SPRING DEFROSTING IN THE RUSSELL CRATER DUNE FIELD - RECENT SURFACE RUNOFF WITHIN THE LAST MARTIAN YEAR ?

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Abstract: Rill erosion on a dune slope in the Russell Crater dune field was detected on a high resolution Mars Orbiter Camera (MOC)-NA image from the latest public release of MOC-data (October, 2001). The identified erosional morphology differs from previously observed gully erosion [1] elsewhere on Mars.
We report here our morphological studies of the erosion features as well as seasonal observations (monitoring) of the dune field with MOC- wide angle (WA) and Thermal Emission Spectrometer (TES) data. The observation indicates that the extremely fresh appearing erosion is caused by recent surface runoff within the last Martian year.

Morphology: The erosion features were found in the high resolution MOC-NA image M1901170. They are located on a 350m high (MOLA-track ap16829) dune slope with a dip of about 8° (MOLA-track ap13426) in the Russell Crater dune field at 54.5°S and 347.3°W (Fig. 1). Additional erosion features occur on the same image at smaller dunes further to the south (Fig. 2). The erosion starts in small alcoves in a dendritic pattern at the dune crest and merges after a short distance in main channels, which have a parallel pattern following the slope topography. The individual main channels are approximately the same size from beginning to end. In contrast to all other observed gullies on Mars they run out and end abruptly on the dune base without a depositional apron. Most of them occur on poleward facing slopes. This is in accordance with the gullies observed by [2].

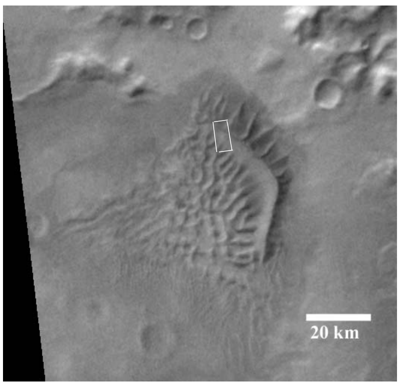

Figure 1. Context image M1901171 for NA-image M1901170. White Area is indicating the subframe (Fig.2).

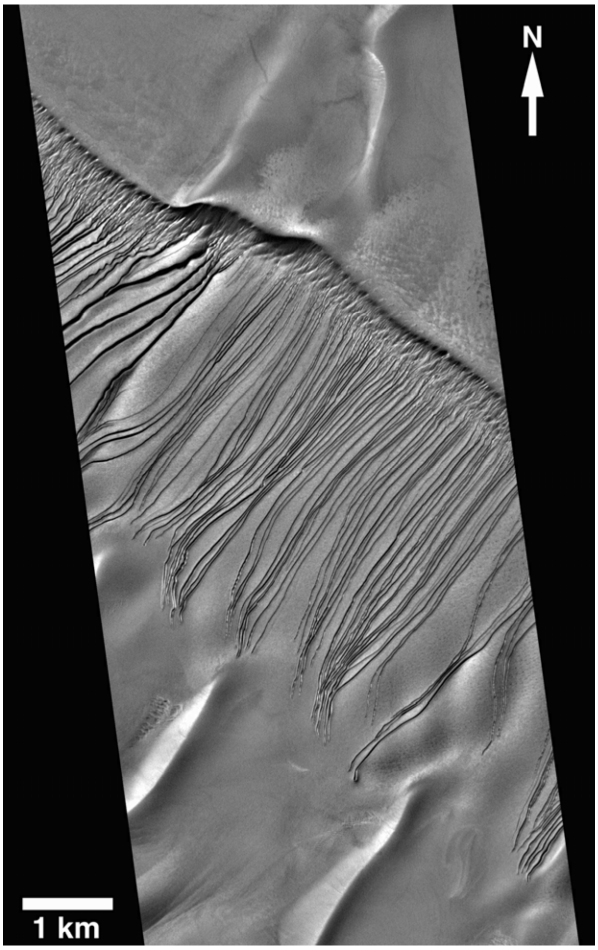

Figure 2. Subframe of MOC-image M1901170 with observed rill erosion.

The morphological forms show strong affinity to rill erosion on Earth [2]. Rill erosion features 1) are fairly straight and furrowlike, with flaring sides, 2) generally start high on the hillslope, near its inflection point below the crest and 3) the channel at the bottom remains very narrow. The development of rills and gullies differs in their genesis. Rill erosion is solely bound to overland flow whereas gullies are formed by subsurface flow, with or without surface wash [2]. The morphology of the rills on dune slopes in Russell Crater indicates that overland flow is the major process responsible for their formation. However, the lack of an alluvial cone at the channel terminations and the process of overland flow under current Martian conditions cryptic.

