Experimental Simulation of Martian Slope Streak Formation

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Introduction:

Definition of Slope Streaks (Fig. 1):

Narrow, fan-shaped features that extend down slope, and are usually found on dust covered and equatorial regions of Mars.

Hundreds of meters long and present no topography. All slope streaks start as a point source, progressively widening, then narrowing to a lobate or digitate end [1].

Easily recognizable due to the presence of albedo contrasts with their surrounding environment [1,2].

First discovered in1977, and currently forming.

Figure 1:A group of slope streaks on Mars © HiRISE

Different Theories for their formation:

Dry theory: slope streaks are landslide scars [1]. A thin layer of dust would shift to reveal an underlying coarser, darker debris, thus revealing the streak like feature.

"Wet" flow theory [3]. This theory states that slope streaks occur because of runaway propagation of percolation fronts.

Methods:

Mix water and Natrosol (natural cellulose ether), which is a commercial thickener that changes the viscosity of a fluid without altering its other properties.

Add food coloring to increase contrast between substrate and solution.

Run 50 mL of the solution:

Using a funnel and 15 m long piece of polyethylene tubing with a 19 mm diameter

Down two wooden flumes (Fig.2). One of them at room temperature with dimensions of 0.5x3 m^2 filled with MMS (Mars Mojave Simulant) and the other one at -20 degrees Celsius with dimensions 0.9x1.5 m^2 filled with sand.

Let the streaks dry. Measure width, thickness and other relevant aspects of the resulting streak every 5 cm.

Figure 2: Simulations at room temperature are run in this flume filled with Mars Mojave Simulant, which consists of finely ground up basalt.

Results:

Figure 3: These simulations were run at room temperature using a solution of viscosity 0.021 Pa s on MMS at a 20 ° slope angle.

- At lower viscosities with a 20° slope angle:
  - ◦ Gully-like features (Fig. 3).
  - ◦ More noticeable at room temperature than at -20 °C.

Figure 4:These simulations were run at room temperature using a solution of viscosity 0.724 Pa s on MMS at a 20 ° slope angle.

- For higher viscosities with a 20° slope angle, as well as with all viscosities at a 10 degree slope angle:
  - ◦ Fluid widens quickly as it progresses down the slope (Fig. 4).

Figure 5: This simulation was obtained with a solution of viscosity 0.003 Pa s that was run at -20° C with a 20 ° inclination angle. This close up draws attention to the levee llike features present.

- Using sand as a simulant:
  - ◦ Lower viscosity solutions present levee like features (Fig. 5).
  - ◦ More pronounced at room temperature [6] then at -20°C.

Figure 6: This simulation was obtained using a solution of viscosity 0.075 Pa s that was run at room temperature with a 10 ° inclination angle. The cracks here are especially visible.

Figure 7: This simulation was obtained using a solution of viscosity 0.573 Pa s that was run at room temperature with a 10 ° inclination angle.

- Using MMS as a simulant:
  - ◦ No levee like features.
  - ◦ cracks present for all the runs (Fig. 6).
  - ◦ High viscosity fluid seeps of to the side (Fig. 7), thus somewhat disrupting the appearance of the streak like feature.

	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 10 °	0.070994
0.075 Pa s simulations at room temperature at 10 °	0.075758
0.075 Pa s simulations at -20 °C at 20 °	0.034841
0.075 Pa s simulations at room temperature at 20 °	0.014868

Table 1:This table compares simulated slope streaks and those on Mars. The value of the ratios of the Martian slope streaks are not my own [6]

Discussion:

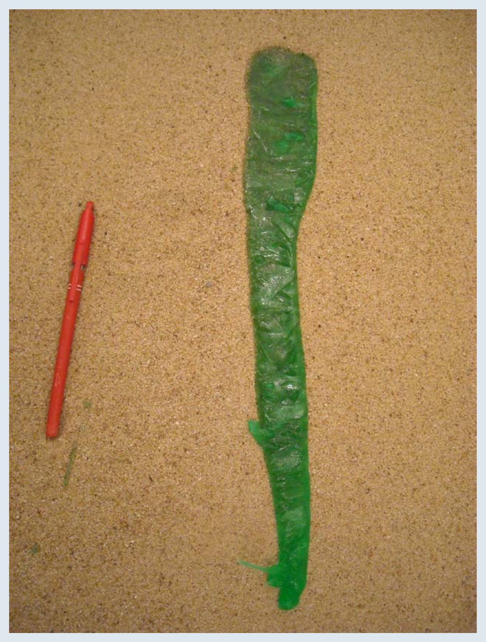

Figure 8: This simulation was run at -20 °C using a solution of viscosity ~ 1 Pa s on sand at a 20 ° slope angle.

- High viscosity fluid freezes before it has chance to sink in when run at -20 °C (Fig. 8).
  - ◦ Salts lower the freezing point of water.
  - ◦ Aqueous solution on Mars would contain salts.
  - ◦ To get more accurate results: mix in salts to our solutions to run at -20 °C.

Figure 9: These simulations were run at room temperature using a solution of viscosity 0.075 Pa s on MMS at a 10 ° slope angle.

- How different viscosities compare to Martian slope streaks:
  - ◦ The lowest viscosities presented alcove-like structures.
  - ◦ The highest viscosities spread laterally lot.
  - ◦ The best simulations occurred for streaks created using fluid of a viscosity of about 0.07 to 0.75 Pa s (Fig. 9). The resulting streaks appeared longer and thinner, thus more closely resembling the Martian streaks (Table 1).

Conclusions:

- Same general shape as Martian slope streaks:
  - ◦ Starting at a point source
  - ◦ Widening
  - ◦ Then narrowing
  - ◦ Ending in lobes or digits.
  - ◦ Follow the topography of the terrain
  - ◦ Present for the most part no other discernable topography, which are problems associated with some dry flow models.
- However, our simulations widen a lot sooner than the Martian streaks do.
- Scaling Problem : Our simulations are only a couple of meters long at the most, while the Martian streaks are hundreds of meters long.

References:

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