GEOGRAPHIC SETTINGS OF GULLIES IN THE NEWTON-COPERNICUS REGION OF MARS: IMPLICATIONS FOR GROUNDWATER, SNOW, AND DUST. R.S. Morgan[1] and A.H. Treiman[2]. [1]Dept. Physical and Life Sciences, Chadron State College, Chadron, NE 69337. [2]Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058 <treiman@lpi.usra.edu>.

Martian gullies are composite landforms developed on steep slopes by movement of debris from a depression (the alcove), through a channel, and into a depositional fan or deposit downslope [1,2]. Many hypotheses have been proposed to explain the how debris could be mobilized to produce gullies, including: seeping groundwater, melted ground ice or snowpack, liquid CO_2, and dry flow. We test these hypotheses by analyzing the distribution, orientations, and shapes of gullies in an area including the basins Gorgonum, Newton, and Copernicus. Our results are not consistent with simple versions of any published hypothesis.

Method. We studied locations, orientations, and characteristics of gullies in 154°-172°W – 30°-65°S, which includes Gorgonum Chaos, Newton and Copernicus basins, and part of Sirenum Fossae. Narrow angle MOC images (www.msss.com) and Themis VIS images (themis.asu.edu) were examined for gullies, and >150 and >60 respectively showed them. MOC images were processed in ISIS for map projection and georeferenced for ArcGIS. THEMIS image data were annotated manually onto a MOLA elevation image.

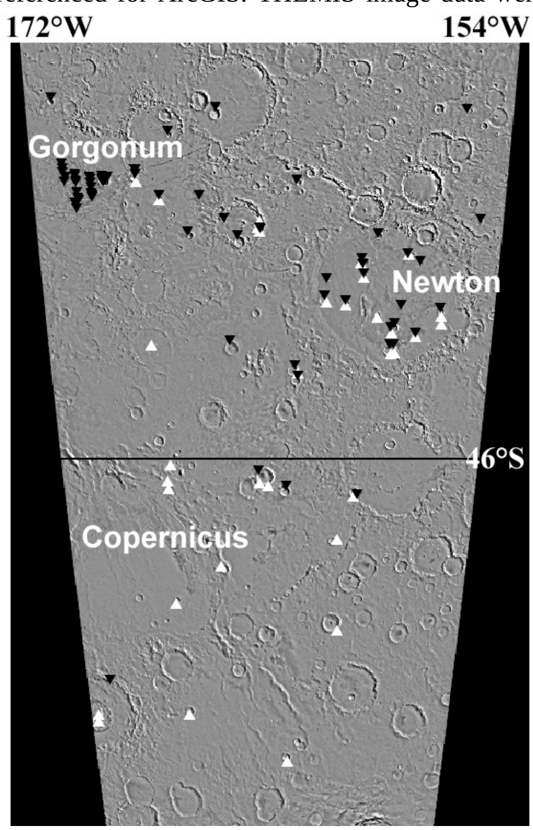

Figure 2. Gullies locations and facings 154°-172°W, 30°S-65°S: MOC images. White arrows are equator facing gullies; black are pole facing gullies. Base image is Viking composite.

Geography Results. Geographic distributions of gullies and their facing directions are shown in Figures 1 and 2. There are equal numbers of pole-facing and equator-facing gullies [3], excluding the many S-facing gullies in Gorgonum. Most gullies at lower latitude face southward (toward the pole), while those at higher latitude face northward (see also [4]). The transition from pole-facing to equator-facing is at ~46°S, but gullies of both facings occur throughout the area. The transition latitude appears to be farther north to the west (Fig. 1).

The orientations of selected gully systems are shown in Fig. 2. Gullies rarely face W or NW. That figure also shows the MOLA topography under the gullies; gully facing is not cleanly related to elevation nor slope direction. For instances, gullies in S Newton face upslope (S, SE, SW), and those on the NE of Copernicus basin face upslope (N, NE).

Morphology Results. We classified gullies on MOC images as to characteristics of alcoves, channels, and deposits. Alcove types are: lengthened, widened, occupied, and abbreviated (following [1]), plus badlands and bare slope (no alcove). We also classified by alcove location (top slope, rock layer, smooth), channel type (short, long, straight, crooked, widened, narrow, meandering, multiple channels/tributaries, braided), and depositional structure (fan, digits, nodular surface, absent). We noted no correlations among these properties, or among any of them and elevation, geologic setting, or geographic setting.

Implications. The geographic distributions of gullies are not obviously predicted by proposed hypotheses for their origins.

