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

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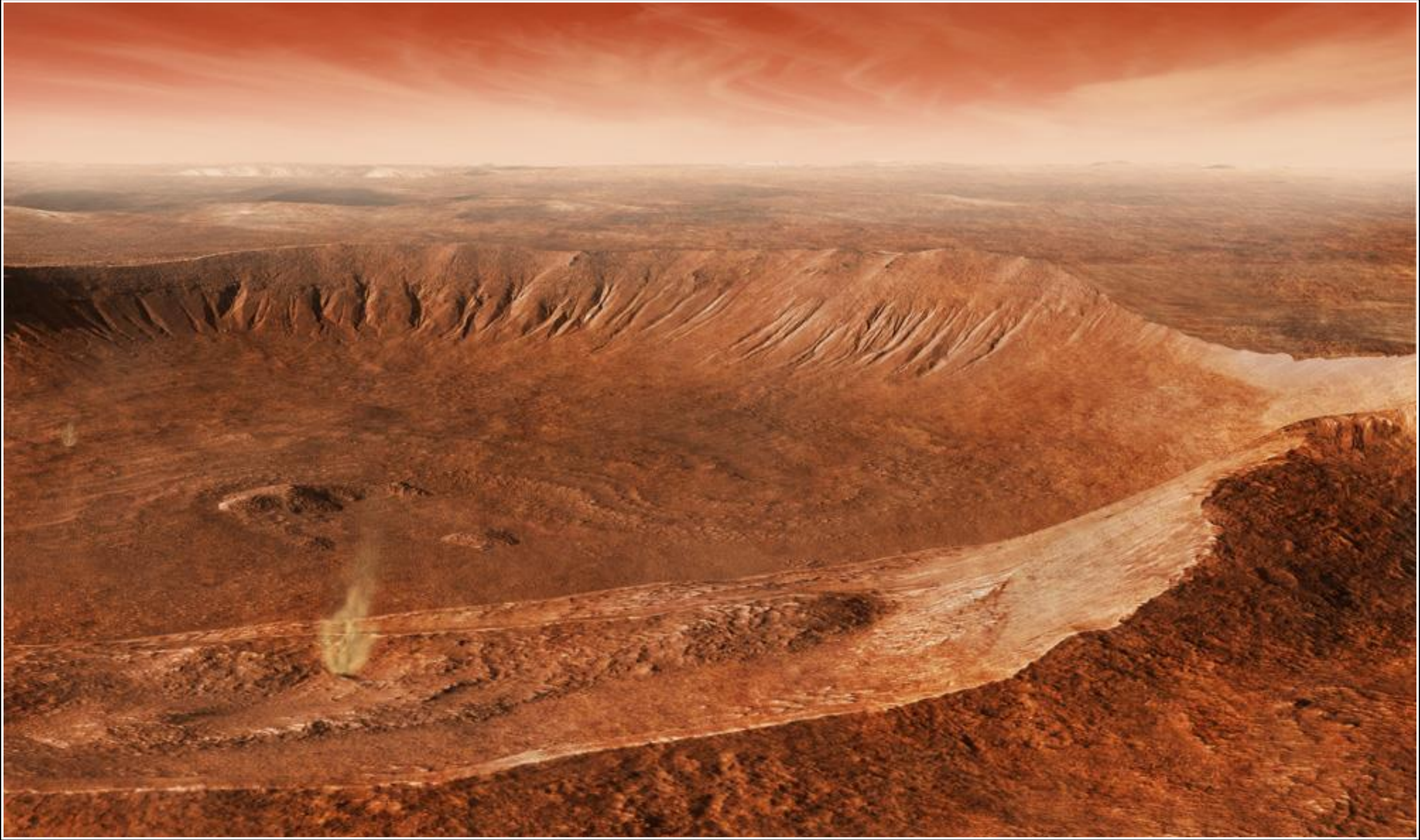


