EXPERIMENTAL SIMULATION OF THE EFFECT OF VISCOUS FLUIDS ON MARTIAN GULLY FORMS. Howe, K. L.[1], Rivera-Valentin, E. G.[1], Chevrier, V.F.[1], Dixon, J. C. [1, 2]; 1- Arkansas Center for Space and Planetary Sciences and [3]Department of Geosciences, University of Arkansas, Fayetteville AR 72701; 2-Department of Geology, 113 Ozark Hall, University of Arkansas, Fayetteville, Arkansas, 72701. khowe@uark.edu

Introduction: Many studies on martian gully formation processes [1,2,3,4] have been conducted since Malin and Edgett reported their discovery on Mars's surface [5]. The processes that form these features remain elusive despite these investigations. This may be partially due to the lack of experimental simulations of martian gullies; numerical modeling is more often invoked in order to attempt to explain their origin [6]. Gully simulation is important for experimentally validating formation hypotheses and numerical models. Both dry and wet flow processes have been proposed for the different types of gullies seen on Mars [1,2,3,4].

We have developed a set of flume simulation experiments to test gully formation processes at Earth surface conditions with the objective to produce gullies in the flume with morphometric parameters similar to those seen on Mars [7,8]. The objective of the study reported here is to simulate flows of higher viscosities to account for the potential role of brines [6] and/or debris flows [3] in gully formation.

Figure 1. 1.5 × 1 meter flume used in our experiments of gullies flow.

Methods: In order to vary the viscosity of the fluid in the simulations, Natrosol, a commercial natural cellulose ether, was added to the water. The viscosity of the solution is a direct function of the Natrosol concentration. Moisture content of the Natrosol powder was measured and taken into account during solution creation. Natrosol powder was slowly added to water with constant stirring. To date, the resulting viscosities range from 0.003 to 0.023 Pa.s (i.e. a range similar to values extrapolated from observations of gullies [3] and measurements on brines [6]). We also colored the solutions to increase contrast with sand and to experiment with superimposition of successive flows.

Experiments were conducted in a 1.5 × 1 m flume (Fig. 1) filled with medium grain size sand. The experiments were run over a slope angle of 20°, similar to the average slope of martian gullies [4]. A 500 mL Natrosol/water solution was poured into a funnel attached to a 5/8'' tube resting on the surface.

The flow was recorded using a digital video recorder and digital images were taken after the simulations were complete; this allowed for later image analysis and interpretation of morphometric features. Gully parameters were measured after photos were taken: alcove and apron lengths were recorded as well as the width of each gully section every 5 cm; when appropriate, levee height and length were measured. These dimensional parameters

Figure 2. Left: incised gullies from the inside of a southern near polar crater; White arrows denote North and down slope is toward the bottom of the image Right: low viscosity (0.005 Pa.s) flows simulated in a flume from the same point source.

were chosen for their relevance to observations of gullies from orbit.

Results: The 0.1 wt% and 0.3 wt% Natrosol solutions yielded viscosities of 0.003 and 0.005 Pa.s, similar to those of some brines [6]. These solutions formed gullies with distinct alcoves, channels and aprons as well as levees. Multiple simulations from the same point source yielded similar morphologies stacked on top of each other (Fig. 2).The second flow traveled down the same channel and formed a fan in a similar area and with similar properties.

Features produced with higher viscosity solutions (0.023 Pa.s) show channels that generally widen down slope with very little topography. Discrete levees can be seen on the edges of the flow, only 0.5-1.0mm high. Velocity of these solutions was about 1.0 cm/sec, much slower than the 50cm/sec velocities of the lower viscosity solutions. Channel lengths for the higher viscosity flows were 110 cm, about 30 cm longer than channels of low viscosity flows.

Discussion: The viscosity of the solution has a clear effect on the morphologies of the simulated gullies, as was expected. As seen in Fig. 2, the lower viscosity solutions (0.1% and 0.3% Natrosol) created gullies with similar morphologies as those produced during water and water/ice slush experiments [, 7,8] and those described by Malin and Edgett [5]. These lower viscosity solutions may be analogous to gully formation by liquid brines [6]. Other analogues of the high velocity debris flows are gullies carved from debris flows. Multiple measurements taken from all three gully sections will be used for future modeling work to further constrain the data.

Figure 3. Left: Slope streaks from the inside of a southern near equator crater. White arrows denote North and down slope is toward the bottom of the image. Right: higher viscosity flows (0.023 Pa.s) simulated from a point source in a flume; change of shape at the bottom of flow due to the flow hitting the wall of the flume.

Higher viscosities generated low velocity flows in our simulations (about 1cm/sec). The resulting features were more linear with little to no topography (Fig. 3). We interpret this result as absence of infiltration in the sand of the fluid, due to its too high viscosity. These morphologies strongly resemble slope streaks, which are found in similar latitude regions as gullies. Slope streak formation processes are debated as to a wet or dry genesis [9]. Martian slope streaks have a wedge-shaped and branching to braided “fan” area that shows no deposition; there is little to no topography observed. Slope streaks appear to originate from a point source, as was used in our simulations. Our simulations are also consistent with observations of scarps at the edges of the slope streaks [9]. Therefore, slope streaks could eventually result from the flow of a viscous fluid on the surface, or more probably be linked to the relationship between viscosity and grain size. Further scale analysis will help solve this issue.

Conclusions: Depending on the viscosity of the fluid, our experiments may represent brine solutions, debris flows, and even slope streaks. The low viscosity flows produced gullies similar to those originally documented on Mars, whereas the higher viscosity solutions produced morphologies similar to slope streaks. This data can be used to constrain the formation of different gully types as well as be collected to validate numerical models. Further work will especially focus on the effect of the viscosity versus grain size relationship to explain the transitions between different morphologies. Such experiments with tightly controlled parameters will also be a useful tool for validation of numerical fluid flow modeling.

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