UNDERSTANDING THE ROLE OF CO_2 FROST SUBLIMATION ON MARTIAN GULLIES. G. Ito[1,2], M. Sylvest[1], J.C. Dixon[1], [1] Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR, [2] University of Michigan, Ann Arbor, MI

Introduction: Gullies on Mars (Fig. 1) typically resemble those on Earth, and are composed of alcoves, channels, and talus aprons. Martian

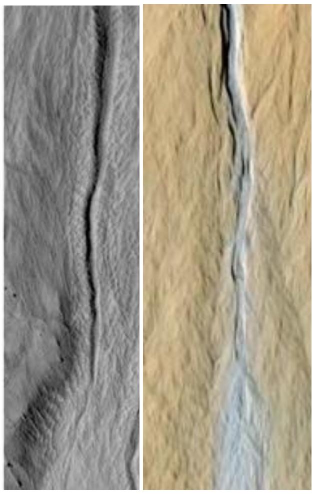

Fig. 1. HiRISE images showing morphology of a Martian gully [1].

gullies are thought by many to be created by running liquid water [2]. However, granular flow caused by sublimation of CO_2 frost [3] is a feasible alternative. This hypothesis does not require liquid water, which is often unstable on the surface of Mars. CO_2 hypothesis may be able to explain why active gullies are found in HiRISE images [1] at locations where temperatures and pressures are below the triple point of water. Unlike liquid water, CO_2 is abundant and is the principle constituent in the atmosphere of Mars. CO_2 frost regularly condenses and sublimates on the surface according to diurnal and seasonal temperature changes [4]. During this process, sublimating CO_2 gas acts as a lubricant to aid the flow of grains [5]. Knowing the limited availability of liquid water, high abundance of CO_2, and the lubrication ability of CO_2, there is a high possibility that CO_2 sublimation is playing an important role in the initiation and the development of Martian gullies. Our goal in this study is to conduct an experiment that tries to further the understanding of Martian gullies by observing grain movements caused by sublimation of CO_2 frost.

Methods: Apparatus preparation and experiments were conducted in a 3 °C cold room. Regolith (JSC Mars 1) was poured into a plastic container (Fig. 2. I) to a thickness of about 0.5 cm. Next, a layer of shaved dry ice was placed on top of the regolith. Then, the dry ice was covered with a thin layer of more regolith. This layering of regolith and dry ice simulates the Martian surface when CO_2 frost forms and is covered with aeolian deposits. The container was set at typical Martian gully slopes (20° to 35°). A 300 W halogen lamp was set at 25 cm above the slope to speed sublimation. The surface movements of the regolith were recorded with a HD webcam (Fig. 2. II), for an average of 40 minutes.

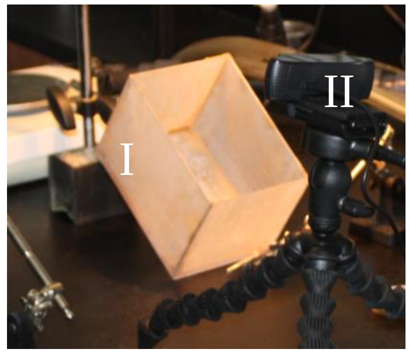

Fig. 2. Experimental set-up. I. Container. II. Webcam.

Results and Discussion: The mass movement was best described by a combination of

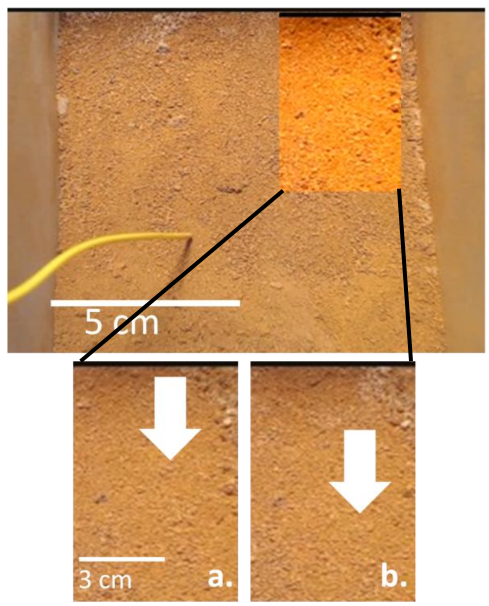

Fig. 3. Still images of regolith movement at 28° slope, 128 sec. apart. Arrows indicate positions of one sample grain.

