EXPERIMENTAL SETUP TO RECORD THE BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION OF CO_2 ICE UNDER POLAR MARTIAN CONDITIONS. R. Karimova[1] and I. B. Smith[1,2], [1]York University (4700 Keele St, Toronto, ON M3J 1P3, rushana@yorku.ca), [2]Planetary Science Institute.

Introduction: The North and South Polar Seasonal caps, as well as the South Polar Residual Cap (SPRC) on Mars are composed of carbon dioxide ice [1,2]. They have been extensively studied using data from orbital missions and Earth-based observations. The seasonal deposits have different spectrophotometric behaviors from the SPRC [2] that provide clues as to their formation and evolution on seasonal timescales.

The southern seasonal cap exhibits distinct behaviors and spectral signatures [3], such as the unusually dark cryptic terrain and bright Mountains of Mitchell, whereas the seasonal ice is typically highly reflective. The differences in the appearance of the CO_2 ices have been attributed to the textures or contamination of the deposits by dust or water ice [4].

To help in our understanding of the ice, we can infer the physical properties of the surface from orbital data using radiative transfer models. These models are usually validated with laboratory measurements of the spectral bidirectional reflectance distribution function (BRDF) [5]. Several laboratory facilities capable of characterizing the BRDF of planetary materials have been created [e.g.: 5-7] where various minerals and ices have been studied. However, the BRDF of CO_2 ice has not been yet reported in the literature [8], likely due to the challenges of working in low temperatures and pressures.

At York University we are building an experimental setup that will allow us to record the BRDF of CO_2 ice not only deposited but also kept under polar Martian conditions throughout the duration of measurements. We will also be able to record spectral reflectance under a wide range of geometries, including low grazing angles, since we can place a goniometer inside our environmental chamber, without the restrictions of fixed windows through which similar measurements have been conducted before.

As a first step, we created CO_2 ice under stable Martian pressure and temperature conditions in our environmental chamber (~-125° C and 6 mbar). Here we report the various textures we observed which are similar to textures reported by [9]. Next, we will record the reflectance of these textures of CO_2 ice under various geometries.

Experimental setup: *Environmental chamber.* We create CO_2 ice and conduct all measurements inside the environmental chamber. The cylindrical stainless steel vacuum chamber is 1 meter long and 70 cm in diameter and is equipped with liquid nitrogen (LN2) cooled platen and cylindrical shroud (Fig1.). The platen and shroud provide a more homogeneous cooling of the atmosphere in the chamber to avoid a steep temperature gradient within the ice, which was missing in previous experiments.

The CO_2 ice grows on a 10 cm by 10 cm copper cold plate, also cooled with LN2 from the bottom, and features an electric resistive heater for finer temperature control and more uniformity. We monitor the temperature of the sample plate, the shroud, and the atmosphere with thermocouples mounted on the cold plate, on the shroud and suspended above the cold plate.

The pressure is monitored by a Super Bee Pirani pressure gauge and a gas independent Kurt J. Lesker capacitance manometer, and the input of CO_2 gas is controlled by an Alicat mass flow controller. Both temperature and pressure systems are monitored and controlled by LabView software written in-house. We record the ice growth using a web-camera and a digital microscope.

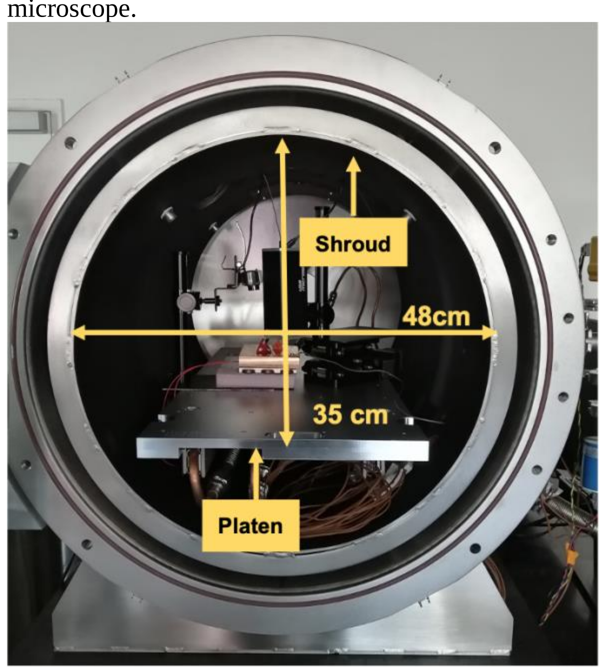

Figure 1. View of the vacuum chamber with the door open. The shroud is coated with black body paint. The copper sample plate can be seen in the middle.

