AN EXPERIMENTAL SETUP TO STUDY CO_2 ICE IN A SIMULATED MARTIAN ENVIRONMENT.

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Introduction: CO_2 constitutes the North and South Polar Seasonal ice caps [1] and the perennial South Polar Residual Cap (SPRC) [2]. Massive deposits of CO_2 ice were also found buried in the South Polar Layered Deposits using SHARAD data [3, 4]. CO_2 processes are closely related to major geomorphological features at extreme latitudes, such as pits, fingerprint terrain, jets, dunes, and polygonal throughs [5, 6, 7, 8]. There are numerous observations of the ice from remote sensing instruments; however, there is not sufficient data under laboratory conditions in order to unambiguously interpret the remotely-sensed data [9]. Better constraints of the CO_2 ice optical, mechanical, and crystalline properties under Martian conditions could help answer the questions regarding its role in the past and current climate, it's role in affecting the surface features we observe, and the ice's long-term unexpected stability in the SPRC.

We have created an experimental setup to investigate the formation, behavior and optical properties of CO_2 ice under such conditions at York University. We create CO_2 ice and record some variability of textures similar to ones reported by [9] and are further expanding our capabilities to conduct experiments under more precise pressure-temperature conditions, and time-scales for ice deposition more realistic for Mars.

Current experimental setup: The setup consists of a 50-liter cylindrical stainless-steel vacuum chamber, evacuated by a dual-stage rotary vane vacuum pump to pressures of on the order of magnitude of 1 torr. CO_2 gas is then introduced into the chamber, where an aluminum plate is simultaneously cooled by liquid nitrogen (LN2) flowing in copper tubing. The formation of the ice on the plate is recorded using a generic USB camera and a USB digital microscope under 50 to 100 times magnification.

We created CO_2 ice during 10 to 20-minute runs and observe surface and interior changes.

During the entire experiment, as ice deposits, the pressure within the chamber continues to decrease. Our setup is not yet sensitive enough to monitor the pressure closely, but this capability is being installed presently.

Preliminary results: During each run, a transparent, approximately five-millimeter-thick layer of CO_2 ice grew within 2-10 minutes (Fig. 1a). During growth, the ice rapidly fractured in polygonal patterns (Fig. 1b). The numerous fractures annealed within seconds, healing the ice to be transparent again, while more, new fractures continued to form each second (Fig. 2). The process of fracture, heal, fracture, heal takes <5 seconds and repeats numerous times in the experiment.

After reaching a steady state with no more slab ice growth, the surface accumulates very small grains that are highly reflective and not transparent (Fig. 1c). This ice has a different texture that appears more porous, with finer crystal size. In some instances, instead of this uniform frost layer, separate larger crystals form on the transparent ice. This texture was also reported by [9]. A thin non-transparent layer drapes over these crystals, within 15 to 20 seconds, while still preserving their distinct shape (Fig. 3).

Upon completion of the experiment, in some runs we see "bubbling" during venting the chamber before the sublimation of the ice. Another type of recorded activity was the formation of singular pits in the top frost layer, potentially, due to the escape of sublimated CO_2 gas from the bottom layer.

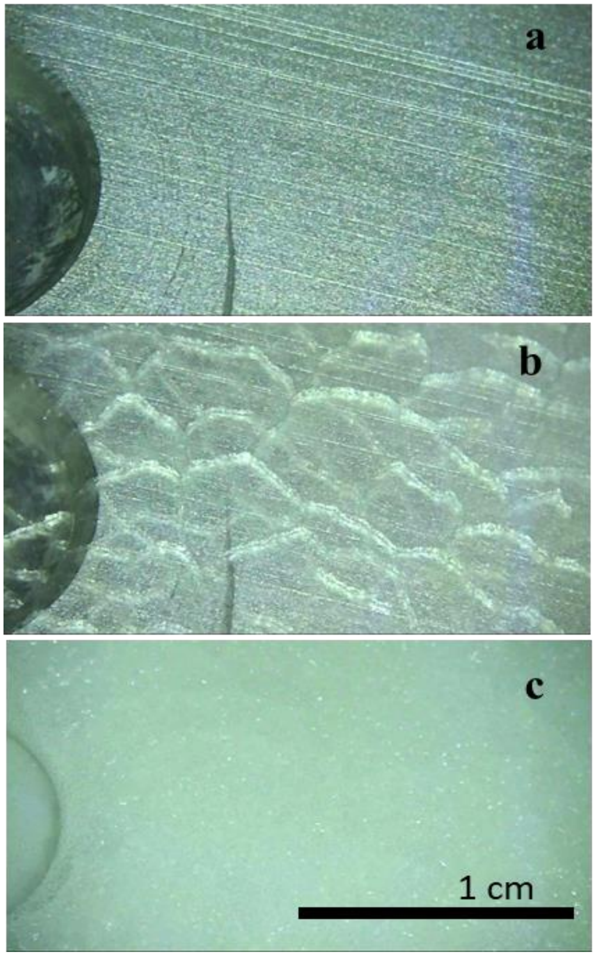

Figure 1 (a) Transparent CO_2 ice; (b) Fracturing of ice; time interval between photos is one second (c) fine non-transparent frost, image taken 108 seconds later.