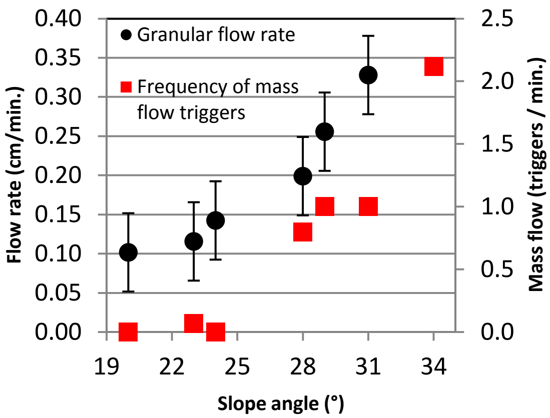

Fig. 4. Plot showing granular flow rate and frequency of mass flow triggers vs. slope angle.

granular and mass flows (Fig. 3). The mean velocity of granular flow was within a range of 0.1 cm/min. to 0.4 cm/min. Average granular flow rate increased with slope angle (Fig. 4). These rates were determined by measuring the distance a single grain traveled on a video playback and dividing that distance by time of travel. Scaling correction was done using the size of the thermocouple wire. CO_2 sublimation on slopes closer to the critical angle (34°) was likely to have a greater impact on gully morphology than lower angles. Additionally, grains fell down the slope rather than being uplifted by sublimating gas. Occasional collapses triggered mass flows, and the frequency of collapses generally increased with angle steepness (Fig. 4). A large collapse occurred at 34° where multiple layers slid together, and an alcove-like formation was observed (Fig.5). This was drastically different from other mass flows in which only the top regolith slid. 34° is the critical angle for this material; it is likely that the weight of a pile of regolith that formed during preparation caused a larger stress which led to this

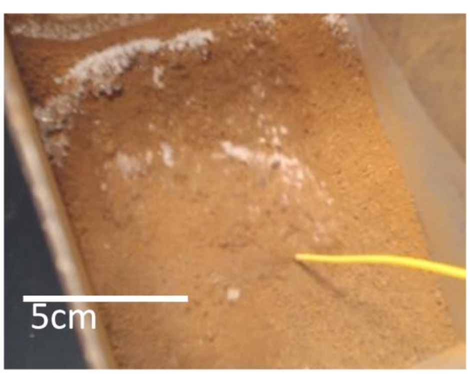

Fig. 5. Still image of a large collapse that occurred at 34° slope.

larger collapse. This may be tied to the initiation of alcoves. Furthermore, a channel could have been created from the grain flow after the collapse, but the apparatus used in this experiment was insufficient in size, the regolith was too homogeneous, or other factors might have had an influence. Another implication may be that the collapses and grain flows create gullies indirectly by moving larger rocks on Martian surface.

Conclusions: Sublimating CO_2 gas from frost alone can cause granular flows in regolith. Factors such as the limitation of the apparatus size or the homogeneity of the regolith may have restricted the formation of channels. We would like to use a larger container in the future to allow space to form alcoves, channels, and talus aprons. Nevertheless, there were signs of gully morphology, an alcove-like formation, during the collapses. Even if CO_2 sublimation does not form gullies independently, it may be an indirect cause as granular flows and collapses can initiate other mechanisms that form gullies. CO_2 frost sublimation is likely to be playing an important role in forming Martian gullies.

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