

REGIONAL DIFFERENCES IN GULLY OCCURRENCE ON MARS: A COMPARISON BETWEEN THE HALE AND BOND CRATERS. D. Reiss¹, H. Hiesinger¹ and K. Gwinner², ¹Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (dennis.reiss@uni-muenster.de), ²Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Rutherfordstraße 2, 12489 Berlin, Germany.

Introduction: Gullies on Mars are interpreted to indicate liquid water in the recent past. The strong latitude-dependence of gullies [e.g. 1] suggests a climatic influence on their formation. However, in some regions multiple gullies occur in one crater while none have formed in another crater nearby. This is the case for the Hale (gullies) and Bond (no gullies) craters, respectively. These regional differences have been interpreted as an argument for a groundwater gully formation and against a climatic influence on gully formation [2]. The formation of gullies on Earth depends on several parameters including; rainfall and/or melting of snow, the presence of steep slopes and sufficient amounts of fines/debris [e.g. 3]. We compared the Hale and Bond craters and considered the thermophysical properties, slopes, and morphologies to investigate why the occurrence of gullies in neighboring craters is so different.

Data: We investigated the Hale/Bond region (north of the Argyre Basin, 325°E and 35°S, Figure 1) with Mars Orbiter Camera – Narrow Angle (MOC-NA) imagery, Thermal Emission Imaging System – Infrared (Themis-IR) nighttime Band 9 temperature data, Thermal Emission Spectrometer (TES) thermal inertia data and High Resolution Stereo Camera (HRSC) topographic data.

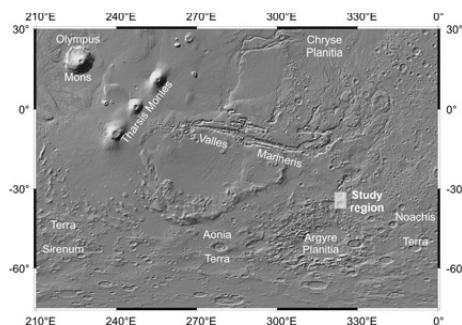


Figure 1. Location of the study region on Mars (MOLA shaded relief).

Results: A survey of MOC-NA images (release AB-S16) (Figure 2) for the presence of gullies revealed that they occur – with one exception – exclusively on slopes of the Hale crater. The exception in Bond crater are small gullies that occur on slopes of a

small crater which is superposed on the central Bond crater floor.

Thermal Properties. Differences in the thermophysical surface properties were derived from nighttime THEMIS-IR images and TES thermal inertia data (Figure 3). South-facing gullied slopes in the Hale crater show low nighttime temperatures (indicating unconsolidated material), while higher temperature slopes (indicating consolidated material) occur in the Bond Crater. Lower spatial resolution TES thermal inertia values for these regions confirm the surface material grain size differences.

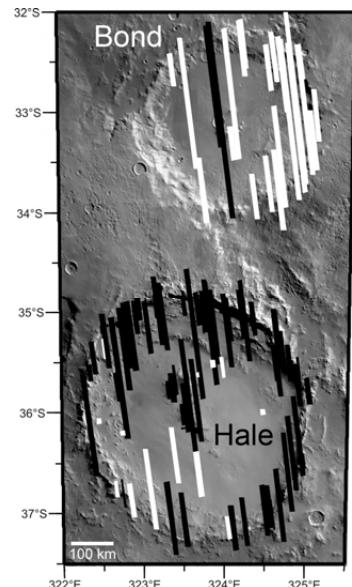


Figure 2. Survey of MOC-NA images. Black areas are MOC footprints representing images with gullies and white areas are footprints representing images with no gullies (Background: Mosaic of HRSC images 511 and 533).

Slopes. The Bond crater is highly degraded with crater wall slopes varying between 10° and 20°. This is in contrast to the more pristine Hale crater with slopes in the range of 20° to 30°. Slope angles were derived from HRSC stereo data (100 m/pxl). Figure 4 shows a typical traverse across the Bond and Hale craters with measured slope values.

Morphology. The different thermophysical surface properties of unconsolidated (gullies) and consolidated (no gullies) material is confirmed in the morphology as

analyzed in MOC-images. Bond crater slopes show degraded mantle deposits which are interpreted to be cemented material (Figure 5, A and B). South-facing slopes of the Hale crater show gullied slopes incised into talus material. Themis-IR temperatures and TES thermal inertia values of gullied north-facing slopes in the Hale crater indicate consolidated material, however gullies are found on slopes $\geq 20^\circ$. An explanation for the occurrence of gullied slopes in consolidated material might be that these gullies are old and the surface material is cemented. Figure 6 shows an example of this region. The debris aprons of these gullies are cratered in contrast to the pristine morphology of gullies on the south-facing slopes. Furthermore, the debris aprons have been eroded leaving behind steep scarps indicating that the debris aprons consist of cemented material.

