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Experimental Assessment of the High Reflectance Pitted Terrains on Vesta

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Abstract

The pitted terrains around the Marcia crater on Vesta exhibit a higher reflectance and stronger pyroxene band absorptions with respect to their immediate surrounding. Here we present the results of laboratory experiments considered to reveal the process behind this spectral variation. We find that a mere grain size separation effect cannot be the cause for this phenomenon and that it must be of compositional character.

1. Introduction

Pitted terrains on Vesta occur in and/or around relatively young craters and due to their geomorphological appearance and similarity with Martian pitted terrains [1,12] they have been linked to volatile loss [4]. The surface regolith in the broad region of Marcia crater and its surrounding is characterized by a high amount of OH-bearing materials [3] and by a generally lower reflectance and diminished absorption features (likely due to chondritic contamination [e.g. 8,11]).

Within this region, pitted terrains distributed around Marcia crater show a higher reflectance and stronger pyroxene absorptions with respect to their immediate surroundings (Fig. 1), which was previously described in [5] and [6]. The spectral properties match those of more or less pure eucrites which are members of the endogenic HED meteorite group. Some of the pitted terrains also exhibit a local depletion in OH (Fig. 1, lower right panel), as revealed by the 2.8 µm band depth distribution map generated by [2]. The upper panel in Figure 1 shows stronger pyroxene absorptions as greenish colors.

Interestingly, volatile loss is generally not linked to an increased reflectance and enhanced absorption features [e.g., 9,10] and has not been observed on Mars or Ceres. However, (1) particle size segregation, (2) removal of darkening agent and (3) compositional differences due to endogenic or impact related processes might be able to create the observed features on Vesta. Here, we present the primary results of our laboratory sublimation experiments and their implications in order to explain the observed spectral variations.

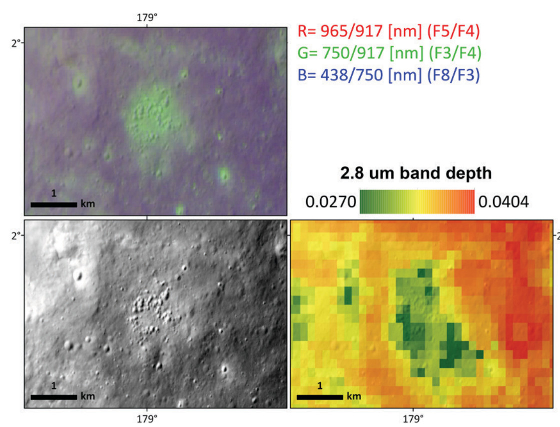

Figure 1: Pitted terrain SW of Marcia. All three panels show the same locality. The lower left panel is a clear filter Framing Camera image at LAMO resolution (~16 m/px). The RGB in the upper panel was generated with FC HAMO data (~60 m/px). Lower right panel was generated by [2] with VIR data.

2. Experimental Setup

All experiments were conducted in the Planetary Spectroscopy Laboratory (PSL) at DLR in Berlin [7]. The reflectance was measured from 0.4 to 1.1 µm in a Bruker 80V spectrometer (biconical, phase angle 30°). We mixed hypersthene as an endogenic analogue (~70-99 wt%) with Murchison chondrite (1 wt%) as well as montmorillonite and carbon black (30 wt%) to create Vestan material analogs.

We placed the samples on top of a water ice layer inside a cylindrical sample container (~5x5 cm), then left it to degas under vacuum (~10^{-5} bar) and a temporarily applied temperature of ~200°C in an emissivity chamber. A metallic lid was placed on top of the sample container (with a small opening of

~3 mm), from where we retrieved the emerged dust (which stuck to the lid) after the experiment.

3. Results

We observed fine-grained particles ("dust") emerging from the container at several sudden events during the experiment. The retrieved dust exhibits a high reflectance but weaker pyroxene absorptions than the original material (labeled "dry mixture" in Fig. 2). The dust contained both endogenic hypersthene particles as well as most of the dark components (i.e., Murchison and carbon black). In the sample container, mostly large hypersthene grains remained (few to none dark components observed). This residual material exhibits low reflectance but strong pyroxene absorptions. We note here that also grains of intermediate size emerged from the sample container but did not get stuck on the lid. We were able to partly retrieve this material from the chamber, which exhibits even larger pyroxene absorptions and higher reflectance than the remaining material in the sample container. However, this emerged material still exhibits a significantly lower reflectance with respect to the original material.

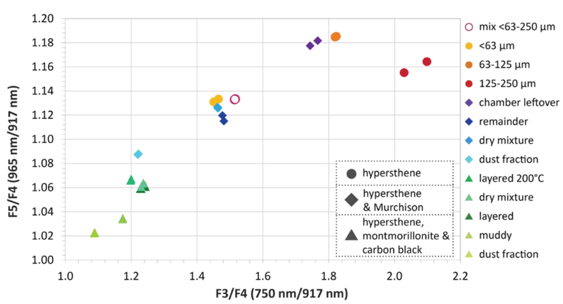

Figure 2: Laboratory data of three different materials (note the different symbols). Note that for all materials, the dust/small grain size fraction has the lowest F3/F4 values (x-axis). However, the pitted terrains on Vesta exhibit higher F3/F4 values than their surroundings. Larger grain size fractions exhibit higher F3/F4 values but much lower reflectance, which is contrary to what we observe on Vesta.

4. Discussion

Our experimental work and the orbital observations imply that grain size segregation and/or the removal of a darkening agent cannot sufficiently explain the spectral behavior of the pitted terrains on Vesta. It is more likely that other, so far undetected compositional differences cause the observed spectral characteristics. As indicated by the depletion of these local areas in OH, the dehydration of phyllosilicates due to heating might play a significant role.

Deposition patterns and geomorphological evidence furthermore suggest that the pitted terrains are associated with the emplacement of Marcia ejecta, which is still ongoing work.

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