EXPLORING VARIATIONS BETWEEN ACTIVE MARTIAN GULLIES IN THE NORTHERN AND SOUTHERN HEMISPHERE.
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Introduction: Active martian gullies were first observed within the southern mid-latitudes, on both dune and non-dune (e.g., crater walls, hillslopes) slopes [1-3]. These features usually consist of an alcove, channel, and apron (Fig. 1,2), although some smaller features on dunes lacked the channel. Those studies also showed that activity was likely tied to winter, suggesting a seasonal frost-driven process. Since those first investigations, the activity within the southern mid-latitudes has been quantified and timing has been constrained further to late winter/early springtime (possibly related to springtime sublimation-driven or initiated processes) [4-6]. While CO_2-frost driven mechanisms have been proposed as possibilities for this present-day martian surface activity [e.g., 6-11], the exact drivers/process for either dune or non-dune gully formation have not yet been determined.

Investigations of gully activity in the northern hemisphere yielded a different picture, as described below. In this study, we begin to investigate whether all gullies may be formed by the same general process that is modified in different latitudes due to different environmental conditions, or if the observed differences may be indicative of different genesis/evolution processes. We outline broad similarities and differences observed for dune- and non-dune features, between different latitudinal bands – focusing on morphology and size of the gullies, activity rates and types, and local geological context.

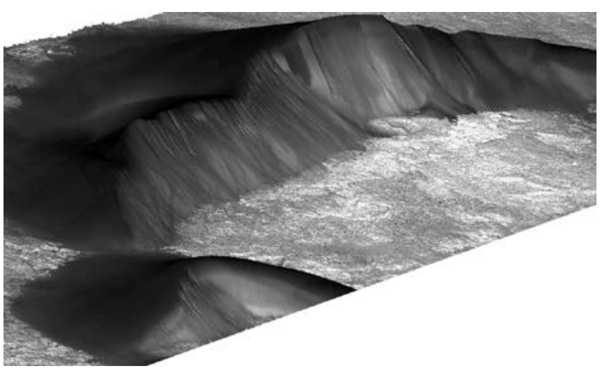

__Figure 1.__ Active dune gullies extend down the downwind slope of this megabarchan at the edge of Kaiser Crater dune field (46.8°S, 20.1°E). These are massive features (on a very large dune – 750 m tall), and some exhibit repeat activity over multiple Mars years. DTM was generated from PSP_006899_1330 and PSP_006965_1330 (NASA/JPL/UA/USGS).

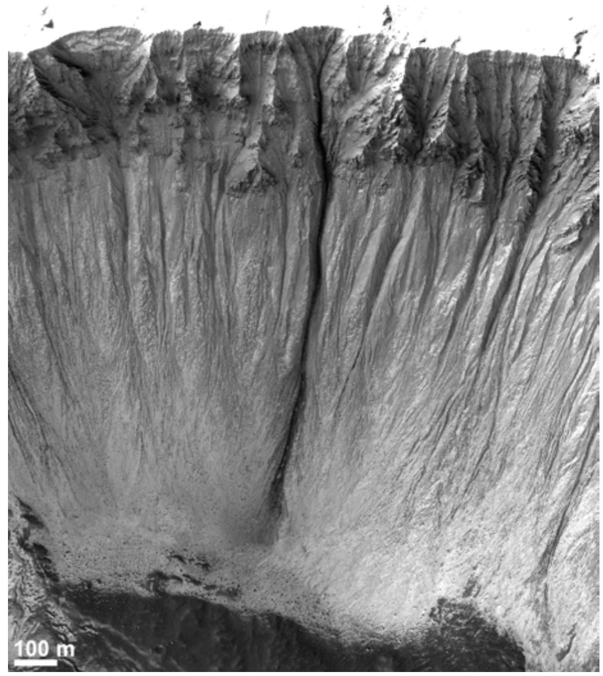

__Figure 2.__ New flow burying seasonal frost in Selevac crater (HiRISE image ESP_027567_1425, 37.4°S, 229°E). The crater wall is in shadow and image has been stretched to enhance contrast.

Differences in non-dune gullies: Non-dune gullies reveal distinct differences between hemispheres. Roughly 20% of monitored gully sites in the southern hemisphere have been observed to be active, compared with 5% in the north, despite similar monitoring intervals [6]. Additionally, changes observed in northern-hemisphere gullies are generally small, while the southern-hemisphere flows include large lobate deposits and substantial changes in channel mor-phology (Fig. 2) [6]. Variations with latitude are possible; the south polar pit gullies, the highest-latitude group of such features, are particularly active, but it is not certain whether this is due to latitude or some other characteristic of the cluster such as low thermal inertia [5]. These differences, however, are all consistent with expectations based on a seasonal frost-driven process. Seasonal CO_2 frost is more abundant in the southern hemisphere due to the longer winter, and is more abundant at higher latitude.

Differences in dune "gullies": The first active dune "gullies" reported in the northern hemisphere were in the polar erg [12], but these features were much smaller than the large active dune-gullies in the south, and generally lacked a channel (Fig. 3) -- the lack of a channel yielded debate about whether these should be called "gullies" (vs. alcove-apron features; hence the quotation marks). Furthermore, alcove formation within the north polar erg occurs before sublimation begins [13-15], possibly during early autumn [15], and the northern alcoves form in a single winter and then infill (vs. widening via repeat activity the next winter). These differences in morphology, size, and activity timing suggest that the north polar alcoves may form through a different process than the larger southern dune-gullies. However, the dunes are significantly smaller in the north polar fields than in the southern mid-latitudes. And recently we have found features with channels in a few polar dune fields [16] and dune-alcove activity in the northern mid-latitudes [17]. In addition to these features, we aim to re-examine the smaller "gully" features observed in the southern mid-latitude dune fields that may better resemble the northern dune-alcoves in shape and size. These new observations add information towards determining if we are looking at a spectrum of dune-alcove formation from the same process, or if different drivers play a role in separate dune avalanche populations.

Implications: Martian gullies are found at a range of latitudes [18] and studies have often considered them in aggregate, within one population. However, sufficient data about gully size, morphology, location, and activity in a range of locations [e.g., 5,6,15,19] may now exist to investigate whether similar-appearing features are forming in the present martian climate through different processes, or if observable differences are indicative of the location-specific environmental conditions affecting surface expressions of a common process. An improved understanding of present-day martian gully formation will also aid in interpretation of older features and the process(es) and environmental conditions they are hypothesized to reflect.

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Figure 3. *A large new dune gully that formed within Tleilax dune field (unofficial name; 83.5N, 118.5E). The largest alcoves in the north are much smaller than the largest alcoves studied in the southern mid-latitude dune fields. However, the amount of material that can be moved downslope in a single winter is comparable (few to hundreds of cubic meters of sand) – in the north, the alcove is not re-activated (although new alcoves may form near this feature in subsequent winters), while in the south an alcove may widen and grow over multiple winters. This alcove is 32 m wide, 40 m long, and extends up to 10 m into the dune brink (the line dividing the shadowed upwind slope from the downwind slope, in the upper half of the image). HiRISE image ESP_035310_2635 (NASA/JPL/UA), illumination is from the left and north is up.*