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Updates on the mineralogical analysis of dark materials in Martian craters

D. Tirsch (1), R. Jaumann (1,2), F. Poulet (3), L.H. Roach (4), J.L. Mustard (4), J-P.Bibring (3) and G. Neukum (2)

(1) German Aerospace Center (DLR), Berlin, Germany, (2) Institute of Geological Sciences, Free University Berlin, Germany, (3) Institut d'Astrophysique Spatiale, CNRS Université Paris-Sud, Orsay, France. (4) Dept. of Geological Sciences, Brown University, Providence, RI, USA. (daniela.tirsch@dlr.de, Fax: +49-30-67055442)

Introduction: A refinement of the mineralogical analysis of dark materials in Martian craters is presented here. 70 localities of dark material deposits, including dunes, dune fields, and sand sheets, were examined by using near infrared spectra from the MarsExpress/OMEGA spectrometer [1]. Additionally, near-infrared MRO/CRISM data [2] with a spatial resolution of up to 18m/px were used to derive spectral information of dark layers exposed at impact crater walls. These layers are supposed to be a local source for the material inside the craters [3, 4]. A similar mineralogical composition would prove this suggestion.

Methodology: For every location, we analyzed at least two different OMEGA orbits. The data were corrected for solar irradiance and atmospheric absorptions. The mineral detection was done using an IDL routine that applies a ratioing technique to the geometrically and atmospherically corrected OMEGA data. The applied technique was developed and described in detail by [5]. The spectral parameters used for the mineral detection were derived from [5] as well. They include the typical absorption features for every mineral of interest. Using these different spectral criteria, the distribution of high- and low-calcium pyroxenes, olivine, and hydrated minerals could be mapped. For this analysis, the spectral range from 1–2.5 µm was considered. CRISM targeted observations covering dark layers are rare so that only a few observations could be analyzed yet. Spectral ratios were use to enhance the spectral signature of the present minerals.

Results: The method outputs are images comprising the absorption band depths for the minerals of interest. The overlay of these absorption depth images onto the original OMEGA images allows the mapping of mineral absorption depths on the surface. Figure 1 reflects a typical result for the analyzed localities. The major part of the dark material shows pyroxene absorptions, whereas olivine can (if existing at all) solely be detected in smaller patches, mostly located at the interior of the dark patch. At Dawes crater, the olivine bearing patches comprise dark dunes, while the surrounding is covered by pyroxene bearing dark sands. Note that the dune material shows pyroxene absorption, as well. The global mineralogical distribution of the studied dark dunes and sand sheets is shown in figure 2. As already known from multiple former studies [e.g. 6, 7], the analysis yields a higher content of mafic unoxidized minerals. Pyroxene is the predominant mineral, whereas olivine was found in 20 of the 70 localities. In certain places and solely in parts of the material depositions, hydrated minerals were detected [8]. These minerals point to a partial aqueous alteration of dark material. However, the hydrated signal could alternatively emanate from altered material underneath a thin deposit of dark material [5]. This supposition is preferable for at least 3 locations at Arabia Terra, where all hydrated mineral detections are located. For five out of 70 locations, no mafic signature could be assessed. The flat and featureless spectra of these dune fields point to a coverage of dust onto the dark deposits' surface. For two northern crater dune fields, no mineralogical composition could be analysed because water ice covers the spectral signature of the dunes. Concluding, the results show that the analysed dark intra-crater deposits are in a whole of the same mineralogical composition and thus might have the same origin. The observed distribution of mafic minerals is comparable with the results of [9, 10].

CRISM spectra taken from dark material, which just comes out of a dark layer at a crater wall (figure 3) point to olivine and pyroxene bearing material that is weathering into the dunes. The dunes itself show obvious pyroxene content but no strong olivine absorptions. The lack of strong olivine signature in the dunes could be an effect of grain size. However, the results establish a mineralogical association between wall material and dune material. Conversely, not every CRISM scene reveals this mafic composition of the dark layers. Dust accumulation on shallow crater walls is supposed to be the reason for the lack of a distinct signature. Further investigations incorporating a bigger number of CRISM observations have to be done in order to prove the suggestion of the generic correlation between dark layers and intra-crater material.

References

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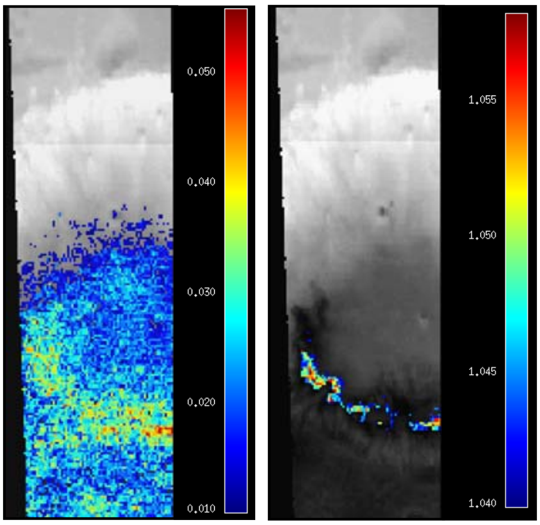


