163, 263–327. [3] Prettyman et al. (2011) Space Sci. Rev. 163, 371–459 [4] E. Ammannito et al. (2016) Science, 353, issue 6303. [5] Carrozzo et al. (2018), Science Advances, vol. 4, 3, e1701645

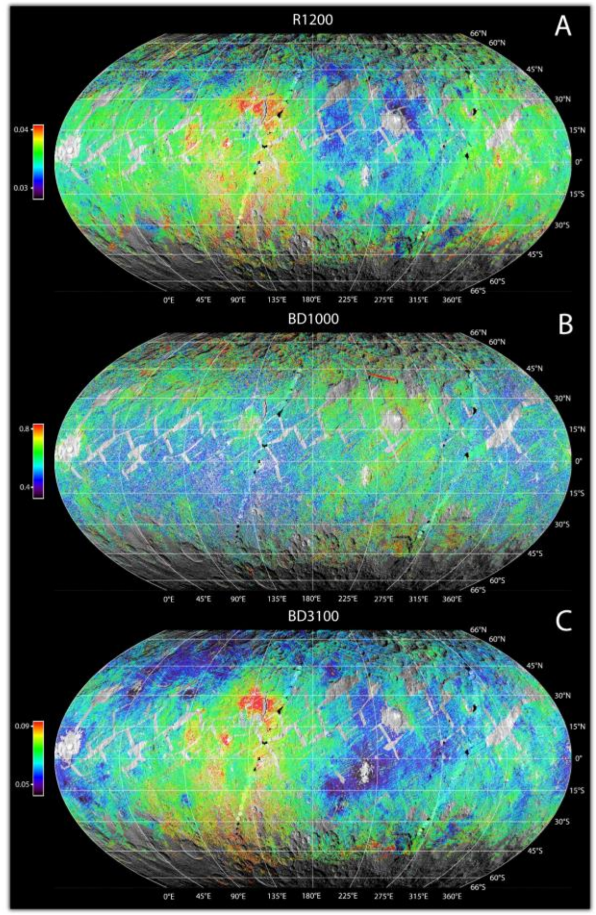

Fig.1 Distribution and intensity of the carbonate absorption in VIR data. A) Reflectance at 1.2 µm B) Intensities of the 1.2 µm absorption feature (DB100) and C) Intensity of the 3.1 µm absorption feature. The maps are superimposed on the Framing Camera images using a transparency of 30%.

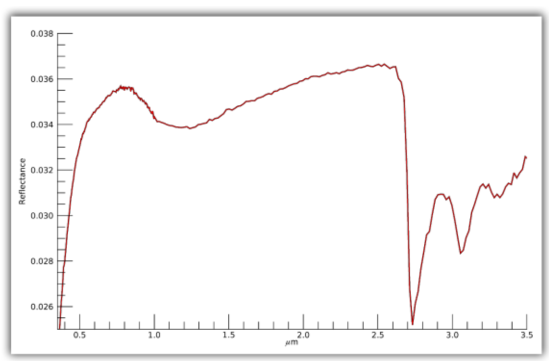

Fig.2: average Ceres spectrum from 0.25 µm to 3.5 µm, showing the 1.2 µm band.