RECENT DEBRIS FLOW DEPOSITS IN A PRISTINE IMPACT CRATER, MARS: INSIGHTS FROM TERRESTRIAL ANALOGOUS ON SVALBARD.

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Introduction: Gullies on Mars are known to display a diverse range of morphologies but typically include an alcove, channel and apron [1]. Several hypotheses have been proposed to explain their genesis ranging from grain flows [2], debris flows [3] to fluvial erosion with alluvial deposition [4]. The observed range of gully morphologies asks for several mechanisms which likely will be polygenic due to local differences in climate and colluvial source material. Studies indicate that the common mechanism is fluvial deposition [5] in contrast to debris flow dominated fans which have only been documented at three sites [5,6,7]. These sites formed debris flow deposits of apparently fine-grained dusty mantle material. Here we report on unusual Martian debris flow deposits in an unnamed southern hemisphere crater which is rich in coarse colluvial material. Interior walls display well-preserved debris-flow deposits, debris plugs and levees. Morphologies that are diagnostic for debris flows on Earth. The crater interior also displays numerous fresh-looking rock falls pointing to an efficient weathering environment. This raises the following questions: Why do so well-developed debris flows occur here and not in other nearby craters? What role does the coarse colluvial material play in debris flow initiation and development? What are the timing of these events? Here we describe the debris flow morphology and we compare the morphology of debris-flow deposits on Svalbard as potential terrestrial analogs.

Data and method: The analysis on Svalbard is based on high resolution imagery with the High Resolution Stereo Camera - AX (HRSC-AX) [4], which is an airborne counterpart to the HRSC aboard the Mars Express orbiter. For comparison we use satellite imagery obtained by the High Resolution Imaging Science Experiment (HiRISE) which has a similar resolution of 25 cm/pxl. Image analysis is complemented by field work for ground truth. This method has proven to be useful in previous investigations [5,6,7].

Observations: The study site is a ~4.5 km unnamed crater located in the Aonia region (centered at 45.11 S; 274.2 E). The crater is superposed on the ejecta blanket of a much larger 17 km rampart crater (Fig. 1A). Nighttime THEMIS IR-images suggest a ejecta surface of either coarse-grained material or consolidated sediments for the study crater (Fig. 1B). Due to the underlying unconsolidated ejecta the former is favored. The study crater ejecta itself has been subjected to minor dessication of a thin mantle layer. Thick debris-flow deposits are present at the pole-facing interior wall of the crater (Fig. 3). Alcoves are incised in highly brecciated material. Numerous distinct, meters high levees are seen (Fig. 2) with crosscutting relationships pointing to multiple debris-flow events. Within debris-flow channels, 10 to 15 m, wide debris plugs with rounded termini are clearly visible (Fig 4B). The crater floor display numerous fresh appearing rock falls, with sizes ranging from less than a meter to ~2.5 m. The pole-facing deposits have a high amount of coarse material incorporated, which some deposits seem to be entirely composed of.

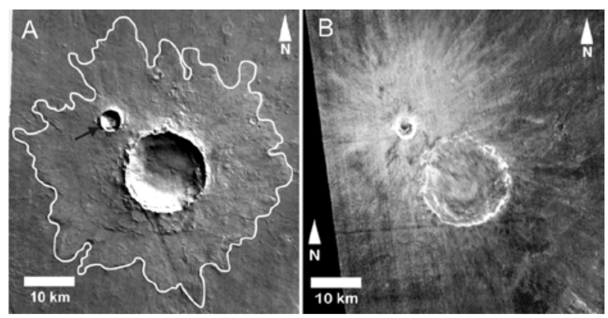

Figure 1. Study areas. (A)The study crater (black arrow) and the larger 17 km rampart crater (white outline). (B) Nighttime Themis IR showing a distinct signature of a rayed ejecta blanket.

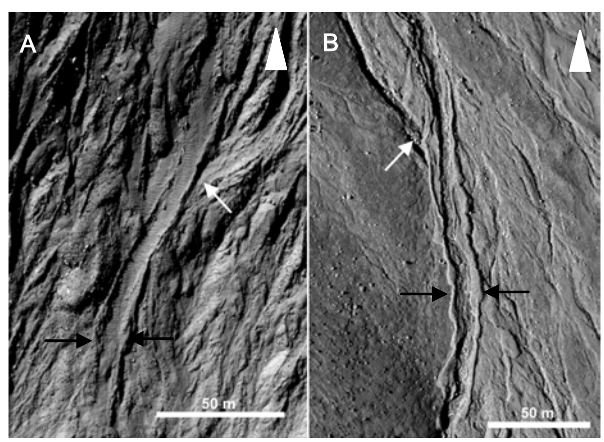

Figure 2. (A) Portion of HiRISE showing examples of well-defined levees' (black arrows) along a debris flow channel within the study crater. (B) Debris-flow levees in Adventdalen, Svalbard. Note the crosscutting relationship in both images pointing to multiple flow events (white arrows).

