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Timing of ice formation at active low latitude Mars gullies

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Abstract

Various mechanisms have been suggested to explain the formation of gullies on Mars, most of which involve melting of water ice or sublimation of CO_2 ice. Currently active gullies have been identified at low latitudes where the presence of CO_2 ice is unclear and where warm temperatures may be reached. We are analyzing OMEGA and CRISM data to precisely constrain the timing and properties of seasonal ice at low latitude active gully sites.

1. Introduction

Formation mechanisms for late Amazonian gullies are still debated, with 3 main classes of potential erosion processes hypothesized so far: mechanisms involving liquid water, in particular through the melting of subsurface or surface water ice [1-4]; dry flow [5]; and erosion linked with seasonal CO_2 ice formation and sublimation [6, 7].

Observations of new erosion features and deposits within existing gully systems have been recently highlighted over a wide range of latitudes on Mars [7-12]. These observations provide the opportunity to study the potential contribution of these hypothesized mechanisms. Efforts have thus been carried through to characterized ice formation at active gully sites, in particular at higher latitudes where a major seasonal ice cap forms and sublimates seasonally [13-14].

Active gullies have been identified down to 29°S in the southern hemisphere [11, 12]. At these latitudes, the presence of either CO_2 and/or H_2O ice is restricted to narrow L_S range and small/thin patches localized on the steepest pole facing slopes [15, 16]. Depending on longitude, slope angle, surface and atmospheric properties, ice may or may not be stable at active gully sites.

2. Method

We are currently analyzing near-IR data gathered at active gully site to precisely characterize their seasonal ice cycle. Presence/absence of CO_2/H_2O ice, and periods of ice condensation/sublimation, are compared to the timing of gully change as well as to the change type (deposit, new gully channel, etc…). Contrary to visible imagery, near-infrared imaging spectroscopy makes it possible to identified ice over a wide range of physical properties, including transparent, dusty or µm-thick ice layers [17]. Water and carbon dioxide ice can also be distinguished, and separately identified while mixed, from their specific spectral signatures.

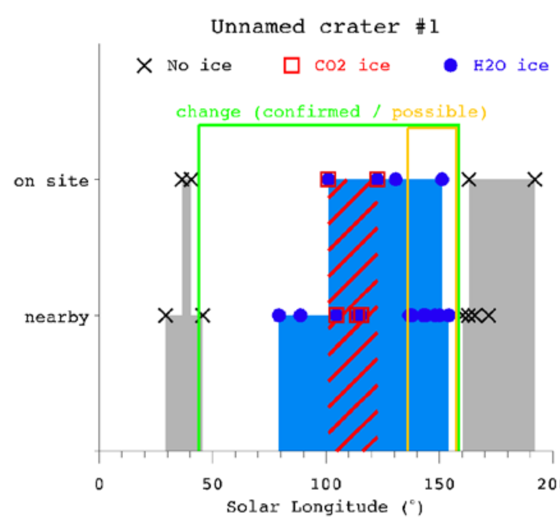

Figure 1: Timing of ice formation at 38.9°S and 223.7°E ("Unnamed crater", see [12]). Detections (red for CO_2 ice, blue for H_2O ice) or robust absences of detection of ice are indicated for both on site and nearby observations when on site observations are missing. The L_S range over which the change happened is indicated (green: confident range; yellow: suspected narrower range). See text for details.

For each identified active gully site at low latitudes (≤ 50°S), we analyze all OMEGA and CRISM data gathered over the site and in a 2° longitude window about the site. Spectra are processed to detect the presence or absence of ice at noise limit [15, 16], with a careful consideration of potential biases such as water ice clouds and surface water ice cover hiding underlying CO_2 ice signatures.

Once the timing of ice formation is determined, we use additional information to better constrain the feasibility of hypothesized mechanisms for each site. Energy balance codes and climatic models are used to quantify temperature, pressure, and greenhouse effect within CO_2 ice [16, 18-19]. Moreover, presence/absence of salts that may lower temperature at which liquid water is stable is also studied using CRISM and OMEGA data [20].

3. Results

We present in Figure 1 the observed timing of ice formation retrieved using this approach for an active gully site located at 38.9°S and 223.7°E and referred as “Unnamed crater” [12]. A new channel incision is observed at this site [12]. According to [12], the change happens somewhere between L_S 136° and L_S 158°. However, clear evidence for the change is only shown between L_S 44° and L_S 158°. In fact, HiRISE images obtained about L_S 136° are difficult to interpret due to the presence of ice. We observe strong signatures of H_2O ice from L_S 79° to L_S 154°. Faint signatures of CO_2 ice at noise limit are found to be restricted to the steepest portion of the slope (that include the active gully location), between L_S 101° and 123°. If the change really occurred between L_S 136° and L_S 158°, then it coincides with the presence of a water-only ice layer undergoing sublimation. The larger (and more prudent) time range includes also the period during which CO_2 ice forms and disappears. However, the observed faint spectral signature and the climate modeling predictions indicate that the layer of CO_2 ice is thin, typically a few hundreds of µm thick, which is poorly consistent with the occurrence of CO_2 jets [19] suspected to play a role in these gully change.

4. Summary and Conclusions

We have started to systematically characterize seasonal ice at gully sites that have been recently reported to be currently active, using OMEGA and CRISM data. We are also using climate models and mineralogical detections to retrieve additional constraints on possible gully formation mechanisms. Preliminary results indicate the presence of both CO_2 and H_2O ice at most sites. Both the destabilization of the slope due to CO_2 ice sublimation and the erosion linked with water ice melting remain conceivable for current gully activity.

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