ASSESSING THE EFFECTS OF HEATING VESTA-LIKE MATERIAL ON ITS SPECTRAL CHARACTERISTICS. T. Michalik[1], A. Maturilli[1], E. A. Cloutis[2], R. Jaumann[3], K.-D. Matz[1], H. Hiesinger[4], K. A. Otto[1], [1] Institute for Planetary Research, German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany (tanja.michalik@dlr.de), [2] Department of Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, MB, Canada R3B 2E9, [3] Institute of Geological Sciences, Freie Universität Berlin, Germany, Malteserstr. 74-100, 12249 Berlin, [4] Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany.

Introduction: Vesta's pitted terrains around Marcia crater show higher reflectance (at 750 nm) and band strengths (750/917 [nm]) than their immediate surroundings [1,2]. In an older set of experiments, we excluded grain size segregation as the sole reason for the spectral differences [3] and therefore want to investigate other possibilities causing this natural phenomenon at the pitted terrains' sites. The spectral differences likely result from a change that occurred after deposition, as the surrounding material appears to be of the same compositional/geological origin. Furthermore, geomorphologic observations indicate that at least some of the pitted terrains' material consists of accumulated ejecta and therefore might have retained impact heat longer than the surrounding ejecta [4].

In the ongoing study we therefore investigate the spectral behavior of several Vesta regolith analog materials upon heating to different temperatures at different time spans. One of the presented Vesta regolith analogs is a terrestrial analog consisting of hypersthene and a carbonaceous chondrite analog (UTPS-TB) created for studies toward the JAXA MMX mission [5]. The other two presented analogs comprise the eucrites NWA5230 (polymict) and JAH626 (shocked) mixed with Murchison (CM2 carbonaceous chondrite).

Method: Before heating, the samples were put into a dry cabinet (moisture <1%) and then cooled down to ~ -80 °C. We used the 'emissivity chamber' of the Planetary Emissivity Laboratory [6] to perform the heating experiments. The chamber reaches pressures down to 10^{-2} mbar. Heat was applied from below using an induction plate and the heating rate averaged around 5-15 °C/min. The samples remained in the chamber at a constant temperature for 2h or 72h. After cooling to room temperature within the chamber the samples were transferred to a Bruker 80V spectrometer [7] where the visible reflectance (0.4 to 1.1 µm) was measured by a Bruker A513 biconical reflectance unit (e=0°, i=30°). We measured every sample at least twice at different spots of the sample to account for natural differences (2 mm aperture) and averaged the spectra afterwards. In order to compare with Dawn Framing Camera (FC) values, we resampled the spectra to match the FC responsivity functions of the different color filters and calculated the 750/917 [nm]-values (seen in Figs. 1, 2 & 3 in the graph legend), which are indicative of the spectral change that pitted materials have undergone after deposition.

Results: Figures 1, 2 and 3 display the spectra of the three mentioned regolith analogs (Fig. 1 comprises terrestrial material, Figs. 2 & 3 comprise the meteoritic material) heated to different temperatures for 2 or 72 h as well as their 750/917 [nm]-values. With respect to the unheated material, the terrestrial materials mostly showed lower reflectance at 750 nm and band strength after heating (Fig. 1) while the meteoritic samples show higher reflectance for each heated aliquot and mostly lower band strengths (Figs. 2 & 3). Differences in reflectance and band strength are sometimes marginal.

Figure 1 shows the spectra of the terrestrial analog. All aliquots show lower band strengths than the unheated material. Moreover, all aliquots except the one heated to 200 °C show lower reflectance. Worth emphasizing is that the aliquot heated to 400 °C for 72 h shows higher reflectance and band strength than the aliquot heated to 400 °C for 2 h.

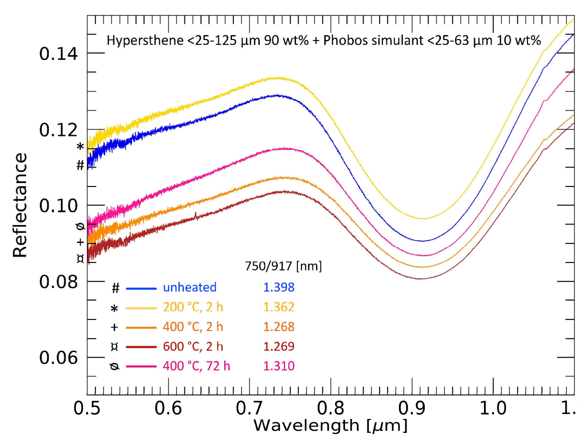

Fig. 1: Reflectance spectra of a terrestrial regolith analog heated to different temperatures for different time spans.

