IS DWARF PLANET CERES AN ORGANIC RICH PLANETARY BODY? G. Thangjam[1], A. Nathues[1], K. Mengel[2], E.A. Cloutis[3], F. Tosi[4], N. Schmedemann[1], F. Zambon[4], P. Beck[5], T. Prettyman[6], T. Platz[1], M. Hoffmann[1], D. Takir[7], S. Protopapa[8]. [1]Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077, Göttingen, Germany, [2]IELF, TU Clausthal, Adolph-Roemer-Straße 2A, 38678, Clausthal-Zellerfeld, Germany, [3]University of Winnipeg, Winnipeg, MB R3B 2E, Canada, [4]Istituto di Astrofisica e Planetologia Spaziali-Istituto Nazionale di Astrofisica, 00133 Roma, Italy, [5]Institut d'astrophysique et de planétologie de Grenoble, Université Grenoble Alpes, France, [6]Planetary Science Institute, 1700 East Fort Lowell, Tucson, AZ 85719-2395, USA, [7]SETI Institute, Mountain View, CA 94043, USA, [8]University of Maryland, Department of Astronomy, College Park, MD 20742, USA. (thangjam@mps.mpg.de).

Introduction: Ceres is the largest and most massive object in the main asteroid belt, as well as the only dwarf planet in the inner Solar System. The three instruments onboard Dawn spacecraft (i.e., Framing Camera/FC, Visible and Infrared Spectrometer/VIR, Gamma Ray and Neutron Detector/GRaND) have been exploring the geologic characteristics of this body. Among the intriguing findings from Dawn, the discovery of aliphatic organics in a localized region around Ernutet crater [1] is one of the most important findings that is worth investigating in detail. It is because the nature and formation of the organic-rich exposures, i.e., either an endogenic or exogenic origin is not unanimously assessed [1-3]. Therefore, we present here the most updated mapping of potential organic-rich areas on a global scale and our ongoing work investigating the organic spectral characteristics using both FC color (0.4-0.96 µm) and VIR spectral (1.0-4.2 µm) data.

Organics on Ceres from pre and post Dawn: Prior to Dawn, the likely presence of organics on Ceres was suggested from ground based observations [4-6]. However, the ~3.4 µm organic absorption was failed to detected unambigously because of the limited signal-to-noise ratio, which is crucial in distinguishing this spectral feature from other features specifically the carbonates. The first unambiguous spectral detection of the organic absorption feature came from Dawn VIR data in and around the Ernutet crater region [1] where the ~3.4 µm feature is outstanding compared to the ~3.9 µm of carbonates, thus allowing a clear distinction of the organics signature from carbonates. It is found in association with small and localized but patchy areas in and around the Ernutet crater, and it is also associated with unique red spectral slope in FC color data [2, 3].

Challenges in identifying organics using VIR: As mentioned earlier, the ~3.4 µm organics band is hard to distinguish from the carbonate band, and in principle a stronger carbonate band could easily mask the organics band. It is worth mentioning that different types of carbonates are found existing on a global scale as well as localized areas [1, 6-8]. Again, the association of carbonates and organics (organo-carbonate) in some of the primitive chondrites, e.g., in multiple CM chondrites like, Nogoya, Jbilet, WIS 91600, is reported using micro-Raman imaging spectroscopy [9]. Meanwhile, VIR data at ~3.2-3.5 µm region needs caution while interpreting this wavelength region [6].

Challenges in identifying organics by using FC data: FC color data is not suited to identify organics [3] due to its limited wavelength range. However, the establishment of a direct relationship of a unique red spectral slope in FC color data with the organics detected in VIR data [2, 3] allows an alternative to investigate the potential presence of organics that could be then cross-checked using VIR data. However, the red spectral slope at Vinalia Faculae at Occator crater is not yet understood in terms of its property and composition [8]. It also implies that the likely presence of organics in Cerealia Facula can not be ruled out. Furthermore, there are multiple sites (Fig. 1) with red spectral slope compared with the average surface spectrum (not as strong as Ernutet- or Occator-type). Therefore, a detailed investigation of the spectral properties of the potential organic-rich sites will be a key in resolving the ongoing discussion about the origin, formation and extent of organics on Ceres.

Combined analysis of FC and VIR: A combined analysis using FC and VIR data is in progress. The FC color data from the High-Altitude Mapping Orbit (HAMO) mission phase (~140 m/pixel) and Low-Altitude Mapping Orbit (LAMO) mission phase (~35 m/pixel) are used to identify and select sites exhibiting red spectral slopes. Then, VIR data from HAMO orbit (~380 m/pixel) are used to carry out a thorough spectral investigation of the selected sites. Differences in spatial resolution of the data from FC and VIR instruments need caution. The VIR data used here are the level-1B (radiance) data archived at the NASA/PDS. These level-1B data are processed encompassing the standard multi-step iteration processes: (1) artifact removal adapted from VIR and VIRTIS team's procedure for artifact removal [10-12], (2) thermal removal [14, 15], (3) photometric correction [12, 16]. Figure 1 shows Occator, Ernutet, and an average HAMO-derived spectrum. A detailed analysis for all the selected sites using combined datasets of FC and VIR is in progress.

