EPSC Abstracts
Vol. 12, EPSC2018-965, 2018
European Planetary Science Congress 2018

Exploring Ceres geology using Dawn Framing Camera

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Abstract

Despite the advanced geologic exploration of Ceres from Dawn observations, some questions remain open. Here we present several of those, and our approach mainly focusing on Framing Camera color data.

1. Introduction

The Dawn spacecraft, equipped with three scientific instruments (Framing Camera/FC, Visible and Infrared Spectrometer/VIR, Gamma Ray and Neutron Detector/GRaND), has been exploring the geology of dwarf planet Ceres since 2015. The eyes of the Dawn mission, the FC, is used for several scientific purpose, for example, geologic mapping, crater counting, surface topography and surface composition. Constraints on the composition of the surface material are derived from color imagery.

Currently Dawn performs its last mission phase, the extension XM2. This orbit brings the spacecraft closest to the cerean surface ever and thus is expected to deliver further insights and details on the cerean geologic evolution. The new data will likely address the open scientific questions.

2. Insights from FC

The Framing Camera is equipped with a clear filter and seven color filters in the wavelength range from 0.4 to 1.0 µm. It is worth mentioning that though the color data is used to constrain the surface composition, it often does not allow unique conclusions because of rather limited wavelength range that are less diagnostic to cerean composition. However, in combination with VIR spectral data the FCs are a powerful tool to detail compositional units.

Figure 1A shows bright and dark material distribution on Ceres highlighting some of the prominent features [1]. The bright material plays an important role revealing surface and subsurface composition. For example, bright material at Occator crater is the most enigmatic geologic feature on Ceres indicating recent geologic activity, possibly lasting until today [1-4]. Meanwhile, an in depth understanding of the cerean dark material is missing, though the very dark material is of similar importance with the bright material. The spectral properties of bright and dark material are found to be altered, changing over time to the cerean average/background material [1]. Further detailed studies of the bright and dark material would shed light on the aqueous and thermal alteration, maturation, and space weathering processes.

Figure 1B shows the color variation across the cerean surface, along with the spectral variations [Fig. C, D]. The different colors indicate compositional variations and/or unique physical properties, which require careful studies in combination with VIR data. For example, peculiar red slope spectra (increasing reflectance with wavelength) have been noted first by [4], and later on VIR observations identified aliphatic organics at these localities [5]. Again, another type of red spectral sloped material is found at Occator's dome, whose nature is not understood yet [6]. Furthermore, multiple sites with less red spectral slope are reported that might be linked to organics [6].

The spectral variations seen in Fig. 1C-D signify important compositional variations across the surface. The red spectral slope of Occator bright red ('o'), Ernutet red ('e'), Ceres average ('c') and bright ('b') and dark ('d') material are shown, including patches with yellow ('y') and less red ('lr') material in color.

3. Future work

An integrated analysis of FC and VIR data is in progress, and expected to answer some of those open questions.

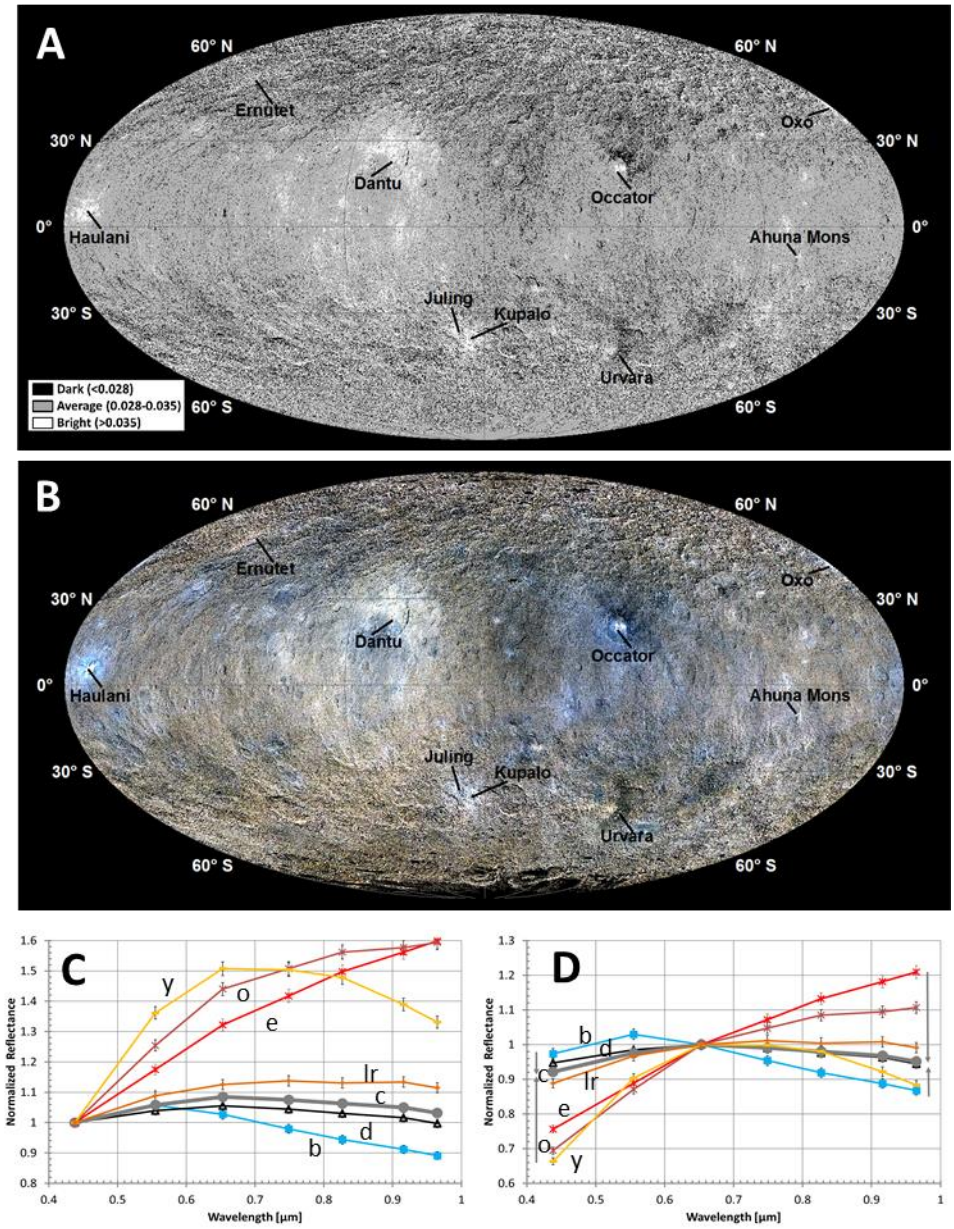

Fig. 1: (A) Bright and dark material distribution on Ceres, (B) Color variation across the surface (R: 0.96, G: 0.65, B: 0.44 μm), (C, D) spectral variability across Ceres surface, normalized at 0.44 μm (C) and 0.65 μm (D). The letters indicate the type of spectra: Occator bright red ('o'), Ernutet red ('e'), Ceres average ('c') and bright ('b') and dark ('d') material, yellow ('y') and less red ('lr') material.

References

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