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Present-Day Gully Activity on Mars as Seen by HiRISE

C. M. Dundas (1), S. Diniega (2), A. S. McEwen (3), S. Byrne (3), C. J. Hansen (4) and the HiRISE Team.
(1) Astrogeology Science Center, U. S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001, USA (cdundas@usgs.gov), (2) Jet Propulsion Laboratory, Pasadena, CA, USA, (3) Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA, (4) Planetary Science Institute, Tucson, AZ, USA

Abstract

Activity in young Martian gullies is seasonally modulated, preferentially occurring around the time of loss of seasonal frost. Observed changes may involve significant morphologic changes including channel incision into colluvial materials. This suggests that currently active processes may account for a substantial part of gully formation.

1. Introduction

Geologically young gullies on Mars, comprised of alcoves, channels and aprons, were first reported by Malin and Edgett [1]. Since their discovery, a variety of formation mechanisms have been proposed [e.g. 1-5]. Most work has supported origins driven or facilitated by liquid water, but other proposals include dry mass wasting or CO_2-driven processes. Recent work [6-10] has indicated that new colluvial deposits form in association with gullies and that activity is seasonally modulated, suggesting that gully activity is affected by volatiles in the present climate. Here we report on observations by the High Resolution Imaging Science Experiment (HiRISE) camera showing gully activity with tighter seasonal constraints than previously observed, including observations of significant morphologic changes.

2. Observations

We have conducted systematic imaging of several gully systems over a Martian year in order to characterize morphology and frost changes with relatively narrow temporal constraints. These observing series include some designed to monitor gully activity as well as some older series targeting seasonal frost in gullies. We supplement this data set with observations of other gully systems where long-baseline HiRISE coverage exists, in order to look for resolvable morphologic changes. Changes have been observed at a number of the well-monitored sites as well as sites with sparse coverage.

Crater wall gullies were observed to change at several sites. The most active was Gasa crater, previously discussed by [7]. A major mass movement within the colluvium occurred in Gasa between L_s 109-152, an interval bracketing the period of maximum seasonal CO_2 frost; minor apron deposits apparently formed before and after this interval. The major flow emplaced thick lobes of material (Fig. 1) and also widened or cleared existing channels. Another monitored gully formed a small dark apron deposit between L_s 136-156 after developing dark defrosting spots and filamentary flow-like features in gully alcoves. Polar pit gullies developed extensive dark channel flows (Fig. 2), culminating in some cases in emplacement of substantial deposits near the end of the defrosting period.

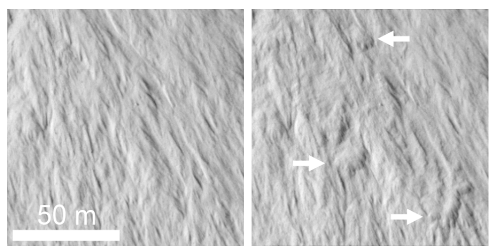

Figure 1: Before-and-after images of part of a new gully deposit in Gasa crater. Arrows indicate examples of deposited material.

Figure 2: Flows in a frosted polar pit gully channel.

Dune gullies also showed winter activity. The most detailed monitoring series covered dunes in Matara and Kaiser craters and show activity through much of the period of seasonal frost, with major morphological changes occurring in the latter part of the frosted period. Changes include major channel incision and formation of a new alcove and channel connecting to an existing channel and apron (Fig. 3).

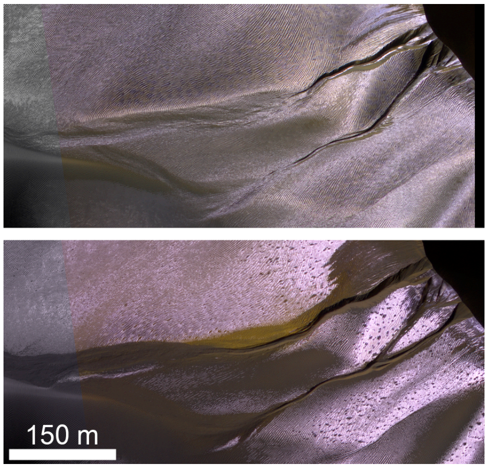

Figure 3: Channel incision and alcove/channel formation on a sand dune in Matara crater.

Changes observed in gullies with less extensive monitoring series are generally similar in nature. Observed changes include channel incision as well as other significant topographic changes within unconsolidated materials. A possibly distinct style of activity is observed at two other sites where multiple relatively dark deposits can be seen in winter shadow but leave virtually no trace once well-illuminated.

3. Discussion

Gully activity on Mars is widespread and may involve major morphologic changes. Current changes are not limited to material falling from alcoves onto aprons but also include incision of large channels; hence, all of the major components of a gully system form in the present climate. While it is quite possible that other processes contributed to gully evolution under different climates at high obliquity, current processes may be sufficient. Given that they form in sand subject to eolian transport, dune gullies resembling classic crater wall gullies may be very recent to have avoided degradation; the observed formation of a complete simple dune gully system supports this possibility. Activity is concentrated in the period of seasonal frost, suggesting that this frost is part of the driving mechanism for gully activity in many cases. Processes that could influence this activity include avalanching and sublimation.

Acknowledgements

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