EPSC Abstracts
Vol. 9, EPSC2014-251, 2014
European Planetary Science Congress 2014

Vesta's diverse lithologies from Dawn FC

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Abstract

We present the results of an extensive mapping effort of the Vestan surface by using Dawn Framing Camera (FC) data. The identified lithologies are of HED, carbonaceous chondritic and peridotitic nature and include specific sites as, for example, the Marcia crater.

1. Introduction

The FC [1] on-board the Dawn spacecraft has imaged the entire visible surface of asteroid 4 Vesta from three different orbits at spatial resolutions of ~250, ~60, and ~20 m/pixel. The FC is equipped with one clear and seven color filters, covering the wavelength range between 0.4 and 1.0 µm [1].

The surface of Vesta is unlike any asteroid visited so far. Albedo and color variation are the most diverse among the objects in the asteroid belt [2]. To date FC data revealed the following different lithologies:

1) Howarditic lithologies
2) Eucritic lithologies
3) Diogenitic lithologies
4) Dark material (DM) dominated lithologies
5) 'Orange material' dominated lithologies
6) Peridotitic lithologies

On Vesta, HED (howardite–eucrite–diogenite) dominated lithologies show the largest spatial extent by far. While diogenites are mainly found within the Rheasilvia basin, eucrites are clustering in a broad range between ~80°E and ~220°E and ±30° latitude [2, 3]. The remaining surface is rather howarditic with the exception of units 4) to 6). Terrains showing DM have been identified in several geologic settings [3, 5]. Framing Camera color spectra [3, 5], and spectra acquired by VIR [5], indicate that DM, which is mixed with materials indigenous to Vesta, is spectrally similar to carbonaceous chondrite meteorites (CC), and thus of exogenic origin, i.e. due to the infall of carbonaceous volatile-rich material. The identified lithologies of 'orange material' are likely HED impact melt covering, for example, areas around the craters Oppia and Octavia [6]. Olivine-rich lithologies have been identified around and in the craters Bellicia and Arruntia [7, 8] as well as several other impact craters [9, 10]. These dunitic or harzburgitic lithologies are small scale and their origin, either endogenic or exogenic, is still under debate [11].

2. Data Processing

We use level 1c FC images that are corrected for the "in-field" stray light component [12]. The processing is performed by the ISIS software [13], which does the photometric correction using Hapke functions. For the analysis, a global FC color mosaic from HAMO and HAMO2 orbits was computed. The spectral cube is analyzed by ENVI and ArcGIS software. The required shape model was derived from FC clear filter images by Gaskell [14].

3. Results

Our detailed investigation of the Vestan surface revealed for the first time the presence of an absorption feature at ~0.7 µm for several DM localities [4]. In order to identify potential sites showing the DM 0.7 µm feature we extracted those that meet the following criteria: 1) I/F reflectance $R_{(0.653)} \leq 0.09$ are assumed to be caused by carbonaceous chondrite material with minor HED admixtures, 2) $(R_{(0.438)})^2/R_{(0.917)} \leq 0.085$, and 3) $(R_{(0.653)}*R_{(0.749)})/R_{(0.438)} \leq 0.115$; where $R_{(\lambda)}$ is the reflectance in a filter centered at λ µm.

Fig. 1 shows the spatial distribution of DM sites that meet these criteria. The concentration of DM on the low albedo hemisphere of Vesta, along and inside the crater rim of the Veneneia basin (purple line) is striking, suggesting that DM was deposited by the Veneneia impactor.

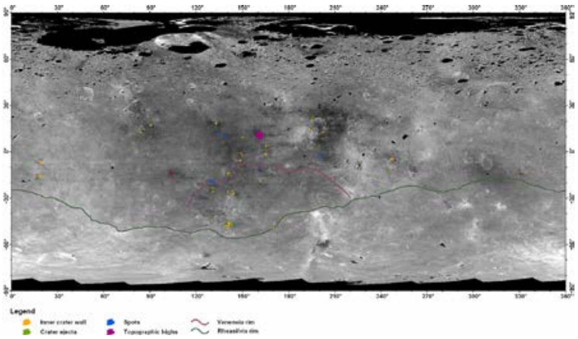

Figure 1: Global distribution map of different geologic DM units on Vesta (Claudia coordinates).