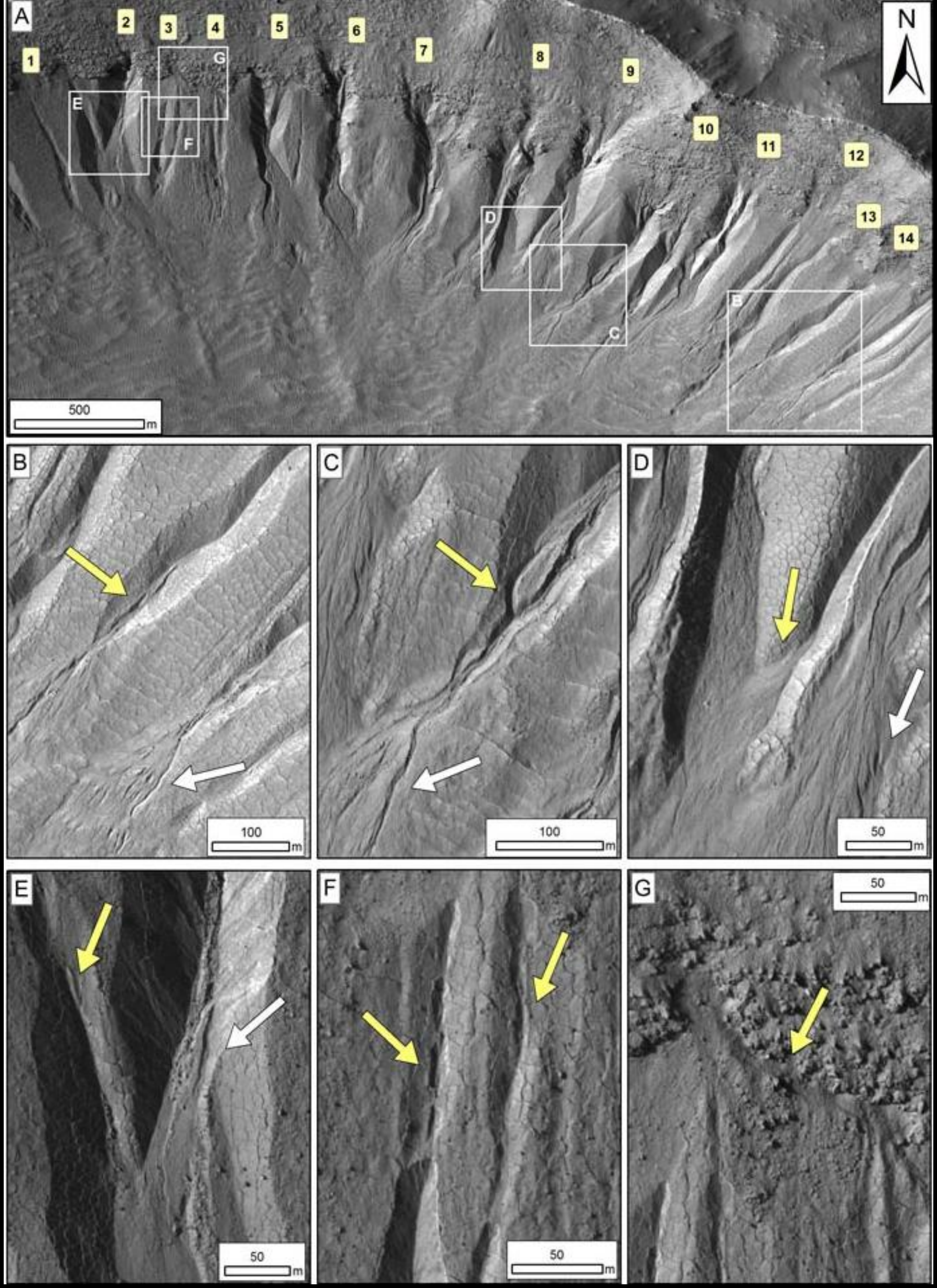
Gullies residing within a small crater located in the Martian highlands.
(www.stevenhobbsphoto.com.au)

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

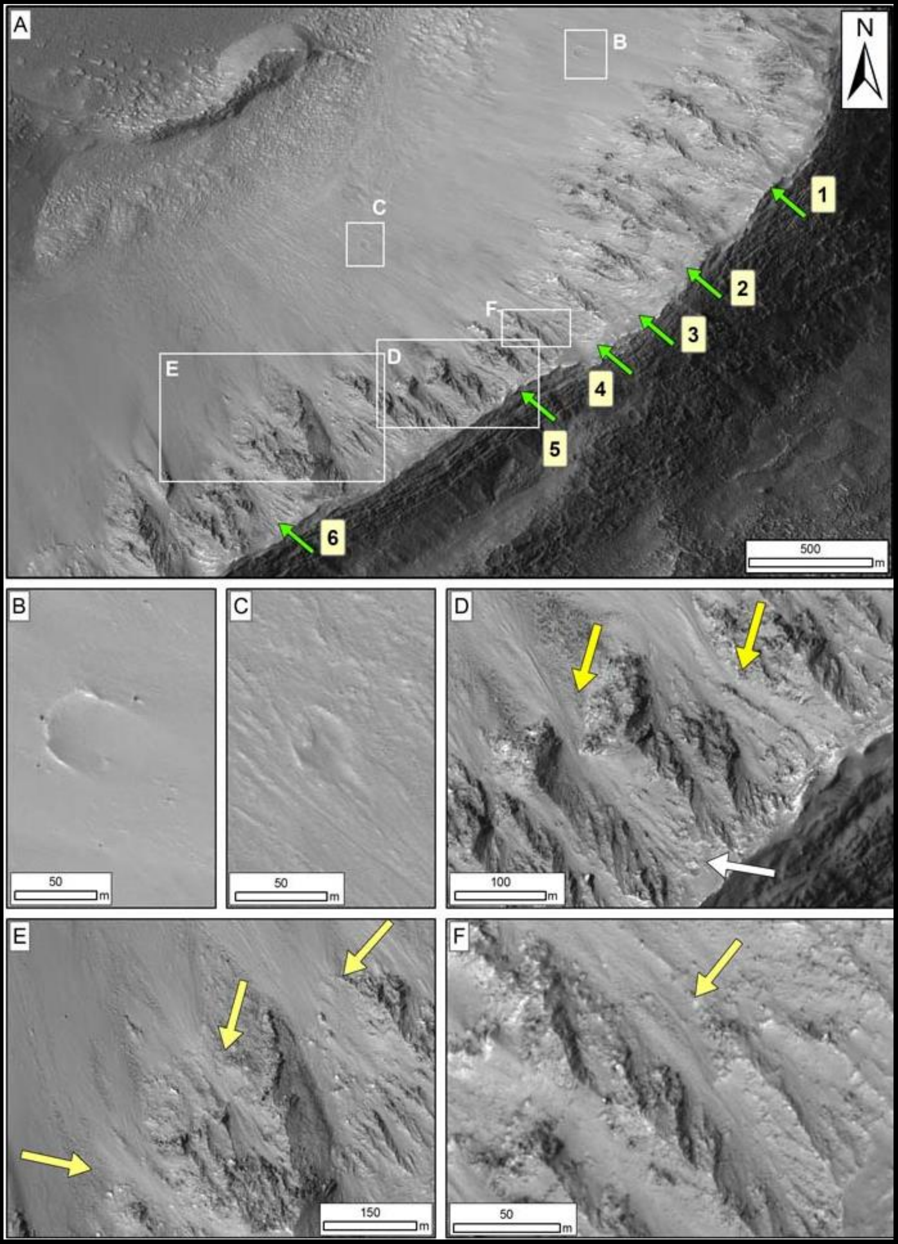
- Slope angles: 12º – 35+º from gully head to depositional apron
- Slope angles typical of Martian gullies
- U and V shaped gully channels – no bedrock exposures observed
- Profiles show curved transition from gully head to deposition – melt water?
- More than one gully process
- Secondary channels incised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

