

CONTEMPORARY GULLY ACTIVITY IN SISYPHI CAVI, MARS. J. Raack¹, S.J. Conway², T. Heyer¹, M. Philippe², H. Hiesinger¹, A. Johnsson³, D. Reiss¹, ¹Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Germany, (jan.raack@uni-muenster.de), ²Laboratoire de Planétologie et Géodynamique, Université de Nantes, France, ³Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden.

Introduction: We present the results of our study regarding gullies and their ongoing activity/modification within the Sisyphi Cavi region on Mars. Recent studies have shown gully activity in this region [1,2], in which Raack et al. [1] proposed a potential formation process for one active gully: dry flows of sandy/dusty material over a sublimating translucent seasonal CO₂ slab ice.

In the same region, numerous dark spots [3,4] and dark flows [5,6] have been identified on dunes as well as on slopes of the polar pits during spring. This activity is most likely triggered by basal sublimation of seasonal CO₂ ice followed by degassing through small cracks in the ice slab, carrying darker sand and dust to the surface [4,6]. On sloping surfaces, these lofted materials may move downslope leading to dark flows [5,6]. The morphological similarity between dark flows within a gully in the northern region of Sisyphi Cavi [1] and the dark spots and flows in the same region during spring leads us to hypothesize a similar formation mechanism.

For our study, we performed an intensive survey of all the gullies in Sisyphi Cavi, based on multi-temporal CTX (n=382), HiRISE (n=212), TES, and HRSC (n=28) datasets, to compare the activity of gullies with activity of dark spots in this area.

Methods: *Study region:* Sisyphi Cavi is a pitted terrain in the south polar region of Mars. Our study region (340° to 10°E and 66° to 76°S) comprises all of the pits of Sisyphi Cavi (Fig. 1). The relatively steep slopes of the numerous pits host fresh-looking gullies with ongoing present-day activity [1,2]. The depth of the pits is up to ~1 km [1]. It is proposed that the pits were formed by collapse caused by basal melting of volatile-rich material by subglacial volcanos [7]. During southern winter, the complete region is covered in centimeter to decimeter thick seasonal CO₂ slab ice contaminated by small amounts of H₂O and dust [1].

Mapping and orientation: Using CTX images, we mapped all gullies in Sisyphi Cavi, based on a clearly visible alcove (n=17.063, Fig. 1), and measured their orientation. To account for any eventual bias caused by differing frequencies of cavi slopes per orientation, we normalized the orientation of all gullies after measuring the general orientation of slopes >6° in the complete study region.

Multi-temporal analyses: We used the web-based tool MUTED [8] to easily identify and download multi-temporal HiRISE images with an overlap of at least two images. We identified 25 different regions in the study area with high-resolution multi-temporal coverage,

seven of them with present-day gully activity. Overall, we identified 36 individual active gullies (Fig. 2). Activity is characterized by dark flows or moving/rolling boulders/stones, all of them with visible sediment transport. 10 of the 36 active gullies could be narrowed down to occur in a specific time interval during one martian year (MY), due to a high number of HiRISE images at that time.

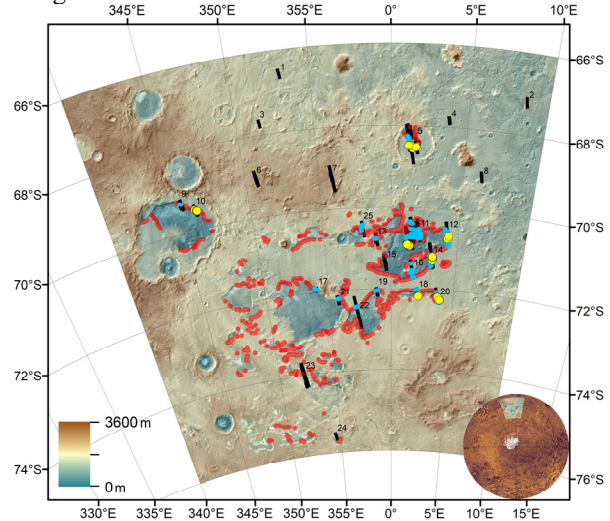


Fig. 1: MOLA shaded relief with digital terrain model superposed. Black rectangles: multi-temporal HiRISE image footprints. Red dots: mapped gullies based on CTX imagery (n=17.063). Blue dots: mapped gullies based on multi-temporal HiRISE imagery (n=2067). Yellow dots: active gullies (n=36).

