Hartley 2: Landing sites of particles ejected from the nucleus (#2465.166)

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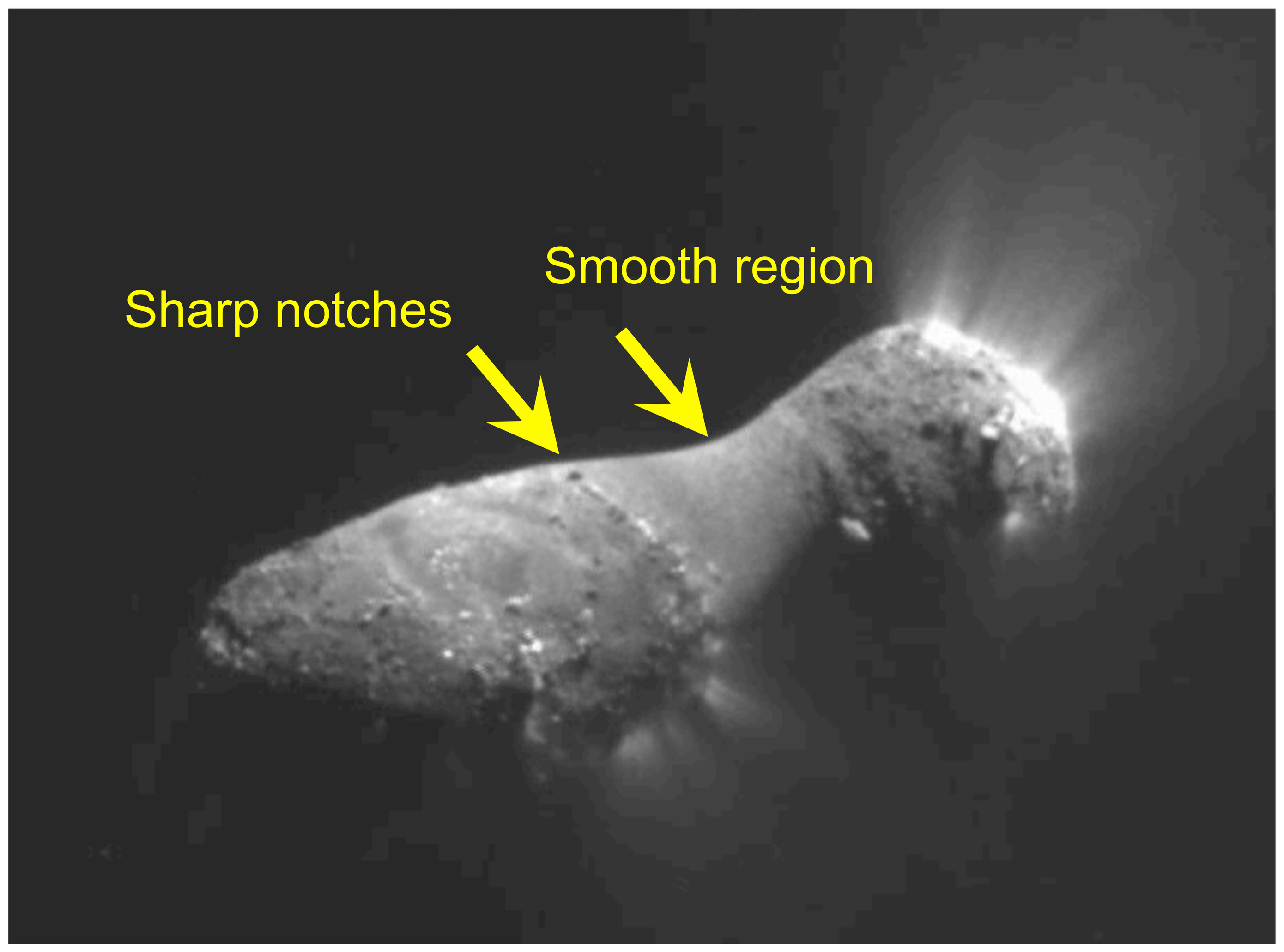
Introduction and Summary:

- Jupiter Family Comet 103P/Hartley 2 contains smooth terrains that are thought to be depositional in nature [1].
- We study the particle dynamics around Hartley 2 to explore where ejected particles are deposited on the nucleus.
- We consider particles ejected from active regions on both Hartley 2's large and small lobes.
- We find that particles do not concentrate in the waist region of the nucleus, but are widely distributed about the nucleus, particularly in potential low areas that limit post-deposition fluidized transport mechanisms.
- We find that while deposition of ejected particles would partially contribute to the formation of the smooth waist, another mechanism is necessary to complete it.

