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FIELD STUDIES OF GULLIES AND PINGOS ON SVALBARD – A MARTIAN ANALOG.

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Introduction: The gully systems on Mars [1] have been found to superpose young geological surfaces such as dunes and thermal contraction polygons [2]. This in combination with the general absence of superimposed impact craters suggest that the gullies are relatively recent geological formations [3]. The observed gullies display a wide set of morphologies ranging from features seemingly formed by fluvial erosion to others pointing to dry landslide processes. A recent discovery [4] suggests that this is an ongoing process, which appears to occur even today.

Several formation mechanisms have been proposed for the Martian gullies, such as liquid carbon dioxide reservoirs [5], shallow liquid water aquifer [6], melting ground ice [7], dry landslide [8], snow melt [9] and deep liquid water aquifer [10]. However, none of these models can alone explain all the gullies discovered on Mars. So far Martian gullies have been studied only from orbit via remote sensing data.

Hydrostatic pingos are perennial ice-cored mounds that may reach an elongated or circular radius of approximately 150 m. They are found in periglacial environments where they are formed by freezing processes in the continuous permafrost. The pingos go through different evolutionary stages as they mature, where the final stage leaves an annular rim left by the collapse of the summit.

Images from the High Resolution Imaging Science Experiment (HiRISE) show small fractured mounds in the Martian mid-latitudes [11]. Even though some differences are observed, the best terrestrial analogues for the observed mound morphology are pingos [11].

Gullies and pingos found in Arctic climates on Earth could be an analog for the Martian ones. A comparative analysis might help to understand the formation mechanisms of the Martian pingos and gullies and their possible eroding agent.

Svalbard as a Martian Analog: Svalbard is situated at 74°-81°N and 10°-35°E, in the discontinuous zone of permafrost, and is a fairly good analog for comparative Martian studies. On a scouting mission performed in July 2006, gullies similar to those previously studied on Mars [12], were identified by our team in the valley of Longyearbyen and on coastal slopes of Isfjorden. Longyearbyen has a typical periglacial environment and the braided river system in the valley drains from the two glaciers, Larsbreen and Longyearbreen. The valley bedrock consists mainly of sandstone, shales and schists from the Cretaceous and Tertiary [13]. The valley slopes are covered with talus and gullies, which are underlain by a permafrost layer. The depth to permafrost is approximately 1 m.

Gullies on Svalbard exhibit the same kind of characteristic features as Martian gullies (figure 1), such as alcoves, channels and debris aprons. The theatre-shaped alcove tapers down-slope, where the V-shaped channel commences. The gullies on Svalbard have consolidated strata layers in the alcove regions, which have been detected also for some of the Martian alcoves. Moreover, the channels of the gullies on Svalbard tend to streamline around obstacles in a similar manner as of the Martian gullies.

Project Description: The purpose of this project is to improve the understanding of the formation mechanisms of Martian gullies and to investigate whether water could be the eroding agent. The study consists of three phases. In the first phase, annual variations of the Svalbard gullies will be studied by deploying temperature, RH and moisture loggers in strategic places in and around the gullies. This equipment was deployed in the summer of 2007 and will collect data for a year. In the summer of 2008 the data will be collected. As a second phase, remote sensing data over these gully locales at Svalbard will also be analyzed. This will be done with the help of imaging and thermal emission data with a similar methodology as used previously for Martian gullies [2][12]. The third phase will be carried out *in situ* on Svalbard in July 2008, where additional morphometric measurements will be performed, including a more thorough investigation of soil/ground characteristics in order to link these to local climate conditions.

From these observations we expect to derive correlations between gully morphology and environmental parameters, which can be used to help determine whether the gullies on Mars were caused by processes related to similar circumstances in the ice-rich permafrost on Svalbard.

Close to the gully sites on Svalbard there are pingo formations and tundra polygons and during the summer of 2008 we intend to investigate these further and compare them with Martian analogs. This will give us a chance to study a range of landforms with permafrost affinity and put them into a context of periglacial development on Mars.

A survey of the microflora ranging over the length and width of the Svalbard gullies will also be conducted using a battery of exo-enzyme assays commonly used to identify extremophile organisms. These surveys will be used to design experiments to predict the distribution of aquifer-bound micro-organisms immediately following a gully forming outburst of water from such a aquifer. Adjacent terrain along the gullies will be used as a control.

