SIMULATION OF MARTIAN GULLIES USING WATER/ICE SLUSH. K. A. Coleman[1], J. C. Dixon[1,2], K. L. Howe[3], L. A. Roe[1,4], V. F. Chevrier[1] 1W.M. Keck Laboratory for Space Simulations, Arkansas Center for Space and Planetary Science, MUSE 202, Fayetteville, Arkansas, USA 72701 <ksacolem@uark.edu>, 2Dept. of Geological Sciences, 113 Ozark hall, University of Arkansas, Fayetteville, Arkansas, USA, 3State University of New York at Geneseo, 4Dept. of Mechanical Engineering, University of Arkansas, Fayetteville, AR, USA.

Introduction: Gullies are widespread on slopes on the surface of Mars [1] and have been investigated by numerous workers [2-4], yet their origins remain elusive [5-9]. In an attempt to pursue the potential of a water-based origin for these forms, we undertook a series of flume experiments at Earth surface temperatures and pressures. Our objectives were to produce forms that resemble those most commonly observed on Mars (Fig 1), documenting their morphometric characteristics and identifying any statistically significant relationships between form and controlling factors of slope and flow rate. Evaporation rates have recently been shown to be lower on Mars [10] than originally suggested [11]. These experiments were conducted using slush-ice because of suggestions that surface and subsurface ice could be partially melted by summer insolation [6] and the initial convincing arguments that gullies were created by debris flows composed of liquid H_2O mixed with rocks and residual water ice [1].

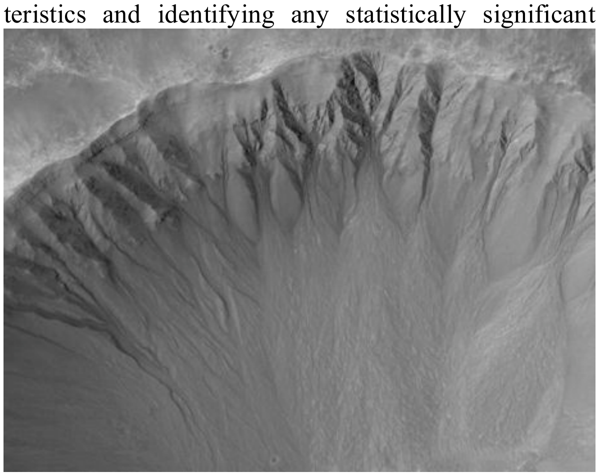

Figure 1 Gullies on the northern portion of a crater in MOC image S1201001. Alcove and aprons on these gullies are long while the V-shaped channels are shorter. Image Credit: NASA/JPL/Malin Space Science Systems

Methods: Experiments were conducted in a 1m x 1.5m flume filled with medium grain size sand [12 and 13]. The experiments were run over a slope angle range of 10° - 40°, corresponding to the range for gullies on Mars [4]. A water-ice slush was fed through a Cole Parmer Masterflex peristaltic pump with 1.8 ID mm silicone hose .3 m long to be released just below the surface at the top of the slope. Flow rates of slush input were controlled by the peristalic pump to coincide with flow rates from our earlier experiments with liquid water. Gullies were produced at four slope andles (10˚, 20˚, 30˚, and 40˚) with four flow rates (445, 705, 965, and 1260 ml/min) at each angle. A Canon Power Shot A710Is camera attached to a camera and lighting arm recorded "gullies" from multiple viewing and lighting angles. A 15 cm ruler and label, identifying run number and run conditions, were included in each photograph. Thirteen morphometric parameters were identified and measured on each gully on which they occurred. These were length, depth, and two width components on each alcove, channel and apron and a total gully length. In addition an attempt to measure saturation of the subsurface was made by collecting saturation measurements in the apron deposit and downslope of the "gully" immediately after flow stopped.

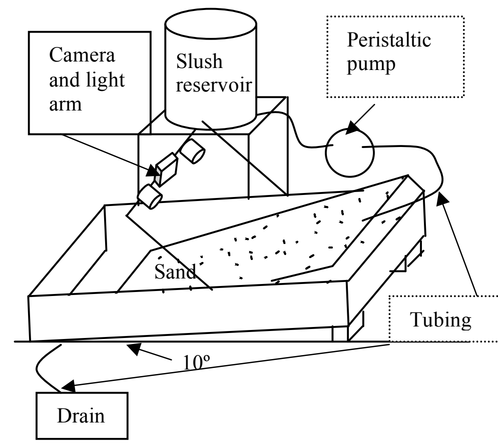

Figure 2 A schematic of the gully simulation flume used in our experiments. A slope is built within the flume and water/ice slush is fed through a Cole Parmer Masterflex peristaltic pump with 1.8 ID mm silicone hose .3 m long to be released just below the surface. Morphometric forms are measured and recorded with a camera mounted on the camera arm.

