

Experimental Study of CO₂ Sublimation as a Trigger for Mass Wasting

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BACKGROUND

- CO₂ sublimation proposed source of Mars gully evolution [1]
- Proposed mechanisms for Mars gully modification by sublimation
 - CO₂ frost avalanches [2,3]
 - Frosted granular flow [3]
 - Sediment fluidization [4]
 - Trigger for debris avalanches [5]
- First direct experimental study of CO₂ sublimation as trigger for mass wasting

METHODS

- Stratified Slope Models
 - 5 – 10 mm layer of granulated CO₂ ice mixed in JSC Mars-1 regolith simulant
 - JSC Mars-1 base
- 150 W halogen lamp 25 cm above slope (Fig.1)
- 6°C ambient temperature
- Stereo HD videography
- Digital elevation model (DEM) & motion detection analyses

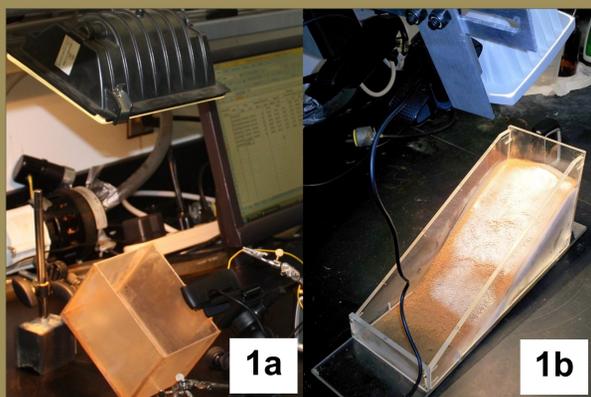


Figure 1: (a) 1st experiment: 12 x 18 x 12 cm tall Lexan box. (b) 2nd experiment: 12 x 30 cm Plexiglass box with sloping sides.

References: [1,5] Raack, J. et al. (2012) LPS XLIII, Abstract #1801. [2] Ishii and Sasaki (2004) LPS XXXV, Abstract #1556. [3] Hugenoltz (2008) Icarus, 197, 65-72. [4] Cedillo-Flores (2011) GRL, 38, L21202.

