DARK MATERIALS IN MARTIAN CRATERS. R. Jaumann[1], K. Stephan[1], F. Poulet[2], D. Tirsch[1], R. Wagner[1], H. Hoffmann[1], D. Reiss[1], E. Hauber[1] J.P. Bibring[2], G. Neukum[3] and The HRSC Co-Investigator Team,
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Introduction: Aeolian processes affect much of the uppermost surface of Mars. Wind will transport pre-eroded material and pile it up into various bedforms. Sub-aerial transport of granular material via saltation and traction typically requires sand-sized particles on Earth and also on Mars [1]. Edgett and Parker (1998) [2] characterized aeolian bedforms based on their brightness relative to the adjacent terrain as darker, brighter or of the same albedo. Malin and Edgett (2001) [3] observed in Mars Observer Camera data two major types of bedforms: ripple-like bedforms that are the same or lighter than the surrounding terrain, and larger dune-like bedforms that are always darker than the albedo of the surrounding terrain. The larger dark-toned dunes overlay the light-toned ripples at places where they occur together indicating the dune material to be more mobile [3]. The dark dune material is mostly located in depressions such as impact craters. The low albedo and mobility of these materials indicate fundamental differences in composition, physical material properties and origin with respect to the surrounding.

Dark material in craters: Dark dune-like features with an albedo < 0.15 are accumulated in topographically confined spaces such as impact craters. Dune fields on the floors of impact craters are isolated features that mostly exhibit barchan morphologies (Fig. 1 and 2).

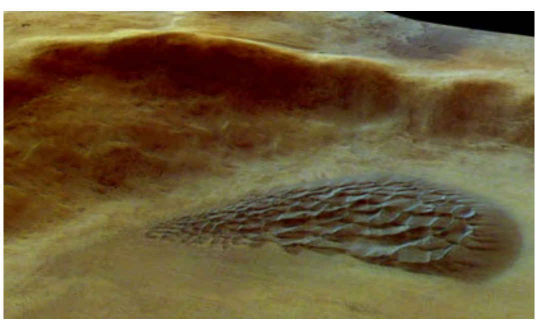

Fig. 1. Dunes of dark material in an impact crater of Argyre Planitia (Mars Express HRSC image, ESA/DLR/FUB).

The barchan shape of the dunes indicates a dominant unidirectional wind field [4] and the isolated characteristics of the dune field suggest a reduced material supply. Usually the barchan morphologies are compact with narrow short horns, broad stoss and low slip faces. Barchan horns are also observed to extend downwind transforming into linear dune forms. In most cases the dune crests are sharp and look relatively fresh.

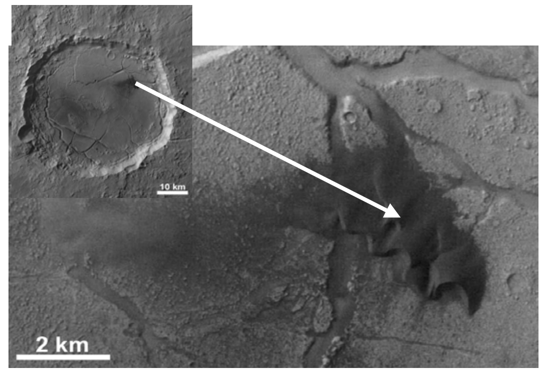

Fig. 2. Small dune field in a crater 5°S, 343°E (Mars Express HRSC image, ESA/DLR/FUB).

In the vicinity of the dunes a thin layer of dark material covers the ground indicating the unconsolidated characteristics of the material and erosion by grain release and aeolian scour (Fig. 2). However, so far the comparison of dune fields with MOC and Viking images shows no evidence for dune migration during the period of the last two to three decades (see also [3]).

Based on topographic profiles of the Mars Express High Resolution Stereo Camera [5] we identified that the dark material is not necessarily located at the deepest point of the depression (Fig. 3), indicating local transportation within the crater.

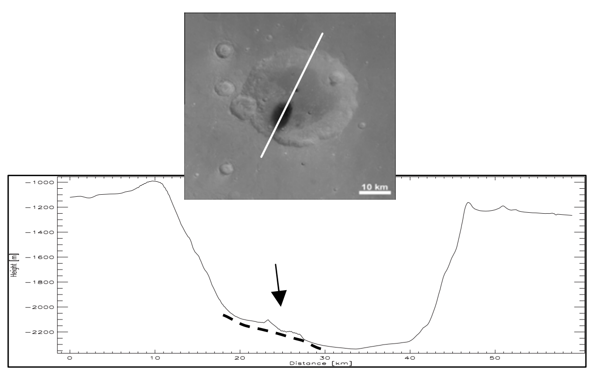

Fig. 3. Dark material in a crater at 11°N, 209°E. The material accumulates on the southwestern lower wall about 150m above the deepest point. (Mars Express HRSC image, ESA/DLR/FUB).

Dark material in impact craters can be found on both Martian hemispheres, indicating that this material is distributed all over Mars by aeolian processes, whereas the craters act as a topographic trap. Some of the fields of dark material show evidence for such an allochthonous distribution process by thin layers of dark material outside the crater (Fig. 4).