Near-surface liquids. Gullies might form as fluid-rich debris flows, with the fluid escaping or seeping from extensive underground deposits of groundwater [1,2,5] or ground-CO_2 [7-9]. Solar heating, obliquity change, and other processes are commonly invoked also. A preponderance of pole-facing gullies [1] could suggest a control from solar heating, possibly in the past when Mars had a greater obliquity [6]. However, gullies are not predominantly on pole-facing slopes (Figs. 1, 2; [3]). Further, groundwater should flow downhill, and so one might expect that gully-bearing walls would face down regional and local slopes. This is, in general, not observed; for instance, gullies in and NE of Copernicus are on NE-facing slopes, the regional uphill direction.

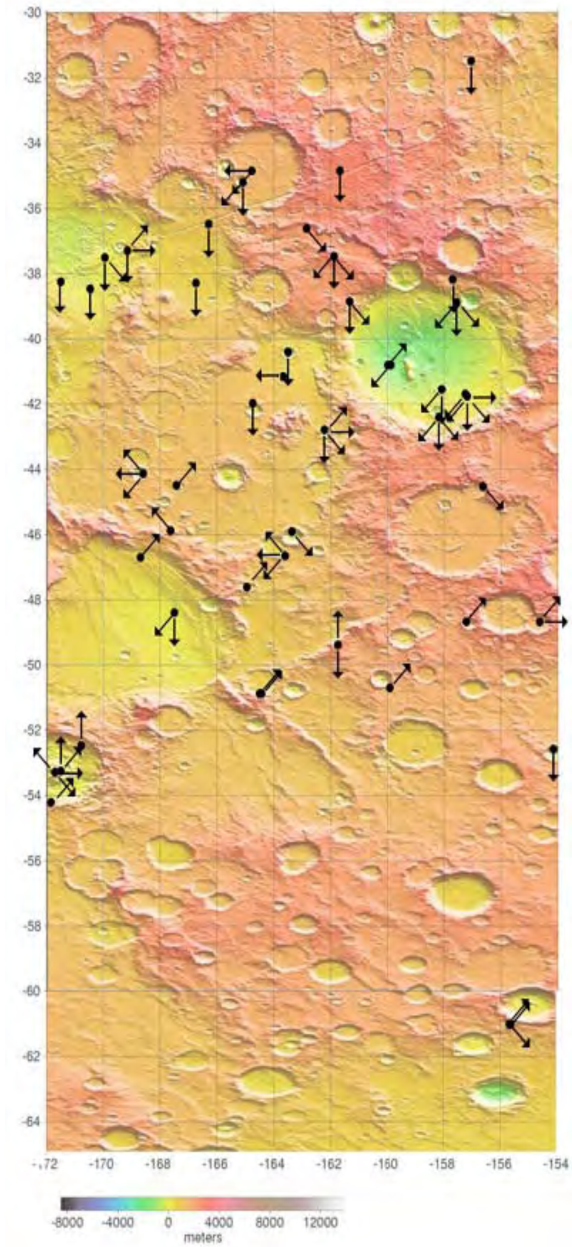

Figure 3. Gully sites and facings (arrows) from THEMIS and selected MOC images, on color-coded MOLA elevations.

Solar Insolation. Several hypotheses call on solar heating to help form gullies – to assist in escape of groundwater [6], to melt ground ice [10-12] or to melt snowpack [13,14]. Equator facing gullies are common at all latitudes, although the proportions change with latitude (Fig. 1). Thus, specific slope angles and directions are not required for gully formation, and simple models of solar insolation do not account for the latitudinal distribution of gully locations. Nor do solar insolation models explain the rarity of west-facing gullies nor the longitude dependence of facing (Figs. 1,2) we observe (if it is real [4]).

Geothermal. Internal heat has been blamed for formation of liquid water, either by melting of near-surface ground ice [14] or by 'eruption' of liquid water from depth [15]. These models are inconsistent with the widespread distribution of gullies across Martian mid-latitudes [2,5] and their distances from volcanos [16] or other eruptive constructs (like mud volcanos).

Aeolian Processes. Two hypotheses invoke gullies in relation to wind-blown material, either snowpack pasted onto slopes [17] or dust/silt dropped there [16]. Melting snowpack [17] has the problems cited above for solar insolation. Also, the snow that forms gullies in the 46°-65°S region would have been deposited by winds blowing from the north. Though not impossible, this is not within simple models of equator-ward flow of polar, water-rich air [17].

Deposition of dust to form gullies [16] avoids the problems and questions of groundwater availability and of slope orientation with respect to solar heating. The simple wind model of [16] explains in general terms the preponderance of gullies in southern mid-latitudes, but does not explain the latitude-dependence of gully facing direction (Fig. 1).

Conclusion. In the Gorgonum-Newton-Copernicus region, the most striking features of the distribution of gullies are: that their facing direction depends strongly on latitude, that their facing direction and other properties are independent of elevation and slope, and that the few face west. These observations are not explained simply by any published hypothesis about gullies: groundwater, CO_2, solar insolation, snowpack, nor dry dust/silt.

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