OBSERVING SEASONAL ICES ON GULLIED SLOPES IN SISYPHI CAVI WITH CASSIS AND HIRISE

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Introduction: Since their first observation by Malin and Edgett (2000) [1] martian gullies have been abundantly studied, but their formation mechanism is still under debate [e.g. 2, 3]. Gullies are kilometre-scale landforms typically composed of an alcove, a channel and an apron [1, 4]. Some of them are active today and at times of year when the Martian surface is at its coldest - when CO_2 is condensed on the surface [5, 6]. A link between seasonal frost deposits and gullies seems likely, but their exact relationship is still under discussion. In this study, we investigated the evolution of seasonal frost deposits over the gullies in Sisyphi Cavi in an attempt to further elucidate this relationship (68-74°S; 345°-5°E) [7, 8].

Methods: We analyse repeat images of gullies in Sisyphi Cavi taken by MRO/HiRISE (High Resolution Imaging Science Experiment; [9]; 0.25-1 m/pixel) and by TGO/CaSSIS (Colour and Stereo Surface Imaging System; [10]; 4.6 m/pixel) in four colour filters (BLU, PAN, RED and NIR centred on 497.5, 677.4, 835.4 and 940.2 nm respectively [10]). In particular, the BLU filter is particularly sensitive to surface frosts [e.g.,11].

Results and discussion:

General evolution of seasonal frost. For any given latitude and slope orientation the general evolution of the frost deposits is consistent from year to year. From the middle-end of winter to the beginning-middle of spring, we observe surface frost with superposed dark spots, dark flows and dark fans (Fig. 1A). These features appear when a continuous slab of frost is present on surface [5, 7, 8]. The dark spots and fans tend to be more abundant earlier in the season and the dark flows more abundant later in the season (Fig. 2). Then, from the beginning-middle to the end of spring, the frost brightens and starts to become discontinuous across the surface (Figs. 1B; 2). Morphologic changes in gullies occur at the end of the defrosting period [7, 8] when dark spots, dark flows and dark fans are no longer visible. Within this general sequence, gully-alcoves usually defrost before the channels and aprons (Fig. 1B). Yet some patches of frost persist inside the channel and at the bottom of the alcove (Fig. 1C). Gullies defrost generally later than surrounding terrain, with the notable exception of sandy areas, such as dunes.

Effects of slope orientation. For a given latitude, the timing of defrosting differ yet the sequence remains the same (Fig. 3). The defrosting starts and ends earlier for slopes oriented towards the equator as compared to poleward slopes (Figs. 2, 3). This is true for the general orientation of the gully and also for slope facets inside the alcove and the channel. The dark spots, flows and fans persist later in the season on the pole-facing slopes compared to the equator-facing ones.

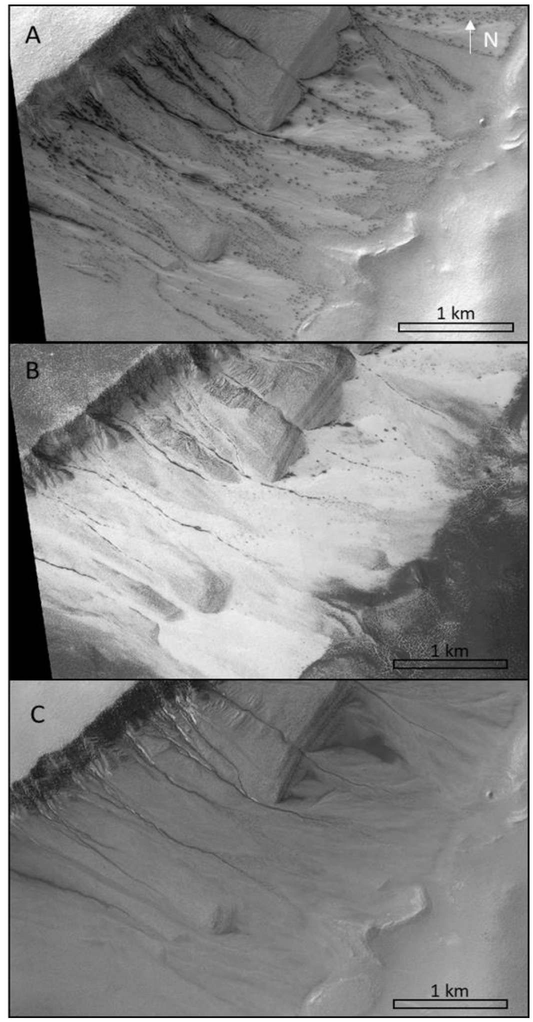

Fig. 1: Seasonal frost evolution over gullies in Sisyphi Cavi (68.5°S; 1.3°E). HiRISE images (relative albedo): A) ESP_028802_1115, taken at solar longitude (Ls) 173.3°, B) ESP_030147_1115, Ls 235.9°, C) ESP_021589_1115, Ls 248.7°.