Figure 2 shows the spectra of the meteorite NWA5230 mixed with small amounts of Murchison material. So far, this sample was heated to 300 °C for two different time spans. The aliquot heated for 2 h shows slightly higher reflectance and band strength with respect to the unheated one while the aliquot heated for

72 h shows a significantly higher reflectance but lower band strength.

Figure 3 shows the spectra of JAH626 mixed with Murchison material. Two aliquots were heated to 200 and 600 °C for 2 h. The spectra of both heated aliquots show higher reflectance but lower band strength.

Worth noting is also that the meteoritic samples show a steeper visible slope ('reddening') upon heating (Figs. 2 & 3) while the terrestrial analog (Fig. 1) does not experience this spectral change which could be due to different oxidation states of iron in the terrestrial/ meteoritic samples.

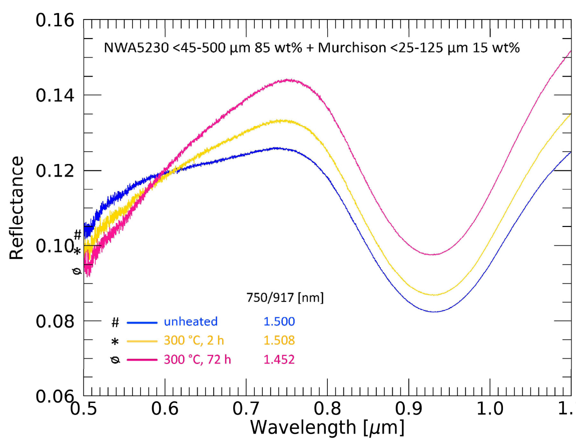

Fig. 2: Reflectance spectra of polymict eucrite NWA5230 mixed with Murchison heated to 300 °C for different time spans.

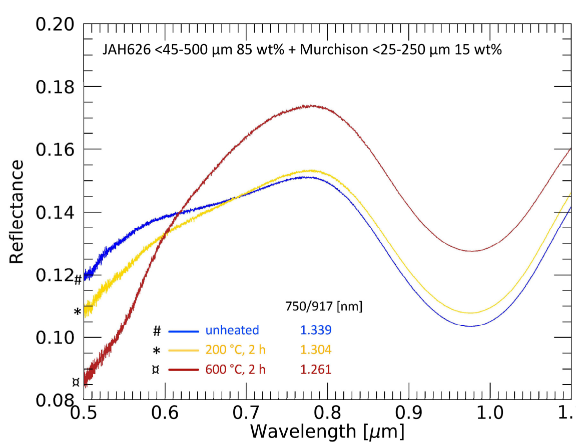

Fig. 3: Reflectance spectra of shocked eucrite JAH626 mixed with Murchison heated to different temperatures for 2 h.

Discussion: All our samples underwent variable spectral changes upon heating. The terrestrial regolith analog containing hypersthene (Fig. 1) shows that an aliquot heated to the same temperature as another one but for a longer time span can result in higher reflectance and band strength which is a promising result for the situation on Vesta as the pitted terrains' material there was probably heated to the same temperature as their surroundings (both comprise ejecta) and the pitted terrains' material was accumulated (indicating heat retention). However, the changes of reflectance and band strength for long-term heating do not show the same trend for every sample investigated here (compare Figs. 1 & 2) but our experiments are not yet complete due to laboratory restrictions during the pandemic. We aim to complete the ongoing experiments with 2 and 72 h and also plan on undertaking even longer-term heating experiments (i.e., one week) to evaluate the spectral changes after even longer time spans.

A combination of several processes – including grain size segregation upon explosive degassing – is also conceivable. Smaller grain sizes favor higher reflectance while larger grain sizes favor higher band strengths [e.g., 3,8]. We therefore additionally plan to measure samples with different grain sizes and chondrite abundances.

Our experiments also show that heating of eucrites mixed with Murchison results in considerably steeper visible slopes (Fig. 3). This observation could be interesting regarding another feature on Vesta – the "orange material", especially associated with the crater Oppia. The orange material is characterized by a steep visible slope and in some cases by very well-defined geologic units. The orange material is assumed to be impact melt [9].

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