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Experimental simulation to analyse geomorphological properties of cometary surfaces with outgassing volatiles

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Abstract

We want to study the development of cometary and other outgassing surfaces of airless planetary objects with analog laboratory experiments on Earth. The focus is on the evolution of different morphologies, taking into account the composition of the sample material and variable insolation flux. Our aim is to understand how different cometary materials interact and how the appearance of cracks and boulders develop during insolation and outgassing.

1. Introduction

A vast amount of image data with previously unknown surface features have recently become available through the Rosetta mission and will be complemented by the Hayabusa2 and Osiris-Rex Missions arriving at their target asteroids this year. The characterization of these features and the understanding how they evolve are tasks that are not completed until now.

The relation of surface features with the volatile content of the host body and the evolution of these features under outgassing conditions is the aim of a set of experiments suggested in this abstract [1].

Here, we present the set-up and parameters of a number of experiments related to the evolution of volatile-rich planetary surfaces. We aim to investigate boulders, crater-like depressions and cliffs composed of volatile rich material. Of particular interest is the formation of new structures and their relations to previous morphological features.

2. Methods

The Simulation Chamber for Imaging the Temporal Evolution of Analogue Samples (SCITEAS) facility is a small thermal vacuum chamber and provides spectral analyses of analogue materials in the visible and near infrared range [2]. In addition to in-situ and remote studies, a direct interaction with the sample material and its residuals is possible. The chamber allows investigations how water ice on small bodies sublimates with respect to the presence of various other materials.

During the analogue experiments we will investigate the influence of the sample composition to the evolving morphology. Here, the content of silicate dust will be considered as well as the distribution of these materials within water ice samples. Previous studies revealed different surface evolutions during sublimation if non-volatile materials are distributed as inclusions within water ice particles (intra-mixture) or if they fill the space between particles of pure water ice (inter-mixture) [3]. Combined with a predetermined morphology (Figure 1), the alterations of the surface during the sublimation process will be characterized.

Of particular interest are the formation of cracks and pits and the conditions under which they would occur on a surface of a comet or an asteroid. To simulate processes that correspond to the local conditions on a rotating body, the insolation should be realized in intervals and from different angles to the surface.

Following direct observations on small bodies and previous analogue experiments with SCITEAS and the KOSI project [4], a number of parameters were selected and predetermined most realistic before the experiments start (Table 1). During the experiments these parameters will be monitored and analyzed in detail after the experiment has ended.

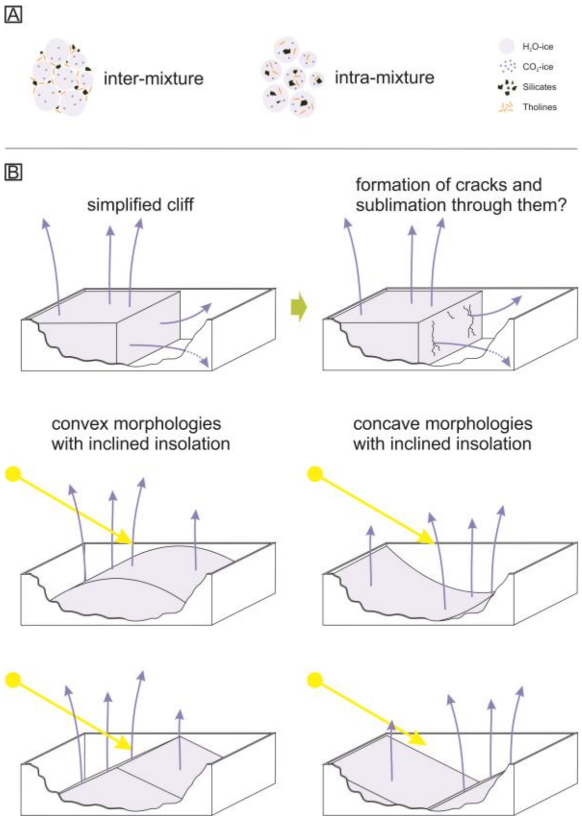

Figure 1: A) A schematic view of different mixtures of water ice and accessory materials. B) Some simple morphological features in the sublimation chamber as analogue to the surface of a volatile rich body.

Table 1: Predetermined variables with initial values.

Parameter	Initial Value
Material composition	
H_2O content	40-90 %
Dust content	10-60 %
Org. content	0.1-0.5 %
Material properties	
Porosity	70-80 %
Grain size	5-67 µm
Insolation properties	
Insolation period	6-13 h
Insolation flux	200-900 W/m^2
Background temperature	180-210 K

3. Objectives

To achieve a better understanding of the evolution of cometary surfaces the planned analogue experiments will help to answer the question what the influence of initially different morphologies to their development is and how long initial structures are stable until they disappear under given volatile content. Furthermore, it is of interest what new structures form during the sublimation of volatiles and if the formation of fractures or cracks is related to specific morphologic features. Also the periodicity of insolation may have an influence to the surface evolution.

To achieve these objectives a subsequent analysis of the residual material is essential. It has to be clarified to what extent the bonding forces of the residuals change and up to what static stress they form stable structures. The gained results will finally help to generate a vertical profile in dependence of material composition, insolation, and initially morphology.

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