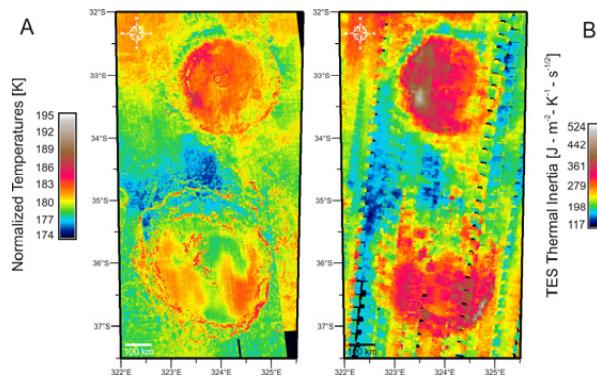


Figure 3. (A) THEMIS-IR Band 9 nighttime image mosaic (100 m/pxl) with normalized temperatures. Blue colours indicate fine grained material and red colors indicate consolidated material. (B) TES thermal inertia gridded data (3 km/pxl). Blue colours indicate high amounts of unconsolidated fines and red colours high amounts of rocks, bedrock and/or duricrust.

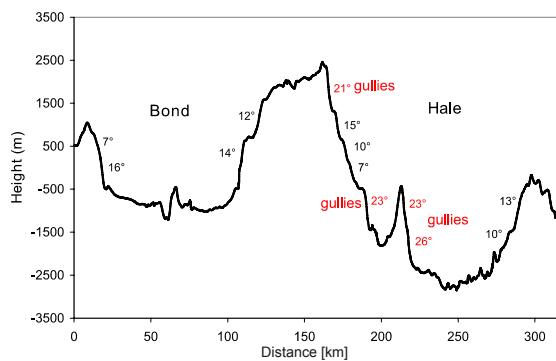


Figure 4. Topographic profile across the Bond and Hale craters (North-south direction) derived from a DTM of orbit 2526_1 (100 m/pxl). Gullies are found on slopes $>20^\circ$ (red color).

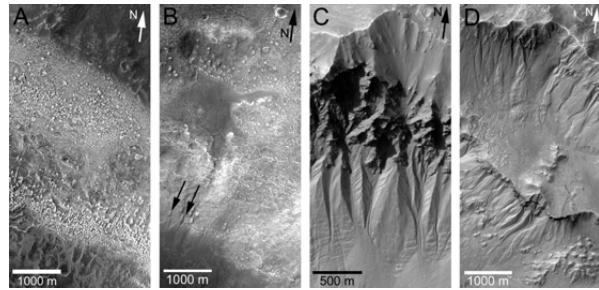


Figure 5. Examples of the northern slope morphology for the Bond (A, B) and Hale (C, D) craters. Gentler slopes of the Bond crater show a degraded mantle morphology with sublimation pits. Arrows in B indicate the possible remnants of the former intact mantle (smooth unit at the base of the slope). Steeper slopes of the Hale crater show gullies incised into talus material (MOC-images A: E1103249; B: R1301793; C: E0502006; D: E1400853).

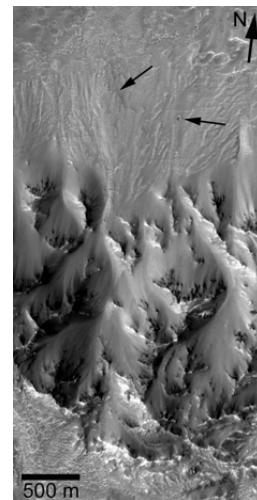


Figure 6. Example of a gullied north facing slope in the Hale crater. Arrows show an eroded debris apron at the distal end leaving behind a steep scarp and a crater superposed on gully deposits (MOC-image R1103008).

Conclusions: We conclude that the occurrence of gullies in the Hale/Bond region more likely depends on the distribution of unconsolidated material and/or steep slopes. The regional and local gully distribution is likely to vary because of differences in topography and surface material composition and is not an argument against a climatic influence on gully formation.

References: [1] Head J. W. et al. (2003) *Nature* 426, 797-802. [2] Edgett K. S. et al. (2002) *LPS XXXIV*, Abstract #1038. [3] Costa, J. E. (1984) Physical geomorphology of debris flows, in: Developments and applications of geomorphology, edited by J. E. Costa and P. J. Fleisher, Berlin, Springer-Verlag, 268-317.