Seasonal Observations: MOC-WA and TES indicate marked changes in the characteristics of the Russell Crater dune field within a Martian year. Figure 3 shows the average temperature and albedo as a function of L_S, whereas the second year (beginning of autumn) starts at L_S=360°. TES thermal bolometer (5.5 - 100 µm single band) brightness temperatures and TES visual bolometer (0.3 - 2.7 µm) lambertian albedo were aquired at the same location of the dune field within an area of 55.2°S - 54.4°S and 346.8°W - 348°W. All TES-derived data are afternoon (2 p.m., local time) measurements.

Wintertime temperatures at about L_S160° are near those of frozen CO_2 (~148K) and the images show a covering of bright (albedo ~0.3) frost. In early spring the temperatures increase rapidly and reach their observed maximum with 276K (near the water ice sublimation temperature) in mid spring (L_S ~230°). Within the same time period the albedo decreases to 0.1. So the defrosting of the dune field took place within in a very short time span. In mid spring and late summer the dune field shows a defrosted dark composition with low albedos near 0.1. In the end of summer the temperature begins to decrease. By mid to late autumn the albedo increases and the temperatures decrease and reach again those of frozen CO_2, indicating the return of frost on the dune field.

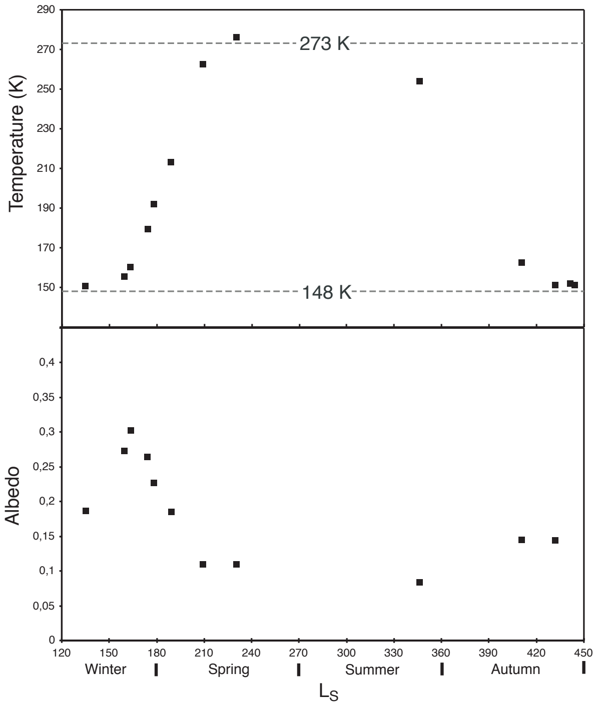

Figure 3. MGS TES thermal bolometer temperatures and visual bolometer albedos observed at the same time like MOC-WA and MOC-NA images.

The seasonal changes in frost cover on the Russell Crater dune field are similar to those observed at the Richardson Crater dune field (72.4°S, 180.0°W) [3] with slightly higher temperatures and albedos.

Discussion: The morphology of the rills indicates that overland flow probably causes the erosion. The MOC-image was acquired in mid autumn at L_S 50° and the very fresh appearing rills suggest that the erosion took place by a defrosting process between late winter and mid spring indicated by the TES-data. We favor an erosion process by liquid water: the rills are located in absolute elevations of ~200 m, and the retreat of the south polar cap leads to an increase of the atmospheric pressure in the southern spring [4, 5] which could allow liquid water to be stable in this region [6]. The lack of a depositional apron may be caused by compaction of the dust material with potentially simultaneous sublimation of the fluid.

Alternatively it is possible that the rills were formed by an unknown warming process of CO_2-sublimation in late winter to early spring.

Further observations will be made to identify and understand seasonal erosion processes.

References: [1] Malin M. C. and Edgett K. S. (2000) Science*, 288,* 2330–2335. [2] Higgins C. G., (1990), In: Higgins, C.G. and Coates Groundwater geomorphology, Boulder, Colorado, Geological Society of America Special Paper 252, 139-155. [3] Supulver K. D. (2001) *LPS XXXII,* 1966. [4] Hess S. L., et al. (1979) JGR, 84, 2923-2927. [5] Houben H., et al. (1997) JGR, 102, 9069-9083. [6] Haberle R. M., et al. (2001) JGR, 106, 23317-23326.