NEW AND RECENT GULLY ACTIVITY ON MARS AS SEEN BY HIRISE. Colin M. Dundas[1], Alfred S. McEwen[1], Serina Diniega[2], and Shane Byrne[1]. [1]University of Arizona, Lunar and Planetary Laboratory, Tucson, AZ 85721 (colind@lpl.arizona.edu), [2]University of Arizona, Program in Applied Mathematics, Tucson, AZ 85721.

Introduction: Distinct, geologically young gullies on Mars have been taken as evidence for surface liquid water in the recent past [e.g. 1]. A variety of formation processes have been suggested. Fresh, unmodified deposits are found in association with many gullies. Several of these have been observed to form in the decade since the gullies were initially observed by the Mars Orbiter Camera (MOC) [2]. To better understand the current evolution of gullies on Mars, we have examined images from the High Resolution Imaging Science Experiment (HiRISE) camera to find recent deposits.

Image Survey: We examined all Extended Science Phase HiRISE images with center latitudes between 20°-60° N and S, and all Primary Science Phase images including the words "gully", "gullied" or "gullies" in the description. Dune gullies were examined in a separate study [3]. We noted the existence of deposits which were distinct in color or tone, and which showed no significant modification such as eolian ripples or smeared edges. These were classified as fresh deposits, and are likely to have formed very recently. We examined preexisting HiRISE, MOC and Context Camera (CTX) images to determine if it was possible to constrain the formation date of each deposit.

We found nearly fifty deposits which we classified as fresh, although in most cases a formation time could not be determined. Only two deposits in the northern hemisphere were considered definitely fresh, while a few others were marginal candidates. Southern-hemisphere fresh deposits equatorwards of 40° S showed a strong tendency to occur on pole-facing slopes, while those south of that latitude had no such tendency. These orientation preferences resemble those of gullies as a whole [4-6]. Both relatively bright and relatively dark fresh deposits were observed.

The formation times of a number of the new deposits could be constrained to within one Mars year (Fig. 1). The intervals show a tendency to include winter and exclude summer. This tendency is also observed in dune gullies with the classic alcove-channel-apron morphology [3].

For two new deposits in Gasa Crater (35.7° S, 129.4° E), before-and-after HiRISE coverage allows very small changes to be observed. In these cases, distinct topographic changes are observed, including movement of meter-scale boulders and erosion or burial of meter-scale topography within a channel (Fig. 2). This site also highlights the fact that some new deposits have relatively little tonal contrast with their surroundings, but are very distinct in HiRISE color.

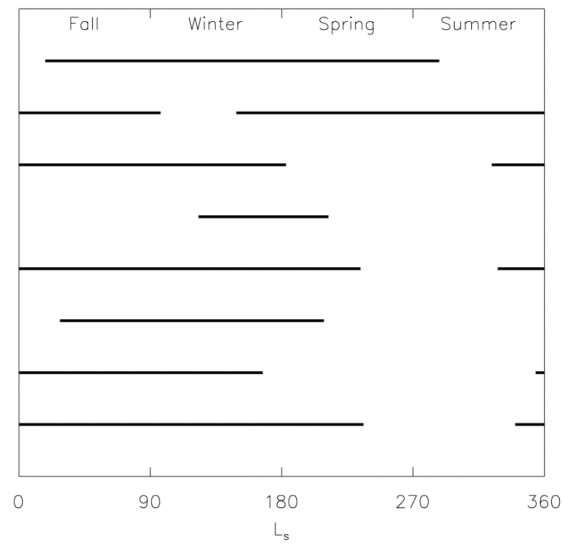

Figure 1: Formation intervals of new gully deposits constrained to within one Martian year. (Not all deposits formed in the same year.)

Discussion: The similarity of the latitudinal and orientation distributions of fresh deposits and all gullies suggest that the process or processes creating these deposits can act on most gullies under current conditions. Topographic changes are significant in at least some cases; these are not simply thin veneers or albedo changes. Hence, the fresh deposits examined here indicate movement of significant amounts of material within current gullies, and thus an important contribution to their morphological evolution.

The tendency of the activity timing intervals to include winter and exclude summer suggests that a seasonal process contributes to this activity. It is very difficult to produce geomorphically relevant quantities of liquid water in the current Martian climate, particularly in the winter. Suggested liquid-water mechanisms for gully formation include groundwater release [1], snowmelt [7], and melting of near-surface ground ice [8]. In the present climate, ground ice and seasonal water frost will likely sublimate before melting [9-10], remnant snow from high obliquity is not plausible [11], and no water table has so far been detected by sounding radar [12]. Even under optimal conditions, melting of seasonal frost at present would produce very small water volumes [13] unlikely to move boulders.

Other proposed mechanisms for gully activity involve frost, particularly CO_2, in several fashions [5, 14-16]. CO_2 frost forms on pole-facing slopes at latitudes as low as 30° S and can form accumulations of many centimeters [17]. These mechanisms would preferentially operate during the winter, when frost is most abundant. However, some fresh deposits do occur on equator-facing slopes where seasonal frost is unlikely; these are more likely to be dry granular flows, which are consistent with many properties of recent deposits [18-19].

