Dark Dunes in Martian Craters D. Tirsch[1], R. Jaumann[1,4], D. Reiss[1], J. Helbert[1], F. Forget[2], E. Millour[2], F. Poulet[3] and G. Neukum[4], [1]Institute of Planetary Research, German Aerospace Center, Berlin, Germany (daniela.tirsch@dlr.de); [2] Laboratoire de Météorologie Dynamique du CNRS, IPSL, Université Paris 6, Paris; [3] Institut d'Astrophysique Spatiale, CNRS Université Paris Sud, Orsay, France; [4] Planetology and Remote Sensing, Free University Berlin, Germany.

Introduction: As a result of weathering and aeolian processes a fine-grained dark material is distributed all over both Martian hemispheres. It is characterizes by a much lower albedo (< 0.15) than the surrounding terrain. Regional scale controls such as wind regime, sand supply and climate cause different morphologies and particle sizes of the material [1]. The appearance and the amount of the dark material are very different. On impact crater floors, it is frequently accumulated as dune fields. Outside of the craters, the material builds thin layers with a thickness of centimeter to meter. The intracrater dune fields mostly exhibit barchan morphologies (Fig. 1) but also thick transverse dune fields, depending on the sand supply.

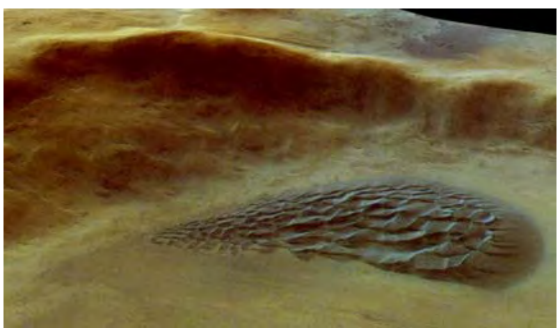

***Fig. 1**: Barchan dune field of dark material in an impact crater of Argyre Planitia (HRSC image, ESA/DLR/FUB)*

The dune type can be used as an indicator for the sand supply and shows the direction of the wind at the time when the dune was built. HRSC data show that the material is blown into as well as blown out of a crater, indicating that they can act as a trap or as a source. In some cases, dark layers in crater walls with down slope running dark streaks seem to be an additional supply for the dark material inside of a crater.

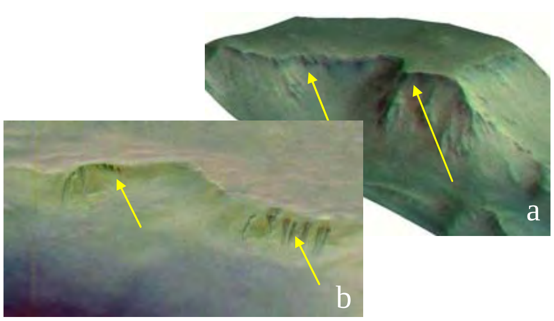

***Fig. 2**: Dark layers in the walls of craters at (a) 3°S, 308°E and (b) 53°S, 247°E (HRSC image, perspective view, ESA/DLR/FUB)*

Volume of the dunes: If the weathering of the dark layers in the crater walls was an appreciable source mechanism for the material, there should be a correlation between the degradation stage of the craters and the amount of material inside. We measured the dune volume using HRSC-DTMs and estimated the total amount of material inside the craters. So far, no significant relation between crater degradation stage and dune volume could be recognized. Furthermore, we could verify that the dune volume is not associated with any other attribute of the craters (e.g. crater depth, diameter, lat/lon).

Interaction between dune surfaces and wind: Many dunes show a thin layer of dark material extending downwind from the dune to its surrounding indicating an unconsolidated characteristic of the material and erosion by aeolian scour. However, not on every dune such a grain release can be observed. This poses the question if some dune surfaces are recently not influenced by the wind. A comparison of modeled wind fields from the Mars Climate Database (MCD) [2, 3] and the Mars Global Reference Atmospheric Model (MarsGRAM) [4] with the morphology related wind direction of the dune fields yields that both wind directions do not coincide in every case. This is a first hint for a possible consolidation of some dune surfaces. For more detailed information concerning the surface properties, we analyzed the nighttime brightness temperatures and the thermal inertia of the dune surfaces.

Brightness Temperatures of the dune surfaces: The brightness temperature (BTR) from THEMIS data can provide significant information about the physical property of the dune surface in terms of a possible bonding of particles. Loose (unconsolidated) fine-grained material cools more rapidly at night than coarse-grained sediments and solid rock [5]. If the dune surfaces have warmer brightness temperatures at night with respect to the surrounding, it can be supposed that the surface is consolidated. To make sure that the lower temperatures at night are due to the surface properties and not caused by a CO_2- or H_2O-frost layer we have measured the absolute temperatures of the dune surfaces at night. All measured temperatures lay above the maximum CO2-frost temperature, which is about 148 K [6]. However, for some dunes a water ice layer is a likely factor influencing the surface temperature. These dunes were excluded from our analysis. The following figures give examples for cold (Fig. 3) and warm (Fig. 4) dune surfaces at night.