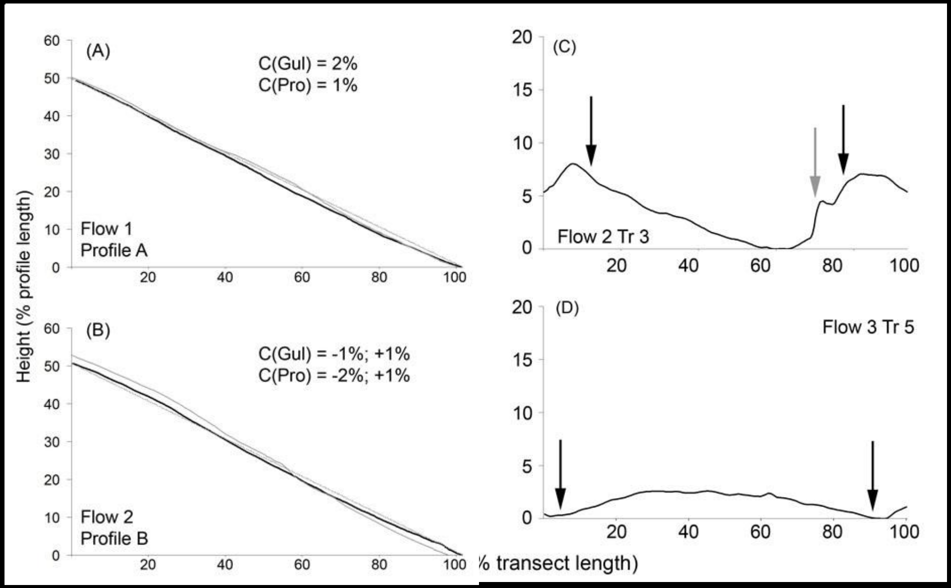


Gullies on the crater's northern rim (Hobbs et al., *2013a*., orthorectified HiRISE stereo pair ESP_011817_1395 and ESP_011672_1395)

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 40º
- Straight profiles from head to depositional region (profile graph)
- Evidence of bedrock altered morphology (grey arrow, transect graph)

