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Distribution, Geological Context and Orientation of Gullied Slopes in the Northern Hemisphere from the Evaluation of HRSC and MOC-NA Data

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Several morphologic characteristics, such as deep incised and sinuous channels or levees suggest that a liquid, most probably water, played an important role during the formation of Martian gullies[1]. However, the current climate in the northern hemisphere of Mars does not allow the existence of substantial amounts of liquid water for a long time. Therefore, the exploration of particular young landforms, such as gullies is a valuable tool for understanding the most recent climatic history of Mars. In order to complement and complete an earlier survey conducted by Balme et al. (2006) [2] for the southern hemisphere, we evaluated HRSC [3] and MOC-NA [4] data covering the northern hemisphere for analysing geographical and latitudinal distribution, geological context and orientation of gullied slopes. Constraining such parameters helps to shed light upon the formation mechanisms of gullies on Mars, as preferred latitudinal regions or orientations strongly indicate the influence of insolation and/or climatic conditions.

Out of 21,042 MOC-NA images (0°-90°N) we detected 3195 gullies in 311 images. All these gullies are located between 30°N and 76.6°N, with a significant increase of frequency between 35°N and 55°N. Most gullies found in this survey are located on the slopes of impact craters (81.2%), 11.7% in graben structures and fretted terrains and 7.1% at isolated knobs and hills. The orientation of gullies changes with latitude. Between 30°N and 40°N 61.9% (n=635) of the gullies are situated on poleward facing slopes. Between 40°N and 50°N 69.4% (n=819) of all gullies are located on equator-facing slopes. Due to the small number of gullies at crater walls observed north of 60° (n=89, 3.4%) we binned all gullies north of 50°N into one group spanning a latitude band of 50°N-80°N with n=386 (14.9%). 67.3% (n=261) of these gullies occur on slopes facing the equator.

In 50 of 230 evaluated HRSC image strips we identified 2293 gullies. All gullies occur between 30.8°N and 74.9°N. The area between 35°N and 55°N shows gully densities higher than 0.1 gullies/1000 km^2. As for the MOC survey all gullies could be attributed to one of the three major groups of geological settings: 65.5% on slopes of impact craters, 26% in graben structures and fretted terrains, 8.3% at isolated knobs and hills and only 0.2% in small depressions. Similar to our MOC survey, the orientation of gullies changes with latitude: between 30°N and 40°N most gullies (n=327, 77.3%) are situated on poleward-facing slopes. Between 40°N and 50°N 587 gullies (68%) occur on slopes facing the equator. Due to few gullies found north of 60°N (n=8, 0.5%) we binned in a comparable way as we did it for the MOC survey all gullies north of 50°N into one group (n=219, 14.6%). These gullies were mostly located on northeast-facing slopes. In this latitudinal bin, 327 gullies (77.3%) are situated on slopes facing the pole.

The distribution in mid latitudes as well as the change of gully orientation at 40°N indicate that gully formation strongly depends on deposition of water ice and insolation. High frequencies of gullies on isolated hills are difficult to associate with the groundwater formation thesis. The model of Costard et al. (2002) [6], where sources of gullies depend on accumulation and melting of near-surface ground ice during phases of higher obliquity, is in good agreement with our results and the observations of Balme et al. (2006) [2] in the southern hemisphere, which are also based on MOC-NA and HRSC data. Our survey appears to be a promising basis for developing this model on a global scale. On the technical side, differences in orientation data between 50°N - 80°N show the importance for the using of different datasets, i.e. high resolution/ low coverage and low resolution/ high coverage, for this type of hemispheric surveys.

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