Europlanet TNA Report

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Reimbursed	Yes

Project Title – **Analysis of active dust devils and dust devil tracks in southern Marocco as planetary analogs for Mars**

Scientific Report Summary.

Dust devils are low pressure vortices formed from unstable near-surface warm air generated by insolation and are common on Earth and Mars. Surface tracks left by passages of active dust devils are numerous on Mars, but they have been only detected at a few locations on Earth. First in situ studies on Earth in China and by the Mars Exploration Rover on Mars showed that dust devil tracks (hereinafter DDTs) are formed by the erosion and subsequent entrainment of dust into the atmosphere. Surface areas within the track are less covered with dust than outside the track and the underlying substrate consisting of coarse sand grains become more visible. The resulting albedo difference between the DDTs and the surrounding areas is probably caused by the different grain sizes (brightness is photometrically inversely proportional to grain size) rather than by differences in mineralogic composition between the dust and the underlying coarse sands. Based on our analysis of the field work data obtained in Morocco the DDT formation seems to be consistent with previous studies in China and on Mars. Currently, data analysis in the laboratory is still ongoing due to the large amount of sample material. In situ data sets include microscopic imagery, albedo measurements, soil samples, and dust/soil samples taken within active dust devils.

Full Scientific Report on the outcome of your TNA visit

1. Introduction

Dust devils are low pressure vortices formed from unstable near-surface warm air generated by insolation and are common on Earth and Mars. They are visible as dust devils due to the entrainment of fine particles. Dust devils are contributors to the atmospheric opacity on both planets by their ability of lifting fine particles even in higher atmospheric layers. Surface tracks left by passages of active dust devils are numerous on Mars, although only about 10% of active dust devils create tracks [1]. In situ studies by the Mars Exploration Rover (MER) in Gusev crater showed that dust devil tracks (hereinafter DDTs) are formed by the erosion and subsequent entrainment of dust into the atmosphere [2]. Surface areas within the track are less covered with dust than outside the track and the underlying substrate consisting of coarse sand grains become more visible [2]. The resulting albedo difference between the DDTs and the surrounding areas is probably caused by the different grain sizes (brightness is photometrically inversely proportional to grain size) [2] rather than by differences in mineralogic composition between the dust and the underlying coarse sands. On Earth, DDTs are rarely observed in satellite imagery [3,4,5,6] and in situ studies were so far only performed in China [5,7]. First in situ investigations of DDTs on Earth showed that passages of active dust devils remove a thin layer of fine grained material ($< \sim 63$ µm), cleaning the upper surface of coarse sands (0.5 – 1 mm) [5]. This erosion process changes the photometric properties of the upper surface causing the albedo differences within the track to the surroundings [5] and is consistent with the formation mechanism proposed by [2] for DTTs on Mars.

2. Results

Dust devils and their tracks were analyzed in situ in April 2012 in southern Morocco west of the town of M'hamid. Here, we focus on one study area, a sand sheet at 29.89°N and 6.33°W, marginal to an erg known under the local name "Erg el Mhâzîl".

2.1 Dust devil track observations

One high resolution satellite image revealed numerous locations of DDTs in our study region

(Figure 1A) and relatively nearby. They always occur on low albedo sand sheets. Field work shows that these areas consist of a ripple surface. Based on the height, wavelength and grain size the ripples can be classified as granule megaripples. Individual ripples in the study area are 3–5 cm high and the ripple wavelength varies by 50–75 cm. Grain size analyses show that the ripples are dominated by very coarse sand (1–2 mm), whereas the surface layer below is dominated by very fine to fine sand (0.063–0.25 mm). This study area was visited for three full days. In total, only five definite DDTs were observed, two of them directly by observing the active dust devil which created the track. Figure 1B shows one of these tracks. The DDTs were in general about 2 m wide and 50-100 m long. The width of the tracks is in good agreement with previous satellite observations. More than 50 active dust devils (diameter sizes from 1-20 m) were detected in 3 days within the study area. However, the real number of active dust devils was likely much higher, because we did not monitor the area systematically and were often concentrated with doing measurements.