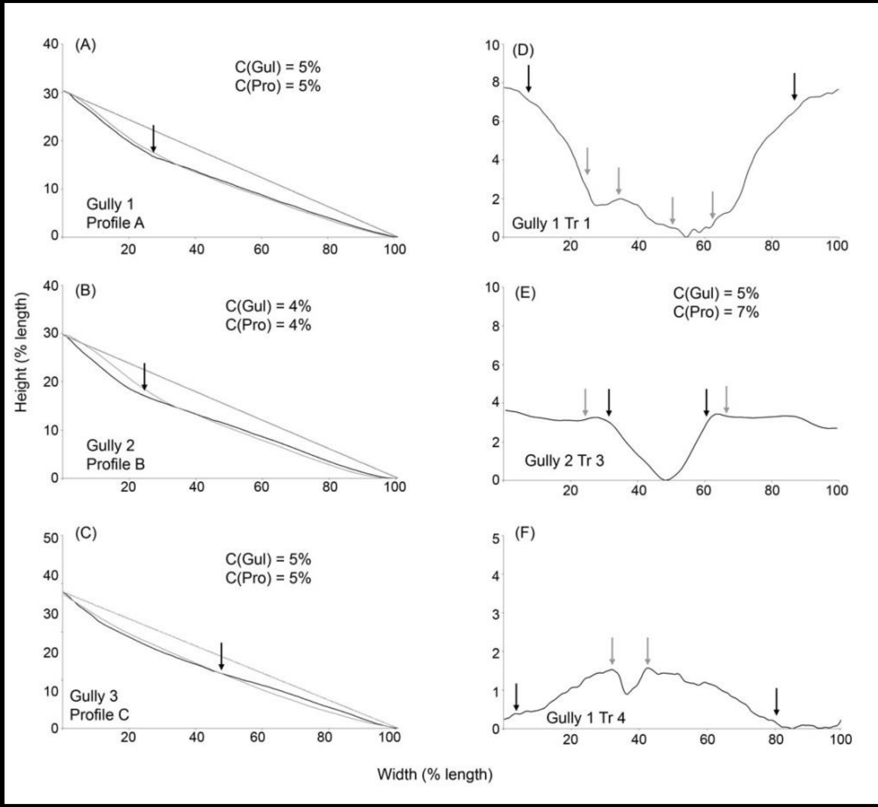


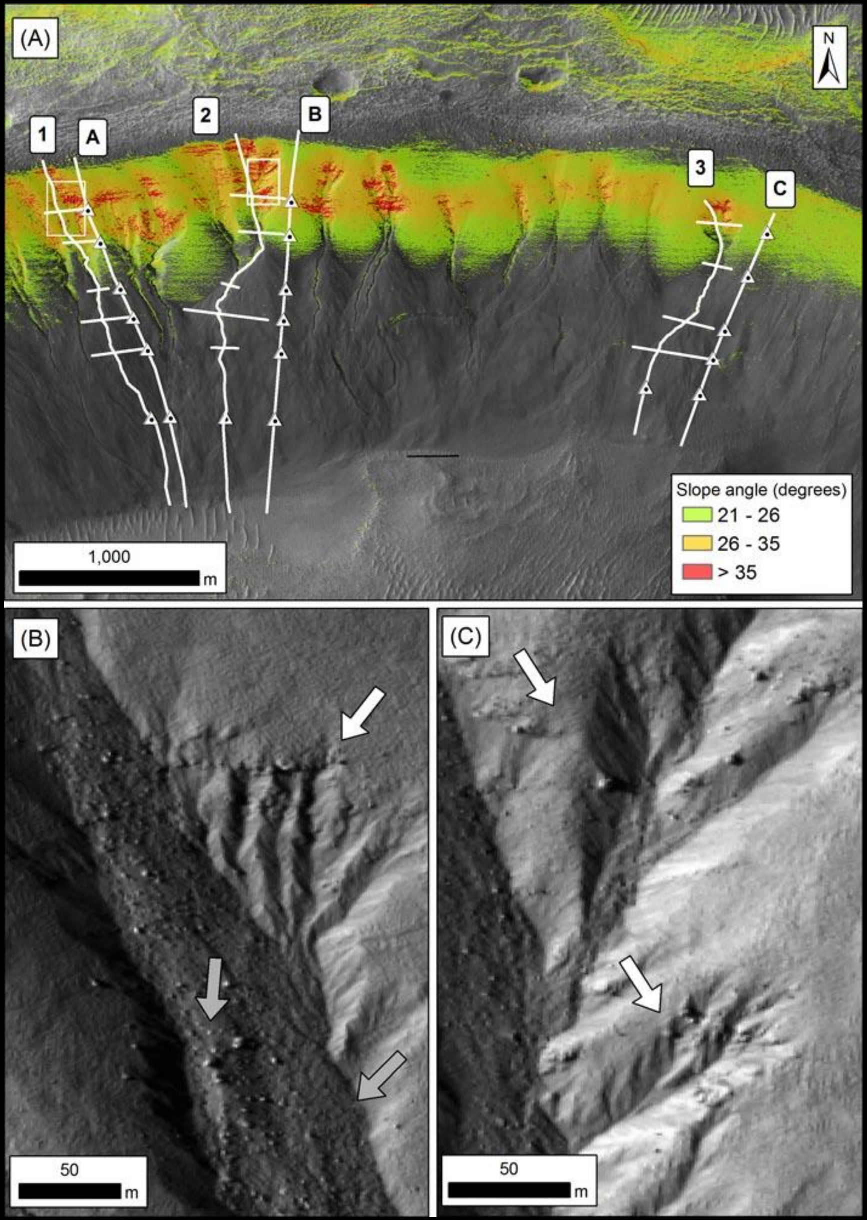


Ravines on the crater's southern rim (Hobbs et al., *2013a.*, orthorectified HiRISE stereo pair ESP_011817_1395 and ESP_011672_1395)

