UNDERSTANDING MARTIAN GULLIES Howe, K. L.[1, 2], Coleman, K .A.[2,3], and Dixon, J.C.[2,3] 1Department of Geological Sciences, State University of New York at Geneseo, Geneseo NY 14454; 2W.M. Keck Laboratory for Space Simulations, Arkansas Center for Space and Planetary Science, University of Arkansas, and 3Department of Geosciences, University of Arkansas, Fayetteville AR

Introduction: Images from Mars Orbital Camera (MOC) on Mars Global Surveyor (MGS) showing landforms consistent with terrestrial fluid movement, were studied by Malin and Edgett in 2000. It has since been confirmed that the landforms are channeled forms [1] and that they formed recently on the martian surface [2]. Questions regarding martian gully formation arose when it was realized the gullies are often located in areas with surface temperatures below water's freezing point.

The objective of the study reported here is to simulate gully formation with morphologies similar to those observed on Mars as a step toward identifying the potential for a fluid mode of formation. The study also seeks to develop laboratory experimental procedures to test the theory of fluid behavior on Mars and to compare morphometric results with data from MOC and MGS.

Methods: Simulations were run in a 1X1.5m wooden flume filled with medium size sand. A slope was built from the sand and experiments were run at 10º, 20º, and 30º of slope corresponding to the range on Mars. Fluid flowed from an overhead bucket, through a flow meter and then through buried tubing before emerging in the sand at the break in slope.

Each slope was tested four times at four different flow rates: 445 ml/min, 705 ml/min, 965 ml/min, and 1260 ml/min. After each run, seventeen parameters (Figure 1) were recorded and saturation was calculated. The data were then graphed against changes in slope and flow rate. Digital photos were taken for later analysis of morphometric features.

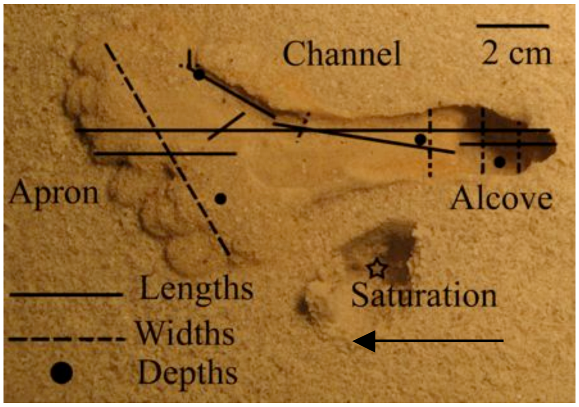


Figure 1: Measurements of 17 gully parameters plus saturation allows for analysis of gully morphology. Arrow indicates down slope direction

Results: Our simulation experiments successfully produced "gully" forms that resemble those forms observed on the martian surface. Two principal forms were observed: shorter wider forms and longer narrow forms. The gullies displayed the three dominant form components widely recognized in gullies on the surface of Mars: alcove, channel, and apron. In addition to the W/L relationships identified above, apron forms were either steep or gentle.

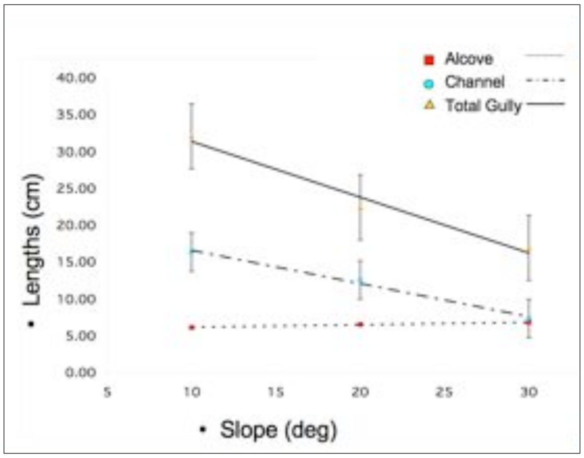
Several statistically significant relationships were found between flow rate and gully form (Figure 2). At lower flow rates gullies tended to be shorter while those at higher flow rates were longer. Measurements indicated that the increase in overall length is the result of the increase in length of all measured morphometric components.

The parameters with the strongest relationship to slope are as follows: total gully length, total channel length, and apron length. These three parameters all displayed an inverse relationship to slope. Of those parameters measured, only alcove length appears to have a positive correlation to increasing slope. Increasing slope has consistently stronger relationships with parameters than increasing flow rate.

