DISTRIBUTION OF PHYLLOSILICATES ON CERES. E. Ammannito[1], M.C. DeSanctis[2], M. Ciarniello[2], A. Frigeri[2], F.G. Carrozzo[2], J.-Ph Combe[3], B.L. Ehlmann[4], S. Marchi[5], H.Y. McSween[6], A. Raponi[2], J.C. Castillo-Rogez[7], M.J. Toplis[8], F. Tosi[2], F. Capaccioni[2], M.T. Capria[2], S. Fonte[2], M. Giardino[2], R. Jaumann[9], A. Longobardo[2], S.P. Joy[1], G. Magni[2], T.B. McCord[3], L.A. McFadden[10], E. Palomba[2], C. M. Pieters[11], C. A. Polanskey[7], M.D. Rayman[7], C. A. Raymond[7], P. Schenk[12], F. Zambon[2], C. T. Russell[1] and the Dawn Science Team
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Introduction: Studies of the dwarf planet Ceres using ground-based and orbiting telescopes have concluded that its closest meteoritic analogues are the volatile-rich CI and CM carbonaceous chondrites [1, 2]. Water in clay minerals [3], ammoniated phyllosilicates [4], or a mixture of brucite, Mg_2CO_3 and iron-rich serpentine [5, 6] have all been proposed to exist on the surface. But the lack of spectral data across telluric absorption bands in the region 2.5 to 2.9 µm — where the OH stretching vibration and the H_2O bending overtone are found — has precluded definitive identifications.

The Dawn spacecraft has been acquiring data on dwarf planet Ceres since January 2015 [7, 8]. The VIR spectrometer (0.25-5.0 µm) acquired data during all the mapping orbits performed by the spacecraft [9]. The average thermally corrected reflectance spectrum of Ceres shows that the 2.6–4.2µm region is characterized by a broad asymmetric feature, characteristic of H_2O/OH bearing materials, with several distinct narrower absorption bands [10]. This spectrum is compatible with the presence on Ceres' surface of a mixture of ammoniated-phyllosilicates, Mg-phyllosilicates, carbonates, and dark materials [10]. A strong 2.7-µm absorption dominates the overall spectral properties, and it has been attributed to OH-stretching vibrations in phyllosilicates [11] while the weaker 3.05 µm absorption has been attributed to the presence of NH_4^+ in phyllosilicates [12].

Measurements and data analysis: Using the spectra acquired from an altitude of 4400 km equivalent to a nominal linear resolution of 1.1 km/px for the spectrometer VIR, maps have been made of the variability of the position and intensity of the absorption features at 2.7 and 3.05 µm.

Figure 1 illustrates the processing done on each spectrum to compute the position and intensity of the two absorptions. The band continuum of each band has been computed as the straight line between the two local maxima. The continuum-removed spectrum is the ratio of the smoothed spectrum and the continuum. After the continuum removal, the band center (BC) is defined as the wavelength that corresponds to the local minimum while the band depth (BD) is defined as 1-(Rc/Rb), where Rb is the reflectance at the band minimum and Rc is the reflectance of the continuum at the same wavelength as Rb. Figure 2 shows the distribution of the BCs of the absorption features at 2.7 and 3.05 µm while Fig. 3 shows the distribution of the BDs.

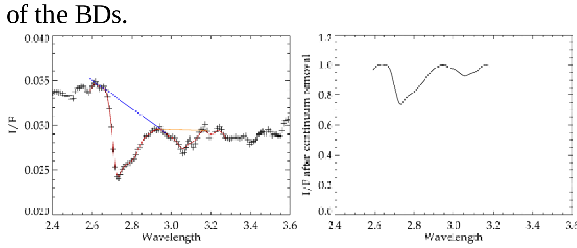

Fig. 1. a): Example of a Ceres spectrum (black crosses) with superimposed the smoothed spectrum (red line). The blue and yellow lines represent the straight line used to compute the continuum of each band. b): Continuum-removed spectrum (black line).