Kaiser Crater Gullies

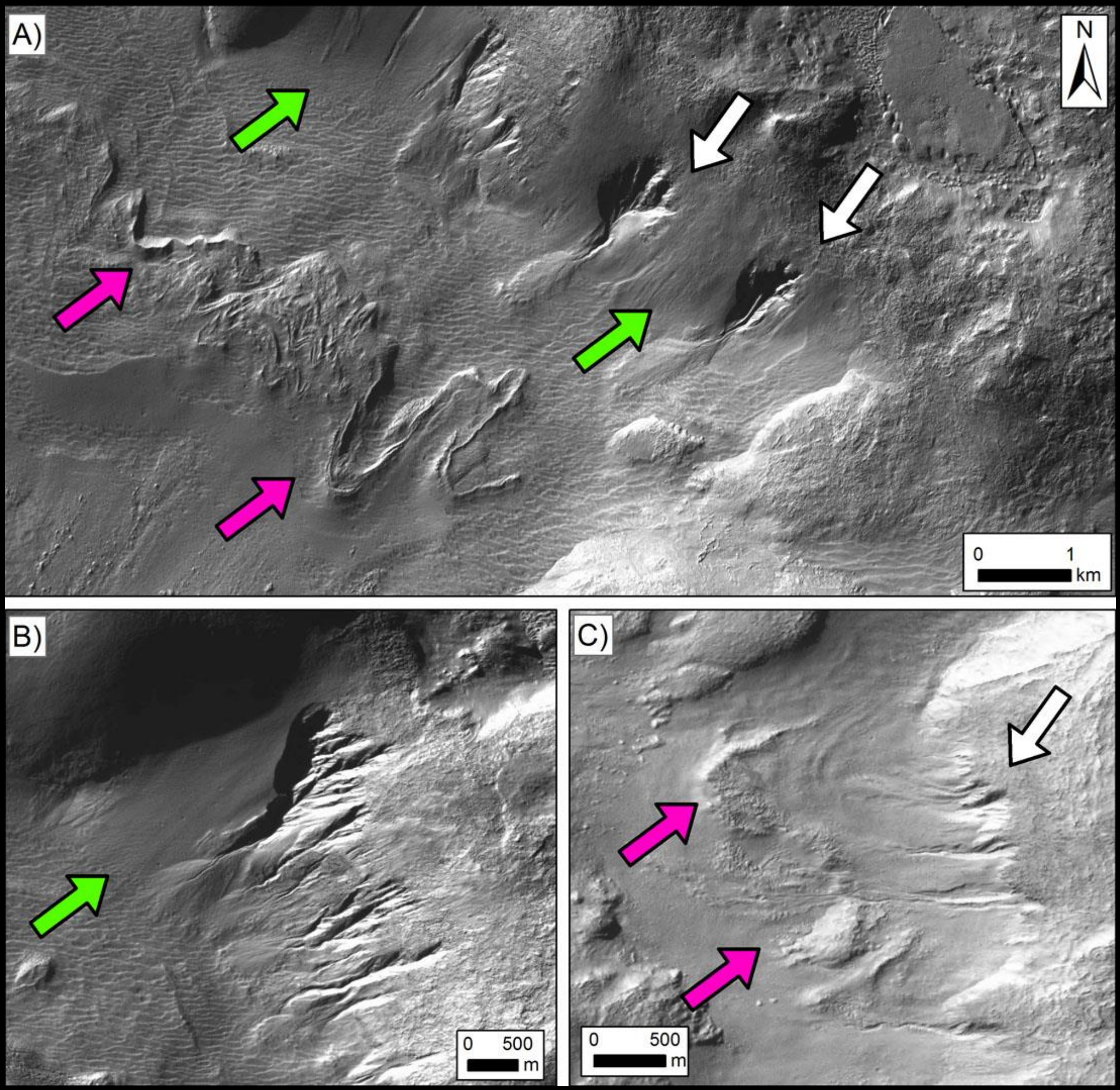
- Located inside Kaiser Crater
- Overall lower slopes, longer fan run outs (A)
- Alcoves in-filled with sediment (B)
- V-shaped chutes on >35º slopes (B), (C)
- V-shaped, leveed lower channels (transects)
- Evidence of multiple erosion (grey arrows, B)





Gullies in Kaiser Crater (Hobbs et al., *2013b*)