Thermal analyses: We downloaded the maximum daytime surface temperatures (TES datasets) of the study region, binned them into 2° latitude groups (5 groups within the study region), and plotted the mean values against solar longitude (L_s) to investigate the average surface temperatures and to see the rise of temperature during the last stages of surface defrosting. The rise of temperatures is clearly visible due to high variations of the mean temperatures (caused by partial frosted and de-frosted surfaces at the same time) and a general decrease of the surface temperatures during mid-spring to beginning of summer.

Results and Conclusions: *Timing of activity:* On HRSC and CTX images, we identified defrosting of the surface based on: (1) visible frosted/defrosted ground (high albedo of frosted ground), (2) dark defrosting spots, and (3) dust devil tracks (which can only form on defrosted, loose material). The observed defrosting was

correlated to the rise of maximum surface temperature: the complete surface defrosting happens about 10-15° L_S after the rapid rise of surface temperature. All observed activity occurred during these last phases of surface defrosting (between $L_S \sim 225^\circ$ and $\sim 260^\circ$), when the occurrence of dark spots decreases and the increase of surface temperature was at its maximum (Fig. 3). Of the 10 active gullies, within one Mars year, 6 of them show periodic activity.

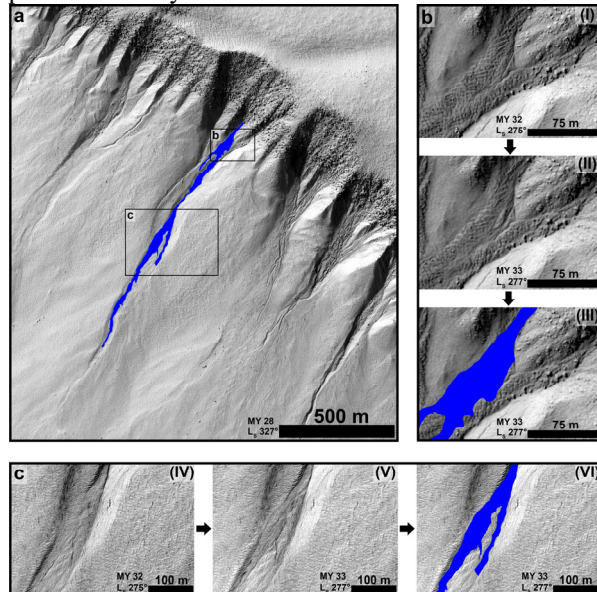


Fig. 2: HiRISE-images of the largest identified active gully in the study region. Material was transported over 1 km down the slope with observable erosion, deposition, and moving boulders. Activity was visible between MY 32 and 33, and no activity occurred before or after. (a) Overview with affected region of activity mapped in blue, (b+c) Details with ‘before-after’ images. North is up.

Erosion/origin of material: We identified the origin of transported material in some active gullies: (1) Material was eroded from the walls of gully channels, and (2) material in the alcove was eroded and headward erosion was identifiable. This mechanism was proposed in [1], but not actually observed due to the lack of HiRISE coverage in 2015.

Orientation: All gullies in the study region show a clear north-south orientation, but active gullies have a southwest or northwest orientation. The reason for this difference is not clear, because we expected activity to be most intense on slopes with the highest present-day insolation, which are north-facing slopes.

Possible formation mechanism: Based on our survey and preliminary results, we identify a strong temporal relationship between gully and dark spots/flows activity. We also observed, that material was eroded on gully channel slopes where dark spots/flows transported

this material. Our work confirmed the potential formation mechanism proposed by [1]: dry flows of sandy/dusty material over a sublimating translucent seasonal CO_2 slab ice with the added caveat that activity only occurs at the very end of surface defrosting, similar to the activity in linear gullies [11], but not the activity in classic gullies [12].

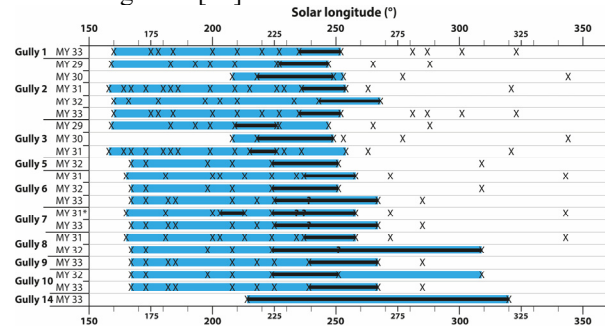


Figure 3: Diagram of 10 different gullies with contemporary activity within one MY. Six of the 10 gullies show periodic activity within different martian years (y-axis). The crosses represent single HiRISE images; the blue bars represent the identified surface frost coverage from the beginning of surface frost (beginning of blue bar) to the first image without any identifiable surface frost (end of blue bar). Black bars represent identified activity from between the “before” and “after” HiRISE images.

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