Discussion and Conclusions: The maps in Fig. 2 show a remarkably homogeneous distribution of the spectral position of both absorption features. The average values are 2.727±0.005 and 3.061±0.005 µm respectively. Since the position of both features is sensitive to the chemical composition of the phyllosilicates, we conclude that the composition of phyllosilicates does not significantly change across the mapped portion of Ceres' surface. The computed values are indicative of Mg-OH phases, like antigorite (Mg-serpentine) or saponite (Mg-smectite) [11]. The pervasive presence of Mg-, rather than Fe-serpentine on Ceres may be interpreted as an indication that alteration had been generally extensive, while the lack of geochemical variation inferred from band center position indicates that this is true throughout the exposed upper crust with no significant compositional gradients. The possibility that there has been a very effective post-impact homogenization process that is not apparent at this spatial scale is unlikely, because while we do observe band depth variation in some young craters, such variation is not associated with band position changes.

Figure 2 shows the distribution of the intensity of both absorption features. For the 2.7 absorption, the average value is 0.251±0.006, while the range of variability is between 0.20 and 0.29. For the 3.05 absorption, the average value is 0.055±0.012, while the range of variability is between 0.03 and 0.09. The two distributions broadly match. Among several possibilities, the most likely explanation for the variability in intensity is a changing abundance of phyllosilicates within the assemblage forming the surface of Ceres.

In conclusion, while the chemical composition of the phyllosilicates is remarkably constant, their abundance is variable. The compositional homogeneity characterized by the pervasive presence of Mg- and NH_4-bearing phyllosilicates indicates endogenous formation by a globally widespread and extensive alteration processes while the variations in the amount of phyllosilicate suggest the existence of a vertically stratified upper crust.

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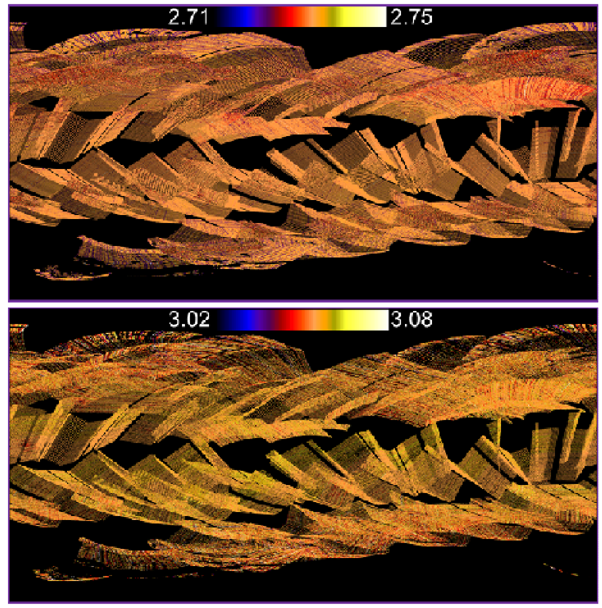

Fig. 2. Band Centers (BC, μm) of the 2.7 (top panel) and 3.05 (bottom panel) absorption features.

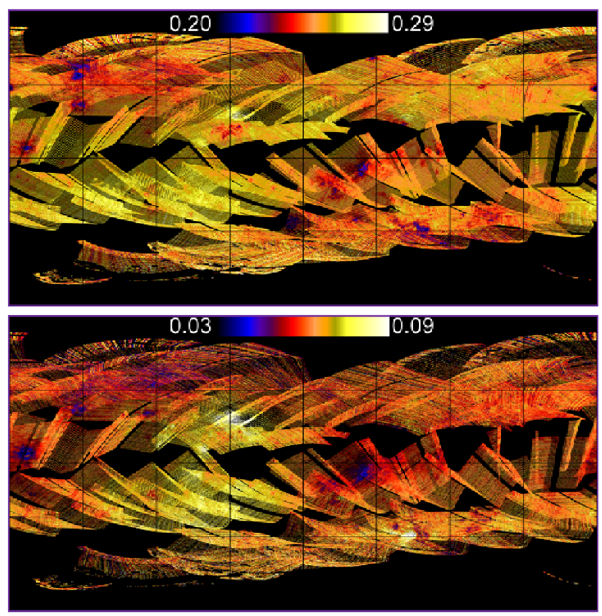

Fig. 3. Band Depths (BD) of the 2.7 (top panel) and 3.05 (bottom panel) absorption features.