Regional Analysis - Gullies

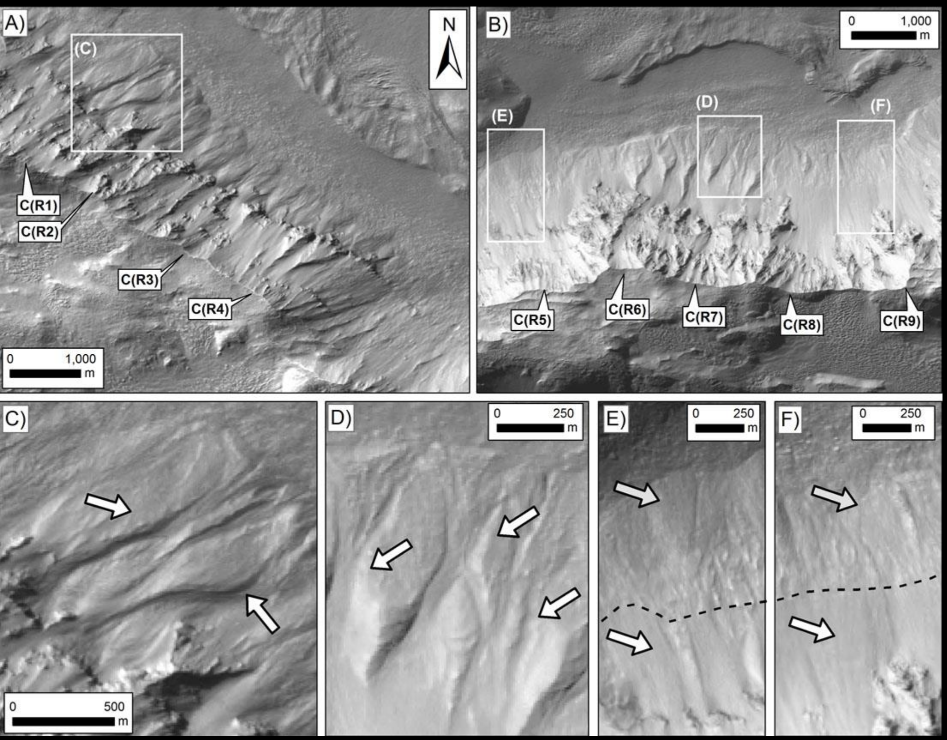


- Lower resolution datasets
- All gullies located within fresh, sharp rimmed craters
- Nil gullies found in Noachian craters with comparable slopes – lack of LDM?
- Consistently co-located with ice flow features (pink arrows)
- Very diverse morphology (eg white arrows)
- Gully morphology changes significantly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

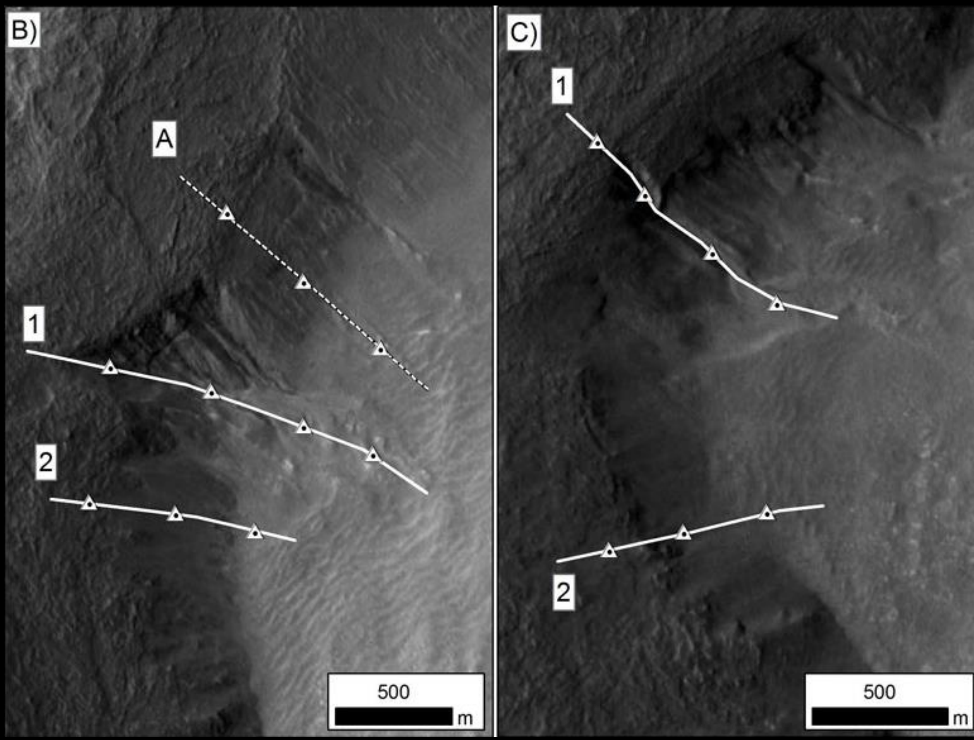
Ice features (pink arrows) pasted on terrain (green arrows) and gullies (white arrows) (Hobbs et al., *in prep*)

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)



