MELT WATER SLOPE STREAKS IN HAUGHTON CRATER AS POSSIBLE MARS ANALOGS.

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Introduction: Haughton crater in the Canadian Arctic has been extensively used as a Mars (and lunar) analog over the past 20 years to address questions associated with planetary analogs and exploration. Here we report on small scale, semi-seasonal slope streaks formed on the crater walls that we observed during the Mars Society-sponsored M160 expedition to the F-MARS facility on the NW rim of the crater.

Description: Slope features are common along the NW rim of the crater (Haynes ridge) and elsewhere. They consist of dark, linear streaks, mostly straight but sometimes deflecting around obstacles. The streaks start in long-lasting snow patches and generally narrow down slope and mostly have simple terminations. Occasionally the termini branch. Some of the streaks are associated with the tops of solifluction lobes with further discharge from their toes (Fig. 1). Those measured by us using Google Earth imagery from the study area are typically a few hundred meters long and a few meters wide. Mean slope over the length of the streaks was 5.07°, with a range of 2.31-8.87° (Table 1). Overall longer streaks had lower slopes because they extended from the top of the ridge to the lower slopes. Slopes were concave, with the steepest parts near the crest of the ridge just below the snow patch alcove. Short slope segments exceeded 20° angles in the nivation hollows formed by snow patches.

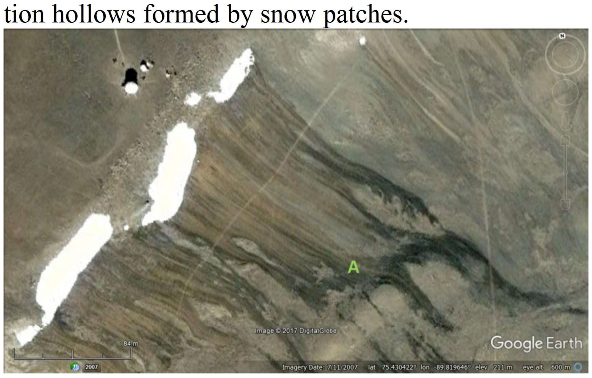

Figure 1. Active melt water streaks and solifluction lobes (A) below F-MARS station (top left). (Photo: GoogleEarth.)

Mean length (m)	Mean width (m)	Mean aspect ratio	Length range (m)	Width range (m)	Mean slope (deg)	Slope range (deg)
232	7	34:1	7-1038	1-32	5.07	2.31-8.87

Table 1. Measurements of melt water streaks along Haynes Ridge (N = 51).

At ground level the streaks are composed of trails of trickling melt water that flow between and sometimes over stony ground. Stone coverage varies from 100% to 50% with any intervening fine-grained soil being fully saturated. The dark color comes from a combination of the wetted surface and black microbial biofilms on the rocky surfaces (Fig. 2). The melt water streaks observed by us resemble features described as water streaks at other high latitude locations [1], [2], melt water features from Haughton crater [3], and appear distinct from gully and gully-like features previously described from Devon Island [4], [5], [6] because of the near absence any cross sectional relief associated with the streaks.

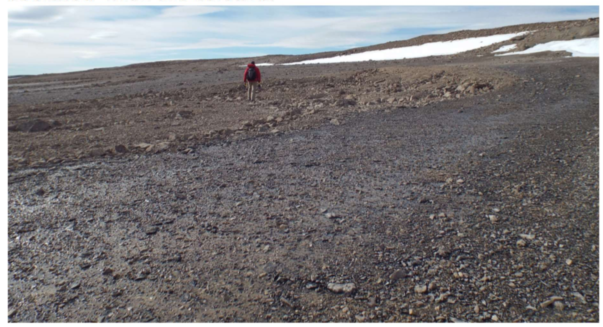

Figure 2. Melt water streak formed by snow patches to right. Wetted surface colonised by dark biofilm. (Photo: Jonathan Clarke.)

