**EXPERIMENTAL SIMULATION OF MARTIAN SLOPE STREAK FORMATION.** de Mijolla, G. M.[1, 2*], Howe, K.L. [1] and Dixon, J.C[1, 3] .
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**Introduction:** Slope streaks are narrow, fan-shaped features that extend down slope, and are usually found on dust-covered and equatorial regions of Mars. They are hundreds of meters long and present no particular topography. They do present certain defining characteristics. Indeed, all slope streaks start as a point source, progressively widen, then narrow to a lobate or digitate end [1]. Slope streaks are usually found on terrains that have a slope of 7 to 25 degrees [1]. They are easily recognizable due to the presence of an albedo contrast with their surrounding environment. This contrast is of about 10 percent for dark slope streaks and 3 percent for bright streaks [1,2].

Slope streaks were first identified in Viking orbiter images as early as 1977. The appearance of new slope streaks since then has suggested that they are currently forming. The new slope streaks are consistently darker than the pre-existing ones. This leads scientists to believe that slope streaks start out dark and then lighten with time.

However, the means by which they are forming is uncertain. The most widely accepted theory of formation is the dry-flow theory [1]. This theory states that slope streaks are landslide scars. A thin layer of dust seemingly shifts to reveal underlying coarser, darker debris, thus creating the streak-like feature. With the possibility of liquid water on Mars being explored, another theory has emerged: the "wet" flow theory [3]. This theory states that slope streaks occur because of the runaway propagation of percolation fronts.

Following previous experience with Martian flow feature simulations [4], we have simulated the formation of slope streaks using viscous fluid, which could be similar to some liquid brines [5], in order to test the feasibility of this last theory. We have expanded on past experiments [6] that have already been carried out by modifying certain conditions to better approximate Martian conditions. The past simulations were carried out at room temperature with sand as a substrate. Using fluids of similar viscosities that were used previously, we ran our simulations both at -20 degrees Celsius using sand and at room temperature using MMS (Mojave Mars Simulant), which is finely ground up basalt. These simulations are close to Martian conditions,. Indeed, the Martian regolith is thought to be composed of basaltic dust.

**Methods:** To simulate the formation of these slope streaks, we used natrosol, which is a natural cellulose ether. It is a commercial thickener that changes the viscosity of a fluid without altering its other physical properties. We mixed different amounts of Natrosol with water using a magnetic stirrer for 1-8 hours, depending on the desired viscosity of the resulting fluid. The viscosity of the fluid was measured using viscosity ball drop tubes. We then added 3 to 4 drops of food coloring to the solution, thus adding to the contrast between substrate and solution. We then ran 50mL of the solution down two wooden flumes using a funnel and a 15 cm long piece of polyethylene tubing with a 19 mm diameter. One of the flumes was at room temperature with dimensions of 0.5x3 $m^2$ and filled with MMS (Mars Mojave Simulant) (Fig. 1. The other one was at -20 degrees Celsius with dimensions of 0.9x1.5 $m^{2.}$ and filled with sand. These flumes were first inclined at an angle of 20 degrees. Then the experiments were repeated at an inclination angle of 10 degrees.

Once the streak-like features had dried or frozen, we measured the width, depth, and other noteworthy aspects of the features in 5 cm increments, as well as overall length.

Figure 1: One of the wooden flumes that was constructed to study the streak-like features in the simulations.

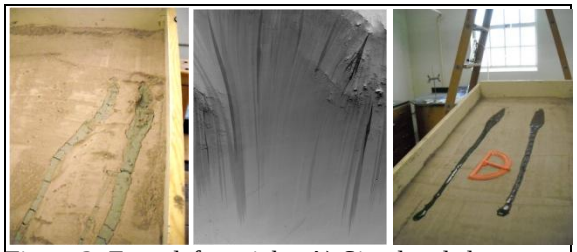

Figure 2: From left to right: A) Simulated slope streak using fluid of viscosity 0.003 Pa s run at room temperature with MMS ; B) Group of slope streaks on Mars; C) Simulated slope streak using fluid of viscosity 0.075 Pa s run at room temperature with MMS.