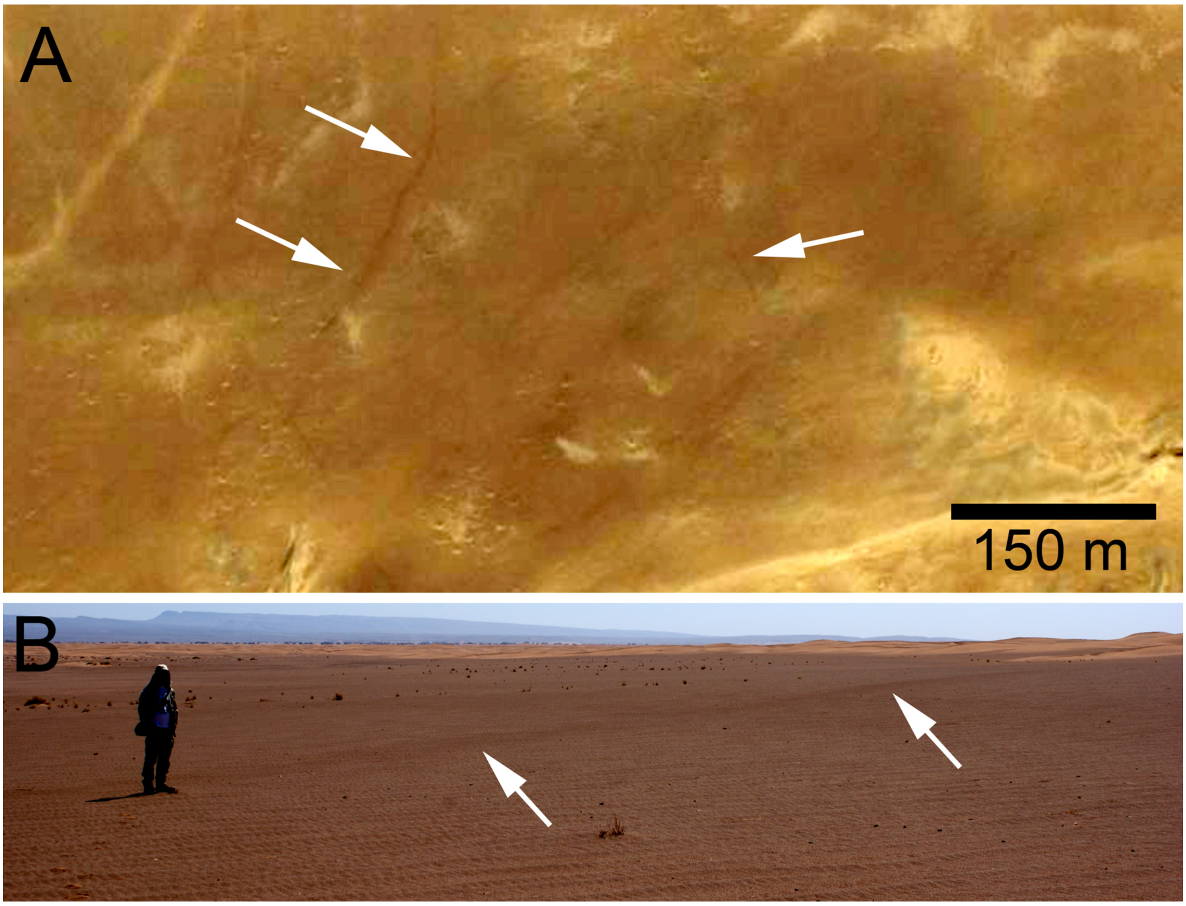

Figure 1: (A) DDTs (white arrows) in the study region as seen in high resolution satellite imagery (Quickbird2, ~65 cm/pxl) accessed through Bing Maps. (B) Field photo of a DDT in the study area.

2.2 Microscopic imagery

Areas outside and inside of a DDT were imaged on 17 April 2012 with a handheld microscope (Figure 2 A and B). Very coarse sand grains within the DDT (Fig. 2B) appear less dust (< 63 µm) covered than outside the track (Fig 2A), but this is very hard to quantify due to the low amount of dust. In general, the amount of dust on top of very coarse sand grains is very low compared to investigated areas in China (Fig. 2D). Figure 2C shows a very low dust amount on top of the very coarse sand grains, equal or less dust covered as in Figure 2B (within a DDT). It was taken on 22 April 2012, the field day when no DDTs were observed, although many dust devils occurred (e.g., Fig. 3).