Results: Gully forms were successfully reproduced and displayed development of the fundamental morphological components observed on Mars: alcove, channel, and apron [1]. Slope–gully form relationships for each component revealed the following results higher slope angles formed shorter gullies with thicker apron deposits. Flow rate-gully form relationships revealed the following relationships longer gullies were seen at higher flow rates.

Discussion: We have previously shown that gullies with morphologies resembling those of Mars can be produced by running water within our experimental flume and that it is possible to quantitatively identify controlling factors on gully morphology at earth temperatures and pressures. By moving to ice slush fluids and higher viscosities we are moving toward martian conditions in the silumations because average martian

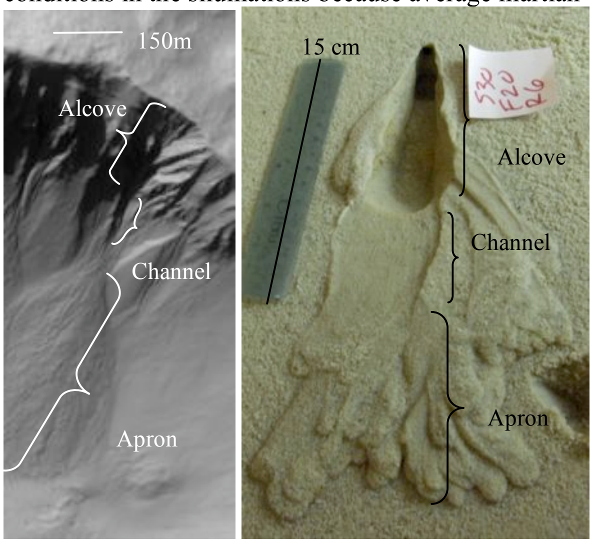

Figure A) A gully seen in MOC image E1900319. Notice the long, wide alcove and narrow channel. The apron extends and widens to fill the slope and the sediment carved out of the alcove is visibly deposited in the apron. Image Creadit: NASA/JPL/Malin Space Science Systems. B) A gully created in our flume. This gully is at 30° slope so it carves out a relatively long, wide alcove. The sediment is visibly deposited in the apron. Scale bars show that these gully forms are very different in size, however, they contian similar morphological features.

surface temperatures near 273K would indicate the presence of ice in any pure water present on the surface.

Once again saturation of the surface was an independent variable that was not accounted for. It seems apparent from our experimental results that saturation affects the morphometric form of the gullies, but no statistical relationships have been identified that explain this relationship. Length/width (L/W) ratios were calculated for each morphometric component of 12 martian gullies and compared to the L/W ratios of simulated gullies. L/W ratios for martian gully alcoves averaged 1.99 while the same ratio on silumate gullies averaged 2.22. The L/W ratio average for martian channels at 5.51 does not compare as well to silumated gullies at 3.93. This means that martian gully channels were relatively shorter than those silumated in the flume. This matches well with the visual identification that channels on Mars are shorter. Much of the V-shaped gully form that is identified as channel is actually a well developed erosional alcove. Finally the apron L/W ratios for martian gullies are 2.3 while those for the simulated gullies are 1.28 which shows that martian gullies are relatively long and narrow compared to silumations.

Conclusion: Forms visually similar to those observed on Mars can be created by water/ice slush in the laboratory flume under terresterial conditions. Morphometric parameters can be measured and permit identification of controlling factors. Experimental simulation of gullies appears possible with proper scaling of experimental parameters. Although flume gully parameters are not directly scalable to Mars, they will be used to verify the results of numerical models that will be used to develop dimensionless parameters for the flows. These scalable parameters will be used to develop the next round of flume experiments, to be performed in our Mars Environmental Chamber, with outputs that can be scaled to the gullies on Mars.

References: [1] Malin, M.C. and Edgett, K.S. (2000) *Science, 288,* 2330-2336. [2] Heldmann, J. L.and Mellon, M.T. (2004) *Icarus, 168,* 285-304. [3] Balme M. et al. (2006) *JGR, 111,* E05001. [4] Dickson, J. L. et al (2007) *Icarus, 188,* 315-323. [5] Musselwhite, D. S. et al. (2001) *GRL, 28* 1283–1285. [6] Costard F. et al. (2002) *Science, 295,* 110-113. [7] Christensen, P.R. (2003) *Nature, 422,* 45-48. [8] Heldmann, J.L. (2005) *JGR,110,* EO5004. [9] Bart, G. D. (2007) *Icarus,187,* 417-421. [10] Sears, D. W. G. And Moore S. R. (2005) *GRL, 32*, L16202. [11] Ingersol, A. P. (1970) *Science, 168*, 972. [12] Dixon et al. (2007) *Mars Gullies: Theories and Tests.* [11] Coleman et al. (2007) *2nd International Workshop Exploring Mars and its Earth Analogues.*

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