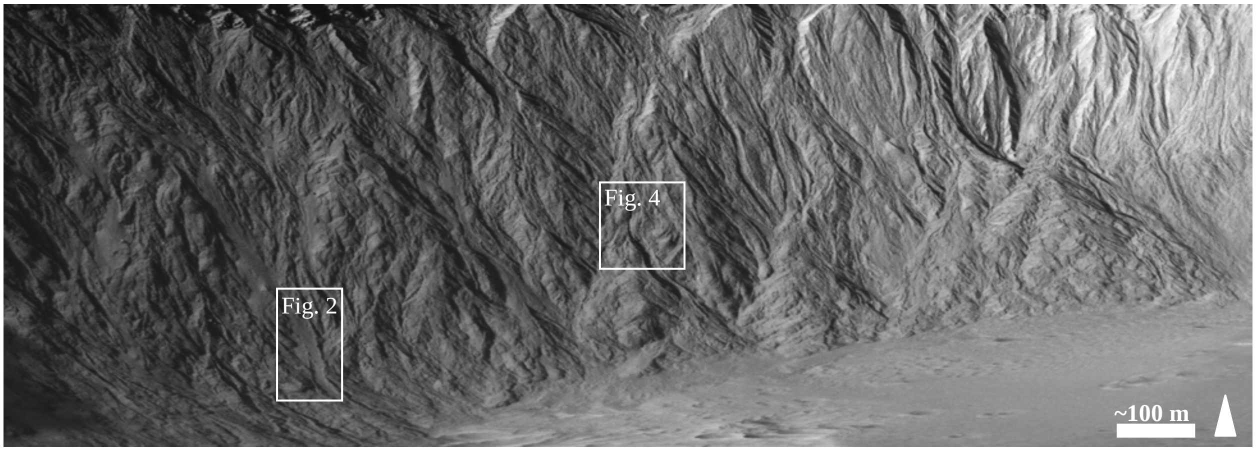

Figure 3. HiRISE image draped on a HRSC DTM for oblique context view. Image show the pole-facing slope which is completely dominated by debris flow fans.

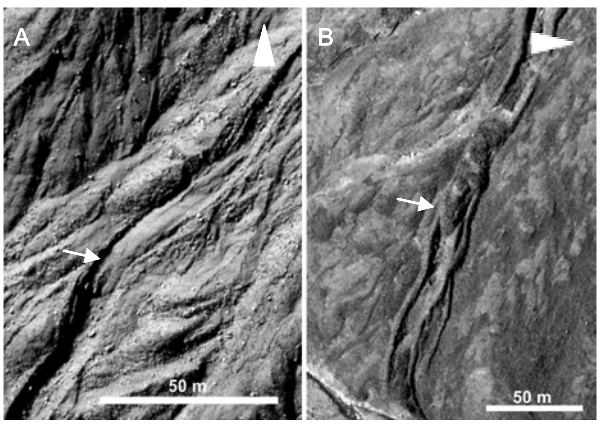

Figure 4. (A) Subsets of HiRISE image showing a debris-plug in the studied crater crater (white arrows). (B) Debris-flow plug in Adventdalen Svalbard.

Discussion: Despite numerous investigations of gullies using HiRISE images only three debris-flow sites has been documented so far [5,8,9]. The previously investigated sites show fluvial channels and that the debris flows most likely originated from the ice-dust mantle forming smooth-textured lobes. What is puzzling is that some of these previously documented gullies apparently incise the bedrock (e.g. [5,9]) but none or very small amounts of coarse material are incorporated in the debris flow deposits. In contrast, our study area displays no clear fluvial channels but instead numerous well-developed leveed channels, overlapping terminal lobes and snouts of coarse debris. In addition channels with debris plugs are clearly visible. Although a ice-dust mantle component of these debris flows cannot be excluded a striking difference is the presence of significantly more coarse grained colluvial material from the exposed crater rim. Furthermore the crater displays a spectrum of mass wasting, ranging from debris flow dominated (pole facing) to single-channel gullies (west and east facing) and grain flow (equator facing). This suggests that distinct morphological characteristics are influenced by solar insolation. A preliminary crater retention age analys of the studied crater's ejecta suggest an age of ~200 Ka. This is very young and may point to the stop time of debris flows.

Conclusions: (1) Morphologic evidence for debris-flow dominated gullies on Mars is rare. (2) Most gullies on Mars seem to be formed by fluvial processes with alluvial deposition. (3) The fresh impact crater's steep slopes cause an abundant supply of coarse colluvium which may mimic the paraglacial adjustment and gully initiation and development on Svalbard. (4) The unusual steep slopes of the fresh crater in combination with the poleward-facing slopes may have favored higher deposition and melting of atmospheric water-ice during high obliquity and consequently higher energetic flows. (5) The less abundant dust-ice mantling at this young crater leads us to suggest that the model of top-down melting of snow packs are the primary source of water, not excluding a minor component of melting ground-ice, for the formation of these debris flows. (6) Debris flow processes stopped ~200 Ka ago.

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