**ARCUATE RIDGES AND GULLIES IN MARTIAN CRATERS: DEPENDENCE ON ORIENTATION AND LATITUDE.** D. C. Berman[1] W. K. Hartmann[1], D. A. Crown[1], and V. R. Baker[2], [1]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719; bermandc@psi.edu, [2]Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ.

**Introduction:** At the bases of many mid-latitude crater walls, arcuate ridges with sharp crests can be seen [1,2]. These features are usually located at the bottom of gullied walls of craters, but gullies are not always present above them. Stratigraphically, the debris aprons of gullies overlie the crater wall-facing slopes of arcuate ridges, where the two features coexist, and the debris aprons may infill the region between the base of the crater wall and the arcuate ridge. Some ridges are only slightly sinuous and form one continuous ridge around a portion of the interior crater wall, but in most cases ridges appear as individual features that abut one another. They are often associated with lineations and pitted textures extending onto crater floors. The arcuate ridges resemble terrestrial protalus ramparts or terminal moraines [3,4,5], which suggests they may have a glacial origin. A general survey [2] has shown these features to be common in certain mid-latitude regions.

**Survey:** The Phaethontis Quadrangle (MC-24) was selected for a systematic survey because of the large density of craters in that region with gullies, arcuate ridges, and patterned floors. All 1153 MOC images from mission phases AB1 through R02 in quadrangle MC-24 (30º to 65º S, 120º W to 180º W) were surveyed for craters containing the features of interest. Arcuate ridges were identified according to the morphologies described above. Gullies were identified on the basis of having at least two of the primary features described by Malin and Edgett [6]: head alcoves, channels, and debris aprons. Craters with patterned floor deposits, but no arcuate ridges were also identified. This survey resulted in 364 MOC images which contained one or more of these features. All 485 THEMIS VIS images through the 7/1/04 release within the same region were surveyed, resulting in 67 images with the desired features. The images were then grouped by crater and 225 individual craters, which range in diameter from ~1.5 km - ~50 km, were identified, although few craters larger than 30 km in diameter exhibit these features. Of the 225 craters, 188 contained gullies on some portion of their walls. A total of 118 craters with arcuate ridges were identified; 104 of these craters also had gullies. An additional 35 craters had patterned floors, 13 of which also had gullies.

Each crater examined in MOC and THEMIS images was divided into 8 sectors, and the presence or absence of gullies and arcuate ridges on the crater walls was noted for each sector. Gullies on the northwest, north, or northeast wall were identified as pole-facing gullies; gullies on the southwest, south, or southeast walls were identified as equator-facing gullies. Individual craters exhibited gullies and arcuate ridges in multiple sectors. Results are shown in Figs. 1 and 2 for craters with coverage of at least some portion of both the north and the south walls. The existing literature is inconsistent as to whether pole-facing orientations or equator-facing orientations dominate [6,7], but Figs. 1-3 show that at least part of the discrepancy is a striking latitude effect.

For craters with image coverage of the entire crater (34 craters), 20 had only pole-facing gullies, 2 had only equator-facing gullies, 6 had gullies on both walls, 1 had gullies on the east and west walls, and 5 had no gullies at all. Of the 198 craters that had image coverage of at least some portion of both the north and south walls, 165 had gullies. Of those, 98 (59%) had gullies only on pole-facing slopes, 28 (17%) had gullies only on equator-facing slopes, 32 (19%) had gullies on both walls, and 7 had gullies on the E or W walls. As seen in Fig. 3, all of the craters with gullies only on equator-facing slopes were found between 44º S and 56º S. Craters with gullies only on the pole-facing side were found between 30º S and 48º S. Craters with gullies on both N and S sides were found between 37º S and 64º S. Craters with gullies on only the east and/or west walls were found between latitudes 42º S and 50º S.

The arcuate ridges have an even stronger preference for pole-facing orientations than the gullies; a polar plot of their orientations can be seen in Fig. 4. Of the 99 craters with arcuate ridges with image coverage of both crater walls, 75 had ridges only on the pole-facing side, 11 had ridges only on the equator-facing side, and 13 had ridges on both sides. As with the gullies, between 44º S and 65º S, a larger number of arcuate ridges have equator-facing orientations, but the majority are still pole-facing in that latitude band.

**Discussion:** There are clear associations between gully systems and arcuate ridges, including similarities in geometry of the alcoves and sinuous arcs of arcuate ridges, and the backfilling of arcuate ridges by debris aprons associated with gullies. The latitudinal distribution of gullies and arcuate ridges and the dependence of preserved features on orientation and latitude support a direct association between these features and the emplacement, melting, and removal of an ice-rich mantle [8,9,10]. Mantled crater walls appear to evolve

by large-scale mass wasting of ice-rich material to produce patterned floor deposits, followed by cycles of localized wall slope modification. Formation of gullies occurs by either basal melting or breakout of groundwater, and arcuate ridges form by erosion of the margin of the crater floor deposit and/or deposition of material from the crater wall as it encounters the deposits on the crater floor.

