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Seasonal Activity of Gullies in South Polar Pits, Mars.

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1. Introduction

Seasonal changes of gullies in the south polar region were first reported by [1,2]. These changes were observed within the last two martian years (MY) on slopes of polar pits. Polar pits are located in Sisyphi Cavi at -72.5°S and 355°E and have a depth of up to ~1000 m. The source material of the gullies appears to be fine grained with enclosed large boulders of about 5m in diameter.

[2] presented an overview of all detected seasonal changes of gullies in the southern hemisphere (~30-70°S) without a clear differentiation of gullies on dunes, slopes in mid-latitudes or on slopes of polar pits. In their estimation all these present activity of gullies have a related origin and therefore possibly the same forming mechanism (probable removing of CO_2 frost deposits).

In our investigations we focus only on gullies in polar pits. With high resolution imaging, temperature and spectral data we analyze the exact timing of changes of gullies to detect the possible medium (CO_2, H_2O or dry) and mechanism which initiate present day gully activity in the last martian years.

2. Background

Seasonal activity of gullies under current climatic conditions on Mars was observed by [1-6]. These observations were made on mountain and/or crater slopes [2-4], on dune slopes at mid-latitudes [2,5,6] or on polar pits slopes [1,2]. The suggested mechanisms to form new gully deposits are melting of H_2O-ice [3,5] or sublimation/removal of CO_2 [2,4,6].

Recent polar gullies in the southern polar region were analyzed by [7]. On the basis of observations made with Mars Orbiter Camera (MOC) and Thermal Emission Spectrometer (TES), gully formation was proposed to result from sublimation of CO_2 in spring, triggering debris avalanches [7].

3. Data

Our investigation is based on multiple data sets, including High Resolution Imaging Science Experiment (HiRISE) data with 25 and 50 cm/pxl resolution. We analyzed 95 HiRISE images within the last two MY (29 and 30) including 30 images with no visible gullies and 10 images without a multi-temporal coverage of at least two images. All images of the study region were acquired in spring and summer. Surface temperature data of the study region were derived by TES (~3 km/pxl) between ~13:00 and ~15:00 local time. Near infrared spectral data are based on the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) (18 and 36 m/pxl) and on the Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA) spectrometer (1.5-4.8 km/pxl).

4. Results

4.1 Imagery analysis

Detailed analyzes were made in a polar pit located in a filled crater (diameter ~54km) north of Sisyphi Cavi at ~68.5°S and ~1.5°E. Two locations in the polar pit with clear modifications of the gullies were identified. Region 1 (68.48°S/1.23°E) shows new deposition of dark material between L_S 226° and L_S 247° (MY 29) and the formation of a possible new small apron (width: ~20 m) between L_S 218° and L_S 249° (MY 30). In region 2 (68.54°S/1.44°E) dark material within the channel (Fig. 1a) leads to the formation of new dark deposits (Fig. 1b) between L_S 209° and 226° (MY 29). At L_S 247° deposition of material on the apron shortens the channel by about 40 m (Fig. 1c). Also in MY 30 dark material in the channel is observable at L_S 218° (Fig. 1d) forming new deposits within the channel of about 30 m at L_S 249° (Fig. 1e). No erosional processes in channels or/and in alcoves were observed. Further activity of gullies was observed in three different areas of Sisyphi Cavi but due to limits in image coverage seasonal activity cannot be detected.

4.2 Temperature analysis

TES data of the area analyzed in detail indicate that surface temperatures in autumn and winter are below ~150 K. In early spring (L_S ~220°) temperatures increase rapidly due to solar insolation. TES data show maximum temperatures in early summer between L_S ~270° and ~310° with temperatures up to ~285 K (Fig. 2). Detailed analyses of temperatures of other areas with activity of gullies are in progress.

4.3 Spectral analysis

In the area analyzed in detail, spectral data show a CO_2-cover of the complete study region in early and mid-spring (Fig. 2). At 1.43 µm there are strong absorptions of CO_2-ice. Spectral evidence for CO_2-ice cover in the study region is found until L_S 227°. CO_2-ice free surface are spectrally observed for the first time at L_S 249°. H_2O was not spectrally detected in the study region and a mixture of CO_2 and H_2O as presented in [8] cannot be clearly detected. Unfortunately, there are no spectral data available between L_S 227° and 249°. At this stage we have analyzed 82 CRISM images in Sispyhi Cavi with CO_2-cover or CO_2-ice free surfaces; H_2O was not clearly identified on the surface, but further analysis of CRISM- and OMEGA-data will be done.

