WHAT LAKE GEORGE CAN TELL US ABOUT MARTIAN GULLIES. 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.

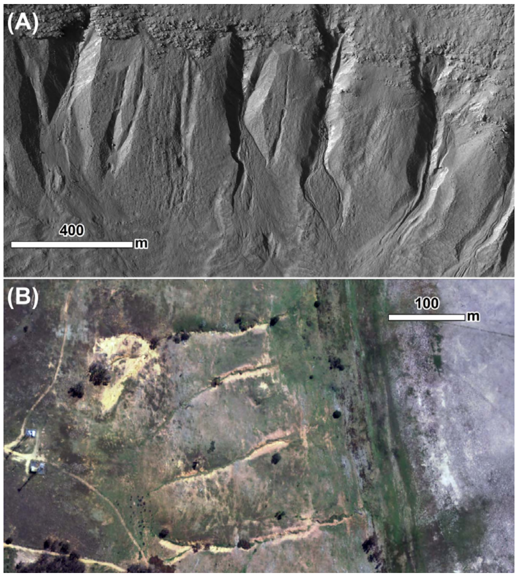

Figure 1. (A) Studied gullies in Noachis Terra. (B) Gullies located on Lake George escarpment.

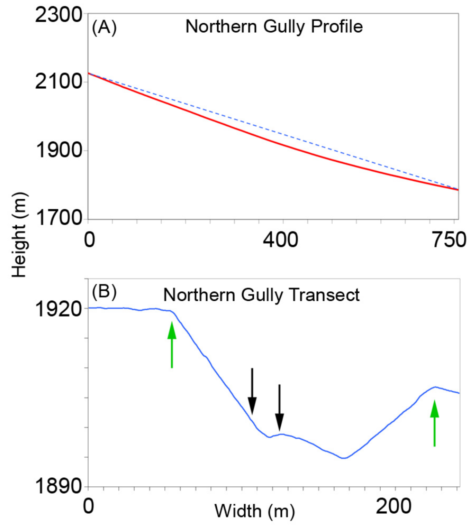

Figure 2. (A) Profile and (B) transect analysis of a northern rim gully. Green arrows on transect denote primary channel erosion, black arrows denote secondary erosion.

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]. Theories ranging from water erosion [2], dry flow [3], and frosted granular flow [4] have been used to explain the origin of Martian gullies. Here we used a high resolution DEM created from HiRISE imagery to analyse gullies within a small crater in Noachis Terra (Fig 1A). We then compared this with a differential GPS field survey of similar gullies within the Lake George escarpment, New South Wales (Fig 1B).

Mars Gullies: The young Martian crater superposes a larger crater and possesses a fresh ejecta blanket and sharply defined rim. The crater presented two distinct erosive morphologies between the north and south rim.

Northern Gullies. The northern gullies consisted of curved slope profiles (Fig 2A) ranging from 34^0-12^0 from gully head to depositional apron well defined V and U shaped channels incised into the northern wall (Fig 2B). Many of the gullies did not possess an alcove though all of the major gully channels commenced immediately beneath layered material approximately 200m below the crater rim. Evidence of

subsequent erosion was also present within the northern gullies. We observed smaller channels incised into many of the original gully channels, as well as superposed depositional fans and cross channel erosion. Unlike the primary channels, the subsequent (and younger) channels occurred at random elevations within the crater wall.

Southern Flows. The southern flows possessed straight profiles flow head to the depositional areas (Fig 3A) and wide, U shaped ridge/spur alcoves (Fig 3B) with long, straight depositional fans. Slope angles for these flows were typically higher (37^0). As with the northern gullies evidence of subsequent erosion and modification was visible within the southern flows. These included elongated craters and light toned debris aprons superposing darker deposits.

