EPSC Abstracts
Vol. 12, EPSC2018-457-1, 2018
European Planetary Science Congress 2018

Active Gullies and Mass Wasting on Equatorial Mars

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Abstract

Mid- to high-latitude gully activity has been directly observed at hundreds of locations on Mars [1]. Here we describe equatorial locations (±25° latitude) with gully-like or other topographic changes in before-and-after images from HiRISE. This activity is concentrated in sulfate-rich sedimentary units, which places constraints on the age and mechanical properties of these deposits. Hydrated sulfates may be the largest equatorial reservoir of H_2O on Mars, and their friability makes them more attractive for in-situ resource utilization (ISRU).

1. Introduction

Mid- to high-latitude gully activity can be explained by the presence of seasonal CO_2 frost and ice, which fluidizes debris flows [1]. The belief persists that gullies do not form in equatorial regions today or in the recent geologic past [2], but there are observations of pristine equatorial features [3, 4] that match the terrestrial definition of gullies in terms of morphology and size. Many of these equatorial gullies are associated with active Recurring Slope Lineae (RSL) [3, 5], but actual topographic changes to the gullies have not been detected except in one possible case [5].

MRO's High Resolution Imaging Science Experiment (HiRISE) [6] has been observing Mars at ~0.3 m/pixel for over 11 years, providing a growing baseline for detection of surface changes. The HiRISE team recently began acquisition of HiKER (HiRISE checK for Exact Repeats) images: full-resolution repeat images within a few degrees of a prior image in illumination and emission angles. We also generated a list of past accidental HiKER image pairs. These image pairs reveal more subtle changes and enable distinguishing where the topography has changed rather than just changing albedo patterns from shifting dust.

2. Equatorial Changes

Previously-reported equatorial topographic changes include slumps on the colluvial fans below active RSL sites in Garni Crater [5] and in Juventae Chasma [7]. These slumps all occurred near the coldest time of year for these locations, L_s 0°-120°, which is opposite to the seasonality of RSL.

We are in the process of searching HiKER pairs over steep equatorial slopes, as well as acquiring new HiKER images. From the effort to date we have found that equatorial changes are most common in sedimentary layers that may be rich is sulfates according to mapping by orbital spectrometers [8], and have concentrated our search in these regions.

The most impressive changes we have found are on bright layered mounds in Ganges Chasma. The steep slopes of these mounds are highly dissected by pristine gullies (Figure 1), and repeat images show multiple changes including movement of boulders down gully channels. Most changes found to date are on south-facing slopes. The active erosion of these mounds suggests that they once filled a much greater volume of Valles Marineris. These mounds are rich in hydrated sulfates, leading to several models for their origin. Perhaps eolian dust and sand were trapped and lithified (weakly) by evaporites formed by evaporation of groundwater discharge [9].

Figure 1: Gullied slopes and colluvial fans on a mound of layered sediments in Ganges Chasm (ESP_032324_1715, 8.4° S, 313.3° E).

A new debris flow with a straight, shallow channel formed on the east-facing slope of a well-preserved 10-km crater at 15.7° S, 203.6° E (Figure 2). This may be better described as a leveed debris flow rather than an erosional gully, but there are many well-developed pristine gullies in this crater, some with distinctive colors from recent activity. Sulfates have been detected near this location [8] but not necessarily in this crater.

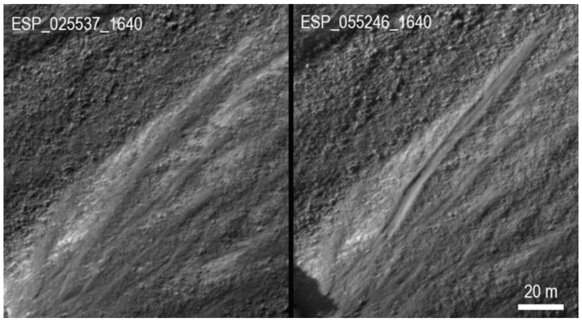

Figure 2: New channel and debris flow that formed on the NE-facing slope of a well-preserved crater at 15.7° S, 203.6° E between 1/7/12 and 6/18/18. Illumination from the left.

Other new topographic changes on steep slopes have been seen in a 9-km impact crater at 23.2° S, 43.2° E; a 3-km impact crater at 11.0° S, 25.9° E; Capri Chasma at 13.2° S, 312.2° E; Aram Chaos at 3.3° N, 339.0° E; Gratteri Crater at 17.8° S, 199.9° E, and Cerberus Fossae at 10.0° N, 157.8° E.

3. Discussion

The origin of mid-latitude gullies appears well-established as CO_2 fluidization [1], but there is no or very little CO_2 deposition in the moderate-to-high thermal inertia regions where we see equatorial gullies, so a different origin is required. Maybe RSL activity carves some of the gullies, but the exact mechanism of RSL activity is unclear. In all cases, we measure or suspect that slopes exceed the stopping angle for cohesionless granular flows, so no fluid is required.

Our observation that hydrated sulfate deposits are especially prone to erosion implies that they are friable and poorly indurated, consistent with the low power required for rock abrasion tool work on such sediments [10] and the near-absence of small impact craters on similar deposits [11]. Typically these sequences are capped by sediments rich in polyhydrated sulfates with up 50% water content [9], a promising unit for ISRU [12], and for which friable deposits can be processed with relatively little energy.

4. References

[1] Dundas C. et al.: The Formation of Gullies on Mars Today. Geol. Soc. London Spec. Pub., 467, http://dx.doi.org/10.1144/SP467.5, 2017.

[2] Harrison, T. N., Osinski, G. R., Tornabene, L. L., Jones: Global documentation of gullies with the Mars Reconnaissance Orbiter Context Camera and implications for their formation. Icarus, 252, 236-254, 2015.

[3] McEwen, A. S., et al.: Recurring slope lineae in equatorial regions of Mars, Nat. Geosci., 7(1), 53–58, doi:10.1038/ngeo2014, 2013.

[4] Auld, K. S., Dixon, J. C.: A classification of Martian gullies from HiRISE imagery. Planet. Space Sci., 131, 88-101, 2016.

[5] Chojnacki M. et al.: Geologic context of recurring slope lineae in Melas and Coprates Chasmata, Mars. J. Geophys. Res. Planets 121, 1204-1231, 2016.

[6] McEwen, A.S., et al.: Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE). J. Geophys. Res. 112, E05S02, 2007.

[7] Ojha, L. et al.: Seasonal Slumps in Juventae Chasma, Mars, J. Geophys. Res. 122, 2193-2214, 2017.

[8] Ehlmann. B.L., Edwards, C.S.: Mineralogy of the Martian surface. Annu. Rev. Earth Planet. Sci. 42, 291–315, 2014.

[9] Murchie, S. et al.: Evidence for the origin of layered deposits in Candor Chasma, Mars, from mineral composition and hydrologic modeling. J. Geophys. Res. 114, E00D05, 2009.

[10] Thomson, B.J., et al.: Estimating rock compressive strength from Rock Abrasion Tool (RAT) grinds. J. Geophys. Res. 118, 1233-1244, 2013.

[11] Kite, E.S.; Mayer, D.P.: Mars sedimentary rock erosion rates constrained using crater counts, with applications to organic-matter preservation and to the global dust cycle. Icarus 286, 212-222, 2017.

[12] Clarke, J.D.A., Willson, D., Cooper, D.: In-situ resource utilisation through water extraction from hydrated minerals—relevance to Mars missions and an Australian analogue. In: Proceedings of the 6th Australian Mars Exploration Conference, 1–16, 2006.