EXPERIMENTAL SIMULATIONS OF MARTIAN GULLIES USING $MgSO_2$ BRINE SOLUTION.

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Introduction: In last ten years, gullies have been spotted on the slopes of Martian hills and craters [1]. These erosive features are an indicator of fluvial activity on the surface of Mars. They have been investigated by numerous authors, yet their formation processes remain elusive [2]. Gullies are often located in areas with surface temperatures below the freezing point of liquid H_2O, thus brine solutions have been proposed as a possible mechanism for there formation, as salts lower the freezing point of water [3]. Since magnesium sulfate ($MgSO_4$) has been detected on the surface of Mars by both orbiters and landers [4], it's a likely source for the brine solutions creating martian gullies.

In order to understand one of the possible formation processes associated with Martian gullies, we performed a series of flume experiments using $MgSO_4$ brine solution at Earth surface temperatures and pressures. Our goal in this study is to both simulate gully formation with morphologies similar to those observed on Mars and to determine whether sulfates can be detected on the surface and/or subsurface of these gullies. This information will help us better understand the processes creating Martian gullies.

Experimental Procedures: In order to reproduce gullies as seen on Mars, we conducted experiments using a $1x1.5m^2$ flume filled with medium to fine grain size sand (sived to a maxium of 500-600 µm) at a slope angle of 16 ± 2 degrees. A solution of 5-10 wt% $MgSO_4$ was poured into a resivour (Figure 1) that was attached to a 5 mm silicone hose at the bottom. The hose is then attached to a rotameter, which controlls the flow rate. The brine then exited the hose at the top of the flume a few centimeters below the surface where there was a break slope.

Gully experiments used various amounts of brine solutions at a flow 1.262 ± 0.126 L min^{-1}. These amounts included 250 mL, 500 mL, 736 mL, 900 mL, 947 mL, 1000 mL, and 1500 mL. Once the gully was formed, it was allowed to dry for 24 hours. To determine if sulfates can be detected on the surface and subsurface of the simulated gullies, we used a Nicolet 6700 FTIR Spectrometer with a fiber optic probe to analyze core samples of the gully forms. The spectra obtained from the core samples were then compared to spectra of epsomite ($MgSO_4.7H_2O$) to determine the detectability of this salt.

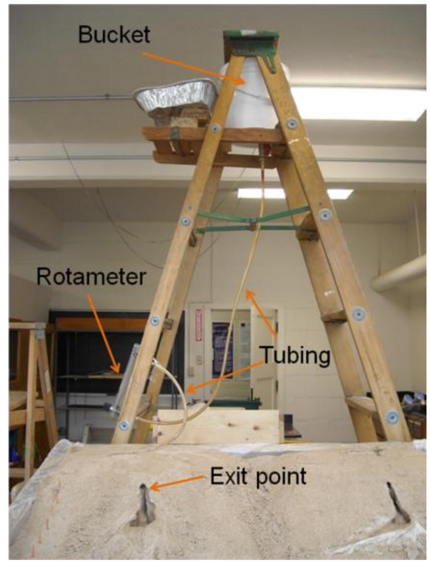

Figure 1: The experimental set up used to create gullies.

Results and Discussion: The three gully segments (Figure 2) were successfully recreated in the experimental simulations and included the typical morphological forms of martian gullies, i.e. an alcove, channel and apron (Figure 3).

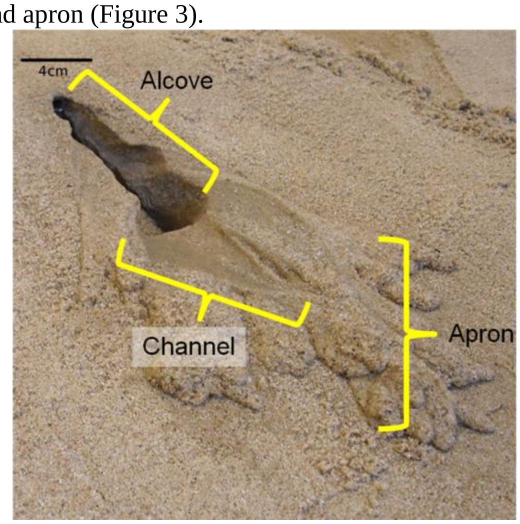

Figure 2: Three segments usually defining gullies on the martian surface and that were studied in the experiments.

