EPSC Abstracts
Vol. 11, EPSC2017-637, 2017
European Planetary Science Congress 2017

Pitted terrains around Marcia crater on Vesta: strong eucritic absorptions and their implications

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Introduction

The NASA Dawn Mission orbited the asteroid Vesta in 2011/12 and obtained high resolution color images of its surface. The crater Marcia is roughly 60 km in diameter and the youngest large crater on the asteroid. In the broad surrounding of the crater, the Vestan regolith exhibits fairly diminished spectral characteristics with respect to Vesta's endogenic meteorite analogues, the HED's (howardite, eucrite, diogenite, e.g., [1], [2]). This is probably due to the input of spectrally darker material by impacts of different types of asteroids/meteorites (e.g., [3], [4]). Vesta also exhibits pitted terrains [5], most prominently present in and around the crater Marcia. In this study, we investigate an interesting spectral feature of some of the pitted terrains, which exhibit strong pyroxene absorption features consistent with those of eucrites, while their immediate surrounding does not show these prominent eucritic spectral characteristics (see Fig. 1).

Data and methods

We utilize Framing Camera color filters in order to identify the different spectral characteristics of Marcia crater and its surrounding with respect to the first pyroxene absorption band (i.e., the reflectance ratios 750/917, 965/830 and 965/917 [nm]). These data are then compared with different meteorite spectra (downloaded from the RELab database at Brown University, http://www.planetary.brown.edu/relabdocs/relab_disclaimer.htm) in order to infer the probable material composition. Additionally, we analyze high-resolution LAMO images (Low Altitude Mapping Orbit, ~ 20 m/px, [6]) and a digital terrain model [7] to reveal the geomorphological settings associated with the pitted terrains.

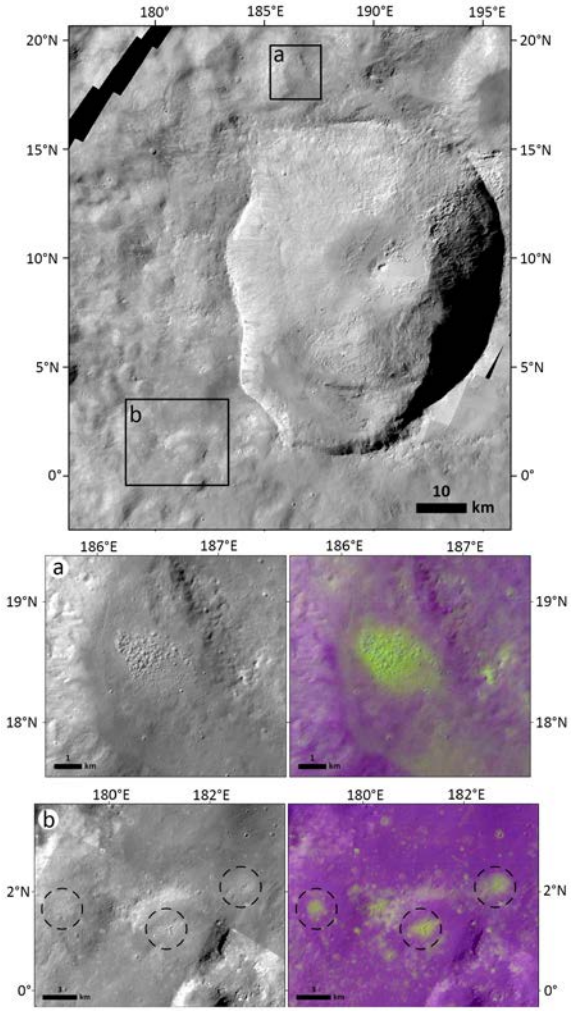

Figure 1: Pitted terrains around Marcia exhibiting spectral characteristics matching those of eucrites. a and b, left, display RGB images composed of R=F5/F4 (965/917 nm), G=F3/F4 (750/917 nm) and B=F5/F6 (965/830 nm), superposed on a LAMO clearfilter mosaic. Greenish/ yellowish colors correspond to stronger absorptions while purple/bluish colors correspond to diminished absorption features.

Spectral and Geomorphological Results

Marcia and its proximate surrounding show diverse spectral characteristics. The most eucritic (endogenic) spectral characteristics according to our spectral comparison with meteorites are locally confined and are found on the western crater rims, at the northwestern crater wall (around a young impact), at some of the pitted terrains located north and southwest of the crater and on some parts of the eastern crater rim. The color ratio data of the regolith material surrounding Marcia plot in an intermediate area between HED color ratio data and those of other meteorites like carbonaceous and ordinary chondrites for the analyzed color ratios.

The pitted terrain found on the floor of Marcia was reported to exhibit a lower reflectance than the average Vesta [5,8]. In contrast, we found that some of the pitted terrains in the immediate surrounding of Marcia, most of which occur within ~ 25 km of the current crater rim, exhibit strong pyroxene absorptions consistent with those of eucrites. The occurrence of those pitted terrains seems to be dependent on their location. The pitted terrain just north of Marcia and the pitted terrains found west/southwest of Marcia exhibit the most prominent eucritic characteristics, whereas the pitted terrains south/southeast of Marcia exhibit only very slight deviations of their spectral characteristics with respect to their immediate surrounding.

The digital terrain model [7] reveals that the pitted terrains do not always occur in topographic depressions. Instead, many of them are situated on a topographic slope.

Discussion

[5] have argued that the pitted terrains on Vesta likely formed by a similar process as on Mars, through volatile degassing. Previous studies have shown that in general, upon losing volatiles, spectra of natural materials become diminished and gradually lose their absorption features (e.g., [9]). This is not true for the pitted terrains surrounding Marcia which is intriguing.

The pitted terrains might be the result of a very young event, thus not exhibiting any space weathering effects described by [10]. However, the pitted terrains most likely formed during the impact process or shortly after. Otherwise, another process must be identified which could trap considerable amounts of volatiles long enough in the immediate subsurface of a regolith layer. Another explanation might involve the devolatilization process itself, which may have removed the darkening agents or darkening effects of other regolith constituents. The fact that some of the pitted terrains are located on topographic slopes might indicate uplift events after devolatilization occurred or different processes leading to those patterns that are not time dependent.

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