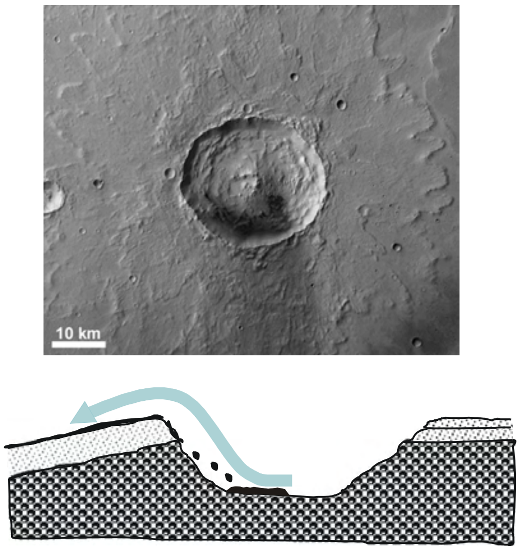

Fig. 4. Dark dune fields in a crater 11°N, 343°E. A thin streak of dark material south of the crater indicates the allochthonous characteristics of the material's origin. (Mars Express HRSC image, ESA/DLR/FUB).

However, some of the craters with dark materials on their floors do not have dark materials outside the crater but have dark outcrops and dark streaks that run downslope, which suggest the dark material to be the result of weathering and erosion of dark underground cut by the impact (Fig. 5).

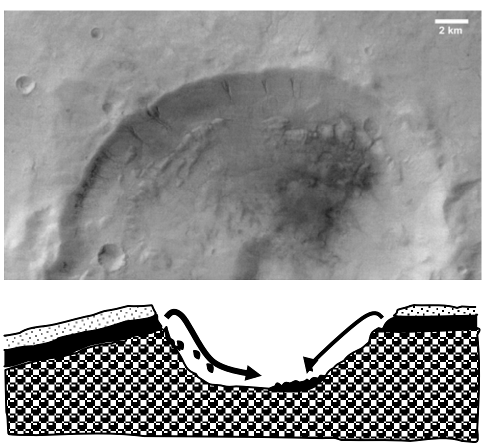

Fig. 5. Dark dune fields in a crater 39°S, 174°E. Dark outcrops and streaks in the crater wall indicate an autochthonous characteristic of the material's origin. (Mars Express HRSC image, ESA/DLR/FUB).

Composition of dark materials: The significant lower albedo of the dark material suggests not only differences in particle size but also compositional differences with respect to the surrounding materials. The dark material seems to be unoxidized and thus should have a strong mafic component. Spectra in the near infrared from the Mars Express Omega instrument [6] indicate a higher content of unweathered mafic minerals such as high Ca-pyroxenes and olivine (Fig. 6).

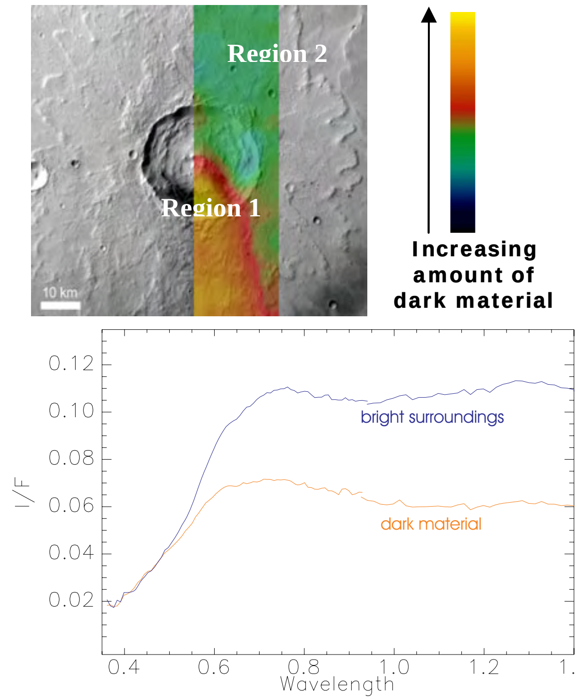

Fig. 6. Distribution of the dark material in the crater of Fig. 4 and its spectral characteristics (red spectrum) compared to the surrounding terrain (blue spectrum) based on Mars Express OMEGA data (EAS/DLR/FUB/CNES/IAS).

Conclusions:

Dark materials are chemically unaltered and probably the result of mechanical erosion and global distribution by aeolian processes. This could indicate recent erosion and redistribution without enough time for chemical weathering. Alternatively, the materials could be old and conditions for chemical weathering have not existed on Mars for a long time.

References: [1] Iversen J. D. and White B. R. (1982) *Sedimentology*, *29*, 111–119. [2] Edgett K. S. and Parker T. J. (1998) *LPS XXIX*, Abstract #1338. [3] Malin M. C. and Edgett K. S. (2001) *JGR*, *106*, 23429–23570. [4] McKee E. D. (1979), *USGS Prof. Pap.*, *1052*, 1–19. [5] Neukum G. et al. (2004), *ESA SP 1240*, 17–35. [6] Bibring et al. (2004) *ESA SP 1240*, 37–49.