LIQUID WATER AND WATER-ICE SLUSH FLUME SIMULATIONS OF GULLY SYNTHESIS VARYING EXIT APERTURE DIAMETER. E. G. Rivera-Valentin[1], P. Gavin[1], K. A. Coleman[1], and J. Dixon[2], [1]Arkansas Center for Space and Planetary Sciences (eriverav@uark.edu, pgavin@uark.edu, ksacolem@uark.edu), [2]University of Arkansas Fayetteville Dept. of Geosciences (jcdixon@uark.edu)

Introduction: Current gully formation hypotheses have included the consideration of fluid dynamics of liquid water, brine, and liquid CO_2 flows, but have also included mass wasting such as landslides and/or dry flows [1]. Formation processes due to liquid water have been questioned by many due to its expected instability on the Martian surface, but recent work has shown that the evaporation rate of water on the surface of Mars is not as quick as previously thought [2]. In an attempt to better understand the origin of gully forms on Mars, this project undertakes the task of simulating both liquid water and water-ice slush flows within a flume. We specifically analyze the effect of the exit aperture diameter on the expected gully morphometric parameters.

Methods: Simulations were conducted in a 1.5 x 1.0 meter wooden flume filled with medium grain size (500-600 microns) sand. The flume was inclined at a 10° angle while the sand within the flume was set at a 10° angle with respect to the box such that the total angle of inclination of the sand plane was 20°. This angle of inclination was chosen because the average inclination angle of the Martian surfaces where gullies are formed is approximately 26° [2].

Three different diameter tubes were chosen: 1.59 cm, 1.91cm, and 2.54 cm. These diameters were chosen so that the openings would be large enough for water-ice slush to flow through but small enough such that liquid water flow would not create a “mudslide”. In order to better simulate wet Martian gully origin, the tubes in our experimental setup were placed at a certain depth below the sand since fluid (or “wet”) flows (expected to produce Martian gullies) are predicted to be associated with crater wall breaches by a near-surface ice or snow layer [1]. To this end, the tubes were placed under the sand and covered with a thin layer of debris.

Seeing that the water-ice slush flow rate would not be a constant due to heterogeneous distribution of the solid ice within the water-ice slush, the flow rate of the liquid water was kept unchecked via mechanical means so that the two experiments could be comparable. An attempt, though, was made to keep a semi-constant flow rate. One liter of water was used per run. The fluid was poured into a funnel attached to the tubes.

A maximum of three runs were conducted at a time within the flume as to prevent overflow from one simulation onto the next. An image database was collected for every run from at least three angles. Any anomalies or interesting findings were also pictorially recorded for each run. A total of six runs per aperture diameter were undertaken for the liquid water runs and a total of 3 runs per aperture diameter were taken for the water-ice slush runs.

The morphometric parameters recorded per run included but were not limited to: alcove length, width and depth; channel length and width; and fan length and width. The measurements were taken with a vernier caliper. For morphometric properties that were out of the caliper measuring range, a measuring tape was used. Fig. 1 illustrates the measured properties. For the purpose of this experiment, the alcove was defined to be the oval feature created immediately in front of the tube whose approximate end is defined by an obvious narrowing of the erosional depression. The channel was defined to be the feature starting at the end of the alcove and ending at the first major feature of sediment deposition. Finally, the fan is defined to begin at the last part of the channel and approximately terminate at the last noticeable flow feature.

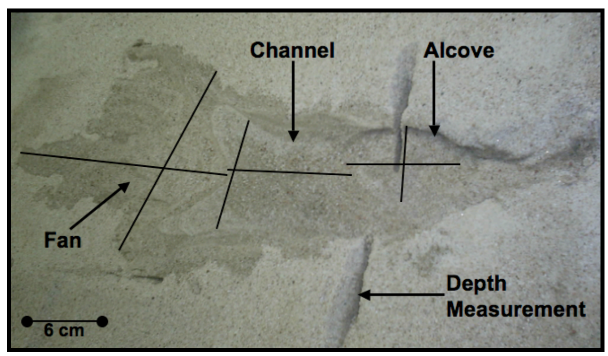

Fig. 1: Image demonstrating the morphometric parameters that were measured.

Wet sand was removed from the flume after every run in an area and set aside to dry. Dry sand was then used to replace the missing sand volume. This was done in an attempt to keep sand saturation constant through out the experiment. It is difficult though to keep this parameter truly constant seeing that only obviously wet sand was removed leaving behind traces of water within the flume. The sand inclination angle was established at two locations every time sand was replaced in an attempt to keep the inclination angle constant throughout the procedure.

Results: Only experimental results that presented a definite pattern are presented here. The data acquired for channel and fan parameters showed a large standard deviation and hence were not presented.

