HOW TO CREATE TRANSLUCENT CO₂ ICE ON MARS: SIMULATIONS USING THE WIND TUNNEL OF AARHUSS MARS LABORATORY. G. Portyankina¹, J. Merrison², K.-M. Aye³, J. J. Iversen³, C. Hansen³, A. Pommerol¹, and N. Thomas³, ¹University of Bern, Sidlerstrasse 5, CH3012 Bern, Switzerland (portyankina@space.unibe.ch), ²Institute for Physics and Astronomy, University of Aarhus, Aarhus, Denmark, ³PSI, Tucson, Arizona, USA

Introduction: The idea of a translucent CO₂ layer covering martian polar regions is widely discussed since the first detection in 2000 of a region in the southern cap that remains cold enough that CO₂ ice must be present late in the spring together with the low albedo [1]. It provoked many specialized observational campaigns [2, 3, 4] and modeling work [5]. The “Kieffer model” for example postulates that the CO₂ seasonal cap anneals into translucent slab ice over the course of a Martian winter [6]. It is known that water ice undergoes an annealing process during transformation from packed snow to firn, and then to crystalline ice. However, the conditions for such annealing in the case of CO₂ are not constrained from observations nor from laboratory experiments. Another possibility for the transparent slab formation, direct condensation from the atmosphere, is also not explored well enough to provide constrains for the models of polar seasonal processes [7, 8]. These models have recently matured quite noticeably, but now they are blocked in their progress by the absence of knowledge about physical and optical properties of CO₂ ice under Martian conditions.

It is also important to mention here that the complete idea of the translucent CO₂ ice layer existing in the polar areas of Mars so far has only indirect evidence. The spectroscopic observations do not provide a conclusive detection of the slab CO₂. In many cases they also vary depending on the instrument and method of data reduction [2, 3].

For the main hypothesis of Kieffer’s model the existence of the translucent CO₂ slab is critical. The knowledge about conditions under which CO₂ slab might be formed would greatly benefit our understanding of what kind of ice is dominant in polar areas during the time of biggest changes – local spring.

The main purpose of the present work can be formulated in one question: under what conditions does translucent CO₂ ice form in the present day Martian polar areas?

Laboratory experiments: The Mars Simulation Laboratory of Aarhus University is a collection of facilities built by an interdisciplinary research team of biologists, chemists, geologists and physicists who work together on joint planetary research. Simulation of Martian aerosols is performed in a recirculating wind tunnel enclosed in a low-pressure atmospheric chamber (Fig. 1). Such a system allows the atmosphere to be controlled and monitored. A liquid nitrogen cooling system allows the simulation of Mars’ low temperatures.

Figure 1. Mars wind tunnel at the Mars Simulation Laboratory of Aarhus University

We used this facility in the framework of Trans-National Access opportunities within the EuroPlanet Research Infrastructure to simulate CO₂ ice condensation in the conditions similar to those expected in the Martian polar areas. Our main goal was to constrain the range of temperatures and pressures that allow CO₂ ice to be formed in its translucent form.

The first round of experiments was conducted in June, 2011 and yielded the following results.

Figure 2 Microscopic image of the transparent CO₂ ice slab with cracks. Black marking painted on the surface of the cooling plate is now underneath the ice layer.
We explored the temperature ranges from 140 K to 170 K at different rates of the CO$_2$ flux entering the previously evacuated chamber. One restriction of the present set-up was a limited flux of CO$_2$ gas entering the chamber, while on Mars the reservoir of available CO$_2$ is virtually unlimited. 

A thin slab of CO$_2$ ice could be produced during several of the runs (one example is in Fig. 2). This indicates that the conditions for the synthesis of such a material are easy to reproduce in the laboratory. The CO$_2$ formed in three different crystalline structures depending on temperature (Fig. 2). This suggests a variability of the properties of CO$_2$ ice that are possibly present on Mars.

![Image](image.png)

**Figure 3.** 4 frames taken with the microscope during one experiment run. The images show different CO$_2$ ice structures that were formed during the run. a) bare plate without ice cover with dark-bright marking to enable contrast estimation; b) crystalline CO$_2$ flakes; c) translucent CO$_2$ slab, note that the bright-dark border is visible through the layer; d) polygons with organized ice crystals.

We estimated the condensation rate of the CO$_2$ via the thickness of the layer that was formed. Due to the low CO$_2$ flux we could only achieve a maximum 2 mm thick ice layer.

**Future work:** The next step of this experimental work is to obtain the optical properties of CO$_2$ slab, mechanical stabilities of the created ice layers and the sublimation rates, all depending on the wavelength and dust contamination levels.

The facilities in Aarhus will be further used for more detailed studies of the condensation and sublimation rates, including runs with various dust inclusions. However the inability to create thicker layers of the CO$_2$ slab is a critical restriction of this facility for our investigations.