EXPERIMENTAL ANALYSIS OF CO_2 SUBLIMATION AND MARTIAN GULLY MORPHOLOGY. R. C. Leone[1], M. E. Sylvest[2,] and J. C. Dixon[2], [1]Colorado School of Mines, Golden, CO, [2]Arkansas Center for Space & Planetary Sciences, University of Arkansas, Fayetteville, AR.

Introduction: CO_2 frost is speculated to play a role in the formation of Martian gullies [1]. Theories include CO_2 frost acting as an avalanche, dry granular flows of CO_2 block ice, or the ground collapsing on liquid CO_2 aquifers [1,2]. Martian gullies are usually found around mid-latidudes and are often pole facing, especially in the southern hemisphere [3,4]. Martian gullies display distinct morphological features such as an alcove at the head of the gully followed by a channel and apron debris fan at the end [5]. Compared to gullies on Earth, Martian gullies are much larger [6]. Martian gullies are also known to be geologically young and active [6,7]. An observational analysis was performed on several simulations in order to determine the behavior of Martian slopes when subjected to CO_2 ice sublimation.

Methods: A 15 x 30 x 13 cm copper box with sloping sides was used as a test section (fig 1). The test section was filled with approximately 10 cm high column of JSC Mars-1 regolith simulant and angled in order to create a slight slope. The regolith was then lightly covered with crushed dry ice and placed in a cold room at approximately 4° C, under a 150 W Halogen lamp. Two cameras were placed above the test section, along with one camcorder at an oblique angle in order to record the experiment. Five thermocouples were placed in the regolith at various depths and one temperature/humidity probe was placed above the test section. Several experiments were run, each lasting from 30-60 minutes when most observed surface activity had ceased. For some experiments a small wedge was placed under the back of the test section in order to create a steeper slope. Some experiments were also overlain with a mix of CO_2 ice and regolith simulant. The amount of CO_2 ice that was used also varied for each experiment.

Photogrammetry: Before the experiments were run, the test section was calibrated by placing 14 dots with a fine point marker around the rim of the box, known as control points, which established the Cartesian cordinate system for the surface relative to the test section. After the experiments were run, stereo image pairs were taken from the webcam videos capturing important mass wasting events and at several time intervals. The stereo pairs, along with the control point coordinates, were then imported into photogrammetry software to generate Digital Elevation Models (DEM), which were used to analyze the experiments. The DEMs were imported into GIS software where several maps such as the slope, direction, curvature, and elevation changes were mapped using a python program.

Figure 1: Test section with regolith and water frost.

Results & Discussion: Several surface activities were observed throughout the experiments. The experiments where the test section was steepened showed the most mass wasting, including a small avalanche (fig 2). The experiments with less CO_2 ice placed on the slope showed less slope movement and less changes in morphology. The CO_2 ice was also observed to be mass wasting as a slump rather than just subliming. Several small granular flow events were also observed.

Figure 2: In this experiment a steeper slope resulted in a small avalanche.

Two experiments showed an approximately 1.3 cm range of elevation change (fig 3). The maximum elevation change for these experiments was 0.72 cm and minimum elevation change was -0.85 cm. The observed avalanche resulted in several morphological changes to the slope, such as a small gully-like alcove and debris apron (fig 4).

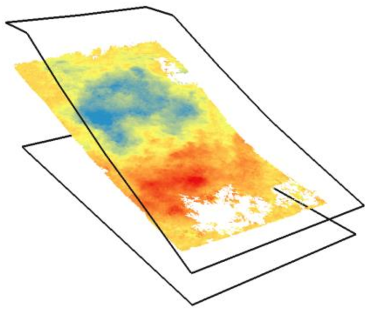

Figure 3: DEM of the elevation change. Blue represents decrease in elevation and red increase.

The slope surface morphology changes can be seen when mapped over time intervals. The last and first time intervals are shown in Figure 4. The maps represent the role of CO_2 sublimation in causing a concentrated area of steep slope angles in the middle of the test section. A significant number of granular flows were observed in this area. This avalanche also created a small debris fan at the end of the slope, similar to debris aprons seen on Martian gullies.

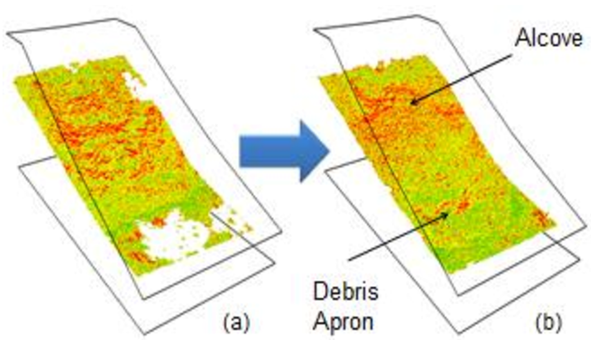

Figure 4: DEM of the slope at the first time interval (a) and the last time interval (b).

The slope and elevation change were calculated on an area in the middle of the test section where the most activity occured. This was done using GIS software by calculating the mean over several squares on a grid. The normalized mean values are graphed over three time intervals in figure 5, with elevation change as the independent variable.

The graph (fig 5) shows that a steeper slope was observed in the area where the elevation change increased negatively. This corresponds to when the CO_2 ice sublimated or where there was a mass wasting event. The graph also shows how the shallower slopes are mostly where the elevation increased positively, where the mass wasting was deposited. This correlation was especially seen at the later time intervals and is portrayed in the graph by the increasing slope bebetween the two variables with time. These observations suggest that as the CO_2 ice sublimated, it caused the slope morphology to change, creating the alcoves and aprons seen in the DEM.

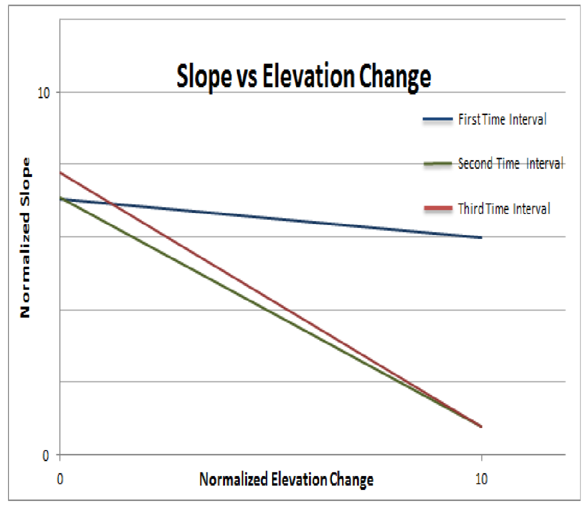

Figure 5: Correlation between elevation change and slope. Note increasing slope with time.

Conclusion: Overall, when the test section had a significant amount of CO_2 ice and was subjected to a steeper slope, sublimation of CO_2 caused mass wasting events and several observed gully morphological characteristics such as alcoves and debris fans. For increased slope angles, the more CO_2 that sublimed, the steeper the slope became. Therefore sublimation caused steeper slopes while deposition due to mass wasting resulted in shallower slopes. Further work is needed to understand the rate of slope movement and what effect changes in humidity and temperature have on this rate, and the formation of gully morphology.

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