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EVOLUTION OF PITS AT THE SURFACE OF 67P/CHURYUMOV-GERASIMENKO

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Abstract. We investigate the evolution of pits on the surface of 67P/Churyumov-Gerasimenko by thermally-induced processes, under the current illumination conditions. We compute the total energy received at the surface of a 125k-facet 3D shape model of the nucleus, including contributions from direct insolation, shadowing, and self-heating. These surface conditions are then used in a 1D thermal evolution model, which we run for 10 orbits for all facets of the studied pits. We find that pits tend to become larger and shallower with time: in other words, cometary activity tends to erase sharp morphological features. We also find that erosion achieved after 10 orbits cannot contribute to forming the pits as observed today. It is, therefore, very unlikely that they were formed by progressive erosion on a Jupiter-Family Comet orbit.

Keywords: Comets, 67P/Churyumov-Gerasimenko, pits, energy model, thermal model, erosion

1 Introduction

Pits ranging from tens to a few hundred meters were observed on the surface of 67P/Churyumov-Gerasimenko (hereafter 67P Vincent et al. 2015). Several studies have investigated the formation and evolution of these features (e.g., Vincent et al. 2015; Guilbert-Lepoutre et al. 2016). Using the 3D shape model of 67P's nucleus obtained from the *Rosetta*/OSIRIS images (Preusker et al. 2017), our study aims to understand how the progressive erosion due to cometary activity might have affected their morphological characteristics through time, and whether this process could be their formation mechanism.

2 Modeling the thermal evolution and erosion of 30 pits during 10 orbits

We study the thermal behavior of 30 pits (and alcoves) during 10 orbits to assess whether they could be formed by progressive erosion under current illumination conditions. For this, we consider a high-resolution shape model of the nucleus, composed of 125k facets (Preusker et al. 2017), allowing the study of several facets for each pits (bottom and walls). We compute the illumination conditions, considering shadowing and self-heating, for a full orbit, with a time step of ~ 8 min. For each facet, these conditions are the surface boundary condition of a 1D thermal evolution model that includes heat conduction, phase transitions, gas diffusion, erosion, and dust mantling (Lasue et al. 2008).

3 Erosion sustained as a result of thermal evolution over 10 orbits

- Our simulations show that direct insolation is generally the main activity driver. Yet, self-heating is not negligible for deep pits and regions shadowed by the small lobe, thus receiving energy from it.

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- The total flux received per orbit is crucial to understand the behavior of activity, but so is the flux received at perihelion. Since activity occurs predominently around the perihelion period, there is an important North-South dichotomy in the activity and erosion patterns (**Fig. 1: left**).
- Cliffs and walls receive more energy than pit bottoms, and thus erode more (**Fig. 1: right**). With time, pits would tend to become wider and shallower.
- Erosion achieved after 10 orbits does not reach the size of pits as observed by *Rosetta*. It is, therefore, doubtful that activity during the recent JFC period was able to produce them.

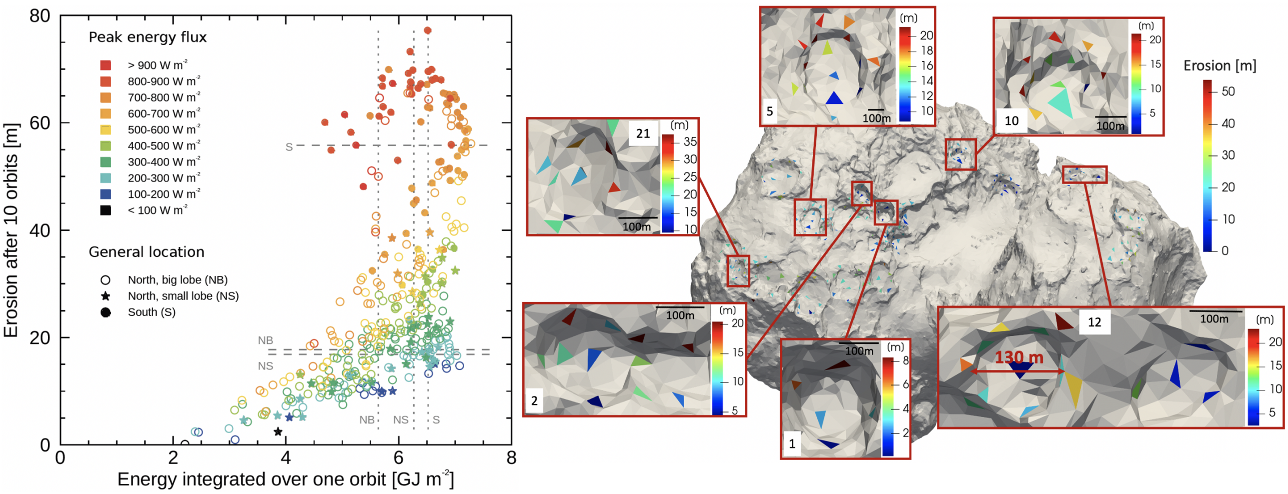

Fig. 1. Left: Erosion of the studied facets as a function of the energy received per orbit; dotted lines show the median of this energy for: the small and big lobes on the Northern hemisphere, and the Southern hemisphere; dashed lines show the median of erosion. The color code provides the peak energy, received close to perihelion. **Right**: Local examples of erosion achieved after ten orbits, highlighting differential erosion and flattening trends.

4 Conclusions

We investigated the thermal evolution of 30 pits at the surface of 67P with the aim of understanding their morphological evolution and origin. We found that pits are likely erased with time rather than formed by progressive erosion. As a corollary, we find at the surface of 67P examples of pits that are remarkably preserved. Thermal processing during the JFC phase might not be the formation mechanism of these features. Consequently, they might have existed prior to the current JFC period of 67P. A comparison with the thermal behavior of surface pits on other JFCs with different dynamical histories (81P/Wild 2, 9P/Tempel 1, and 103P/Hartley 2) would help us better understand the formation mechanism of such features.

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