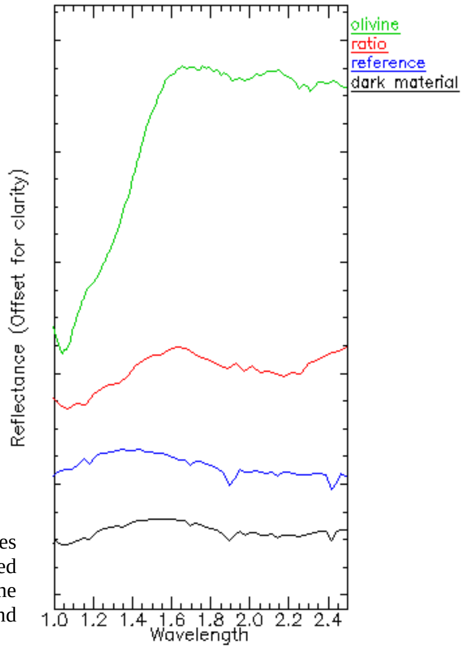
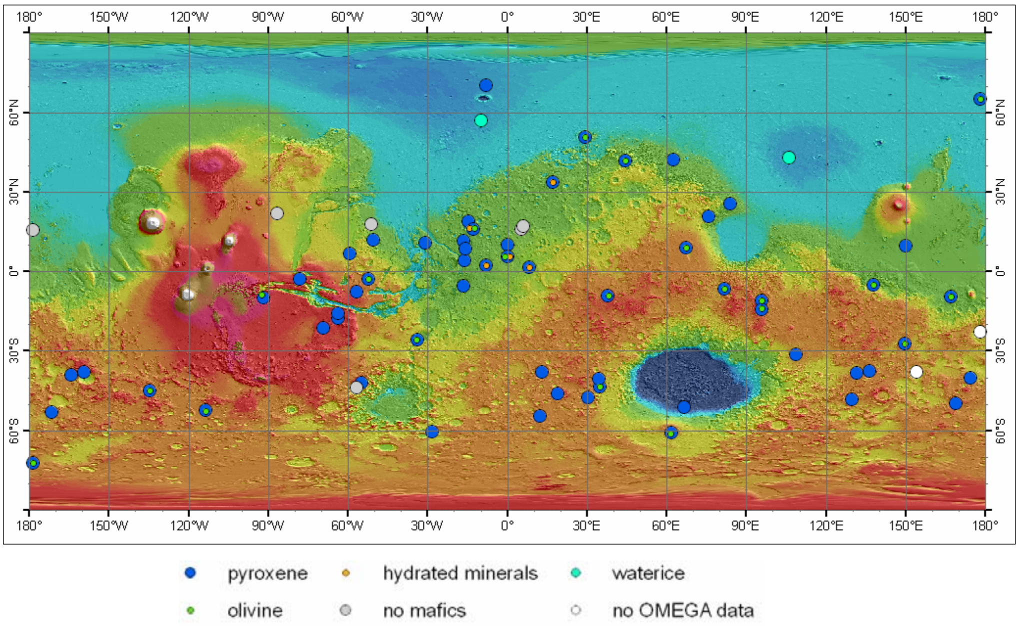
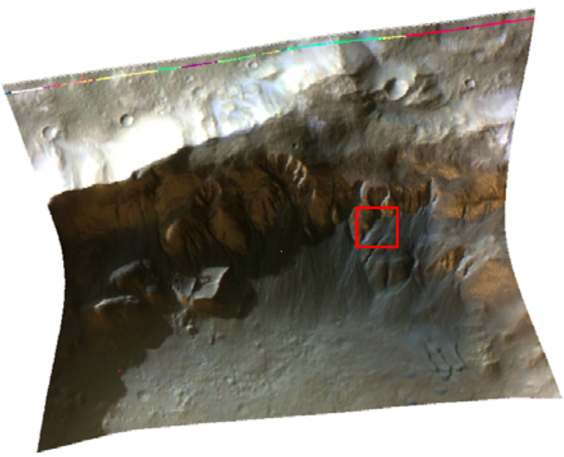


Figure 1: Results of the OMEGA spectral analysis of dark material in Dawes Crater at TERRA SABEA (ORB2384_4). *left*: mapping of pyroxene inferred from the depth of the 2 µm band; *middle*: mapping of olivine inferred from the 1 µm band; *right*: The spectral ratio (red) of dark material spectrum and reference spectrum enhances the spectral features of olivine and pyroxene.



Figue2: Global view on the mineralogical composition of dark intra-crater deposits.



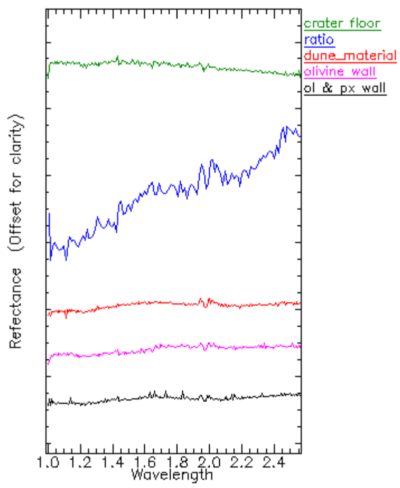


Figure3: Spectral analysis of dark material at crater walls. Red quadrangle in CRISM observation FRT00003266 (left) shows position where the wall spectra (right) were taken from. Ratio of dark material and crater floor (blue spectrum) emphasises the olivine signature.