LABORATORY OBSERVATIONS OF MASS WASTING TRIGGERED BY SUBLIMATION OF CONDENSED CO₂ FROST UNDER MARTIAN CONDITIONS, M. E. Sylvest, S. J. Conway, M. R. Patel, J. C. Dixon, and A. Barnes. 1Arkansas Center for Space & Planetary Sciences, University of Arkansas, Fayetteville, AR (msylvest@uark.edu). 2Department of Physical Sciences, Open University, Milton Keynes, United Kingdom MK7 6AA, 3Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville, AR.

Introduction: When features closely resembling kilometer-scale terrestrial gullies, which are generally formed by fluvial erosion, were identified on Mars, the source of these features was likewise supposed to be the result of flowing water[1]. As water is not stable in liquid form under modern conditions, this posed a quandary for researchers. Further, with the more recent, recurring, high resolution images (i.e. HiRISE, [2]), we are now aware of contemporary evolution of martian gullies [3]. So, either there are currently unforeseen conditions on Mars, under which water is stable, for example brines [4] or aquifers [1], or other processes must be responsible for the observed changes. One frequently mentioned alternative process is the sublimation of CO₂ ice [3,5–7]. The aim of this research is to experimentally explore the potential for CO₂ sublimation cause sediment transport.

Fig. 1: Vacuum chamber (rear) with liquid nitrogen Dewar (front center), heat exchanger assembly (front left).

Approach: The requirements for the procedures and apparatus were to: 1) emplace CO₂ frost on a slope of regolith, without introducing water and other gases; 2) sublimate the frost at martian atmospheric pressure by means of radiant heating, from above the surface; and 3) record any changes and activity of the slope for photogrammetric analysis.

Procedure. The procedure consists of four stages: 1) establishment of a dry atmosphere in the chamber, 2) cooling the regolith sufficiently to support condensation of CO₂ frost at reduced pressure, 3) introduction of cooled CO₂ gas above the regolith to deposit as frost, and 4) video recording the surface evolution under radiant heating.

Apparatus. The centerpiece of the apparatus is a 1m diameter, 2m long vacuum chamber, Fig. 1, housed at The Open University, Milton Keynes, UK. JSC Mars-1A regolith simulant was formed into a slope, inside a box, approximately 30 cm long, 23 cm wide and 12 cm high (internal dimensions).

The box is constructed of coiled, copper tubing. Liquid nitrogen flowing through the coils cooled the slope. Exhaust nitrogen flowed through an external heat exchanger assembly to precool CO₂ gas injected during the frost emplacement process. The box was fitted with a lid, which shielded the regolith from radiant heat transfer during cooling, and protected the slope from disturbances during pumping down. Two High Definition digital video cameras were mounted above the box, along with a 500W halogen lamp, Fig. 2. The insolation stage typically lasted ~100 mins.

Fig. 2: (Left) Side view of box, highlighting relative positions of cameras, heat lamp and heat shield. (Right) Front view of open box, illustrating lid opening mechanism (bottom right), liquid nitrogen lines (center left) and CO₂ supply and diffuser (bottom side of open lid – center right).

Temperatures of the regolith were logged at several depths along the centerline, both near the head and the middle of the slope. Pressure, measured at the top of the chamber, was recorded manually. Slope angles were determined photogrammetrically before, during and after each run.
Photogrammetry. Each pair of movies was synchronized and pairs of frame captures taken at regular intervals using video production software. These image pairs were then used to develop digital elevation models (DEMs) in Agisoft Photoscan, enabling us to estimate the volumes of sediment moved.

**Initial Results:** We performed four experimental runs where the slope was set at or near the angle of repose (~30° for JSC-1A). Detailed analysis is ongoing. In each case we observed mass wasting events triggered by the sublimation of the deposited CO\(_2\) over the whole duration of the insolation. Figure 3 is the cumulative count of software-detected shape movements for each run. Plots are non-dimensionalized in time, to allow comparison of runs with slightly different durations. The highest levels of activity are seen to occur in the first third of the run (approx. 30 mins); however, activity was detected, with sporadic peaks, throughout each run. The total volume of regolith moved ranged from 164 to 216 cm\(^3\) over the four experimental runs.

**Discussion & Conclusions:** The sublimation of CO\(_2\) frost, condensed in situ, on regolith under Mars temperature and pressure, can trigger significant mass wasting. This mass wasting takes the form of discrete events, which occur episodically, throughout the insolation process. No bulk movement of the slope was detected. Therefore, CO\(_2\) sublimation may play a role in observed, present-day gully evolution.