NEW INSIGHTS TO GULLY FORMATION USING HIRISE DIGITAL TERRAIN MODELS. Virginia C. Gulick[1,2], Natalie H. Glines[1,3], Carly A. Narlesky[4], Deborah J. Hernandez[4], Patrick M. Freeman[1,6], J. Alexis P. Rodriguez[1,7]. [1]NASA Ames Research Center, Mail Stop 239-20, Moffett Field, CA, 94035, USA; [2] SETI Institute, Mountain View , CA 94043, (virginia.c.gulick@nasa.gov); [3]NASA ARC/EAP; [4]MBK Engineers, Sacramento, CA 95815, [5]Department of Geologic Sciences, California State Polytechnic University, Pomona, CA 91768, [6]NASA ARC/SJSU Research Foundation; [7] NASA ARC/NPP.

Introduction: Since their discovery in images returned by the Mars Orbiter Camera (MOC) [1], several mechanisms have been proposed for the formation of the gullies on Mars. Proposed mechanisms include water flows from snowpack melt [2], ground-ice melting at high obliquity [3,4], ground-water flow from near-surface aquifers [1], wet debris flows [3,4,5,6,7] and some involving dry mass wasting, granular flows, or exotic fluids [9, 10, 11], and for the linear dune gullies in particular, sliding and sublimation of CO_2 blocks [12, 13]. However, these studies were mostly based on two dimensional image analyses.

HiRISE has taken several thousand stereo image pairs of the surface of Mars to date, many of which can made into HiRISE digital terrain models (DTM). Most images are generally ~0.25-0.50 m/pixel, which yields a post spacing equal to approximately 1-2m with vertical precision in the tens of centimeters [14]. These HiRISE DTMs have enabled a new level of gully studies for quantitative detailed longitudinal profile analysis and more accurate volume calculations using slope, distance and elevation. We have undertaken DTM-based geomorphic studies in several locations [15,16,17,18] to understand the processes involved in gully formation. These locations are all located in craters where gullies have eroded into the underlying bedrock.

Study areas: We have used HiRISE stereo images and Digital Terrain Maps (DTM) to analyze gully morphology and morphometry in four study sites so far. These include gullies located on the central peak of Lyot crater, and on the walls of Palikir, Corozal, and a small unnamed crater within Kaiser crater.

Lyot is a complex crater (~215 km in diameter), located on the edge of the Northern Lowlands just north of the Arabia Terra region (50.4° N, 29.3° E). Our study area consisted of three groups of gullies eroded into the central peak's northern, western, and southern slopes [15]. We used a preliminary DTM version from stereo image pair PSP_008823_2310 and PSP_009245_2310 to measure elevations and to generate longitudinal profiles.

Palikir crater (-41.5ºN, 202.2º E) is a ~15km diameter impact crater located in the larger Newton Crater basin and contains extensive gully systems particularly on its northern and eastern walls. We selected seventeen gullies on the eastern crater wall, ranging from young (or less developed) to apparently older, more highly developed systems. Each gully source is located just below the crater rim; older or more developed gullies have eroded into the crater rim and have exposed bedrock [16]. We used HiRISE stereo images and associated DTM (PSP_005943_1380 and ESP_011428_1380). Palikir Crater is also a confirmed site for Recurring Slope Lineae (RSL) features thought to be caused by super-concentrated brine flows [19].

Corozal crater is an ~ 8km diameter impact crater located within a much larger unnamed crater in Terra Cimmeria. It contains numerous gullies on its northern and eastern walls that are eroded into underlying rock layers. We used a HiRISE DTM from a stereo image pair (PSP_006261_1410_ESP_014093_1410) to analyze twelve gullies on the northeastern crater wall [17].

Results: In all four sites, gullies have eroded into underlying rock layers both in the source regions and further down along the crater slopes. Alcoves and channels tend to be largely free of debris and several areas have well defined tributary channels eroding into bedrock (Figure 1). Interior channels are common within the gullies; they follow sinuous paths and often have deeply incised escarpments and point bar morphology within their meanders (Figure2).

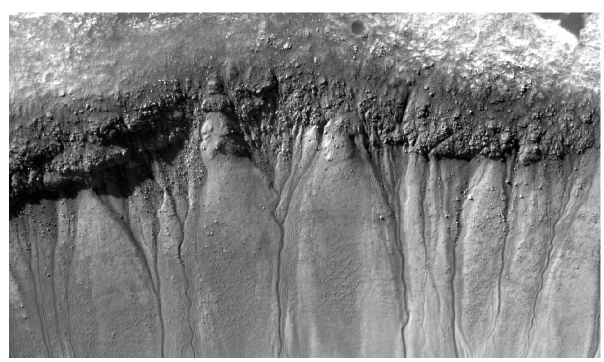

Figure 1: Alcove source areas of gullies in unnamed crater within Kaiser crater shows well-defined tributary channel erosion into underlying bedrock near the rim.

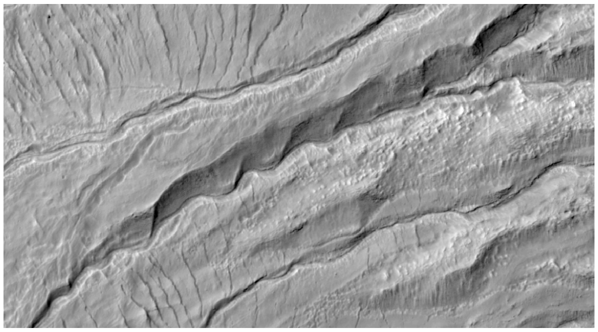

Figure 2: Sinuous paths of interior gully channels in Palikir crater showing steep escarpments and alternating point bar and cut bank morphology.

Longitudinal profiles of gullies in all four locations displayed concave channel profiles. Average gully lengths for Corozal and Kaiser gullies were 754m and 851m, respectively. Lengths of Palikir gullies were significantly longer and varied between 1500m and 3400m. Lyot gullies were the longest and ranged up to 4500m. Average slopes (Table 1) for alcoves, middle channel reaches and aprons are remarkably similar.

Table 1

Ave. Slopes	Lyot	Palikir	Corozal	Kaiser
alcove	22°	20°	23°	18°
Middle reach	16°	16°	15°	11°
apron	11°	-	11°	9°

Apron volumes averaged approximately 40% of the eroded gully volumes in both Kaiser and Corozal craters.

Summary and Conclusion: Although gullies on Mars may have formed by multiple processes, results of our morphometric and morphologic studies of gully systems in these four regions are consistent with a formation by fluvial processes. Longitudinal profiles of gullies in these sites all exhibit concave up profiles. Gullies have eroded into underlying bedrock, form sinuous paths, and exhibit cut bar and point bank relationships consistent with fluvial processes. We have also determined the eroded gully volumes for gullies all four areas. We have measured the corresponding apron volumes for gullies in both Kaiser and Corozal craters and we have determined that the volume of the aprons in both regions is approximately 40% of the eroded gully volumes. Therefore ~60% of the eroded gully volumes are not accounted for in the apron volumes. We propose that a significant portion of this missing volume may have been the water (and volatiles) involved in forming these gully systems.

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