

**DEGRADATION OF MID-LATITUDE CRATERS ON MARS: GULLIES, ARCUATE RIDGES, AND SMALL FLOW LOBES.** Daniel C. Berman, David A. Crown, and Leslie F. Bleamaster III, Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ, 85719, [bermandc@psi.edu](mailto:bermandc@psi.edu).

**Introduction:** The degradation of craters in ice-rich environments is key to understanding the geologic history of the terrain surrounding the crater, as well as the source of the ice (i.e. ground ice or emplaced from the atmosphere as an ice-rich mantle [1-3]). Features such as arcuate ridges, gullies, and small flow lobes found on crater walls and floors can be used to understand the styles of emplacement, abundance, and distribution of the ice. Arcuate ridges and gullies are mainly found in small craters (~2-30 km in diameter); the orientation of these features on crater walls has been found to be dependent on latitude, suggesting that their formation is related to climatic changes driven by obliquity cycles [1-7]. In larger craters (~30-100 km in diameter), potentially ice-rich flow lobes are typically found on pole-facing walls, along with a suite of other degradational morphologies indicative of ice-driven modification processes. Through a series of studies, we have examined small (2-30km diameter) and large (>20km diameter) craters in detail, noting the potential water/ice-rich morphologies present and assessing their relationships to latitude and crater diameter.

**Crater Morphologies:** ArcGIS was used to integrate available datasets (including Viking Orbiter MDIM 2.1 and THEMIS IR mosaics, MOLA 128 pixel/degree DEM, MOC images, and all available THEMIS VIS images) to complete surveys of three study regions, one to examine small craters, and two for larger craters. Every crater in the specified size range for each region, as identified in the Barlow martian crater database [8], has been studied in detail for evidence of gullies and other morphological indicators of ice-rich deposits or fluvial erosion. For the smaller craters, MOC images were used to analyze crater morphologies; for the larger craters, THEMIS VIS images were used. The geomorphic characteristics of each crater were noted to determine relationships between the observed features and factors such as crater diameter, latitude, and wall slopes.

Craters containing gullies also commonly exhibit other features consistent with the presence or flow of water or ice, including arcuate ridges, small flow lobes, valley networks (sometimes with valley floors covered by potentially ice-rich material), narrow runoff channels, pitted and/or lineated floor deposits, debris flows, and lobate ejecta.

**Surveys:** Three study areas have been selected to examine crater degradational morphologies: one in the northern mid-latitudes in Arabia Terra along the dichotomy boundary (30°-55° N, 0°-40° E), one in the

southern mid-latitudes in the highlands east of Hellas Basin (30°-60° S, 110°-150° E), and one in the southern mid-latitudes in the region of Newton Basin (30°-60° S, 180°-240° E). Large craters were surveyed in the Arabia and Hellas regions, whereas small craters were surveyed in the Newton Basin region. Out of 400 craters in the southern study region, as identified by [8], 121 had sufficient image coverage in THEMIS VIS images for more detailed examination. In the northern study region, 116 craters out of 197 were examined. In the Newton Basin region, 225 craters were examined with sufficient MOC coverage, 188 of which had gullies on some portion of their walls.

A distinct relationship between orientation and latitude has been found for gullies, arcuate ridges and lobate flow features in the three regions. In the Newton Basin region, all of the craters with gullies only on the pole-facing walls were found north of ~44° S, whereas all the craters with only equator-facing gullies were found south of ~44° S. Arcuate ridges also exhibited a similar latitude dependence, with craters with only equator-facing ridges being found only south of 44° S. This relationship also exists in the Hellas and Arabia regions, although a smaller number of gullies and arcuate ridges were found in the larger craters.

A multitude of lobate flow features have been found on the walls of large craters throughout both the Hellas and Arabia regions, typically on the pole-facing side. Nearly all of the lobes are on pole-facing walls, and all of the pole-facing lobes are found below 45°. We have found three craters with lobes on an equator-facing wall, two in the southern study region, and one in the northern region. These craters are found south of 50° in the southern region, and north of 45° in the northern region.

**Discussion:** A suite of distinct morphologic features is found to be characteristic of mid-latitude craters. These features (e.g., gullies, arcuate ridges, lobate flows, narrow channels, wider valleys, filled and unfilled alcoves, mantling deposits, and debris flows) appear to be related to the deposition and/or accumulation of ice with subsequent erosion due to mobilization of this ice. Which features develop in a crater is a function of latitude, crater diameter, crater wall slope, and crater rim topography. Gullies and arcuate ridges are common in mid-latitude craters smaller than 20 km in diameter. Lobate flows are common in mid-latitude craters larger than 20 km in diameter and are mostly pole-facing in orientation at lower latitudes, and equator-facing at higher latitudes, similar to the relationship

between gully latitude and orientation [4]. These inter-relationships suggest a dependence on total solar insolation. Cycles of deposition and re-distribution of ice [6, 7, 9] due to obliquity variations [5] are the likely formation mechanism for the observed features.