Interpretation: The prominent fracturing during slab ice deposition is likely caused by strong thermal gradients between the cooled plate and the ambient atmosphere in the chamber, where temperatures are not yet modulated. CO_2 ice healing has been reported previously [9, 10], but the mechanism isn't fully understood.

The different textures of the created CO_2 ice are likely the result of different formation conditions. These texture variations occur as the CO_2 gas pressure drops with time and the temperature increases as the ice surface increases in distance from the plate.

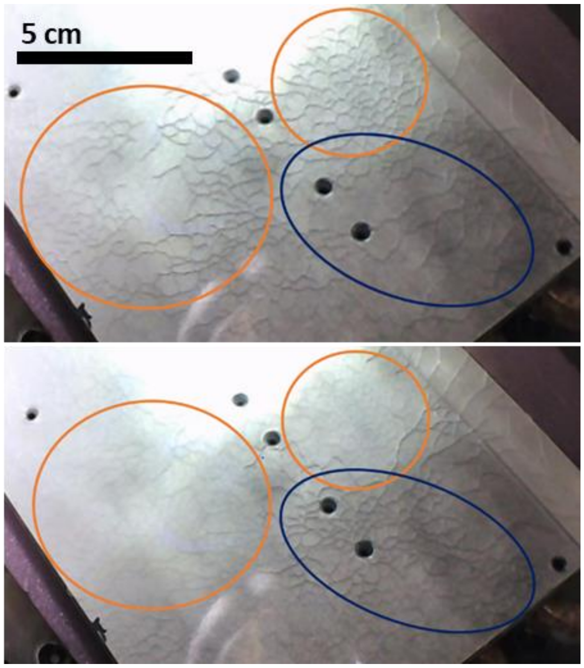

Figure 2 Annealing of fractures on transparent CO_2 ice. Orange: areas of healed fractures; blue: area of new fractures. Time interval between pictures is 2 seconds

Further steps: We continue to improve the setup to better approximate Martian conditions and monitor temperature and pressure. The improvements include more precise gas independent pressure measurement, automated CO_2 gas flow control for creating precise constant pressure, temperature regulation in the form of a cooling shroud and platen system to reduce temperature gradients by cooling the gas above the forming ice. These would allow a slow-rate ice accumulation at larger thicknesses. A further step is to incorporate UV and IR spectrometers to record the surface reflectance of the ice, since there are gaps in laboratory measurements of spectral characteristics of CO_2 ice [11]. One of our main goals is conducting a quantitative analysis of the behavior of the CO_2 ice under various insolation conditions, which could shed light on some current phenomena on Mars, such as the possible differences between visibly dark and bright CO_2 ice areas, as well as the relationship between the formation and persistence of the ice and its albedo.

Acknowledgements: We thank Adrianna van Brennen for her work in assembling the experimental system, which made this work possible.

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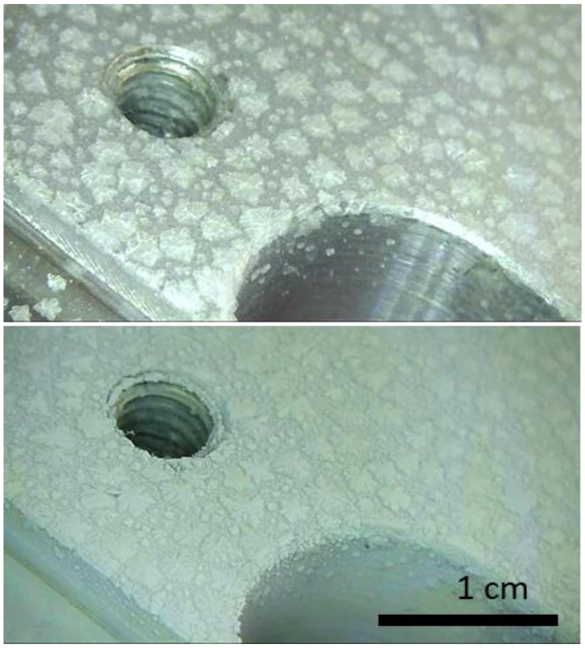

Figure 3 CO_2 ice crystals described by [9] form and then are covered by frost growth. Time interval: 22 seconds