A COMPARITIVE ANALYSIS OF SEMI-ARID AND PERIGLACIAL GULLIES – IMPLICATIONS FOR MARS. S. W. Hobbs[1], D. Paull[1] and J. D. A. Clark[2], [1 A]School of Physical, Environmental and Mathematical Sciences, University of New South Wales, Australian Defence Force Academy, Northcott Drive, Canberra, Australian Capital Territory 2600, Australia. [2]MarsSociety Australia. P.O. Box 327, Clifton Hill, VIC 3068, Australia.

Introduction: The discovery of youthful erosive features on Mars with similar morphology to hillside gullies on Earth have profound implications on the presence of liquid water on Mars [1]. Comparison of Martian gullies with terrestrial analogues is considered a productive method for gaining understanding on how surface processes operate on both Mars and Earth and has vindicated the usefulness of remote sensing in studying geomorphology [2]. Here we compare periglacial gullies located at Pasture Hill, New Zealand (Fig. 1A) and gullies within a semi-arid region of Island Lagoon near Woomera, Australia (Fig. 1B), with Martian gullies in Noachis Terra studied in [3]. We use a combination of exploitation of HiRISE and terrestrial DEMS and fieldwork for our analysis.

Gully Analysis: Initial findings of key parameters are given in Table 1 and typical gully slope profiles are shown in Fig. 2. We studied seven gullies and their fans on the 20-30 m high northern escarpment of Island Lagoon, a region receiving less than 200 mm of rainfall a year [4]. The gully alcoves are topographically controlled by one or two caprock layers, are fed from overland drainage streams and are eroded within a surficial rocky matrix with multiple exposures of bedrock visible throughout the alcove and channels. The gullies themselves consisted of V shaped channels, often with depositional fans shared between two or more gullies. Depositional regions for these gullies typically exceed 50% of the total gully length, leading to flatter profiles (Fig. 2).

The periglacial Pasture Hill gully channels are an order of magnitude larger than the Island Lagoon gullies (Table 1) and the site receives much greater rainfall (818 mm) per year [5]. The Pasture Hill site also experiences snowfall during winter periods. These gullies also presented the greatest variation in morphology of the two terrestrial sites. The alcoves of several of the gullies consisted of bedrock chutes, where numerous dry debris flows were observed. Bedrock exposures were also present within these gully channels, and liquid water was observed actively eroding channels of three of the gullies (Fig. 1A). In contrast no bedrock exposures were observed in adjacent gullies and wasted debris and meter-sized boulders were present on their channel floors.

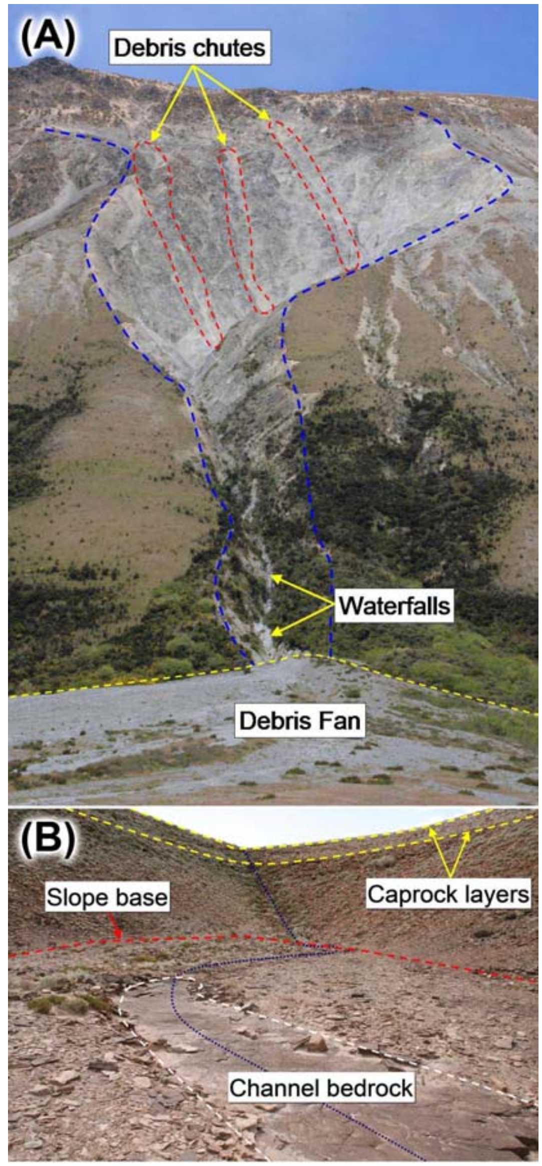

Figure 1. (A) Studied gully in Pasture Hill, New Zealand. (B) Gully at Island Lagoon, Woomera, Australia. Prominent features are labeled on both figures.