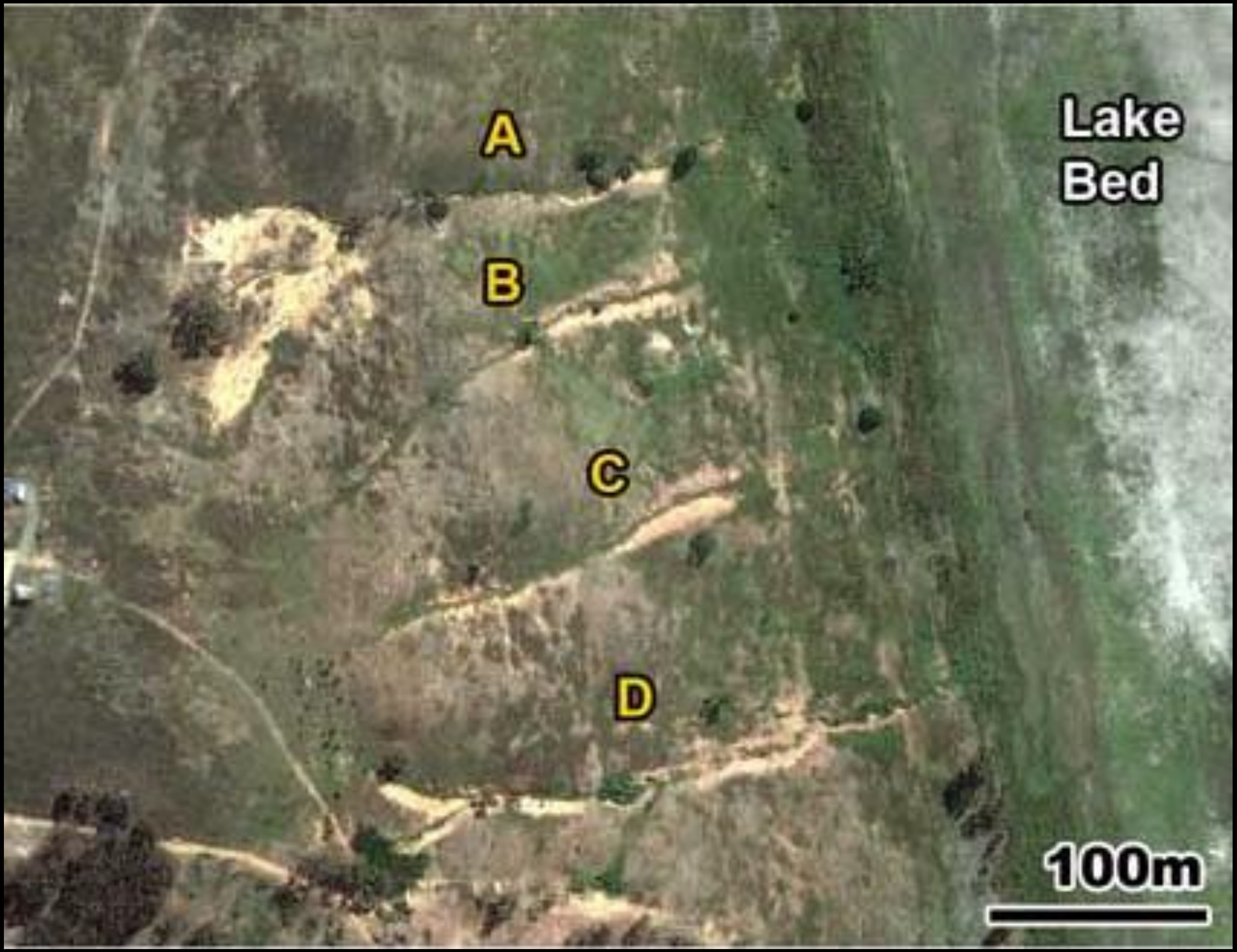
Equator facing ravines showing abrupt morphology changes (Hobbs et al., *in prep*)