Seasonal Changes: Two types of seasonal lightening of these dark streaks were observed by us and are supported by Google Earth imagery: 1) Lightening through drying, and 2) lightening through burial by sheet wash. The smaller and more exposed snow patches shrink with the progression of summer and eventually disappear. The dependent slope streaks dry out and lighten in color (Fig 3). The dead or dormant biofilms become a light grey, only slightly darker than the uncolonized rock and soil. Sheet wash from rain events transport sediment down the slopes and bury the biofilms beneath a thin layer of silt and sand, this too lightens their color (Fig.3).

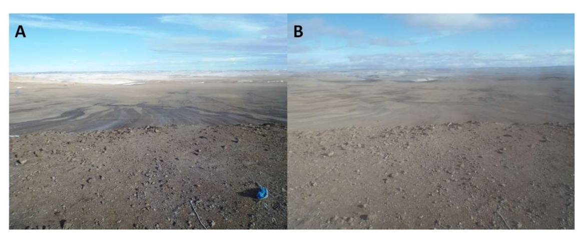

Figure 3. (A) healthy dark biofilms on slope below FMARS. (B) same area with biofilms buried by sheet wash. (Photo: Jonathan Clarke.)

Martian streaks: Streaks, flow features, and deposits are locally common on Martian slopes, including gullies [7] with attendant flows [8], slope streaks [9], and recurring slope lineae (RSLs) [10]. The formation of these features is contested. Gullies and their deposits, like terrestrial examples, are the result of a range of processes [11]. Dark slope streaks are predominantly thought to be formed by dry particulate flows [12] but a role for liquid water continues to be suggested [13]. Recurring slope lineae have been attributed to wet flows formed from deliquescing salts [14] but a dry flow formation has also been proposed [15]. All these martian features have mostly formed on steeper slopes (up to 40º for gullies [16], 11-22º for slope streaks [17], and 25-40º for RSLs [18]) in less eroded craters than Haughton crater, which more closely resembles the more degraded martian impact sites such as Endeavour.

Discussion: The melt water streaks are similar in appearance in imagery and in scale to smaller slope streaks and to RSLs. Our features also have some similarities with martian gullies in their association with surficial deposits of ice, which in the case of the martian deposits is composed of the latitude dependent mantle (LDM). The LDM is thought represent dusty snow accumulations formed during periods of high obliquity [19]. It was these similarities that drew our attention to them as potential Mars analog features.

Significant differences also exist. Unlike the martian LDM associated gullies, significant erosion is absent from our examples. Furthermore, no association of slope streaks has been noted with the LDM or season ice deposits. While the seasonal nature of RSLs is suggestive, to date “wet” formation hypotheses have focused on deliquescent salts, rather than melting of seasonal ice deposits.

Another feature of interest is the dark biofilms, which we interpret as UV-resistant cyanobacteria. Reviews of planetary protection protocols have emphasized the importance of liquid water, especially lower salinity liquid water, in defining “special regions” that need a high standard of protection from terrestrial contamination [20]. As an example the identification of possible RSL near the planned track of the Curiosity rover in Gale crater [21] led to a reassessment of the route because of planetary protection concerns [22] because the rover did not meet the high planetary protection standards required for accessing areas with the potential for surface liquid water.

Analog Application: We propose that the melt water streaks in Haughton crater (and elsewhere) provide the following potential Mars analogs.

1. They provide yard sticks to compare with contentious features on Mars, such as RSLs and slope streaks, that are possibly formed by surface water. Their similarities and differences may help assess whether or not any of the superficially similar martian features have formed similarly by melting of surface ice deposits.

2. The biofilms associated with the melt water streaks may provide insight into aspects of putative martian biofilms formed by microbial communities associated with past or present season melting.

3. By providing a morphologically similar feature to martian slope streaks and RSLs that is associated with water they are a natural laboratory to test issues of planetary protection associated with their study, be it by robotic missions or astronauts.

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