The fact that the alcoves always defrost before the fans independent of orientation is an unexpected result, because based on geometric considerations alone, the sequence of defrosting should proceed sequentially from the equator-facing alcove down to fans, then to flat surfaces then from pole-facing fans up to pole-facing alcoves (which receive the least insolation and hence should defrost last). *Effects of surface type.* The meter-scale surface roughness influences the number of dark spots, dark flows and dark fans. We noticed that meter-scale boulders are preferential locations for the formation of these dark features. Within gullies, rougher surfaces within channels and fans that have been interpreted as signs of more recent activity, are also preferential formation locations [5]. Contrasts in surface type (e.g. the edge of a dunefield) also focus the occurrence of dark spots, dark flows and dark fans. We infer from these observations that the surface roughness and type does influence the stability of the CO_2 ice slab, either mechanically by introducing points of weakness, or by causing local variations in its thickness.

Conclusions:

- The general timing and characteristics of the seasonal defrosting patterns in Sisyphi Cavi are very consistent from year to year, in line with the general trend observed at global scale for seasonal deposits [12].
- Gully alcoves and channels defrost before gully fans independent of orientation. Some frost patches remain in the channels and alcoves at the end of defrosting.
- Surface texture and composition change the timing and frequency of dark spots, dark flows and dark fans.

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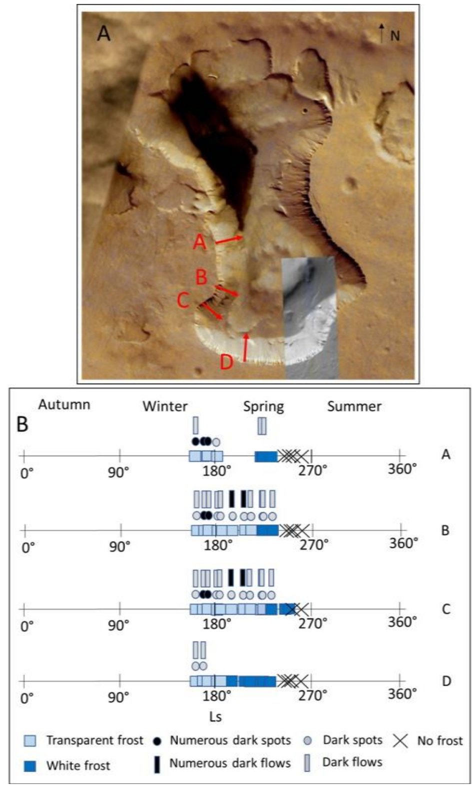

Fig. 2: A) Location of the slopes with frost and gullies with good temporal image coverage in Sisyphi Cavi at 68.5°S and 1.5°E. Red arrows show the orientation of gullies. B) Defrosting sequence for these slopes (in terms of solar longitudes).

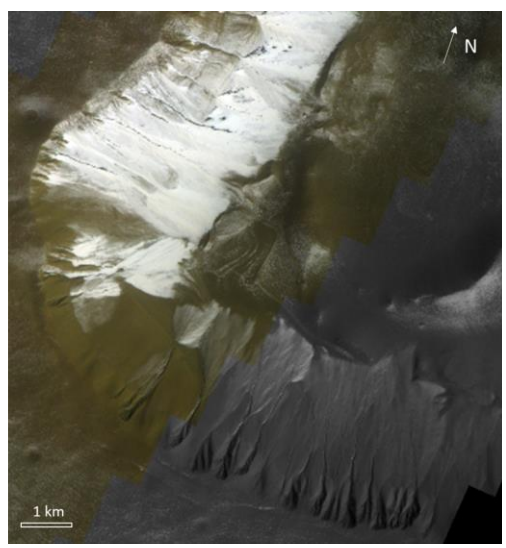

Fig. 3: Influence of the orientation on the distribution of seasonal frost deposits in Sisyphi Cavi (68.5°S; 1.3°E). CaSSIS images PAN-NIR-BLU: MY35_011760_288, Ls 237.4°.