Evidence of multiple erosion events, such as rockfalls, debris flows and smaller channels embedded within the main channels was present at both sites, though these were found to a greater degree at the Pasture Hill location. Additionally, frost related processes and dry mass wasting were also observed at the Pasture Hill site.

Parameter	Pasture Hill	Island Lagoon	Mars
Channel length	245 - 800 m	74 - 265 m	314 - 868 m
Gully Slope	3 - 40°	3 - 37°	12 - 34°
Hill Slope	3 - 42°	2 - 34°	17 - 35°
Sinuosity	1.01 - 1.07	1.04 - 1.1	1 - 1.07
Concavity	10 - 15%	3 - 8%	2 - 8%

Table 1. Key data obtained from the studied gully sites.

Mars Gullies: As detailed in [3] the studied Martian gullies are located within a young, 18 km crater within Noachis Terra. Gullies on the crater's northern rim are most similar to gullies at the terrestrial sites and exhibit U and V shaped channels terminating in depositional fans. Analysis of HiRISE imagery and thermal inertia data revealed no evidence of bedrock exposure within these gully channels.

We also observed evidence of subsequent erosion within the Martian gullies including smaller channels incised into many of the original gully channels, superposed depositional fans and cross-channel erosion.

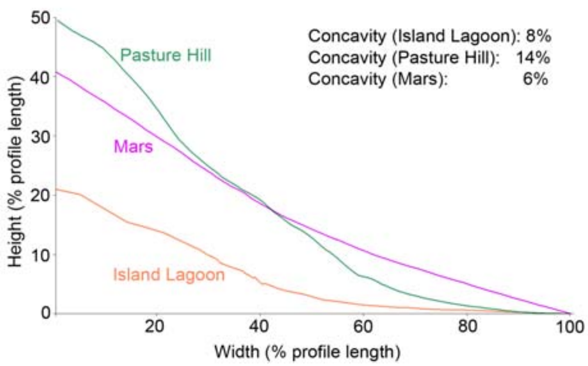

Figure 2. Profile and concavity analysis of studied gullies at Pasture Hill, Island Lagoon and Noachis Terra.

Discussion: Of the two terrestrial sites the Pasture Hill gullies were the most similar to the studied Martian gullies, though slope angles and concavity for these gullies were higher (Table 1, Fig. 2). The varying maturity of the Pasture Hill gullies where not all channels have eroded to bedrock suggests ongoing processes and an evolving landscape. Alternately, the more homogenous nature of the Island Lagoon site suggests more stable geomorphology with fewer active processes occurring. The sparseness of water at the Island Lagoon site could also influence the degree to which these gullies have been eroded.

Both terrestrial gully sites show clear evidence of being influenced by local geology and climatic conditions. Concentration of overland flow and the presence of erosion resistant caprock play a key role in the location and shape of the Island Lagoon gullies. The presence of steeper slopes and greater abundance of volatiles such as water, frost and snowmelt at Pasture Hill has helped carve channels equivalent in size to the Martian gullies.

We also found that comparable slope values of both terrestrial sites instead suggest gully slopes are more influenced by host topography than liquid water content (gully and hill slope values, Table 1). This contrasts with the view that high slope values of Martian gullies are evidence of a sediment-rich erosion mechanism with a reduced water component [6].

Comparison of morphology of the Martian gullies with the terrestrial sites (Table 1) suggests the gullies have been carved by surficial flow of liquid water, possibly derived from degradation of Latitude Dependant Mantle material or atmospherically deposited snowmelt. Although the Martian gully channels are larger than those at the Pasture Hill site they had not eroded to underlying bedrock. This suggests that these gullies are not mature and that erosion may be ongoing. The observation of additional erosive features at the Martian site also suggests additional processes such as dry flow or surface creep may be acting on this site in a similar manner to the Pasture Hill gullies.

Conclusion: Comparative analysis of terrestrial analogues has provided insight into the processes acting on Martian gullies. The morphology and evolution of the studied gullies were greatly influenced by their local environments and climate. The Pasture Hill and Island Lagoon sites have been greatly influenced by local lithology, slope, and abundance of erosive volotiles. Martian gully evolution has been similarly influenced by local processes such as slope, deposition of volatiles and availability of erodable material. Thus, detailed analysis of the local environment is essential in analyzing geomorphological processes. Traditional indicators of water related activity such as slope and sinuosity need to be placed into context of the environment of the study site. In addition, other, non liquid erosive agents such as frost creep and dry mass wasting are probably common features in shaping the ongoing evolution of Martian gullies.

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