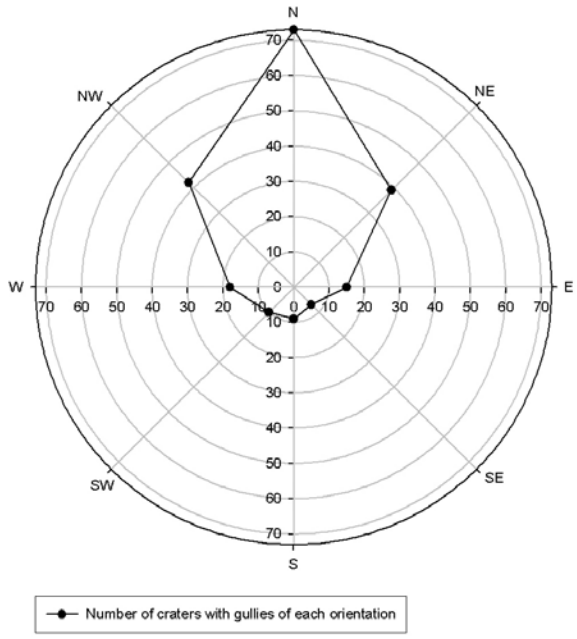


Fig. 1. Orientations of gullies in craters with coverage of N and S walls between 30º and 44º S, in MC-24.

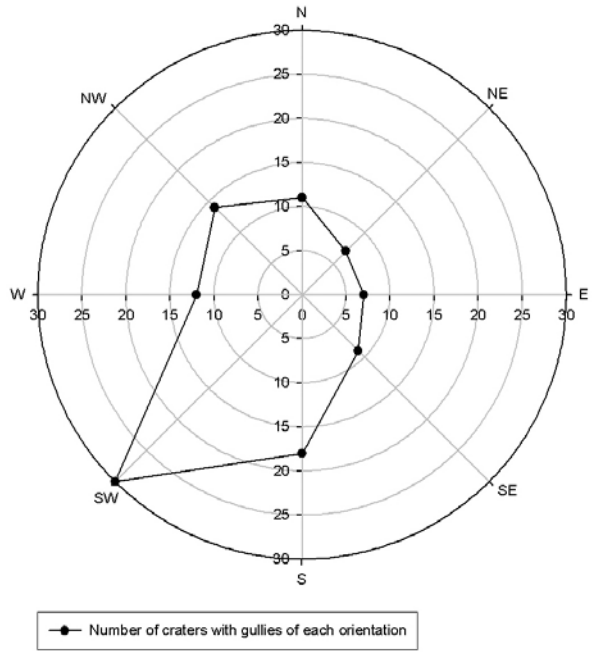


Fig. 2. Orientations of gullies in craters with coverage of N and S walls between 44º and 65º S, in MC-24.

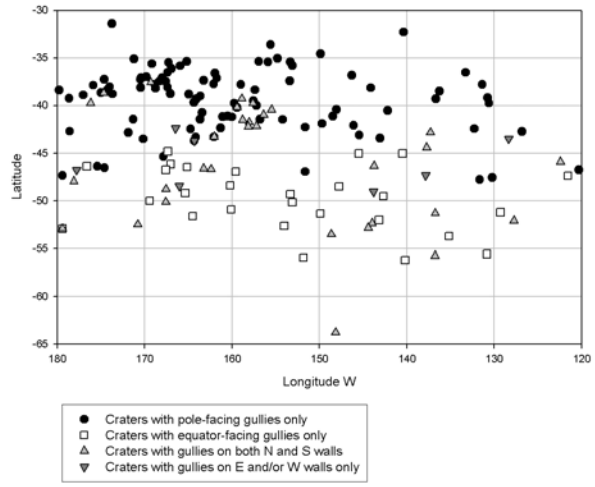


Fig. 3. Orientations of gullies in craters with coverage of both N and S walls in MC-24.

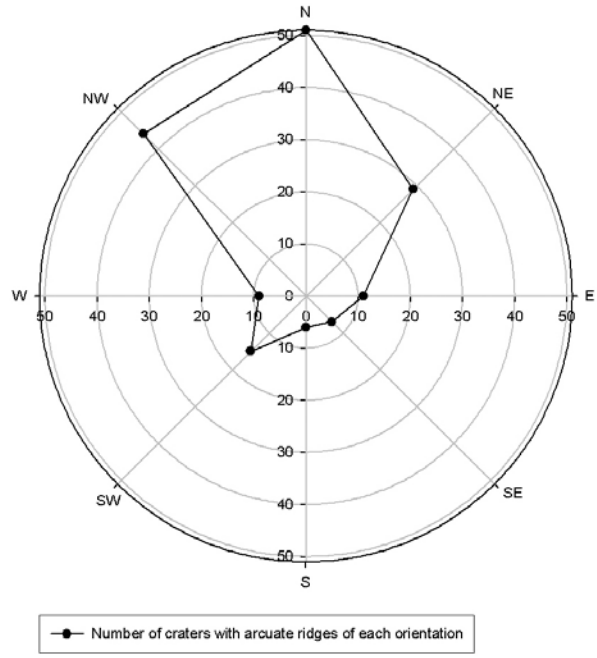


Fig. 4. Orientations of arcuate ridges in craters with coverage of N and S walls, in Quandrangle MC-24.

**References:** [1] Berman D. C. et al. (2005), *Icarus,* in review. [2] Berman D. C. (2003) M.S. Thesis, U. of Arizona. [3] Howard A. D. (2003) *LPSC XXXIV*, Abstract #1065. [4] Arfstrom J. D. (2003) *LPSC XXXIV*, Abstract #1050. [5] Arfstrom J. and Hartmann W. K. (2005), *Icarus,* in press. [6] Malin M. C. and Edgett K. S. (2000) *Science, 288,* 2330–2335. [7] Edgett K. S. et al. (2003) *LPSC XXXIV,* Abstract #1038. [8] Mustard J. F. et al. (2001) *Nature, 412,* 411-414. [9] Costard F. et al. (2002) *Science, 295,* 110-113. [10] Christensen P. R. (2003) *Nature, 422,* 45-47.