GULLIES POTENTIALLY FORMED BY WATER FROM THE SUBSURFACE. K. J. Kolb[1], A. S. McEwen[1], V. C. Gulick[2], and the HiRISE Team, [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721; kkolb@LPL.arizona.edu, [2]NASA Ames/SETI Institute, NASA Ames Research Center MS 239-20, Moffett Field, CA 95135.

Introduction: The Martian mid-latitude gullies have attracted attention because they suggest that water flowed on the surface of Mars in geologically recent times, less than a few My [1]. Recently, Malin et al. [2] reported the detection of potential new gully deposits seen in Mars Orbiter Camera (MOC) images taken merely years apart. It is possible that gully formation is occurring today on Mars.

Understanding gully formation will help determine the recent distribution and cycle of water on Mars, which will aid in evaluating future landing sites as well as the potential for recent and current life on and near the Martian surface. It is commonly believed that liquid water, either pure or salty, forms the gullies. The origin of this water is a topic of ongoing debate. Current leading theories include breakout from a subsurface aquifer [3], melt from near-surface ground ice [4], and melt from under a snowpack [5]. This abstract shows an example of a set of gullies that quite likely formed by liquid water from the subsurface.

Gully Setting: The High Resolution Imaging Science Experiment (HiRISE) camera aboard the Mars Reconnaissance Orbiter (MRO) has revealed details of the Martian gullies that were previously indiscernible. HiRISE image PSP_001552_1410 shows gullies that originate at many elevations along a crater wall. This is unusual; on Mars, gullies commonly occur at one level along a slope, whether or not an obviously related layer is present. The majority of the gullies in this image have alcoves that exhibit a dendritic structure (Figure 1) suggestive of surface runoff. The gullies along the crater wall are good candidates for formation by the melting of near surface ground ice based on the alcoves' structure and the scattered source regions across the crater wall. It is also possible that the seasonal frost seen in Figure 1 melts to form, or at least modify, the gullies.

One set of gullies in this image does not have a distributed source. These gullies emanate from a non-isolated mound on the crater floor (Figure 2). The mound is distinct from, but not separate from, the crater wall. The crater is located in Terra Sirenum, a region where regional groundwater flow has been proposed as the gully forming agent [6]. This gully setting is unique in that its orientation allows us to see into the slope hosting the gullies.

Figure 1. Alcoves with Dendritic Structure.
Scene is ~1.7 km across. The majority of this scene is in shadow. Bright/white regions are locations of seasonal frost.

Hypothesis: We propose that the gullies on the mound formed from subsurface water based on:
1. The presence of a layer in the gully alcoves that extends away from the slope into the mound.
2. A depression existing on top of the mound that appears to have a depth similar to that of the layer from the mound surface.

Along the slope face with gullies, a layer of noticeably different texture stands out. This layer correlates with the alcove bases of the gullies. It appears divided into sections a few meters in size suggesting that water could percolate through fractures between the sections to reach the slope. The layer continues into the mound as seen on the non-gullied slope face. It has a distinct albedo from the rest of the mound on this face, suggesting that some sort of chemical alteration from fluid interactions may have taken place. It is likely that the water that originally formed the gullies came from the subsurface via the layer.

The mound tilts to the left, away from the gullies, but the layer can be seen to dip to the right within the mound (Figure 2). Stereo measurements will reveal whether or not the layer actually dips toward the gullied slope. If the layer dips away from the gullied slope, then the layer was probably not involved in gully formation.

Interestingly, the length that the layer visibly extends into the mound from the gullied slope appears approximately equal to the length of a trough-like depression on top of the mound. Perhaps the depression formed by collapse when liquid was removed from beneath the surface through gully formation, thus weakening the overlying surface. Although gullies are seen at several points on the mound, the depression is only found in one particular region. The depression contains dunes, other materials, and a high standing mound. It is possible that the existence and weight of this mound led to the instability of only this region.