**References:** [1] Squyres S. W. and Carr M. H. (1986) *Science*, 231, 249-252. [2] Hartmann W. K. et al. (2003) *Icarus*, 162, 259-277. [3] Arfstrom J. and Hartmann W. K. (2005) *Icarus*, 174, 321-335. [4] Berman D. C. et al. (2005) *Icarus*, 178, 465-486. [5] Laskar J. et al. (2004) *Icarus*, 170, 343-364. [6] Mustard J. F. et al. (2001) *Nature*, 412, 411-414. [7] Costard F. et al. (2002) *Science*, 295, 110-113. [8] Barlow N. G. (2006) *LPSC XXXVII*, Abstract #1337. [9] Christensen P. R. (2003) *Nature*, 422, 45-47.

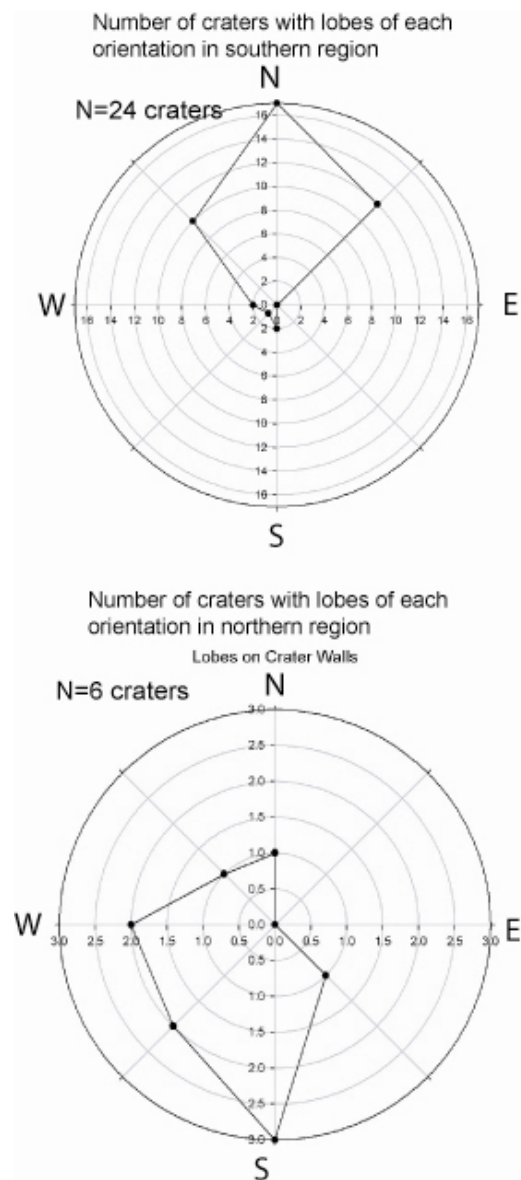


Figure 1. Number of craters with lobes on each of 8 cardinal direction crater walls in the southern and northern regions.

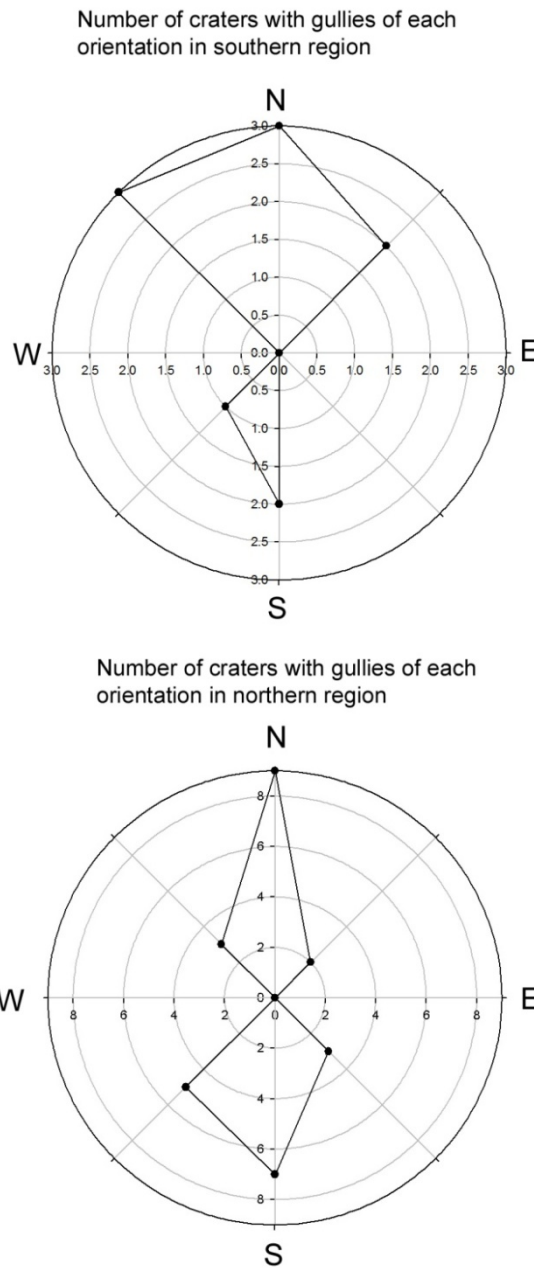


Fig. 2. Number of craters with gullies on each of 8 cardinal direction crater walls in the southern and northern study regions.