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Bowl shaped features on comet 67P/Churyumov-Gerasimenko as a test of cometary material properties

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Abstract

1. Introduction

Comet 67P/Churyumov-Gerasimenko shows a large variety of circular structures such as pits [1], elevated roundish features in Imhotep [2], and a single bowl shaped feature in the Ash region [3]. Analyzing images of the OSIRIS camera gives a set of characteristics of these features that need to be explained by models for cometary formation and evolution. Using the iSALE code [4, 5], simulations of impact experiments into a cometary analogue material have been performed to investigate the plausibility of an impact origin of these features.

An additional impact experiment has been performed by the touchdown of the Philae lander in Agilkia. The depressions left by the impact give an opportunity to test our understanding of the material parameters at the very surface of the comet.

1.1 Modelling impacts into cometary material

Parameterizing the cometary material is the principle challenge of impact simulations. A number of material properties have already been derived from observations, as e.g. an extremely low tensile strength of only a few Pa [6, 7] for boulders as well as the consolidated material in cliffs, and a shear strength of a few tens of Pa [7]. The least constrained at the moment is the compressive strength: While Groussin et al. [7] derived a value of 30 to 150 Pa for the compressive strength on large scales such as cliffs, on the local scale the Philae lander experiment SESAME/CASSE finds a much higher compressive strength in the MPa regime [8]

Exploring the parameter space of strength and impact velocity, we found that only the bowl shaped depression in the Ash region can be directly linked to impact processes. Other features, such as the prominent pit structures and the elevated circular features found in Imhotep can in principle be explained by impactors, but only if additional evolutionary processes are considered, making it complicated to infer cometary material properties using these events.

The bowl shaped features, on the other hand, can be linked directly to impact processes. In this work, in a series of numerical impact experiments we try to recreate the shape and size of these features. This can be used to narrow down the range of plausible strength values and the compaction curve of the highly porous cometary material. Additionally, these values are cross checked by recreating the depressions left by the Philae lander on its touchdown, using the Philae lander as a validation experiment.

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