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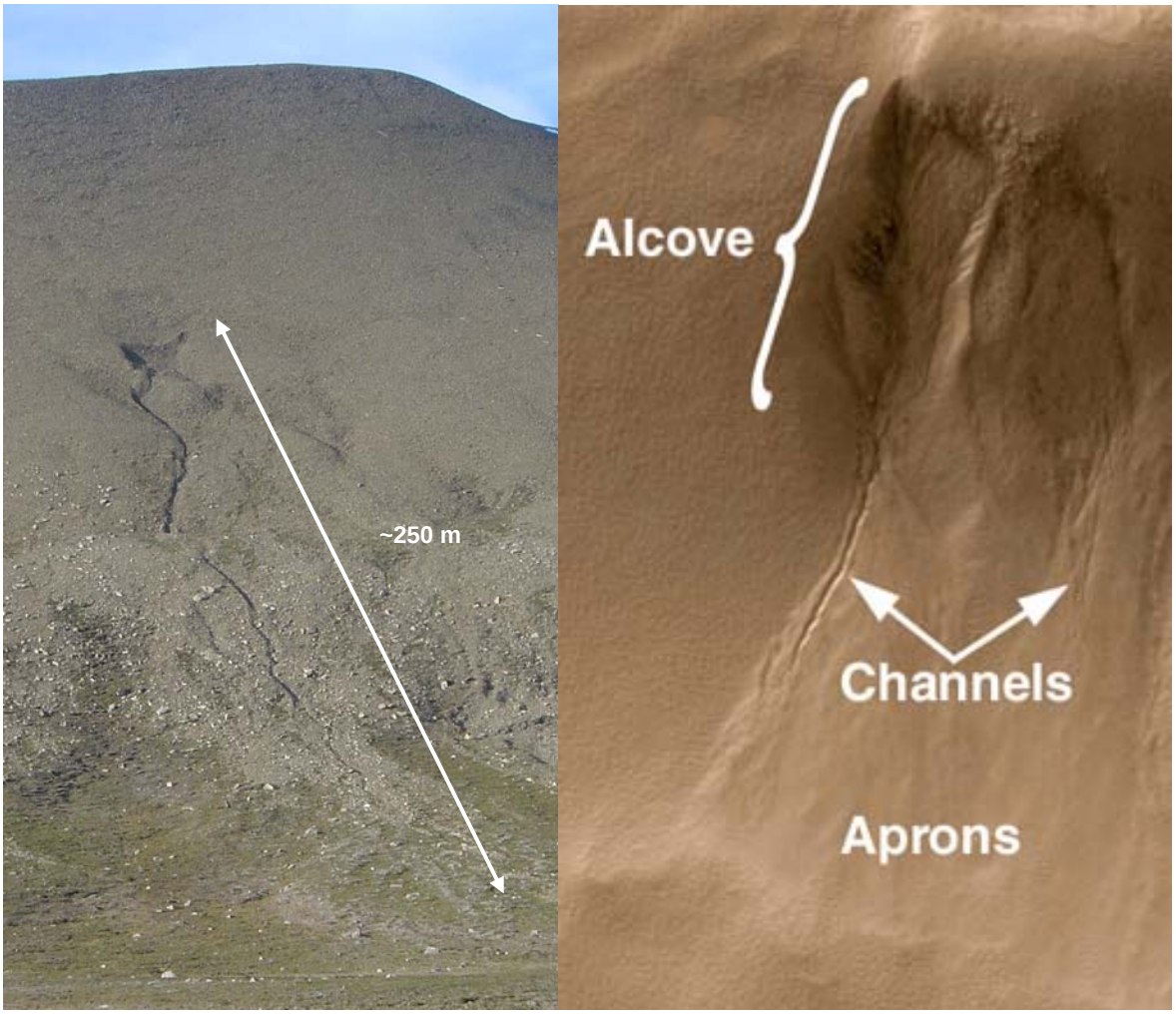

Figure 1: The left side of the figure shows a terrestrial gully on Svalbard (Adventfjorden) and the right side shows a Martian gully, where the image covers an area 1.3 km wide by 2 km long. Left figure credit: Carlsson, E., 2006. Right figure credit: NASA/MSSS.