High flow rates at high slopes often produced "gullies" with the main channel orientated at a high angle to the alcove.

Discussion: The channels of martian gullies were described as "entrenched, steep-walled, V-shaped" [1] with a broad and deep beginning that tapers down slope. The gullies have three parts: an alcove, main and secondary channels and a depositional apron. Although secondary channels are often observed, there is usually one main channel that dominates the gully system. Alcoves are theater-shaped and some are partially filled with debris. Gully apron shapes can be a spectrum between semi-triangular or lobate [1].

During our laboratory simulations, both widened and lengthen alcoves were observed to form. In addition, in several alcoves, larger sand grains were deposited as debris as Malin and Edgett [1] described of the Martian gully alcoves.



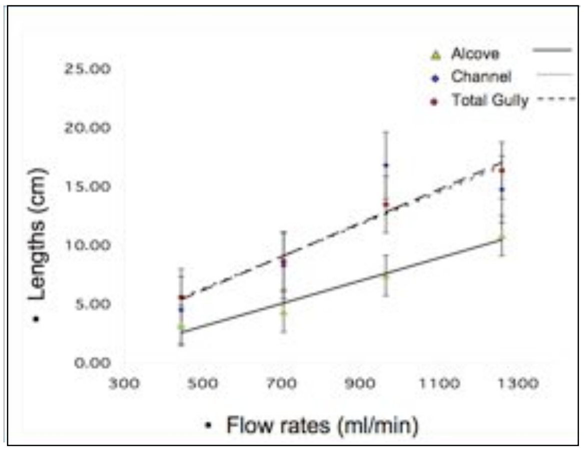


Figure 2: (Top) Graph showing indirect relationship between increasing slope angle and decreasing average gully length parameters. Error bars represent the variation in data. Error bars on Alcove length are not visible behind the data marker. (Bottom) Graph showing direct relationship between increasing flow rate and increasing average gully length parameters.

Although our simulations did not produce V-shaped channels as described for Mars' gullies, the simulations created secondary channels with one main channel that often is wider and deeper at the head when compared to the mouth of the channel. Similar secondary channels (braids) are observed in some Mars channels [1]. Greatest erosion appeared to occur at the head of the channel.

The only indirect relationship with changing flow rate was gully length. This relationship is interpreted to be a function of available energy, which increases as flow increases. With increased flow rate, more energy is available to both erode the channel and to carry the sediment both as bed load and in suspension. Another associated explanation for this effect is the highly unconsolidated nature of the sand grains, as such it may not truly be a good simulate for martian soil.

The finding that gully length was inversely related to slope was surprising. But given the medium used in the experiments may simply be a reflection of the amount of accommodation space available. As sediment accumulates flow decreases and deposition occurs resulting in shortened forms. Data on the relationship between channel length and slope agree with Heldmann and Mellon in that the longest channels on Mars do not necessarily have the highest slope values [2].

The significant positive relationships observed between flow rate and the lengths of each of the principal morphological components of the "gully" form suggests that there is constant channel adjustment in response to changing flow conditions as the "gully" form evolves.

On many of the graphs, substantial outlier values occur. These points are attributed to high sand saturation during the run. The effect of saturation is most notable in the apron. Lower saturation percentages tend to result in a thicker accumulation with a lobate shape. Higher saturations tend to have a thinner apron with a less-defined, but still definite, semi-triangular apron shape.

Conclusion: Simulation experiments in a flume were successful in generating "gully" forms resembling those observed on Mars with three morphological parts commonly identified in martian gullies. Experimental runs have shown that there are significant relationships between flow and form. The effect of saturation on gully morphology has not yet been determined or quantified. We have established that at Earth conditions running water can produce morphological Mars analogs. Application of our findings to understanding martian gullies will have to deal with issues of Mars environmental conditions, regolith characteristics and scale issues.

References: [1]Malin, M.C. and Edgett, K. S., 2000, Evidence for recent ground water seepage and surface runoff on Mars: *Science*, v. 288, n. 5475, p. 2330-2336. [2]Heldmann, J.L. and Mellon, M.T., 2004, Observation of martian gullies and constrains on potential formation mechanisms: *Icarus*, v. 168, p. 285-304.