THE SPECTRAL PROPERTIES OF PITTED IMPACT DEPOSITS ON MARS. T. Michalik[1], V. G. Rangarajan[2], D. Tirsch[2], E. A. Cloutis[3], L. L. Tornabene[4], R. AbuShunnar[5], K. A. Otto[2], [1]Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Invalidenstraße 43, 10115 Berlin, Germany (tanja.michalik@mfn-berlin.de), [2]Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt e.V., Rutherfordstr. 2, 12489 Berlin, Germany, [3]Department of Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, MB, Canada R3B 2E9, [4]Western University, Institute for Earth & Planetary Exploration, 1151 Richmond St., London, ON, Canada N6A587, [5]Freie Universität Berlin, Institut für Geologische Wissenschaften, Malteser Str. 74-100, 12249 Berlin, Germany.

Introduction: The 'pitted impact deposits' on Mars (e.g., Fig. 1) are clustered, polygonally-shaped devolatilization pits that occur ubiquitously on the Martian surface within primary ejecta deposits of impact craters. They were thoroughly studied by [1] and [2], providing details about their geographical distribution, geological appearance and formation mechanism.

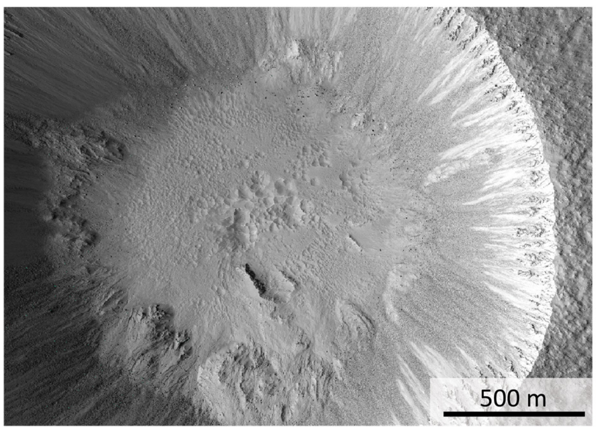

Figure 1: HiRISE image PSP_003608_1510_RED of Zumba crater on Mars with clustered pits in its central ejecta deposit. Zumba is centered near 133.07 °W and 28.68 °S and the shown image is north-oriented.

They occur preferentially in mid-latitudes, which emphasizes the significance of the prevailing volatile/rock-ratio. Moreover, their preservation states and sizes correlate positively with preservation states and sizes of their host craters, showing that they can also be obscured over geological times scales. The pits form by rapidly escaping steam and it was estimated [2] that this process takes place within a few weeks or even months, depending on the abundance of volatiles and deposit thickness. It was also suggested that clasts/particles of diverse sizes were entrained within the escaping steam, thus being transported from the interior deposit to the surface. The ejecta material was concluded to most likely resemble a melt-bearing breccia, showing similarities to the suevite of the Ries crater in Germany [1,3].

Pitted impact deposits also occur on the main belt asteroid Vesta [4], partly exhibiting distinct spectral properties like higher overall reflectance, higher pyroxene absorption strengths at 0.9 and 1.9 µm and a depletion in hydroxyl with respect to their immediate surrounding of the same deposit [5]. The scope of this study is therefore to characterize the spectral properties of the pitted impact deposits on Mars in general as well as to determine whether the Martian pits exhibit similar distinct spectral properties as observed on Vesta.

Methods: We use a combination of different data sets in order to reveal combined spectral and geomorphological information. In particular, we focus on CRISM (Compact Reconnaissance Imaging Spectrometer for Mars [6]) and CTX (Context Camera [7]) data, yet we also use CaSSIS (Colour and Stereo Surface Imaging System [8]) and HiRISE (High Resolution Imaging Science Experiment [9]) data where necessary. CRISM data serves as the primary source for spectral information, with a spectral sampling of ~7 nm, about 500 spectral bands from ~0.4 µm until 3.9 µm and a spatial resolution of ~20-200 m/px. CTX images serve as geomorphological context and provide a spatial resolution of ~6 m/px. We also plan on comparing CRISM data with the limited spectral information of CaSSIS data, which provide a maximum of four spectral filters in the VIS/NIR wavelength region (BLU at ~495 nm, PAN at ~678 nm, RED at ~836 nm and NIR at ~939 nm), yet with a better spatial resolution of up to 4-5 m/px. HiRISE data would provide higher spatial resolutions (up to 30 cm/px) and would serve for more detailed geomorphological correlations if needed.

As we currently have more than 300 identified craters with pitted impact deposits (extension of database in [1]), we will focus on the largest and most well-preserved craters in the beginning and continue with progressively evolved preservation states during the course of this study.

Preliminary Results: Figure 2 shows CTX (Fig. 2a & b) and CRISM data (Fig. 2c & d) of the central peak with nearby devolatilization pits of crater Pal (app. 108° E, 31° S) east of the Hellas basin. Figure 2c shows a ratio of CRISM bands at 716 nm and 501 nm (channels 33 and 11, respectively), possibly indicating ferric iron content, while Figure 2d shows a ratio of CRISM bands at 716 and 1250 nm (channels 33 and 110, respectively), characterizing the absorption band centered near 1050 nm. We use the 1250 nm band as we encounter severe artefacts near the band center wavelengths. Pits appear sensitive to both CRISM ratios, especially pronounced in the lower right image parts. At this point, this could indicate both differences in mineralogy (ferric iron content) and physical material properties like grain size.

