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Spectral analysis of crater central peak material (ccp)

A. Galiano (1,2), E. Palomba (1,3), A. Longobardo (1), M.C. De Sanctis (1), F.G. Carrozzo (1), A. Raponi (1), F. Tosi (1), E. Ammannito (4), C.A. Raymond (5), C.T. Russell (6) and the VIR team.
(1) INAF-IAPS, Rome, Italy (anna.galiano@iaps.inaf.it), (2) Università degli Studi di Roma Tor Vergata, Rome, Italy, (3) ASDC-ASI, Rome, Italy, (4) ASI-URS, Rome, Italy, (5) JPL, California Inst. Tech, Pasadena, CA, USA, (6) UCLA, Los Angeles, CA, USA.

Abstract

The dwarf planet Ceres, the largest and most massive object in the main asteroid belt, is dark and heavily cratered by impacts. The detection of bright spots, especially in the Occator crater, suggested a vertical gradient in Ceres mineralogical composition [1]. Geologic mapping of Ceres enabled the identification of various surface features of interest [2]. Here we focus our attention on the geologic units known as *crater central peak material* (*ccp*). Ccp composes the central peak of several complex craters, probably representative of fresher material coming from the subsurface as a consequence of the impact [3]. We carried out a spectral analysis of ccps found on Ceres to investigate the mineralogical properties of the subsurface material.

1. Introduction

The NASA Dawn mission closely explored Ceres since March 2015. Dawn carries two remote sensing instruments: the *Visible and Infrared mapping spectrometer* (VIR; [4]) and the *Framing Camera* (FC; [5]). The average surface of Ceres is composed by ammoniated (NH_4)-phyllosilicates, Magnesium (Mg)-phyllosilicates, Calcium (Ca) and/or Mg-carbonates, and dark, spectrally featureless material [6]. Bright, widespread areas have been observed on the dwarf planet: the two brightest spots lie in the dome and floor of crater Occator [7] and are referred to as *Cerealia Facula* and *Vinalia Faculae*, respectively. The mineralogical composition of Cerealia Facula is largely different from the rest of Ceres surface, due to the presence of Sodium (Na)-carbonates, Aluminum (Al)-phyllosilicates, ammoniated minerals and dark material [8]. These results, together with the spectral analysis of other bright spots detected by VIR [7] and contrast-rich color mosaics obtained by FC [1], suggest a peculiar composition of the shallow subsurface, different from the average composition observed on the surface. Detailed geologic maps of the dwarf planet have been obtained by using FC images, which allowed the identification of geologic units. To better investigate the possible mineralogical variation in the shallow subsurface, we examined the spectral properties of the geologic unit identified as *crater central peak material* (*ccp*) [2]. This unit is found in the middle of the floor of large craters, and it is supposed to represent shallow subsurface material exposed during the crater formation, after the rebound of the floor and the subsequent creation of a central peak [3].

2. VIR data

To analyse ccps on Ceres, we used hyperspectral data acquired by VIR, i.e. bidimensional spatial images taken in the wavelength range from 0.25 to 5.1 µm. Since the beginning of the mission, Dawn performed several mapping orbits, reducing its altitude from the dwarf planet's surface and acquiring data with increasing spatial resolution. Spectral data from the Survey phase (altitude 4400 km and spatial resolution ~1.1 km/pixel), HAMO phase (altitude 1470 km and spatial resolution 360-400 m/pixel) and LAMO phase (altitude 385 km and spatial resolution 90-110 m/pixel) were used in this work. The photometrically corrected reflectance at 1.2 µm [9] was calculated for the entire dataset.

3. Geologic overview

Central peaks/mounds are topographic features typical of complex impact craters. As consequence of an impact, a shock wave penetrates in the target material, melting and vaporizing the external layer. The shock wave keeps moving below the transient cavity, expelling material (producing ejecta) and ejecting remnants downward (forming the crater floor) or outward (producing crater walls and uplifted crater rim) [10]. To compensate the mass deficit in the transient cavity, the floor begins to uplift [11] and a central peak may eventually form. Peaks are probably composed of fresher subsurface material, even though the contamination with impact melt deposits cannot be excluded [12].

4. Spectral investigation of ccps

We spectrally investigated 32 ccp units, which stand out in geologic maps of Ceres as they exhibit a different color and morphology with respect to the surrounding floor [2]. We focus our attention on spectral parameters related to Mg-phyllosilicates (2.7 µm band), ammoniated phyllosilicates (3.1 µm band) and carbonates (bands at about 3.4 and 4.0 µm). Band depths and band centers were calculated after continuum removal, whose best fit has been detected in [13]. The goal of this work is to undertake a mineralogical analysis of crater peaks and discriminate a possible differentiation between surface and subsurface. The 2.7- and 3.1-µm band depths are strongly correlated on ccps, being shallower than on the average surface of Ceres (Figure 1). This trend agrees with the general behavior of younger Ceres features [14, 15]. The photometrically corrected reflectance [9] is also considered and compared with spectral parameters to improve the mineralogical analysis. For each ccp unit, we compared the spectral parameters with the crater's floor, to detect a possible contamination of the peak by surrounding material. In this way, we can discriminate the ccp that are most indicative of the Ceres' subsurface material.

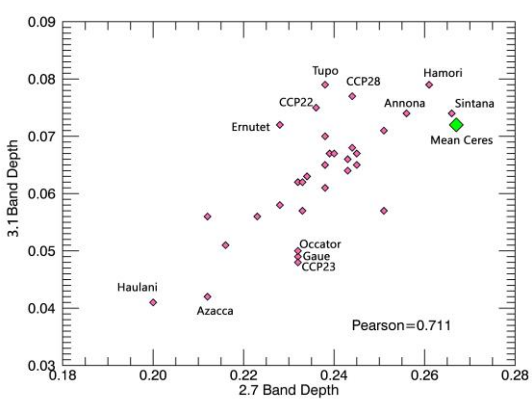

Figure 1: Scatterplot of 3.1 µm band depth in function of 2.7 µm band depth of ccps (pink rhombus) compared with Mean Ceres value (green rhombus).

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