DUST DEVIL TRACKS IN THE TURPAN DEPRESSION DESERT (CHINA): IMPLICATIONS FOR THEIR FORMATION ON MARS. D. Reiss[1], J. Raack[1], A. Maturilli[2], A. P. Rossi[3], and G. Erkeling[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (dennis.reiss@uni-muenster.de), [2]Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Rutherfordstrasse 2, 12489 Berlin, Germany, [3]Department of Earth and Space Sciences, Jacobs University Bremen, College Ring 1, 28759 Bremen, Germany.

Introduction: Dust devil tracks on Mars are frequently observed in satellite imagery [e.g., 1-4]. The resulting albedo contrast after passages of dust devils could be caused by compositional or phototometric differences between the underlying surface material and the removed upper surface layer, or a combination of both. A better understanding of the dust devil track formation process and knowledge about the amount of removed material to create the tracks would also help to improve the calculations for dust entrainment by dust devils. In situ measurements with the Microscopic Imager (MI) onboard of the Mars Exploration Rover (MER) Spirit in Gusev crater showed that surfaces consisting of sand grains within dark dust devil track zones are relatively free of finer grained dust compared to the bright regions outside the tracks [5]. This observation indicates a formation of dust devil tracks caused by different grain size distributions inside and outside the track because the brightness is photometrically inversely proportional to grain size [5]. On Earth, dust devil tracks are rare and only a few observations were so far reported based on satellite imagery [6-10]. First in situ investigations of dust devil tracks on Earth [8, 9] are consistent with the formation mechanism caused by photometric effects on Mars [5]. Here, we report about our in situ measurements and laboratory analyses of soil samples of investigated dust devils tracks in the Turpan depression desert (China). The aim of this study is to constrain the influence of compositional differences of the soil and dust properties in the formation of dust devil tracks.

Results: *Occurrence.* Dark dust devil tracks in the Turpan Depression desert were identified in satellite imagery accessed through Google Earth [8]. Based on the available high resolution Quickbird imagery in Google Earth with a resolution of ~60 cm/pxl we mapped all observable dust devil tracks of the dune field. Dust devil tracks seem to be restricted to flat interdune and peripheral areas of the erg. These regions appear darker in Landsat RGB false color composites in contrast to the brighter dune areas. Field survey revealed that three main surface types can be distinguished based on their morphology and albedo (Fig. 1). Bright dune surfaces are characterized by small ripples (Fig. 1A). The ripple heights are ~1 cm and the wavelengths ~5 cm. Darker flat areas show ripple surfaces with heights of ~3 cm and wavelengths of ~20 cm (Fig. 1B). Even larger ripples occur on low inclined surface areas with heights of ~20 cm and wavelengths of ~100 cm (Fig. 1C). The apparent albedo contrast of a transition zone between a bright dune and a darker interdune surface is shown in Fig. 1D. Based on satellite imagery and field survey dust devil tracks were only observed on darker appearing ripple surfaces, but not on bright dune surfaces.

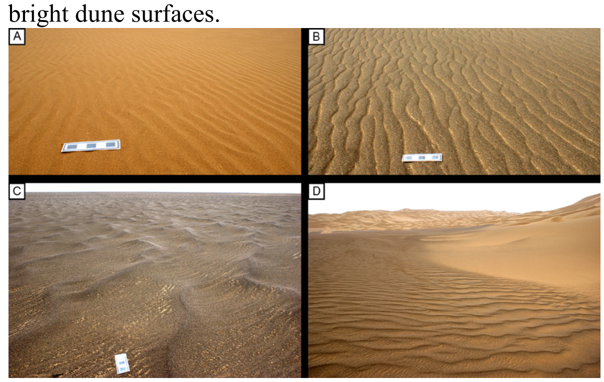

Figure 1. (A) Bright dune surface in the northwestern part of the dune field. (B) Ripple surface on a plain at the western edge of the dune field. (C) Large ripples on an inclined slope at the western edge of the dune field. (D) Transition zone between a ripple surface in an interdune area and a bright dune surface. All scale bars are 25 cm in total width.

Grain sizes. The three main surface types of dunes, ripples and large ripples were analyzed for particle size distributions after [11]. Samples were taken from the upper 1 cm of ripple crests. The bright dune surfaces are dominated by fine sand (125 – 250 µm, 75 wt%), ripple surfaces are dominated by coarse sand (500 – 1000 µm, 68 wt%), and large ripple surfaces by very coarse sand (1000 – 2000 µm, 86 wt%).

Mineralogy. For the mineralogical analysis with a Powder X-Ray Diffractometer and Fourier transform infrared spectrometer, three different main sample grain sizes from dune (125-250 µm), ripple (500-1000 µm), and dust (<63 µm) material were crushed with a disc mill to homogenous grain sizes of ~1-2 µm. Fig. 2 shows the mineralogical results from the three samples derived with the Powder X-Ray Diffractometer. The numbering indicates specific minerals for clarification. In general the mineralogical composition of all three grain sizes is very similar with slight variations in their proportional frequency of specific minerals. Quartz (1) is the main component of all three samples; all other minerals represent minor components. The second frequent mineral found in all samples is Albite (2). The only noticeable difference in the mineralogical composition is the much more frequent presence of Calcite (3) in the dust samples. The IR spectral analysis confirms the Powder X-Ray Diffractometer results.