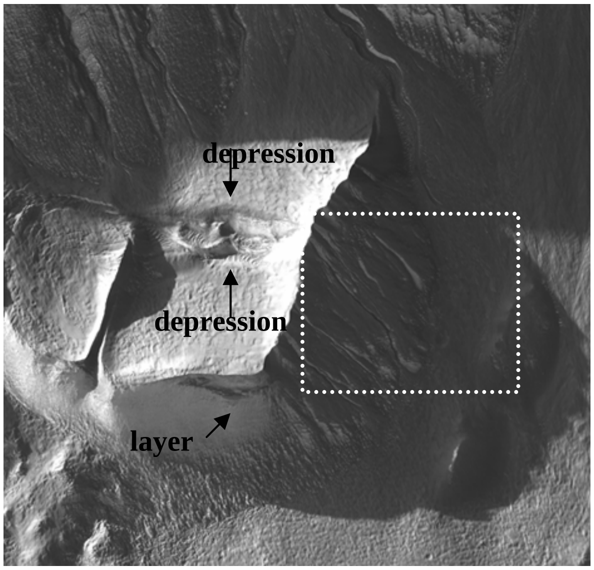

Figure 2. Gullies on Mound.
HiRISE PSP_001552_1410 RED CCDs. Center of entire image is -38.864, 195.911 ºE. North is up, and light is from upper left of scene. Scene is ~1.5 km across.

Besides the dunes, material can be seen at the bottom of the south-facing depression wall. This material was probably separated from the depression's wall during or shortly after the collapse event. Similar depressions or potential regions of collapse could exist behind other gullied slopes and would provide further evidence for subsurface water feeding gullies.

Locally Recent Formation: We suggest that the gullies on the mound formed most recently when compared to other gullies along this crater wall based on superposition relationships with nearby extensive debris aprons.

The crater that this mound is in has abundant evidence of multiple episodes of gully formation. There are complex interactions between channels and debris aprons, both within one gully system and between neighboring gullies. The majority of the gullies within this crater have extensive debris aprons (see MOC E1601453, for example). Several of these large debris aprons are cut by younger channels. One such debris apron wraps around the right side of the gullied mound. The large debris apron does not superpose any of the debris aprons of the mound gullies (Figure 3) suggesting that the mound gullies formed after the extensive debris apron, as well as probably the extensive period of gully formation that occurred within the crater. Stereo measurements or images in southern summer with higher illumination may confirm or disprove the superposition relationships. If the mound gullies did form after the upslope gullies, then it is possible that the source of water existing within the mound was a receding aquifer located behind the south-facing wall of the crater.

Future Work: Color and stereo images of this region will be analyzed as soon as available to address some of the questions resulting from this preliminary evaluation. Stereo measurements are needed to determine whether the layer dips towards the gullied slope and to evaluate how the depth of the depression relates to the elevation of the layer and the gullies. HiRISE images are sure to provide much insight into the mechanism(s) that form and affect gullies.

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References: [1] Mellon M.T. and Phillips R.J. (2001) *JGR*, *106*, 23165-23180. [2] Malin M.C. et al. (2006) *Science*, *314*, 1573-1577. [3] Malin M.C. and Edgett K.S. (2000) *Science*, *288*, 2330-2335. [4] Costard F. et al. (2002) *Science*, *295*, 110-113. [5] Christensen P.R. (2003) *Nature*, *422*, 45-48. [6] Márquez A. et al. (2005) *Icarus*, *179*, 398-414.

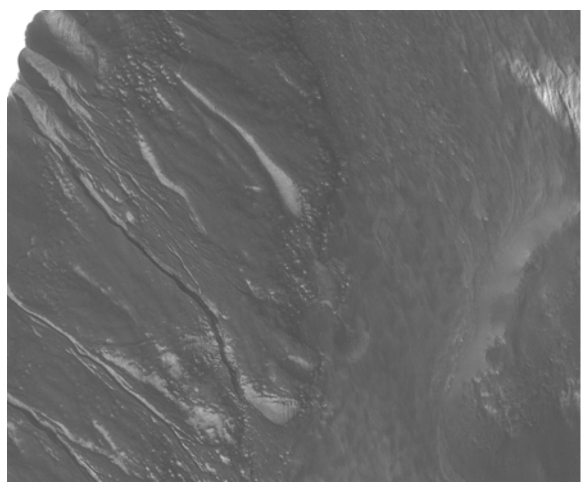

Figure 3. Debris Apron Superposition Relationships.
Region (~640 m across) is from white dotted square shown in Figure 2. Debris apron (bottom center) of mound gully superposes the large debris apron to the right.