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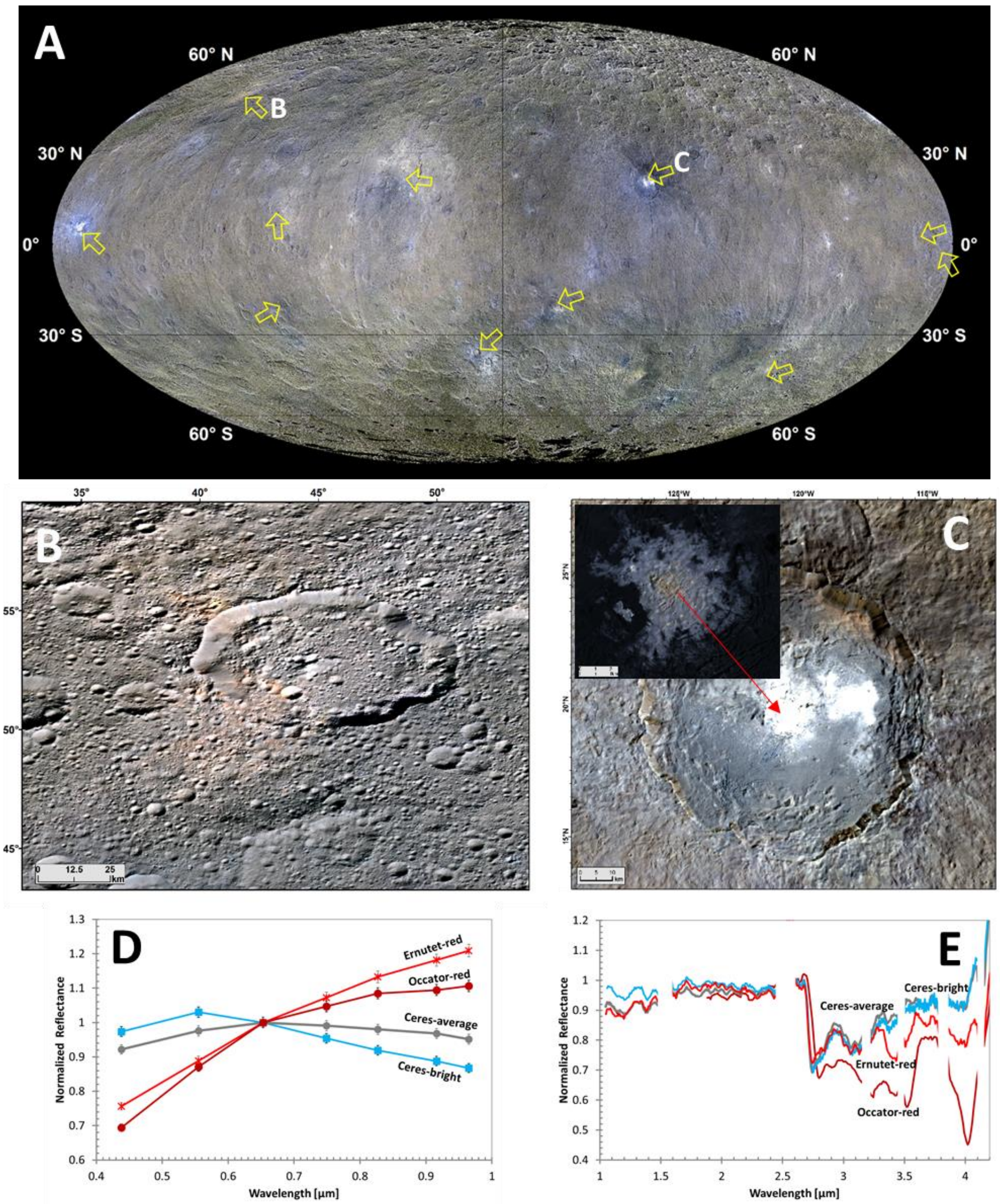

Fig. 1: (A) Global RGB mosaic of Ceres from FC color data (R = 0.96 µm, G = 0.65 µm, B = 0.44 µm) in Mollweide projection centered at 180º longitude. Locations of sites showing red sloped spectra are shown. (B) RGB mosaic of Ernutet crater and the surrounding organic rich areas. (C) RGB mosaic of Occator crater, showing the FC red spectral sloped areas at Cerealia Facula (inset). Normalized spectra of Ceres bright (typical [8]) material, and Occator type of red and Ernutet type of red material from FC color (D) and VIR IR (E) data are shown.