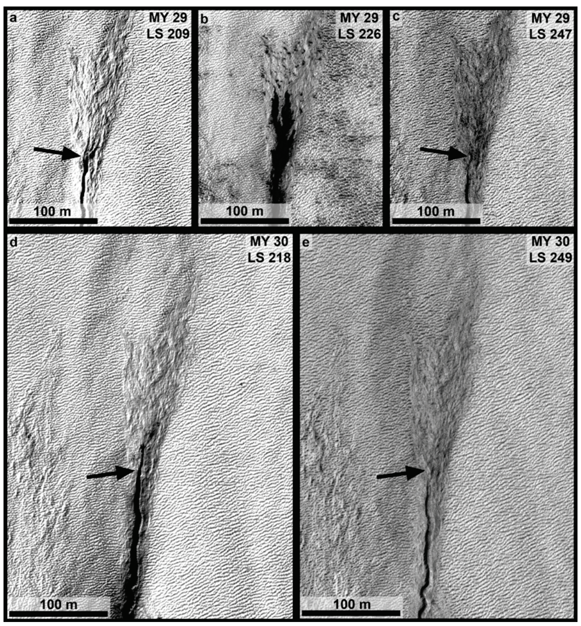

Figure 1: Region 2 with changes of the channel and apron. The black arrows show new deposition forms before and after deposition of material

5. Discussion

New small deposits on the gully apron and transport of dark material in gully channels implies seasonal volatile activity. In the area analyzed in detail activity can be narrowed down to occur between L_S 226° and 247°. Spectral data show a CO_2-ice cover until L_S 227° and an ice-free surface after L_S 249°. Within this time range, the activity of gullies in the area analyzed in detail occurs at temperatures between ~190 and ~260 K. This is also in the range of temperatures where CO_2 sublimates back into the atmosphere. Based on the temperature range, the most likely candidate for the observed new deposits are processes related to the sublimation of CO_2. It is possible that the new deposits on gully aprons were initiated by CO_2/dust avalanches as proposed in [7,9]. An alternative possibility might be that the new deposits were initiated by briny flows (liquid H_2O, melting point lowered due to salts) [10]. Small amounts of seasonal deposited H_2O could be present beneath a later (at higher L_S) deposited seasonal CO_2-layer in the study region. Temperatures are very variable in the time of the observed activity (Fig. 2, large variance of TES-data) and exceed temperatures of 260 K. Some brines have eutectic temperatures down to ~201 K [11], hence brines can remain liquid under temperatures below the H_2O freezing point [10].

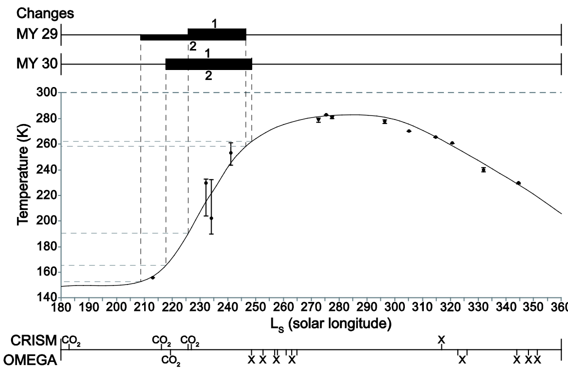

Figure 2: Changes of gullies in region 1 and 2 in MY 29 and 30 (first two lines) and the associated temperature-profile (points represent TES-measurements with their variance) in spring and summer. The line below shows the identified spectral composition of the study region with CRISM and OMEGA (X stand for no CO_2 or/and H_2O-cover).

6. Conclusion

Based on our analysis, seasonal changes of gullies in a south polar pit were clearly identified during springtime. Sublimation of CO_2 is likely to form the changes of gullies, but involvement of small amounts of H_2O(-brines) cannot be ruled out. We are currently analyzing temperature and spectral data of other areas in Sisyhpi Cavi to constrain the formation mechanism of the gullies, i.e., whether the changes in the gullies are initiated by sublimation of CO_2 or by melting of H_2O-brines.

7. References

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