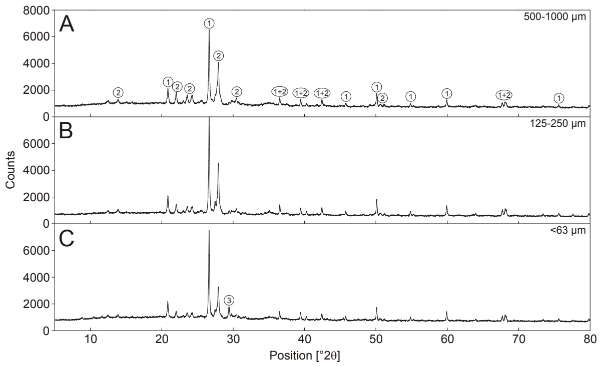

Figure 2. Powder X-Ray Diffractometer results of crushed (A) ripple (500-1000 µm), (B) dune (125-250 µm) surface samples and (C) dust (<63 µm). Numbering indicates specific mineral signatures: (1) Quartz; (2) Albite; (3) Calcite.

Microscopy. For layer thickness estimations of the surficial dust (<63 µm) layer on top of ripple surfaces we measured the radii of particles in high resolution microscopic images. The images were obtained with a handheld microscope in the field to ensure imaging of undisturbed surfaces. We imaged several inside a ~1.5 m wide dust devil track and additionally areas about 3 m outside (left and right) of the track (Fig. 3). Assuming an average material density of 2500 kg^{-3}, our measurements indicate a layer thickness of 2.92 µm outside the track and of 1.71 µm inside the track. This implies that a removal of an equivalent layer of about 1.2 µm by dust devils is sufficient to create a visible albedo contrast. The measured surface area coverage of dust particles onto sand grains amounts to ~18% outside the track and of ~10% inside the track.

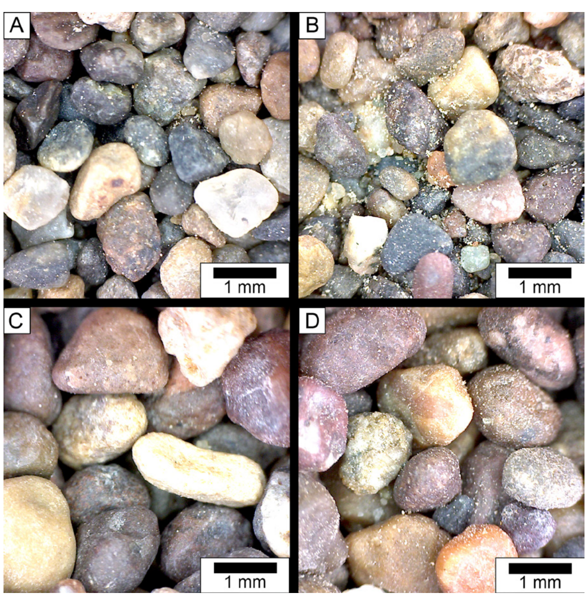

Figure 3. Microscopic imagery (magnification factor 20 x) inside (A and C) and outside (B and D) of investigated dust devil tracks. A and B were taken on ripple surfaces, and C and D on large ripple surfaces. All photographs were taken on ripple crests.

Albedo differences. Albedo differences within two dust devil tracks and their surroundings in the field were measured with a Pyranometer in the visible wavelength range from 300 to 1100 nm. Both measurements were performed during 12 - 15 pm local time but within a time span for individual track areas of 30 minutes. For each measurement 10 spots within as well as outside the track region (at least 3 m far away from the transition zone) were measured to average the single measurements. The albedo difference within the individual tracks and their surroundings is with ~0.5 % and ~0.6 % very low.

Conclusions: Although it is difficult to quantify the influence of the compositional differences between the underlying surface and the removed upper layer of dust in the formation of dust devil tracks, our study implies that the albedo contrast between the track and its surroundings is mainly caused by photometric effects for the following reasons: The occurrence of dust devil tracks indicates that their formation is limited to surface areas consisting of ripple surfaces with grain diameters > 500 µm. No dust devil tracks were observed on bright dune surfaces consisting of fine sands (125-250 µm). This would be in agreement with the formation of dust devil tracks due to photometric effects, because the effect is larger with increasing grain size. The surface area coverage of dust particles onto the sand grains with a difference of about 8 % between inside and outside the track implies that a compositional effect for the creation of an albedo contrast is minor. The mineralogical differences of all samples are very low. The only noticeable difference occurs in the dust samples, which contain a much higher abundance of Calcite in contrast to the sand samples. This might cause an additional effect in the formation of the dust devil tracks, but due to the low fraction of Calcite in the dust it is probably insignificant. Furthermore, laboratory experiments of [12] showed that very small amounts of dust deposits (or vice versa) can significantly change the albedo, which is in agreement with our low measured albedo differences of about 0.5 % and removed equivalent layer thicknesses of about 1.2 µm. However, based on one terrestrial in situ and one martian robotic in situ study [5] we can not exclude that other dust devil tracks are formed due to compositional differences of surface materials.

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