Like gullies and associated fresh deposits, CO_2 frost preferentially occurs on pole-facing slopes, especially at lower latitudes. A role for CO_2 frost in gully evolution could also explain some differences between northern and southern hemisphere gullies. Southern winters are currently longer and colder than northern due to Mars' orbital eccentricity, which causes CO_2 frost to accumulate in greater amounts and at lower latitudes in the south [17]. Northern hemisphere gullies are more degraded than those in the south [20] and we have observed less evidence for recent activity there.

The two new gully deposits observed in Gasa Crater likely formed during southern autumn or winter. Topographic changes at these sites demonstrate that significant movement of material from the upper channels or alcoves to the aprons can occur in the current climate. Since dry flows may also be capable of forming channel-like features [21], it is at least possible that a combination of dry flows and frost processes are responsible for gully formation without liquid water.

Conclusions: Martian gullies show evidence for significant recent activity, including mass movements leading to topographic changes. This activity shows some seasonal tendencies, and may be related to seasonal frost. Further investigation is needed to determine the extent to which such processes are involved in the formation and evolution of gullies.

References: [1] Malin M. C. and Edgett K. S. (2000) *Science*, 288, 2330-2335. [2] Malin M. C. et al. (2006) *Science*, 314, 1573-1577. [3] Diniega et al., this conference. [4] Heldmann J. L. and Mellon M. T. (2004) *Icarus*, 168, 285-304. [5] Balme, M. et al. (2006) *JGR*, 111, doi:10.1029/2005JE002607. [6] Dickson, J. L. et al. (2007) *Icarus*, 188, 315-323. [7] Christensen P. R. (2003) *Nature*, 422, 45-48. [8] Costard, F. et al. (2002) *Science*, 295, 110-113. [9] Ingersoll A. P. (1970) *Science*, 168, 972-973. [10] Mellon M. T. and Phillips R. J. (2001) *JGR*, 106, 23165-23180. [11] Williams K. E. et al. (2008) *Icarus*, 196, 565-577. [12] Farrell W. M. et al. (2009) *GRL*, 36, doi: 10.1029/2009GL038945. [13] Hecht M. H. and Bridges N. T. (2003) *LPSC XXXIV,* abstract 2073. [14] Hoffman, N. (2002) *Astrobio.*, 2, 313-323. [15] Ishii, T. and Sasaki, S. (2004), *LPSC* XXXV, abstract 1556. [16] Hugenholtz, C. H. (2008) *Icarus*, 197, 65-72. [17] Schorghofer, N. and Edgett, K. S. (2006) *Icarus*, 180, 321-334. [18] Pelletier J. D. et al. (2008) *Geology*, 36, 311-314. [19] Kolb K. J. et al. *Icarus*, in press. [20] Heldmann J. L. et al. (2007) *Icarus*, 188, 324-344. [21] Shinbrot T. et al. (2004) *PNAS*, 101, 8542-8546.

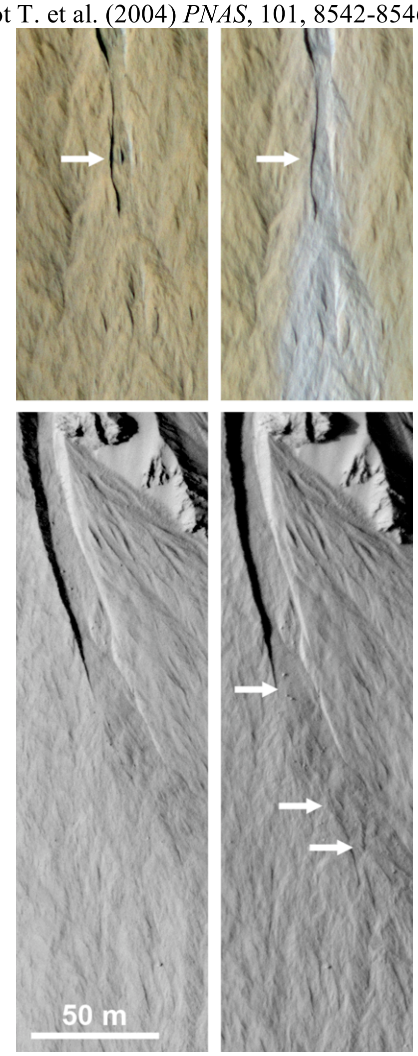

Figure 2: Changes at two sites in Gasa Crater (35.7° S, 129.4° E). Left-hand (before) images are from PSP_004060_1440 and right-hand images are from ESP_012024_1440. Both show a variety of definite and possible topographic changes; arrows indicate the most distinct. Top pair: a ridge in the channel is buried and/or eroded. Bottom pair: Boulders have moved many meters, and other topographic changes are possible. The left cutouts have an incidence angle of 43° and the right have an incidence angle of 57°, so some subtle changes may be due to different lighting. Scale bar applies to all subframes.