NAVCAM OBSERVATIONS OF THE HATHOR CLIFF AND HAPI AREA ON THE NUCLEUS OF COMET 67P/CHURYUMOV-GERASIMENKO.

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Introduction: This work is based on the analysis of images taken by the Navigation Camera (NavCam) of the Rosetta spacecraft at a resolution of 0.7-3 m/px. Our aim is to study geological processes in specific parts of the 67P nucleus, the Hathor cliff and the Hapi region. The used names of features and regions are from [1]. The analysis showed evidence of several types of downslope movement of the nucleus material and is the major topic of this work. Comet 67P belongs to the Jupiter family [2]. Its nucleus is ~4 km across and has a bilobate shape with a smaller lobe known as the Head, the larger lobe known as the Body, and the bridge between them known as the Neck. The steep Head side slope of the Neck depression is the Hathor cliff and the depression floor is called the Hapi area (Figure 1).

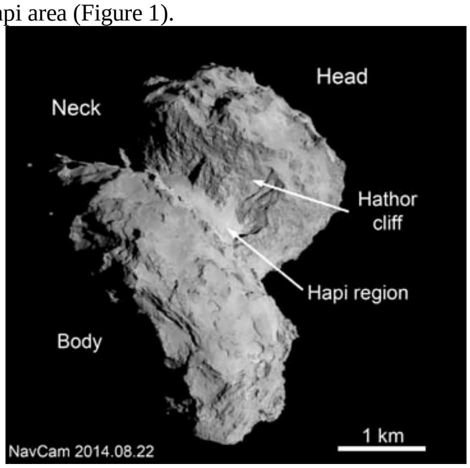

Figure 1. The nucleus of comet 67P.

Description and analysis: It was shown that in the lower part of the Hathor cliff there is a bulge (Figure 2) whose morphology, position on the slope and comparisons with what is observed on other bodies suggest that it may be the body of a landslide. On the cliff a linear feature was identified whose morphology and orientation suggest that it is a tension fracture (Figure 3). If so, its presence implies an extensional environment that agrees with the interpretation of the bulge as a landslide body. On the cliff the downslope lineaments are observed whose positions, orientations and comparisons with the features seen on steep slopes of other bodies, suggest that they may be scars produced by the downward moving boulders and durable parts of landslides. Subhorizontal lineaments also observed on the cliff could be indicators of a layering in the nucleus material (see part Layering in [3]).

The surface of the Hathor cliff looks populated with knobs whose sizes are in the range of a few meters to 10's of meters in diameter. This may be due to the inhomogeneity of the nucleus body material with more durable and less durable parts of the scale of the visible knobs. Formation of the knobby surface texture could be supported by thermal shocks, considering that diurnal temperatures vary over more than 100 K with rates of 2 to 5 K. This agrees with the knobby appearance of the surface of the boulders seen in the NavCam (Figure 4) and ROLIS images (knobs of meters to decimeters across) and may imply the fractal inhomogeneity or thermal fractioning of the nearsurface nucleus material.

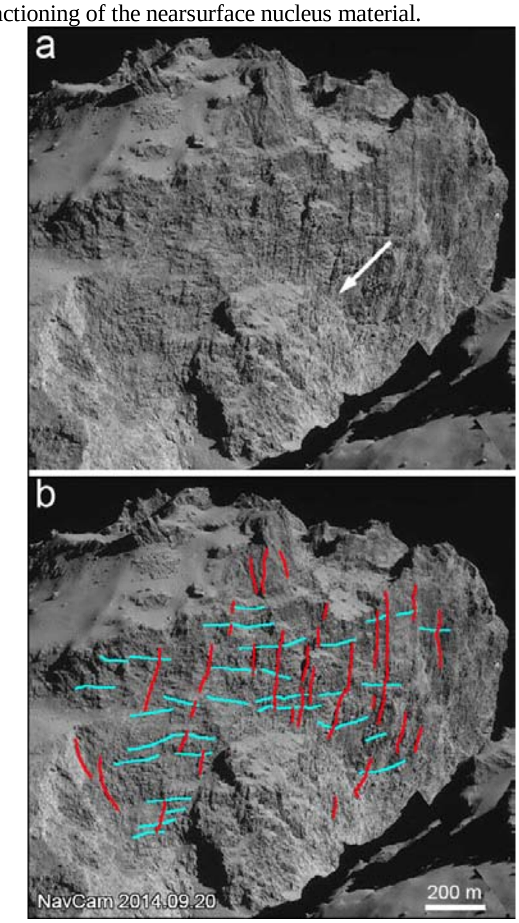

Figure 2. a) Image of the Hathor cliff with the landslide body (arrow). b) The same image with turquoise and red lines designating downslope scars and possible subhorizontal layering, correspondingly.

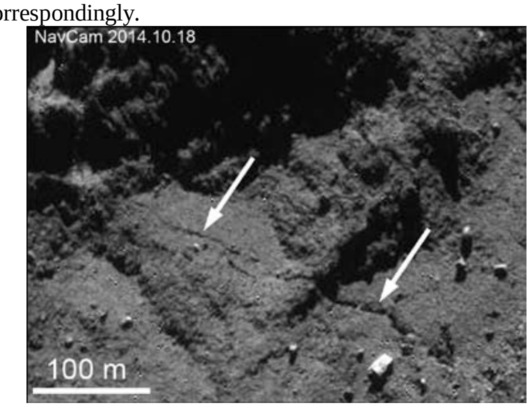

Figure 3. Tensional fracture at the flank of the Hathor cliff.