**Results:** At lower viscosities with a 20 degree slope angle, the fluid presented gully-like features. This was more noticeable at room temperature than at -20 degrees Celsius. The fluid exited the input tube with a high velocity, creating an alcove-like feature.
For higher viscosities with a 20 degree slope angle, as well as with all viscosities at a 10 degree slope angle, the fluid exited the tube at a lower velocity, widening quickly as it progressed down the slope. It then lost energy as it flowed, and gradually thinned out, producing a streak-like feature. It progressed with a lobate front. The high viscosity flows were wider than the lower viscosity flows. Indeed, the lower viscosity flows flowed more quickly because they had a higher velocity upon exiting the tube. With the Mars simulant, the high viscosity fluid did not only flow down slope, but also seeped of f to the side, thus somewhat disrupting the appearance of the streak-like feature. With sand as a simulant, the streaks created using lower viscosity solution presented levee-like features. Previously, the Space Center had run these simulations at room temperature with sand and had noticed similar levees, though they were more pronounced. No such levees were observed when we used the Mars Simulant, which is very fine-grained. However, on all the runs using the Mars Simulant, there were cracks that were formed as the fluid flowed, and which became more pronounced as it seeped in. These cracks appeared to have started because of slight irregularities that are a natural consequence of using such a fine-grained substrate. These cracks developed almost exclusively perpendicularly to the direction of the flow. The area of the streak-like formation that was affected by a crack appeared to be deeper than the area immediately next to it.

**Discussion:** High viscosity fluid has a lower velocity than lower viscosity fluid as it exits the tube. The high viscosity fluid also takes longer to infiltrate the substrate. This means that the higher viscosity fluid freezes before it has a chance to sink in when run at -20 degrees Celsius. However, it is widely accepted that any aqueous solution found on Mars would contain salts that would lower the freezing point of water. Thus to get more accurate results for our experiments, in our future work we will try mixing in salts to our solutions to run at -20 degrees Celsius.

The lowest viscosities we used presented alcove-like forms, while the highest viscosities we used spread laterally a lot. The best simulations occurred for streaks created using fluid of a viscosity of about 0.07 to 0.7 Pa s. The resulting streaks appeared longer and thinner, and thus more closely resembled the Martian streaks.

| **Table 1** | **Width/Length Ratio** |
|---|---|
| Mars slope streaks PSP_009790_1920 | 0.073 |
| Mars slope streaks PSP_001656_2175 | 0.066 |
| 0.075 Pa s simulations at -20 °C at a 10° slope | 0.071 |
| 0.075 Pa s simulations at room temperature at a 10° slope | 0.076 |
| 0.075 Pa s simulations at -20 °C at 20° | 0.035 |
| 0.075 Pa s simulations at room temperature at 20° | 0.015 |

Table 1: Width/Length Ratio of some of the streaks, on Mars and experimental

**Conclusion:** Our simulated features present similarities to the slope streaks present on Mars. Indeed, they have the same general shape, starting at a point source, widening, then narrowing to end in lobes or digits. Another similarity between our simulations and the Martian slope streaks is that they both follow the topography of the terrain, and that they present for the most part no other discernable topography, such as is the problematic case with some dry flow models.

However, our simulations seem to widen much sooner than the Martian streaks do. We must also factor in the fact that these simulations are only a couple of meters long at the most, while the Martian streaks are hundreds of meters long. Thus there is a scaling issue here that must be taken into account.

**Reference:** [1] Sullivan *et al*., 2001, Mass movement slope streaks imaged by the Mars Orbiter Camera: Journal of Geophysical Research, v. 106, n.E10, p. 23,607-23,633. [2] Schorghofer, *et al.*, 2007, Three decades of slope streak activity on Mars: Icarus, v. 191, p. 132-140. [3] Kreslavsky and Head, 2009, slope streaks on Mars: A new “wet” mechanism: Icarus. [4] Coleman, *et al.*, 2009, Experimental simulations of martian gully forms: Planetary and Space Science, v. 57, p. 711-716. [5] Chevrier and Alteide, 2008, Low temperature aqueous ferric sulfate solutions on the surface of Mars: Geophysical Research Letters, v. 35, n. L22101. [6] Howe, *et al*., 2010, Effects of viscosity on the morphology of Martian flow features: LPSC Abstract.

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