The nucleus of 103P/Hartley 2



(Image: EPOXI mission MRI-VIS frame 5004057 from NASA's PDS)

Methods:

We consider the ballistic motion of a small particle ejected from a rotating nucleus. We solve the following equations:

Rotation of the nucleus

$$\frac{d\boldsymbol{H}}{dt} = \boldsymbol{I}\dot{\boldsymbol{\omega}} + \boldsymbol{\omega} \times \boldsymbol{I}\boldsymbol{\omega} = \boldsymbol{\tau}.$$

Dynamics of a small particle

$$\ddot{\boldsymbol{r}} + \dot{\boldsymbol{\omega}} \times \boldsymbol{r} + 2\boldsymbol{\omega} \times \dot{\boldsymbol{r}} + \boldsymbol{\omega} \times (\boldsymbol{\omega} \times \boldsymbol{r}) = -\frac{\partial U}{\partial \boldsymbol{r}}.$$

Assumptions:

- No interactions between particles.
- Particles stick when they land (no bouncing or rolling)

Particle Ballistic motions:

***Simulation settings* [1,2]**

Bulk density	300	kg/m3
Volume	8.23E+08	m3
Rotation (short)	18.4	hr
Rotation (long)	26.72	hr

We use a degraded version of the Farnham shape model to decrease computation time.

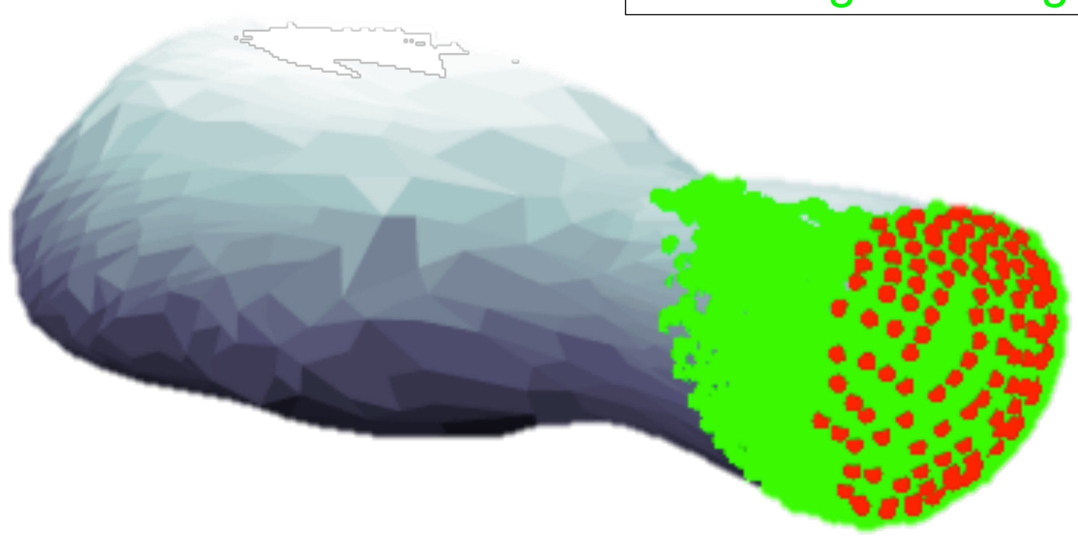
(Credits: Farnham, T.L. and Thomas, P.C., PLATE SHAPE MODEL OF COMET 103P/HARTLEY 2 V1.0, DIF-C-HRIV/MRI-5-HARTLEY2-SHAPE-V1.0, NASA Planetary Data System, 2013)