Goniometer. For recording the BRDF we are currently building a goniometer consisting of two arms that can be rotated by ~90º each along the principal plane. We conduct light from a 10 W tungsten halogen light source into the chamber, as well as the reflectance signal from the sample to the spectrometer using fiber optic cables.

The incident light arm of the goniometer has the fiber optic cable at the base which directs light to an off-axis parabolic mirror at the tip of the arm. The mirror reflects the light onto the sample in a collimated beam about 2 cm in diameter. A convex lens on the other arm collects the light reflected from the sample surface and directs it to a detector fiber optic cable. The spectra are recorded using a NIR Avantes spectrometer between 1-2.5 µm at 12.9 nm minimum resolution.

Preliminary results and interpretation: We have created CO_2 ice under Martian environmental conditions (140-180 K, ~6 mbar). We observe growth of individual crystals that later merge into a single horizontal layer and continue growing vertically forming roughly cuboid crystals (Fig.2). The largest observed separate crystals reached 5 mm in diameter and remained transparent until the ice thickness started increasing. The borders of these crystals were still preserved in the merged polycrystalline layer under these conditions (Fig 2b). Creating a fully transparent layer with larger initial crystal sizes and no clear crystal boundaries in our chamber currently requires pressures higher than 10 mbar. Similar clear ice layer is expected to form on the South Polar seasonal ice cap on Mars as [3,10] reported optical path lengths on the order of centimeters to tens of centimeters from polar CO_2 ice. Clear seasonal CO_2 slab ice has also been invoked in explaining the formation of polar features such as jets and spiders [4].

At the later stages of growth, the CO_2 ice appears highly reflective: first, due to fracturing of the individual crystals and later due to the vertical growth of the crystals. The maximum thickness of ice grown to date is ~5 mm, but we anticipate greater growth with longer experiments.

We also observed fracturing of the clear CO_2 ice when the temperature of the plate was increased from ~164 K to ~167 K using the electric heater under the copper sample plate. These fine fractures covered the entire sample surface and made it highly reflective. When the heater was turned off and the plate cooled again, the fractures "healed", and the ice fully recovered its former transparency.

Future work: We are currently running more experiments to constrain the observed textures and the environmental conditions more precisely. We next plan on conducting long duration runs, on the order of several days, under stable conditions to achieve greater CO_2 ice thicknesses. Finally, using the goniometer we plan to measure the BRDF of the samples under a wide range of incidence and reflectance angles for the main observed textures. We will report on these at the LPSC conference.

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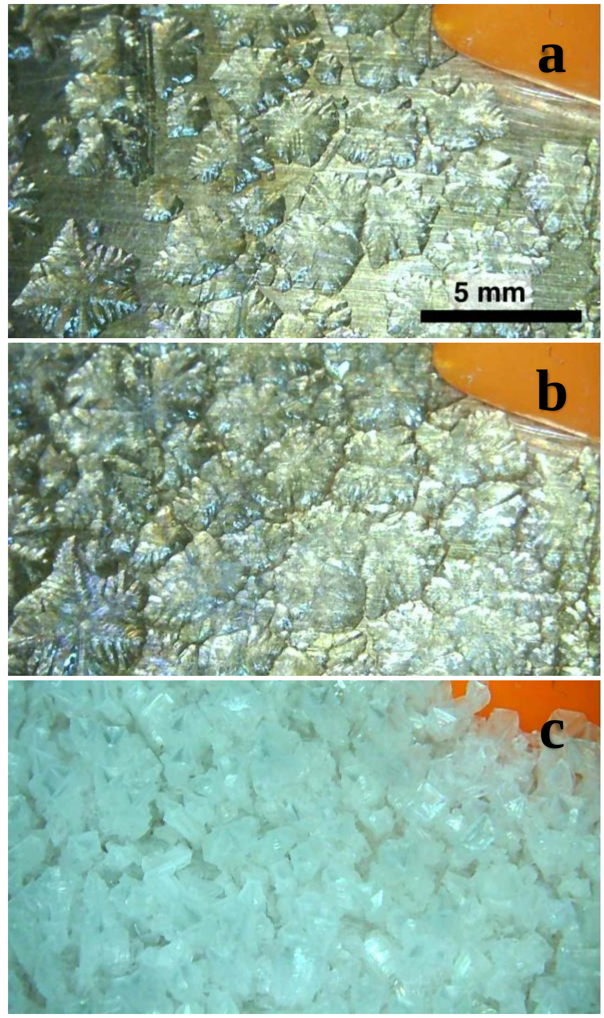

Figure 2. (a) Microscope image of CO_2 crystal growth; (b) 2 minutes later; (c) 30 minutes later

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