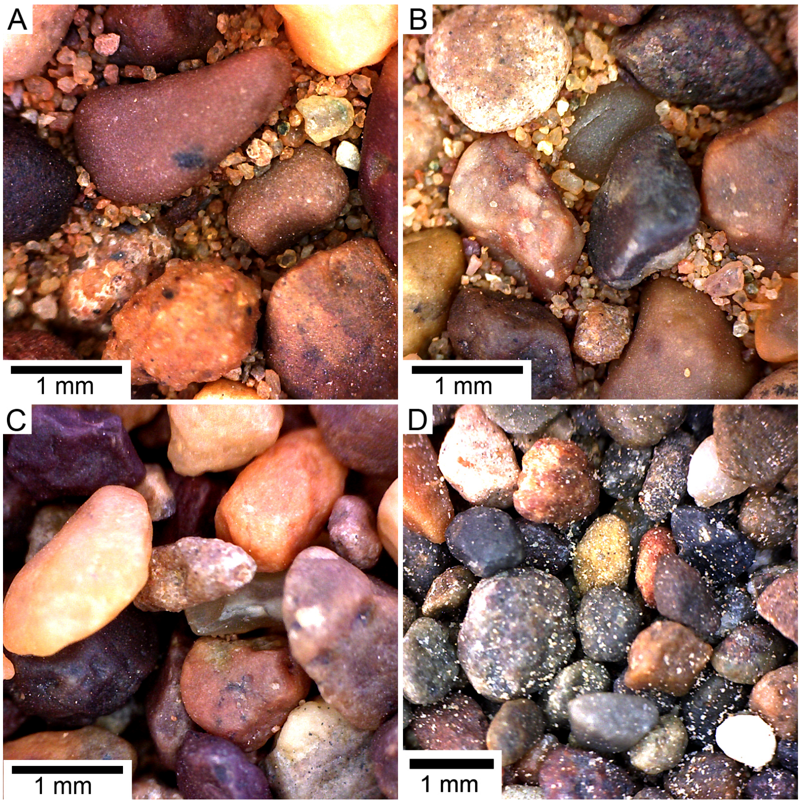

Figure 2: Microscopic images of ripple crests. (A) Outside a DDT (17 April 2012). (B) Within a DDT (17 April 2012). (C) Image taken on 22 April 2012. (D) Surface area outside a DDT in China (see also [5]).

2.3 Albedo differences

Albedo differences within a DDT and its surrounding were measured in the field with a Pyranometer in the visible wavelength range from 300 to 1100 nm. For each measurement 7 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 is with 0.4% lower than two unpublished measurements taken in China with values of 0.5% and 0.6%. First albedo measurements of DDTs on Mars using similar wavelengths from the CRISM instrument revealed albedo differences of 0.9% and 1.2%.

2.4 Dust samples

Particle sizes were sampled within several different active dust devils from the surface up to a height of about 5.3 m above the ground. Entrained sediment was sampled with sticky tape (similar to [8]). Particle size measurements under an optical microscope in the laboratory are still ongoing. First results indicate that some coarse sand grains are lifted within the sand skirt to heights of up to 1 m, before they fall back to the surface. In general grain sizes decrease with increasing height as expected.

Figure 3: In situ sampling of dust up to a height of 4 m within an 18 m in diameter active dust devil on 22 April 2012.

3. Final remarks

Based on our preliminary analysis of the field work data we conclude the following: DDT formation seems to be related to dust erosion changing the photometric properties of the upper surface layer which causes the albedo differences. Other changes of surface patterns like reorientation or redeposition of sand grains within DDTs could not be observed. There is no direct observation that the dust devils affect the granule megaripples. In situ sediment samples from active dust devils on 22 April 2012 - which left no tracks - contained even very coarse sand grains lifted into heights of up to 1 m. On 22 April 2012 no tracks were formed (although more than 20 active dust devils were observed) and microscopic imagery of the surface revealed that it was nearly dust free compared to 17 April 2012. The surface dust cover in southern Morocco is generally very low compared to the study region in China [5] or on Mars [2]. However, this is consistent with the lower frequency and lower visibility of observable DDTs in satellite imagery as well as in the field compared to China or even to Mars where surface dust is much more abundant. The lower albedo differences compared to China and Mars are also in agreement with this formation mechanism for the Moroccan DDTs.

References

[1] Cantor, B.A. et al. (2006) JGR 111, E12002. [2] Greeley et al. (2005), JGR 110, E06002. [3] Rossi, A.P. and Marinangeli, L. (2004) GRL 31, L06702. [4] Neakrase, L. et al. (2008) GSA abstracts 40, 262. [5] Reiss, D. et al. (2010) GRL 37, L14203. [6] Hesse, R. (2012) Aeolian Research 5, 101-106. [7] Reiss, D. et al. (2011) Icarus 211, 917-920. [8] Oke, A. et al. (2007) JAE 71, 216-228.

- Publications arising/planned (include conference abstracts etc)

Currently, two abstracts concerning the field work/data analysis were submitted (see below) to the European Planetary Science Congress and 3rd Conference on Terrestrial Mars Analogues. At each conference a talk will be given. It is also planned to present the results at the 44th Lunar and Planetary Science Conference (LPSC, March 18–22) 2013. Furthermore it is planned to submit a scientific paper to a peer-reviewed journal (e.g., Icarus or Planet. Space Sci.) when laboratory data analysis of the field data is completed.

Reiss, D., J. Raack, G. G. Ori and K. Taj-Eddine (2012). In situ analysis of dust devil tracks in southern Morocco: Comparison with other terrestrial and martian tracks, European Planetary Science Congress 2012, 23 – 28 September 2012, Madrid, Spain, abstract #EPSC2012-389.

Reiss, D., J. Raack, G. G. Ori and K. Taj-Eddine (2012). In situ analysis of dust devil tracks in southern Morocco: Comparison with other terrestrial and martian tracks, 3rd Conference on Terrestrial Mars Analogues, 25 - 27 October 2012, Marrakech, Morocco.

- Host approval

The host is required to approve the report agreeing it is an accurate account of the research performed.