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

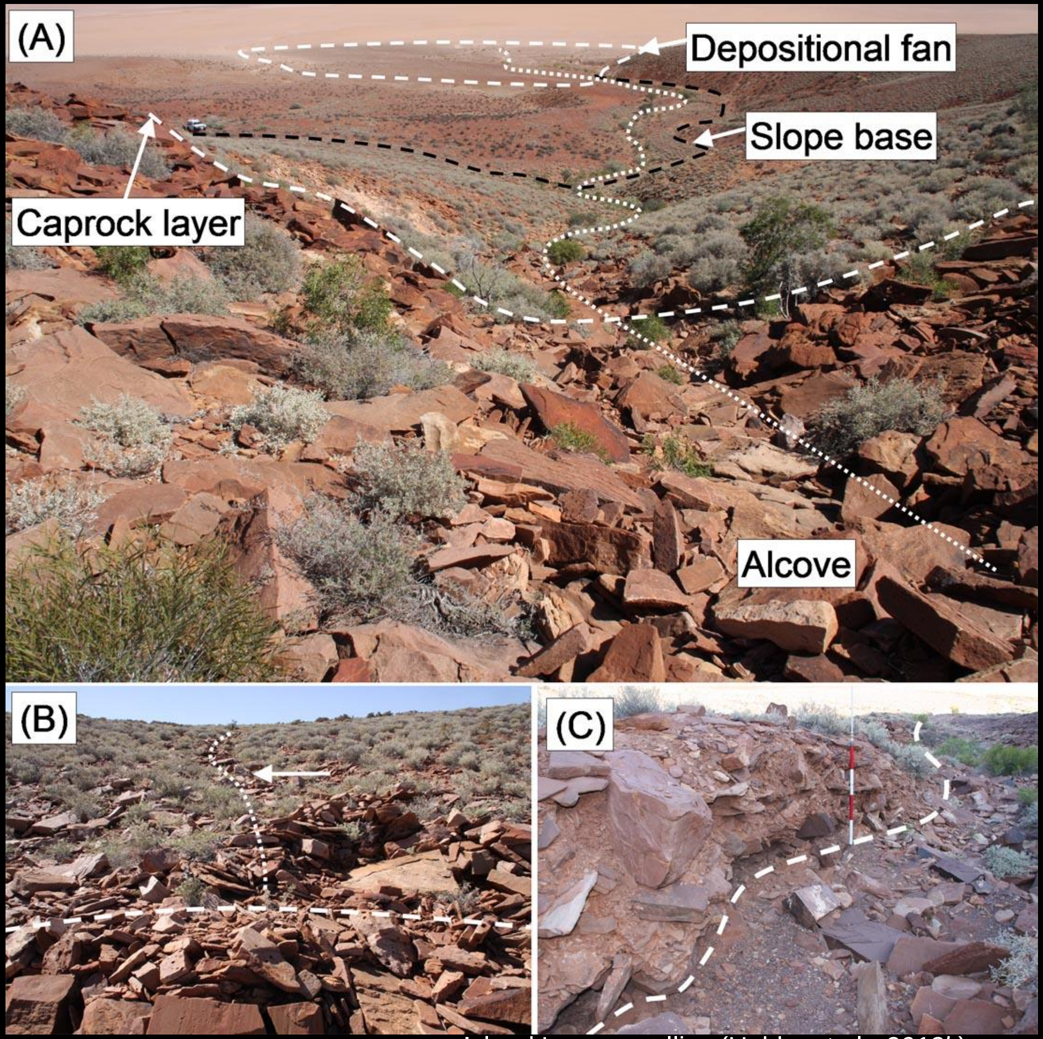
Lake George

- 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)

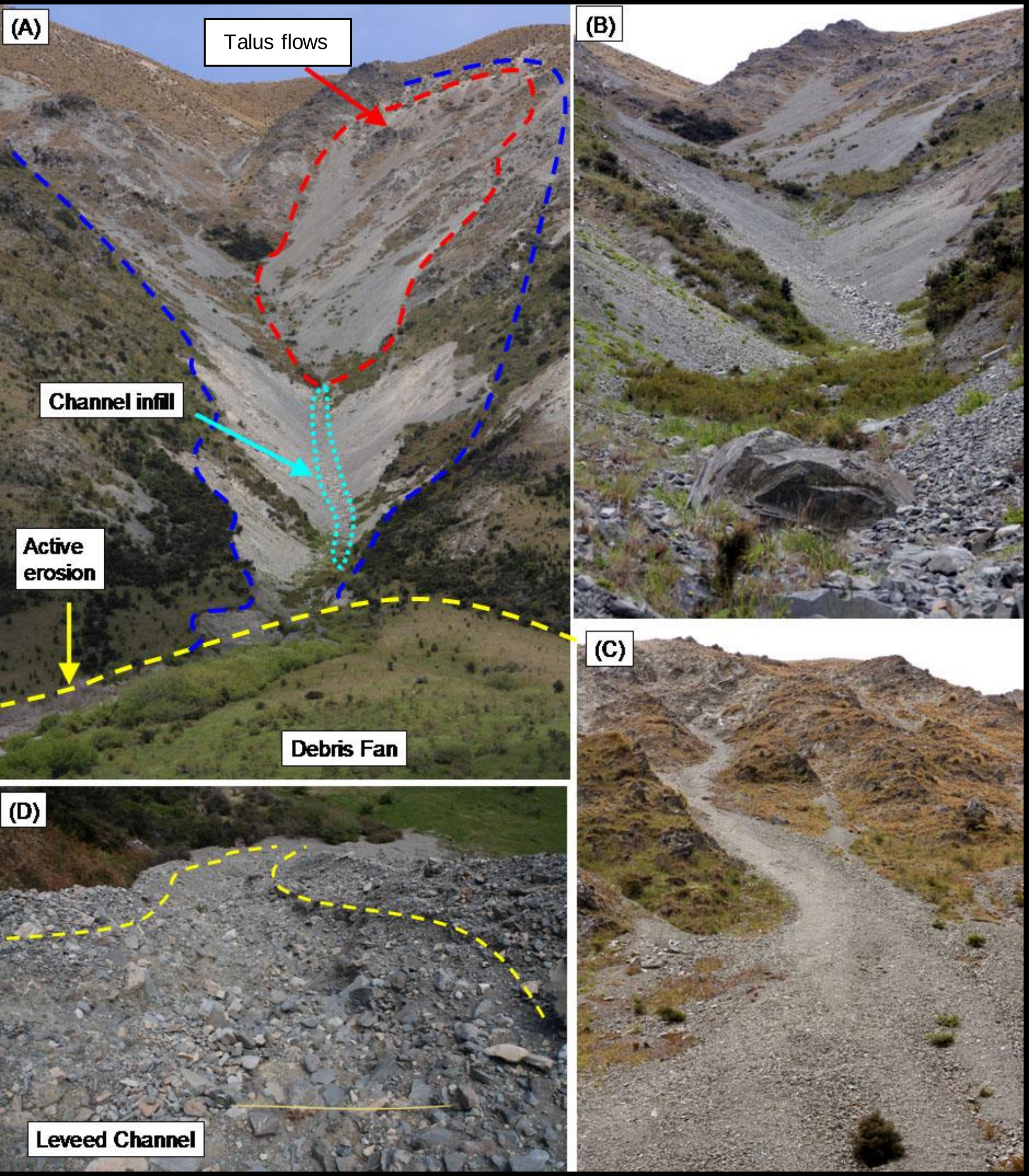
Woomera Gullies



Island Lagoon gullies (Hobbs et al., *2013b*)

- 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.