In addition, we were able to confirm the presence of olivine-rich lithologies in and around the craters Bellicia and Arruntia and were able to identify several previously unknown sites [10, 11], for example, within crater Pomponia near the north pole of Vesta. Olivine-rich sites have been identified by using a three spectral parameter approach described in [8]. The used spectral ratios are BT = $R_{0.92\mu m}/R_{0.96\mu m}$, MC = $(R_{0.75\mu m}+R_{0.92\mu m})/R_{0.83\mu m}$, and MR = $(R_{0.75\mu m}/R_{0.83\mu m})$ / $(R_{0.83\mu m}/R_{0.92\mu m})$. Figure 2 shows all Vesta localities that follow our discrimination. For the first time sites in the Rheasilvia basin have been identified as being potentially olivine-rich. Further sites are in and around the craters Pomponia and Portia.

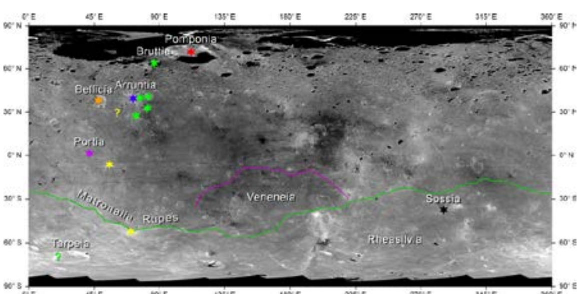

Figure 2: Olivine bearing sites on Vesta (stars) identified by using FC data. Question marks indicate uncertain detections.

Beside the DM and olivine-rich sites, we investigated the Marcia crater lithologies. Marcia is an irregular 62 x 77 km sized crater whose morphology and spectral nature seems to be very special. Figure 3 shows a color ratio mosaic of Marcia, which we will discuss during the upcoming presentation.

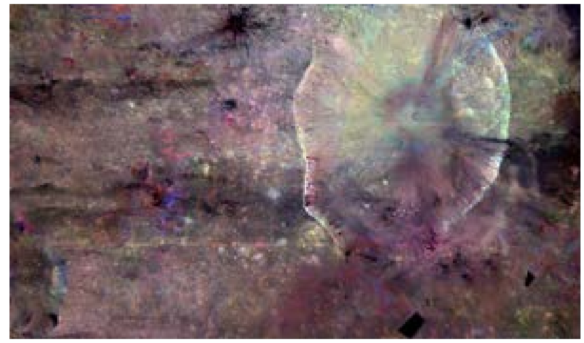

Figure 3: False color-ratio image of crater Marcia.

4. Conclusions

Lithologies that are not dominated by HED material are rare on Vesta. Most of the DM is located inside and along the rim of the Veneneia basin, and it is almost absent in the younger Rheasilvia basin, leading to the conclusion that DM was deposited by the Veneneia impactor [3, 4]. DM in its purest form exists in irregular sub-surface layer(s) or lenses, which are exposed in larger impact craters as outcrops, showing mass wasting down the slopes of the inner walls. Our discovery of an absorption feature that can be attributed to a constituent of CM meteorites, namely serpentine, confirms the theory of an exogenic origin of DM. Olivine-rich material is concentrated in and around the craters Bellicia, Arruntia and Pomponia, as well as two craters near the equator. Few further localities are at or in the Rheasilvia basin. The appearance of the olivine-rich sites at high spatial resolution (~20 m/pixel) is very similar to the DM, i.e. the sites show a layer or lens structure in a similar stratigraphy as the DM along the inner crater walls.

References

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