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Pre-Rosetta expectations on small scale surface characteristics of Comet 67/P Churyumov–Gerasimenko

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Abstract

The similarity between the findings of Deep Impact on comet Tempel 1 and our experimental findings on large samples of an agglomerate of 200 µm grains of amorphous gas-laden ice shows that laboratory simulation of “cometary ice” is a valid approach. The expectations on various surfaces characteristics obtained by the laboratory simulations are discussed.

1. Introduction

At the time this lecture is being delivered (Sept. 2014), we should already have excellent images of large scale features on comet P/67 CG, obtained by the Rosetta spacecraft. Yet, small scale features, on the order of cm will have to await the landing of the Philae probe in November 2014. Nevertheless, we can suggest some small scale surface features based on laboratory simulations of large samples of “cometary” ices. In the Comet Simulation Laboratory at Tel Aviv University, 20 cm diameter and up to 10 cm high samples of an aggregate of 200 µm grains of gas-laden amorphous ice were irradiated by an IR flux of ~1 solar constant [1].

2. Experimental Results

The density of our gas-laden ice samples is 250-300 kg m^{-3}, as compared with the findings of Deep Impact on Comet Tempel 1 (620+470/-330) [2]. Its thermal inertia is I=80 $WK^{-1}m^{-2}s^{1/2}$ as compared with I<100 for Tempel 1, and the tensile strength is 2000-4000 Pa, while for Tempel 1 a value 65 Pa was calculated [2]. Both are very fluffy, and have a very small mechanical strength like talcum powder (fig. 1). Yet, after the ice sample is heated from above, back migration of water vapor beefs up the upper ice layer, forming a crust about 20 times harder (fig. 2)[3].

Ice grains are driven by gas flow from below in a pristine, crust-less, ice samples which cover the ice by a fine powder (fig. 3) [4, 5], similar to the smooth terrains detected on comet Temple 1 [5]. However when a harder and less penetrable ice crust is formed, the ice bulged, and finally cracks and ruptures (fig. 4) forming a shattered terrain (fig. 5).

3. Figures

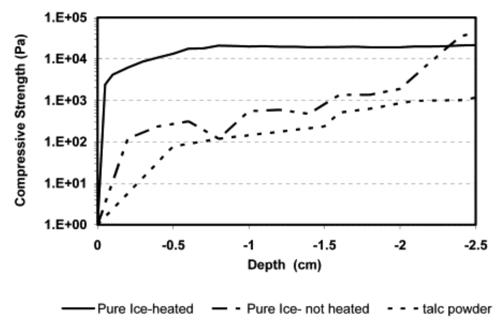

Figure 1: Compressive strengths of irradiated and not irradiated ice samples and that of a sample of talcum powder [2, 3].

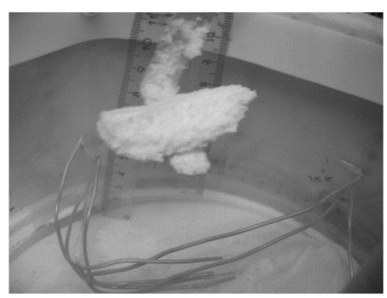

Figure 2: An ice crust which was removed from the top of a several cm thick ice sample, warmed by 1.1 solar constants for 1.5 h. Note the rugged ice structure [3].

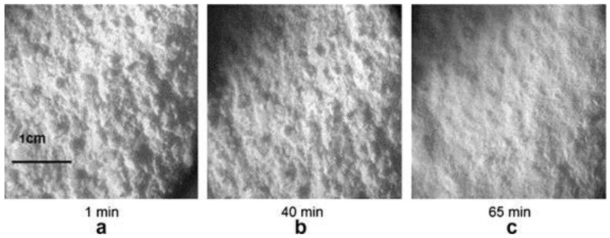

Figure 3: A sample consisting a 1 cm layer of frozen CO_2, between two 1 cm layers of ice. Upon heating, the CO_2 sublimates, spewing a huge number of ice grains which cover the entire sample. At the beginning of the heating process (a) small ”craters” in the ice layer were already existing which were covered by very small grains at a rate of 0.13 mm^3/min (b and c) [3].

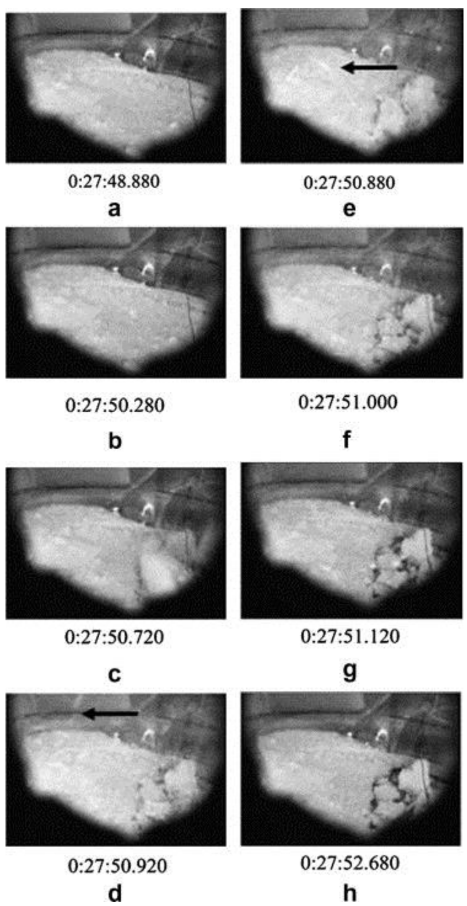

Figure 4: Time sequence of swelling (c), breakage (d and e), and collapse (f–h), in 1.5-cm-thick ice samples having a crust. The magnitude of the collapse is best seen in (h). Streaks of ejected ice grains are marked by arrows in (d and e) [4].

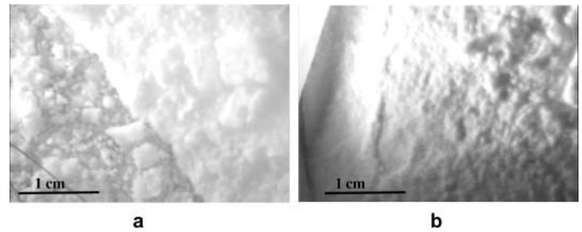

Figure 5: Shattered terrain from the collapse of the ice is seen in (a). An oval crater is seen in (b) [4].

6. Summary and Conclusions

The small scale surface characteristics which will be encountered by the Philae lander can be simulated by laboratory experiments on large samples of an aggregate of 200 µm amorphous gas-laden ice grains. In November 2014, we would be able to compare our experimental prediction with the real surface of comet C-G.

Acknowledgements

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