Figure 3 shows example spectra of the center of a well-preserved pit (upper spectrum) and material adjacent to the observed pits (lower spectrum, locations indicated in Fig. 2c). We observe that the interior of the pit exhibits a slightly higher slope in the VIS range, accompanied by an overall higher reflectance beyond ~600 nm. The depth of the absorption band near 1050 nm does not appear to be different for both regions. This could indicate the presence of ferric iron within the pits or smaller grain sizes due to dust coverage within the pits. CTX data clearly show the presence of dunes within several pits (Fig. 2b).

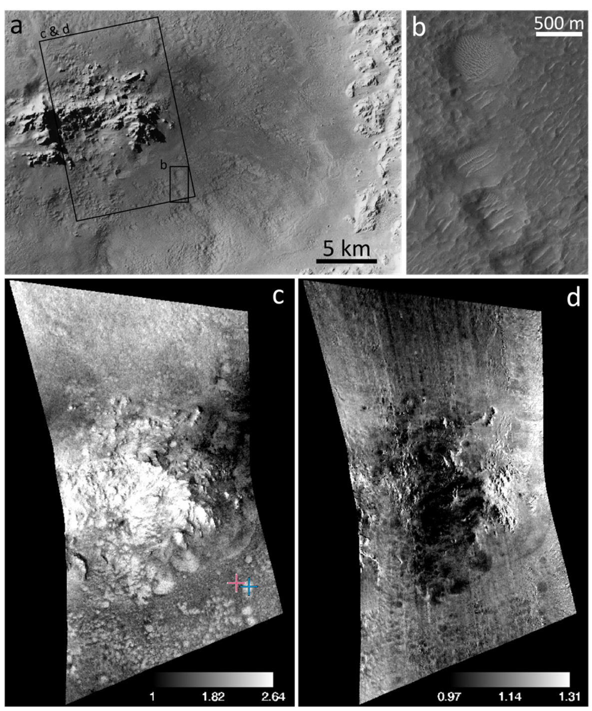

Figure 2: Images of the central peak and nearby pitted impact deposits of crater Pal on Mars. a) CTX image (V01_E108_N-32), b) close-up of pits southeast of the central peak, showing dunes within and outside of pits, c) CRISM ratio 716/501 [nm] and d) CRISM ratio 716/1250 [nm] of image hrl00010d20_07_if182j_mtr3.

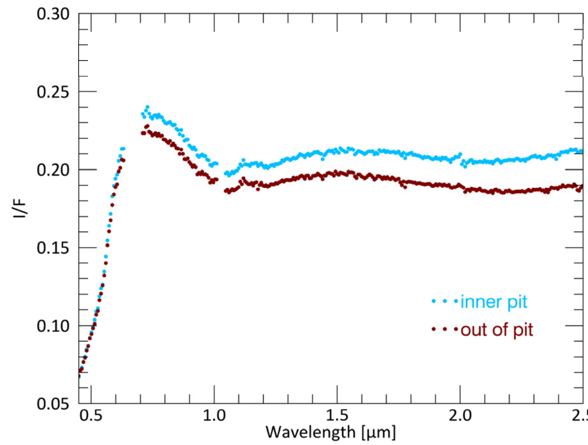

Figure 3: Reflectance spectrum derived from CRISM image hrl00010d20_07_if182j_mtr3 of the center of a pit (upper spectrum) southeast of the central peak of Pal and outside of the pit (lower spectrum). Locations of spectra indicated by red (outside pit) and blue (inside pit) cross in Fig. 2c.

Discussion: This preliminary work requires significant more observations of several craters. Additionally, distinct spectral properties of pitted impact deposits on Vesta occur almost exclusively within the ejecta blanket, thus we might need to focus on the ejecta blankets of craters on Mars as well, where CRISM coverage is unfortunately very limited. CRISM coverage is in general limited and the instrument not operational anymore. We therefore need to consider other sources of spectral information and data sets (e.g, CaSSIS) in order to find suitable data to assess the spectral properties of pitted impact deposits on Mars.

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References: [1] L. L. Tornabene et al. (2012) *Icarus 220,* p. 348. [2] J. M. Boyce et al. (2012) *Icarus 221,* p. 262. [3] Newsom et al. (1986) *Journal of Geophysical Research 91, B13,* p. E239. [4] Denevi et al. (2012) *Science 338*, p. 246 [5] T. Michalik et al. (2021) *Icarus 369,* Article 114633. [6] Murchie et al. (2007) *Journal of Geophysical Research 112*, E05S03. [7] Malin et al. (2007) *Journal of Geophysical Research 112*, E05S04. [8] Thomas et al. (2017) *Space Science Reviews 212*, 3-4, p. 1897. [9] McEwen et al. (2007) *Journal of Geophysical Research 112*, E05S02.