EPSC Abstracts,
Vol. 3, EPSC2008-A-00537, 2008
European Planetary Science Congress, © Author(s) 2008

Debris flows of the mountain massif of Hjorthfjellet and Adventtoppen, Svalbard: Implications for gullies on mountains in the Argyre basin, Mars

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Introduction

Martian gullies resemble terrestrial features formed by mass-wasting processes of a flowing mixture of clastic debris and water (debris flows). Their existence on Mars is interpreted to indicate liquid water in the recent past because of their pristine appearance, their stratigraphic relationships to young surface features, their lack of superimposed impact craters, and their distinct albedo relative to the surroundings, indicating limited dust cover [1].

The global distribution of gullies is limited to mid- and high-latitudes poleward of 30° in both hemispheres, with the highest frequency in the 30°–50° latitude bands [1, 2]. Gullies occur preferentially on poleward-facing slopes [1, 2, 3, 4].

The most likely and physically most plausible medium to explain the gully morphology is liquid water [e.g., 1, 5]. Two main theories exist for the water source. One holds that water was released from the subsurface [1]. The other proposes that water is deposited as near-surface ice or snow from the atmosphere and is subsequently melted by insolation [6, 7].

Debris flows found in Arctic climates on Earth could be an equitable analog for the Martian gullies. A comparative analysis might help to understand their formation mechanisms and the latitude-dependent, but clustered distribution as well as their specific orientations.

The comparative analysis in the Arctic environment of Svalbard will be carried out in July/August of 2008. First results of the analog study of gullies will be presented at the conference.

Debris flows on Svalbard

Svalbard is located at 76°-81°N and 10°-35°E (Fig. 1), in the discontinuous zone of permafrost. Because the landscape of Svalbard is under the influence of the polar desert climate, it is a good analog for comparative Martian studies. These were performed in the last two years in the valley of Longyearbyen and on costal slopes of Isfjorden [8]. This study is complementary to the one described by Carlsson et al., 2008, this issue). Here we will focus on the regional distribution of gullies on the Hjorthfjellet and Adventtoppen mountain massif (Fig. 1, inset and Fig. 2), and detailed local studies of individual gullies on the same mountain massif are carried out as described by [8] and [9]. The Hjorthfjellet and Adventtoppen mountain massif consists of four stratigraphic units of sandstone and shales from the Tertiary and Mesozoic [10].

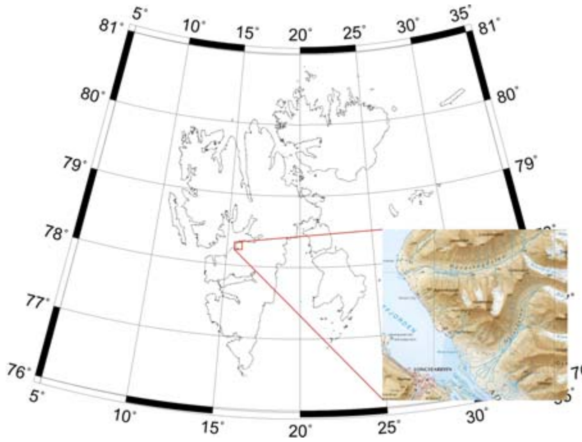

Fig. 1 Location of the Hjorthfjellet-Adventtoppen massif on Svalbard (Topographic map sheet Adventsdalen 1: 100 000).

Several studies concerning talus slopes and debris flows on Svalbard have been performed in the last decades [e.g., 11, 12, 13, 14]. Regional studies of [14] using airborne imagery revealed that there are differences in the frequency and activity of debris flows on Svalbard between east- and west-facing slopes. Åkerman [14] suggested that differences in the solar radiation, the depth of the active layer and the amount of precipitation cause variances in the morphology and morphometry of the debris slopes as well as variances in the frequency and age of debris flows between east- and west-facing slopes. Studies and direct observations imply that debris flows on Svalbard are triggered by high intensity rainfall [e.g., 14, 15].

Fig. 2 Debris flow tracks on the south-west facing slopes of the Hjorthfjellet-Adventtoppen massif on Svalbard (A. Johnsson, 2007).

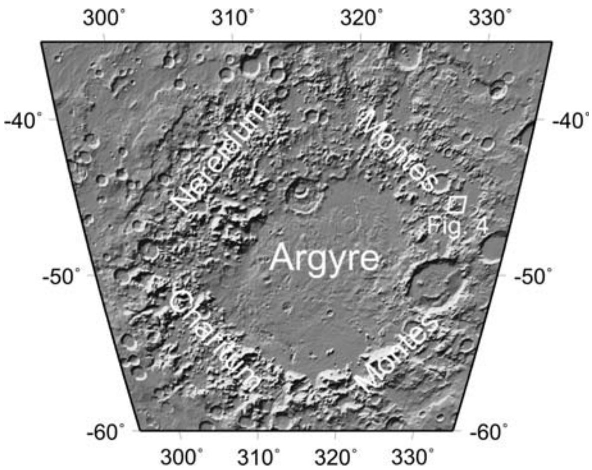

Fig. 3 Study region of the Argyre region. Several isolated mountains occur in the Nereidum and Charitum Montes regions. White footprint shows the location of Fig. 4 (MOLA shaded relief).

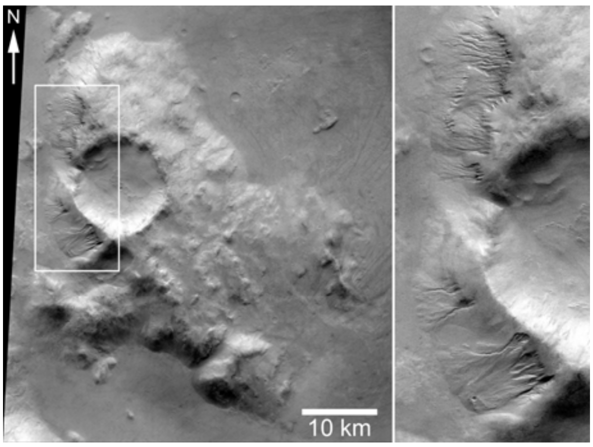

Fig. 4 Gullies on the west-facing slopes on a mountain massif in Argyre, Mars. (HRSC-image h0155_0000 at 45.4°S and 329.4°E, location is indicated in Fig. 3).

Gullies on mountains in Argyre basin, Mars

For a comparative study on Mars we chose the Argyre region. Several isolated mountain massifs occur in the Nereidum and Charitum Montes (Fig. 3) with similar morphologies as the studied massif in Svalbard. A first data analysis with High Resolution Stereo Camera (HRSC) data revealed that gullies occur on the mountain slopes only at specific orientations. Fig. 4 shows an example of an isolated mountain, on which gullies only occur on west-facing slopes.

Project Description

The formation of gullies on Earth depends on several parameters, including rainfall and/or melting of snow, the presence of steep slopes, and sufficient amounts of fines/debris [e.g., 16]. As on Earth, the differences of slope angles and variabilities in bedrock and grain sizes influence the regional occurrence of gullies [17]. The main goals in both study regions on Earth and Mars are to classify different gully morphologies, map their distribution and orientations, gather information about bedrock, grain sizes and slopes and assess how all these parameters might influence the different gully morphologies, orientations, geological settings and their frequency. Airborne imagery from 1999 and a new, planned campaign in 2008 will be used to track the recent activity of debris flows in the last decade. In addition, a planned flight campaign with the High Resolution Stereo Camera (HRSC-AX) at the same time as the field trip might acquire high resolution image (10 cm/pxl) and topographic data (25 cm/pxl), if weather conditions are good.

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