Climate Change, GIS and Mars. What Earth can Tell us About Martian Gullies

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Gullies residing within a small crater located in the Martian highlands.
(www.stevenhobbsphoto.com.au)
Introduction

- Gullies were discovered on Mars in 2000

- Gullies are thought to be geologically young features eroded by liquid water – liquid water on Mars?

- Recent and current mission high resolution imagery and elevation data make possible detailed analysis of Martian Gullies

- Results of analysis are compared with survey data from gullies at arid, temperate and sub-humid sites

- Results of observations contributes to our understanding of fluvial erosion, mass movement and Martian climate change.
Gullies

- Slope angles: 12° – 35° from gully head to depositional apron
- Slope angles typical of Martian gullies
- U and V shaped gully channels – no bedrock exposures observed
- Profiles show curved transition from gully head to deposition – melt water?
- More than one gully process
- Secondary channels incised into original channels (B), (C), (E), (F)
- Superposition of depositional fans (D)
- Cross drainage erosion (G)

Gullies on the crater’s northern rim (Hobbs et al., 2013a., orthorectified HiRISE stereo pair ESP_011817_1395 and ESP_011672_1395)
Ravines

- Wide, U-shaped channels
- Elongated craters – frost creep? (B), (C)
- Subsequent mass flows (D), (E)
- Fine scale V shaped chutes visible (D), (E), (F)
- Probable dry debris movement
- Wide channels with slope values up to 40°
- Straight profiles from head to depositional region (profile graph)
- Evidence of bedrock altered morphology (grey arrow, transect graph)

Ravines on the crater’s southern rim (Hobbs et al., 2013a., orthorectified HiRISE stereo pair ESP_011817_1395 and ESP_011672_1395)
Kaiser Crater Gullies

- Located inside Kaiser Crater
- Overall lower slopes, longer fan run outs (A)
- Alcoves in-filled with sediment (B)
- V-shaped chutes on >35° slopes (B), (C)
- V-shaped, leveed lower channels (transects)
- Evidence of multiple erosion (grey arrows, B)

Gullies in Kaiser Crater (Hobbs et al., 2013b)
Regional Analysis - Gullies

- Lower resolution datasets
- All gullies located within fresh, sharp rimmed craters
- Nil gullies found in Noachian craters with comparable slopes – lack of LDM?
- Consistently co-located with ice flow features (pink arrows)
- Very diverse morphology (eg white arrows)
- Gully morphology changes significantly with erodable material abundance and type (eg green arrows)

Ice features (pink arrows) pasted on terrain (green arrows) and gullies (white arrows) (Hobbs et al., in prep)
Regional Analysis - Ravines

- Some equator facing ravines very diverse (left image)
- Spur and gully alcoves above, sinuous in filled channels below (A, B)
- Abrupt changes in morphology with surface type (A, B, E, F)
- Slopes consistently inherited from host escarpment
- Gully morphology changes significantly with orientation (right image, collocated gullies and ravines)

Equator facing ravines showing abrupt morphology changes (Hobbs et al., in prep)

Gullies and dry ravines co-located within the same arroyo (Hobbs et al., in prep)
Lake George

- Gullies present on Lake George escarpment, NSW
- Similar in morphology to Mars crater gullies
- Multiple bedrock exposures, affecting channel profile

Gullies on Lake George Escarpment (Hobbs et al., 2013a, Copyright Google Earth)
Woomera Gullies

- Arid, geologically old region
- Comparison with hyper-arid Martian environment
- Alcoves reside within cap rock (A, B)
- Fed by overland runoff (B)
- Channels topographically constrained
- Multiple erosion events
- Multiple bedrock intrusions
- Debris flows and dry wasting also present
Pasture Hill Gullies

- Relict glacial environment
- High rainfall/snowfall
- Comparison with Noachian “wet” Martian epoch
- Infilling of channel (B) similar to Kaiser gullies
- Multiple processes:
  - Frost shattering
  - Snowmelt
  - Surface runoff
  - Dry talus flows - Martian ravines? (A;C)
  - Debris flows (D)

Pasture Hill gullies (Hobbs et al., 2013b)
Current Inferences

- Our Martian gullies consistently located in or near ice related features.
- Gully morphology dependant on presence and thickness of erodable slope material
- Evidence of multiple processes, water/ice based and dry wasting acting on gullies
- Complex process of erosion, deposition throughout gullies
- Gully slopes inherited from host environment – implications for dry/water based slope angle inferences (eg angle of repose, static/kinetic friction)?
- Gully shape dependant on local geology (eg bedrock exposure)
- Local climate and orientation also significant factors
- Gully models and inferences MUST be placed into context of the environment of the study site.