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RESULTS

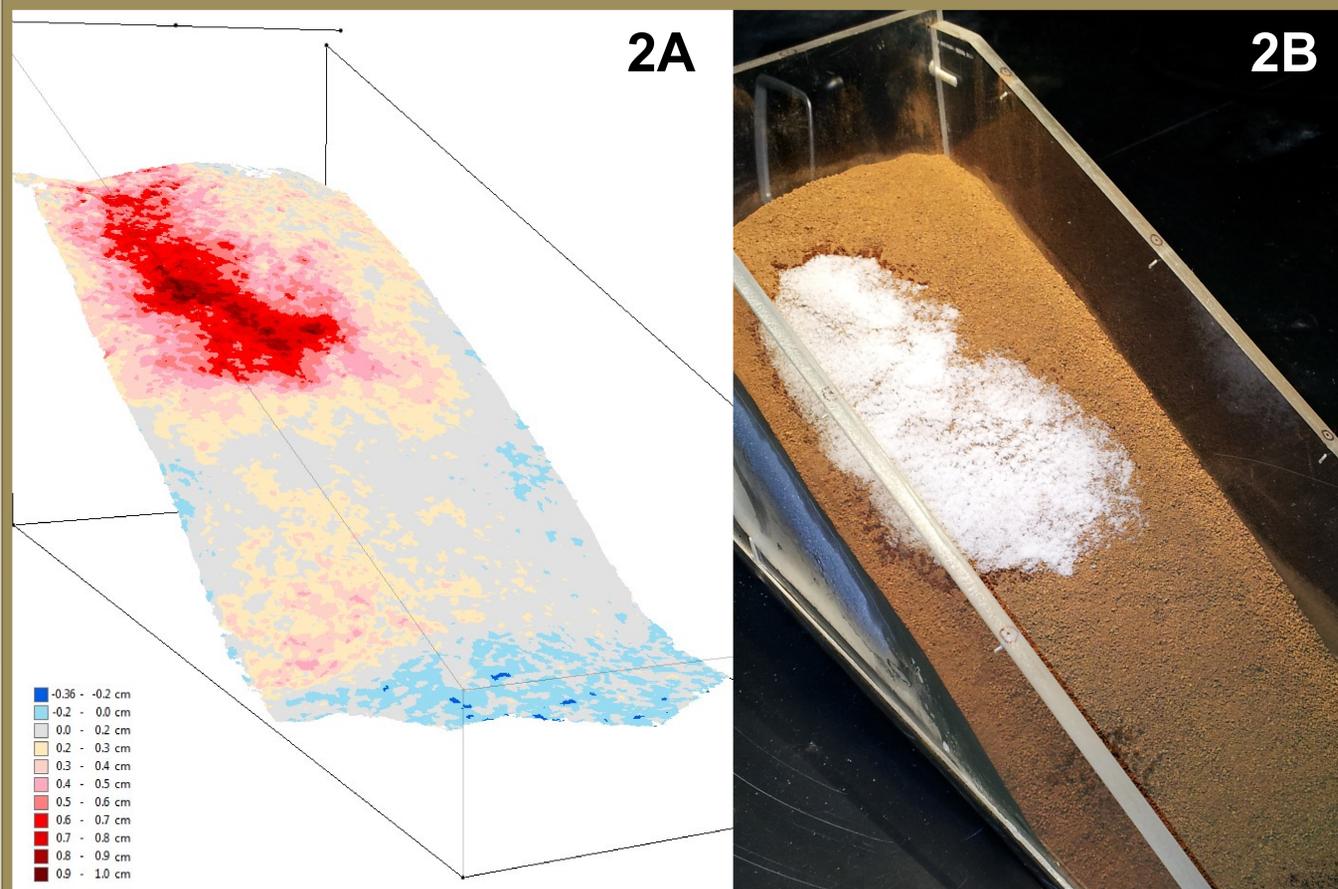


Figure 2: (A) Example DEM of final slope surface with draped color gradient indicating vertical displacement between the first and last surfaces. (B) Final slope surface Red represents reduction of vertical height.



Figure 3. Exposure of CO₂ ice-regolith layer at break in slope highlighted by H₂O frost.

EVENT FREQUENCIES VS CONTROLS

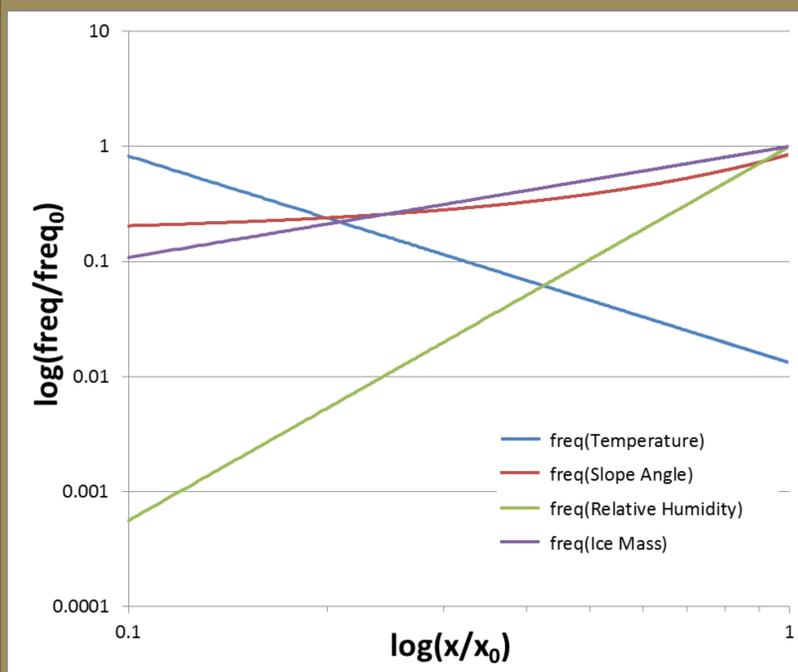


Figure 4: Log-Log comparison of normalized mass wasting event frequency as function of: ambient temperature, mean slope angle, relative humidity and initial CO₂ ice mass. x/x_0 represents the ratio of the particular control value a reference value.

DISCUSSION

- Variety of mass wasting styles related to surface activity
- Low activity:
 - Slope slides as single mass along basal plane (Fig.1a)
 - Surface subsidence controlled by CO₂ concentration (Fig.1b)
- High activity:
 - Individual particle slides dominate
 - Single particles trigger larger-scale movements
 - Infrequent formation of pits and scarps
- Water frost developed on slope surfaces (Figs. 1b & 2)
 - Unquantified influence on surface morphology & activity
 - Locally enhanced stability due to increased surface cohesion
 - Decreased stability due to additional mass

CONCLUSIONS

- CO₂ Sublimation can trigger small-scale mass wasting.
- Frequency of trigger events increased by (Fig.4):
 - Steeper mean slope angles
 - Increased initial CO₂ ice mass
 - Decreased ambient temperature
 - Increased relative humidity