Liquid Water: Fig. 2 shows the relationship between tube diameter and the measured alcove parameters for the liquid water runs. Considering the statistical variation in the data, only the alcove length and depth showed a visible relationship. As it can be seen from Fig. 2, alcove depth stayed fairly consistent at a value of ~ 2.2 ± 0.5 cm. On the other hand, the alcove length seems to generally decrease. Data obtained for both channel and fan parameters presented on average a standard deviation of ~ 5.0 cm.

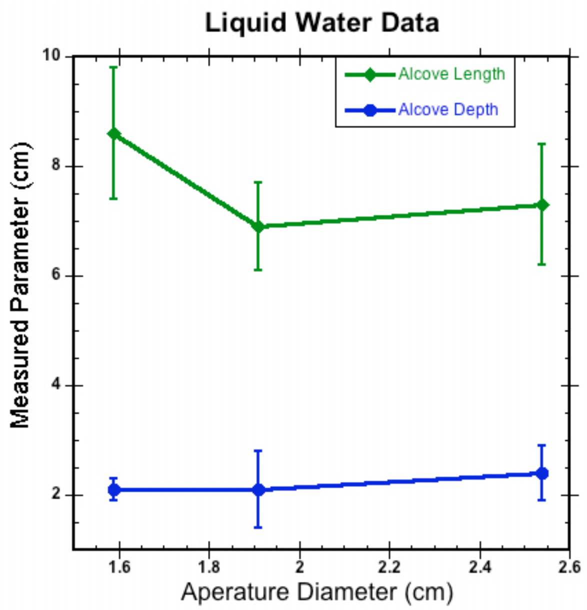

Fig. 2: Plot of presented parameters for the liquid water runs versus aperture diameter in cm.

Water-Ice Slush: Fig. 3 shows the relationship between the exit aperture diameter and the measured morphometric parameters for which a clear relationship was attained. In this case, only alcove width and depth are presented due to their on average low statistical variation. Data obtained for both channel and fan parameters presented on average a standard deviation of ~ 10.96 cm. Alcove depth in this case is seen to increase between the endpoints by ~1.5 ± 0.4 cm. Alcove width is seen to more sharply increase between the endpoints by ~6.8 ± 1 cm.

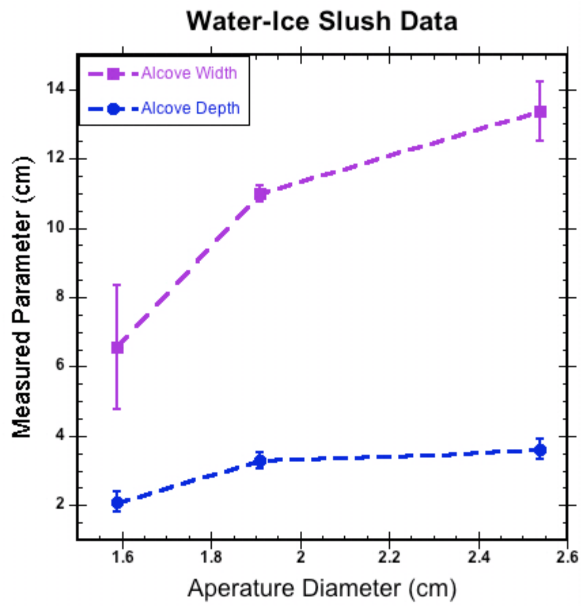

Fig. 3: Plot of the presented parameters for the water-ice slush runs versus aperture diameter in cm.

Discussion and Conclusion: We conclude from our experiments that since fan and channel parameters showed a large variation then there does not exist a definitive correlation between exit aperture diameter and these morphometric properties. More runs in a better controlled environment would improve data and analytical quality.

For the parameters that showed a relationship, we find that the variance in fluid viscosities is significant. The alcove depth for the liquid water runs essentially showed no change with aperture diameter while the alcove length seemed to generally decrease. It was seen in the water-ice slush runs that both alcove depth and width increased with increasing diameter. This may imply that erosional processes, which formed the alcove feature, increased as we changed the aperture. This may be due to the heterogeneous distribution of ice within the slush. As diameter is increased, more ice chunks can flow through, imparting a larger force on the sand surface and thus eroding it more efficiently.

From our experiments, it appears that, at least within the range of the tested diameters, exit aperture size has no significant influence on gully morphologies. The property that may be deduced to have a larger impact on gully morphologies is fluid viscosity.

References: [1] M.H. Carr (2006) **The Surface of Mars**, p.144-146 [2] K.A. Coleman *et al.* (2008) Planetary and Space Science (In Press)