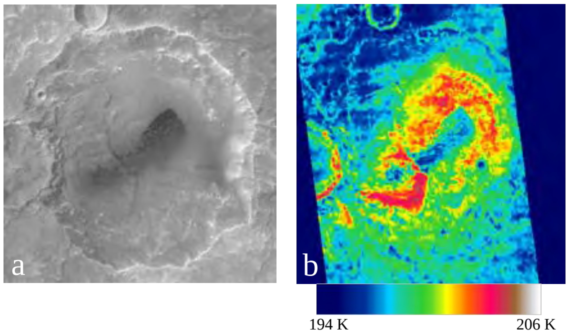

Fig. 3: *(a) HRSC image and (b) THEMIS-BTR nighttime infrared mosaic (normalized temperatures) of a crater at 14.3°S, 95.8°E. The absolute temperature of the dune field is about 200 K (measured from I0670007).*

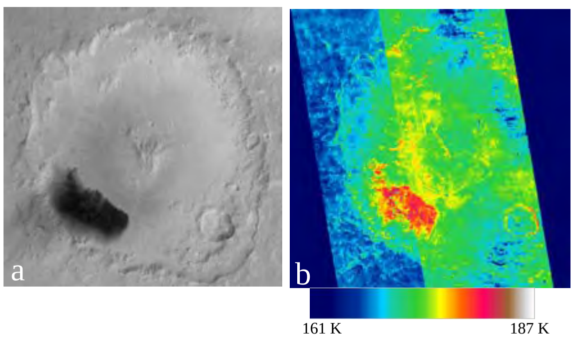

Fig. 4: *(a) HRSC image and (b) THEMIS-BTR nighttime infrared mosaic (normalized temperatures) of a crater at 25.8°N, 83.9°E. The absolute temperature of the dune field is about 190-195 K (measured from I06707015).*

Thermal inertia of dark dunes: The thermal inertia is a measure of a material's thermal response to the diurnal heating cycle. It is closely related to the thermal conductivity of the top few centimeters of the surface and thus directly correlated to the particle size [5, 7, 8]. We have obtained these values from TES data for all the studied craters. The results show different thermal inertia values for the dune fields depending on different grain bonding of the dune material. Some dunes have thermal inertia values around 270-290 $Jm^{-2}K^{-1}s^{-1/2}$ (Fig. 5) corresponding to effective particle sizes in the sand range [1].

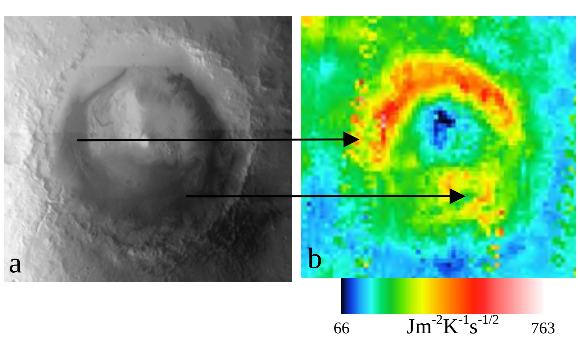

Fig. 5: *(a) HRSC image and (b) TES thermal inertia image of Gale crater. Arrows show the corresponding locations of the dark material in the two images. For the dark material the values are around 270-290 $Jm^{-2}K^{-1}s^{-1/2}$ indicating sand sized dune material.*

In other craters, the dark dunes show much higher inertia values around 550 $Jm^{-2}K^{-1}s^{-1/2}$ (Fig. 6). Such high values (> 386 $Jm^{-2}K^{-1}s^{-1/2}$) correspond to rocks, bedrock and some duricrusts [9].

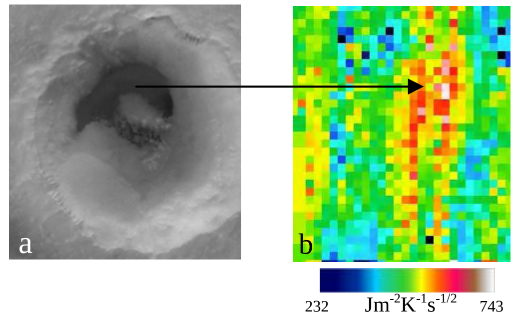

Fig. 6: *(a) HRSC image and (b) TES thermal inertia image of a crater at -53°S, 247°E. Arrows show the corresponding locations of the dark material in the two images. For the dark material the values are around 550 $Jm^{-2}K^{-1}s^{-1/2}$ indicating a consolidated dune surface.*

Mineralogical composition: For the analysis of the mineralogical composition of the dark materials, we used near infrared spectra form the Mars Express Omega instrument [10]. The low albedo of the material points to a strong mafic component. The spectra show a higher content of mafic minerals such as high and low Ca-pyroxenes and olivine. This affirms the assumption that the material is unoxidized.

Conclusions: The dark materials have a mafic composition and are chemically unaltered. Thus, the material is probably the result of mechanical erosion only. The volume of material in a crater seems to be independent from the crater degradation stage and seems to be controlled by the wind regime only. The studied dune fields show significant differences in nighttime brightness temperatures and thermal inertia due to varieties in the physical structure and the grain size of the surface material. The results show that some dune surfaces consist of unconsolidated sandy material that is recently eroded. These dunes are supposed to be active. We assume that dunes with high thermal inertia values, high nighttime brightness temperatures and the absence of interaction with the actual blowing wind have consolidated surfaces consisting of bounded particles.

References: *[1] Edgett, K.S. & Christensen, P.R., JGR 99, E1, 1997 – 2018, 1994. [2] Forget, F. et al., JGR 104, E10, 155-175, 1999. [3] Lewis, S.R. et al., JGR 104, E10, 177-194, 1999. [4] Justus, C.G., et al., Avd. Space Res. 29, Nr.2, 1993-202, 2002 [5] Fenton, L.K. & Mellon, M.T., JGR 11, E06014, doi: 10.1029/2004 JE002363, 2006. [6] Reiss, D., Dissertation, FUB, Dlr-Forschungsber. 2005-05, 2006. [7] Pelkey, S.M., et al., JGR 106, E 10, 23909-23920, 2001. [8]Jakosky, B.M., et al., JGR 105, E4, 9643-9652, 2000. [9] Putzig, N.E., et a.l, Icarus 173, 325–341, 2005. [10] Bibring, J.P., et al., ESA SP 1240, 37-49,2004.*