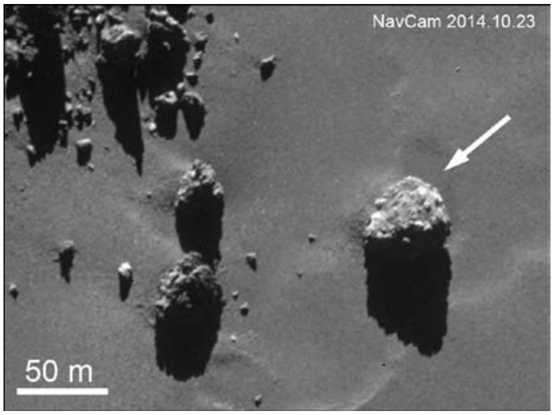

Figure. 4. Boulder Cheops of ~45 m across at the Body lobe at Imhotep.

The Hapi floor is covered with relatively bright fine material whose texture is typically below the image resolution (Figure 5). In the middle (axial) part of the Hapi area there is an elongated cluster of large (20-50 m) boulders. Towards the Hathor foot the boulders look significantly buried by the fine material which dominates at the boundary with the cliff foot and looks as if it is ascending. This may suggest that the Hathor cliff is the source of both boulders and fine material; however, the supply of the fine material and its accumulation close to the foot is greater than the supply of boulders. At a distance the fine material accumulation was less effective and in the area of the cluster of the large boulders it was not enough to essentially bury them.

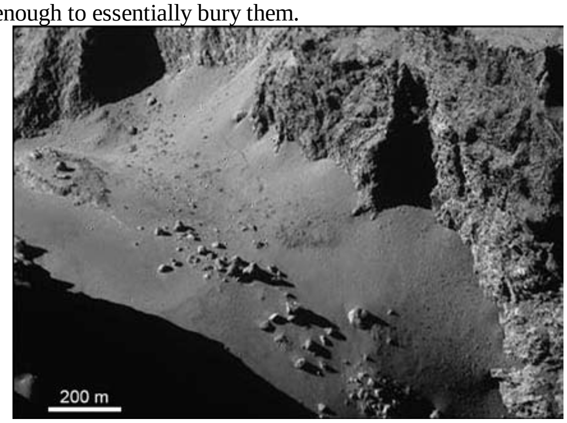

Figure 5. Surface of the Hapi region adjacent to the Hathor cliff.

From the elongated cluster of large boulders towards the foot of the anti-Hathor slope a surface of fine, bright material is seen (Figure 6). The absence of the transitional zone of partly buried boulders at this part of the Hapi floor may suggest that fine material comes from this slope but not the boulders. This may be due to the fact that the anti-Hathor slope (Seth region) consists of a series of terrace-like steps. The boulders are probably mobilized on the slopes of the terraces but the heights of the latter are not high enough to provide the boulders with the necessary acceleration for their long-distance travel down to the Hapi floor and to distribute them to their final destination.

At the anti-Hathor part of the Hapi floor a relatively bright fan-looking feature is seen (inlet in Figure 5), originating from the gap between the two terraces.

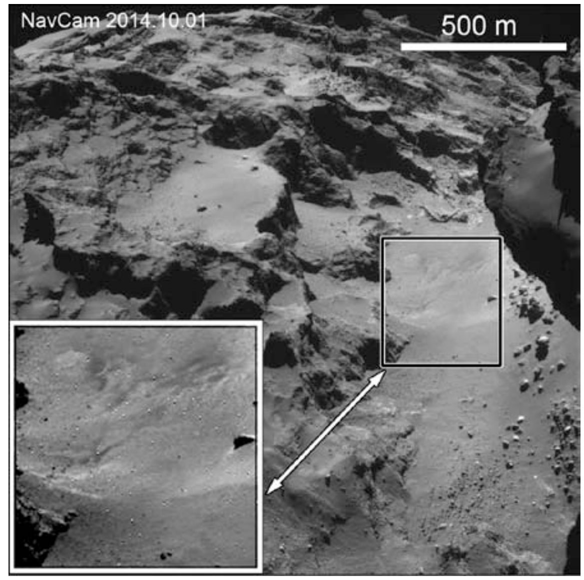

Figure 6. Surface of the Hapi region adjacent to the anti-Hathor slope of the Neck depression. Inlet shows details of the flow-like feature.

The feature is seen in the images taken with the 39 terrestrial days time interval, at different perspective views, so that the feature outlines are skewed but nevertheless recognizable. The fan-like morphology of the feature may suggest its formation by a kind of flow resembling the downslope movement of the pyroclastic flows, snow avalanches or turbidity current seen on Earth. Alternatively, this fan-like feature could be formed due to partial delation by the “subhorizontal” gas jet. If any of these suggestions are correct, then a «flow» of fine material may be one of the mechanisms of its distribution along the nucleus surface.

Conclusions: 1) On the surface of comet 67P’s nucleus three kinds of materials are seen: a) consolidated material outcropped at steep slopes, b) boulders composed of this consolidated material, and c) friable “fine” relatively bright material seen on the subhorizontal surfaces. 2) Despite the very low surface gravity, high steep slopes on the nucleus are an arena of the downslope material movement in the form of landsliding, mobilization, and falling down of individual boulders, as well as mobilization and pouring down of fine material. 3) The latter in some situations seems to be able to move collectively as a flow producing fan-like features. 4) The aforementioned geological processes seem to be initiated and supported by sublimation of volatile component(s) of the nucleus material and thus should be most active on the southern hemisphere when the comet is close to the Sun. The role of meteorite impacts should also be considered.

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References: [1] Thomas N. (2015) *Science* (in press). [2] http://ssd.jpl.nasa.gov/sbdb.cgi?sstr=67P. [3] Basilevsky A.T. and Keller H.U (2007) *Solar System Research*, *41*, 2, 109-117.