Evolution of the Imhotep Basin on Comet 67P/Churyumov-Gerasimenko

Abhinav Jindal¹, Alexander Hayes², Samuel Birch², Orkan Umurhan³, Jean-Baptiste Vincent⁴
¹Cornell University, ²Massachusetts Institute of Technology, ³NASA Ames, ⁴DLR Berlin

Correspondence: Abhinav Jindal (asj59@cornell.edu)

2. Changes in the Imhotep Basin

We track the temporal evolution of 12 scars (‘a’ through ‘l’) in Imhotep for a period of eight months from May 24th, 2015, to January 23rd, 2016 (Fig 2). Rosetta’s first image of the Imhotep basin showed a landscape of smooth terrains with several scars (e.g. scars ‘a’, ‘b’, and ‘c’) which we interpret as remnants of erosional processes occurring during 67P’s previous perihelion passage.

The first changes in the region are observed on June 5th, 2015, and the terrain continues to get modified until November 29th, 2015, when no more changes are detected in this region down to the decimeter scale in the Rosetta data. During this period of observation, we find that scars ‘a’ and ‘c’ are first seen falling upon the cliffs in the western part of the basin.

Most of the scars we observe move at speeds of the order 10cm per day - consistent with the predictions from Blum et al. (2020) for similar features inIraq imply changing jet fractions within the regolith. Based on the patterns observed in the movement of the scars, we have divided the activity in Imhotep into two major parts:

(i) The activity that starts before July 1st, 2015, and (ii) The activity that starts after July 1st, 2015.

3. Sediment Budget for Imhotep

We generate Digital Terrain Models (DTMs) using the photocalinometry technique described by Tune et al. (2019) in order to measure values of net erosion/denposition in different regions of Imhotep and create a sediment budget.

- We use landmarks that have a measurable relief as a baseline for measuring changes in the thickness of the surface regolith.
- We assume that the largest boulders and exposed cliffs are stable, and that smooth terrain material can either erode or deposit around them.
- We choose 5 sub-regions within Imhotep (Fig 5) such that each region encompasses at least two boulders lying in the smooth terrains.
- In order to measure the total erosion/denposition we choose two Rosetta images containing one of our sub-regions of interest:
  - one from September 2014 (the early phase of the mission)
  - another from June 2016 (near the end of the mission).
- We then make DTMs for each of these images, calculate the erosion/denposition, and one another using a 3D affine transformation applied on boulders that are visible in each image.

Our results show that regions ‘A’, ‘D’, and ‘E’ each receive a net deposition of material over the course of the mission, while regions ‘B’ and ‘C’ show net erosion. Our DTM generation procedure fails to converge for patch ‘C’, and even though we are unable to get a total value of erosion, the emergence of buried boulders still confirms that the region undergoes net erosion.

The significant difference in the total amount of material eroded from or deposited to regions in close proximity (~300m) to one another suggests that material transport is significantly affected by local processes.

4. Future Work & Conclusions

- Our observations of scar migration on 67P suggest that erosion and deposition indeed follow the broad trends predicted by Keller et al. (2017) and quantified more precisely by Davidson et al. (2021), where depositional occur in the north during perihelion.
- Scars begin to migrate in the northern region of the basin and then extend across the entire basin as 67P approaches perihelion. The migration we observe, and the ice fraction we predict, is strikingly similar to those in Iraq, suggesting a common mechanism that erodes and deposits smooth terrains.
- However, models do not predict such localized net erosion and deposition on 67P, as measured by our DTMs, and confirmed by analyses of the images. Thus these five regions, separated by only a few hundred meters, exhibit such different denositional histories is a surprising finding, one that hints at significant local transport of materials.

Exactly how such material is transported is left to follow-up studies.

This research is supported by a Rosetta Data Analysis Program grant 80NSSC19K1307. We would also like to acknowledge the Principal Investigator of the OSIRIS camera on ESA’s Rosetta spacecraft, Holger Sierks, and the ESA Planetary Science Archive for the data used in this study. This research has made use of the scientific software Map10View (www.comet-toolbox.com).