When the gullies were left to dry, a white material was often noticed on the surface (Figure 3) mainly near the apron segment of the gullies but very little was seen on channels and alcoves. This material was probably epsomite ($MgSO_4.7H_2O$), which is the stable phase of $MgSO_4$ under terrestrial conditions, a

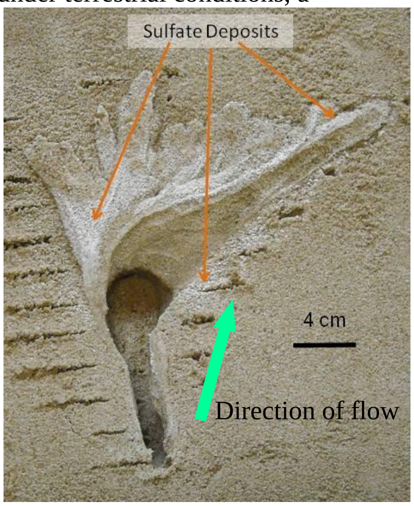

Figure 3: Sulfate deposits (the white material) on the surface of a simulated gully.

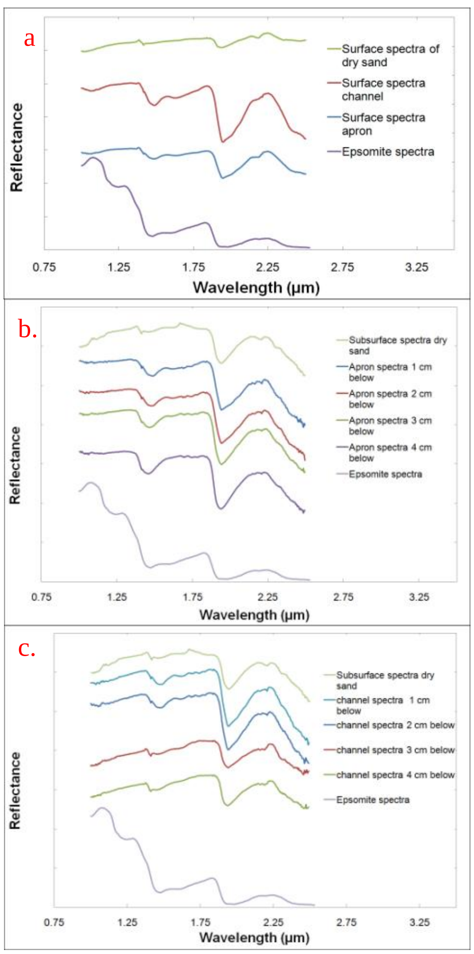

Figure 4: Near infrared NIR spectra of different locations on the gullies formed in our experiments; a. Surface spectra; b. Subsurface spectra of apron; c. subsurface spectra of channel for a gully sample.

FTIR results (Figure 4) show that epsomite was present both on the surface and subsurface of the gullies. Furthermore, epsomite was detected 4 cm below (maximum depth analyzed) the apron while only being detectable up to 2 cm below the channel. This result makes sense since the brines initially flows rapidly downhill while carving out the channel regions thus there is not enough time for the liquid to infiltrate into the subsurface and then precipitate epsomite. However, as the solution flows downhill, it begins to lose some of it's kinetic energy and eventually halts creating the apron segment while depositing epsomite on the surface and subsurface.

Conclusions: The experiments conducted in the flume using brine solutions were successful in recreating gully segments as seen on Mars and in previous experiments using water [2]. This result indicates that a $MgSO_4$ brine solution of 5-10 wt% could be involved in the formation of Martian gullies. The detection of epsomite by the FTIR implicates that sulfates can be detected both on the surface and subsurface of Martian gullies if the proper science instruments are included in future rovers. Current Mars orbiters, however, have not been able to detect sulfates near gullies probably due to not having a high enough resolution to resolve the deposits. Alternatively, being very soft deposits, the salts may have been removed by some physical weathering process (wind erosion), and/or covered by dust. By comparing these simulations with Martian gullies, it may be possible to determine the types of fluids that create these gullies and there origins.

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] Coleman, K.A. and et al., 2008, Experimental simulation of martian gully forms: *Planetary and Space Sciences*, v. 57, p. 711-716. [3] Anderson, Dale T. and et al., 2002. Cold Springs in permafrost on Earth and Mars: *Journal of Geoplysical Research*, v. 107 (E3), p. 5015-5021. [4] Chipera, Steve J. and Vaniman, David T., 2007, Experimental stability of magnesium sulfate hydrates that may be present on Mars: *Geochimica et cosmochimica acta*, v. 71, p. 241-250.