Lake George: The 930 km^2 fault-dammed Lake George basin is located in highlands 40 km north-east of Canberra, Australia [5]. We studied four gullies and their fans on former grazing land along the western fault escarpment. The gullies are eroded through loosely consolidated slope deposits. Field survey using differential GPS of the site revealed evidence of shoreline abrasion of the fans and

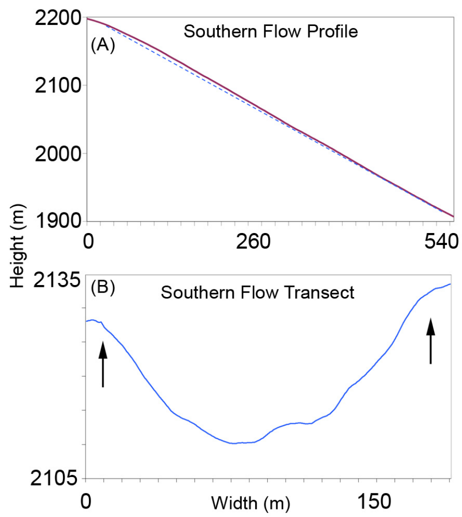

Figure 3. (A) Profile and (B) transect analysis of a southern rim flow. Black arrows on transect denote channel width.

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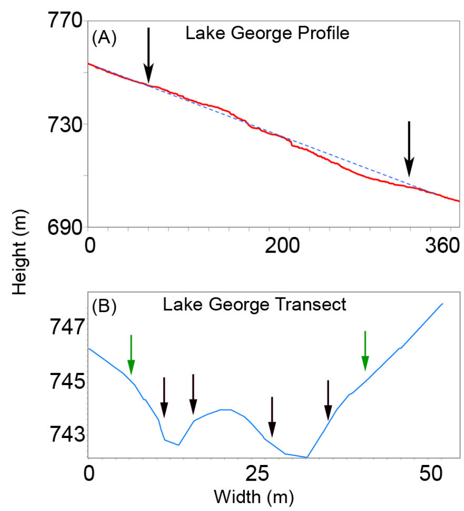

Figure 4. (A) Profile and (B) transect analysis of a Lake George gully. Black arrows on profile denote start and end of channel. Green arrows on transect denote primary channel erosion, black arrows denote secondary erosion.

modification by the gully slope by historical fluctuations in the lake water level. Exposures of bedrock were also visible at the base of the gully channels. The gully profiles were quite linear (Fig 4A), with slope angles ranging from 2-24^0. The gullies themselves consisted of V shaped channels and depositional fans, often incised by smaller channels (Fig 4B).

Discussion: The morphology and presence of subsequent erosional features of the northern Martian gullies suggest a multiple stage process involving liquid water. Aquifer fed melt-water, possibly sourced from impact heat and subsequent erosion derived from degradation of ice–rich, loosely deposited material were the probable drivers of gully formation in the pole facing portion of the Martian crater. The higher slope values of the Martian gullies compared to the Lake George analogues suggest a sediment rich erosion mechanism with a reduced water component [6].

Mass movement was also identified on the crater's southern rim, driven by predominantly dry mass wasting and to a lesser extent possible frost creep and granular flows. A transition from wet dry based erosion mechanisms was also observed between the northern and southern crater rim. An increase in aspect towards the Martian equator revealed an increasing dominance of dry/frost creep processes, indicating that aspect drives the availability of water ice available to create gullies.

Water based erosion in the case of the Lake George gullies has been enhanced by environmental degradation by land clearing and subsequent animal grazing. These processes have exposed loosely consolidated material that has allowed gullies to form through the action of rainfall and piping. The fluvial erosion in Lake George has been of sufficient strength to erode the toes of studied gullies to the escarpment's underlying metasedimentary bedrock.

Conclusion: The morphology and evolution of the studied gullies were greatly influenced by their local environments and climate. The Lake George gullies have been influenced by farming practices, lithology and the influence of varying lake water levels by modifying the host slope, as well as gully deposits. Martian gully evolution has been influenced by impact related processes (slope, bedrock fracturing and possible heating), aspect and obliquity changes. The understanding and appreciation of the local environment is thus essential in analyzing geomorphological processes and traditional indicators of water related activity such as slope and sinuosity need to be placed into context of the environment of the study site. This analysis can be fruitfully applied to other regions of Mars and Earth and provide a greater understanding of how geomorphological processes operate on both worlds.

References: [1] Malin M. C. and Edgett K. S. (2000) *Science 288,* 2330–2335. [2] Heldmann J. L. et al. (2007) *Icarus* 188, 324-344. [3] Pelletier J. (2008) *Geology* 36, 211–214. [4] Hugenholtz C. H. (2008) *Icarus* 197, 65-72. [5] Coventry, R. J. (1976) PhD. Thesis, ANU. [6] Parsons R. A. and Nimmo F. (2010) *JGR, 115,* doi:10.1029/2009JE003517.