Small Lobe's active region

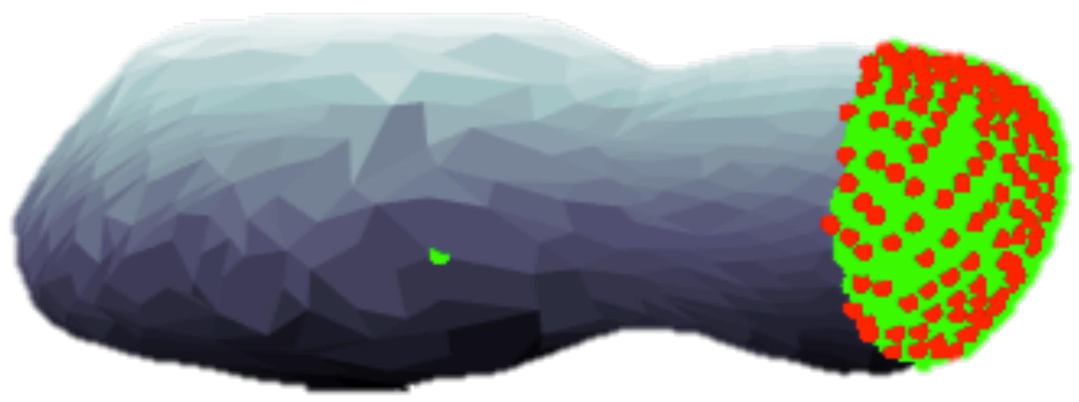
Particles ejected from the small lobe accumulate on the small lobe, some land on the waist

- ejection speed of 0.1 m/s.

- ejection sites in red
- landing sites in green



- ejection speed of 0.2 m/s.

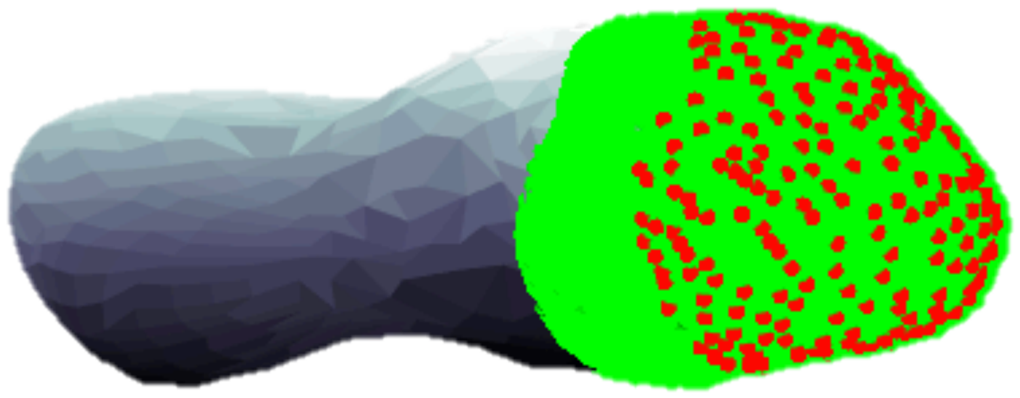


Large Lobe's active region

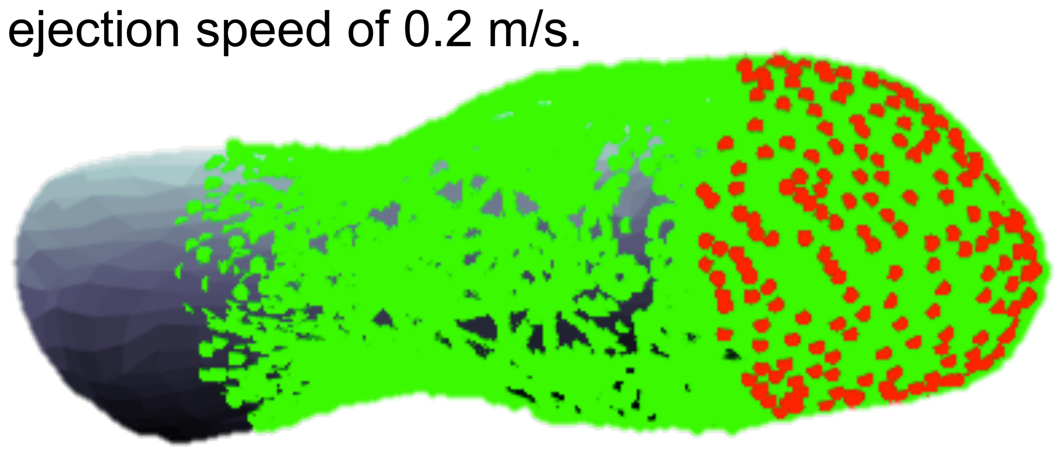
Particles ejected from the large lobe accumulate broadly across the large lobe, waist, and small lobe

- ejection sites in red
- landing sites in green

- ejection speed of 0.1 m/s.



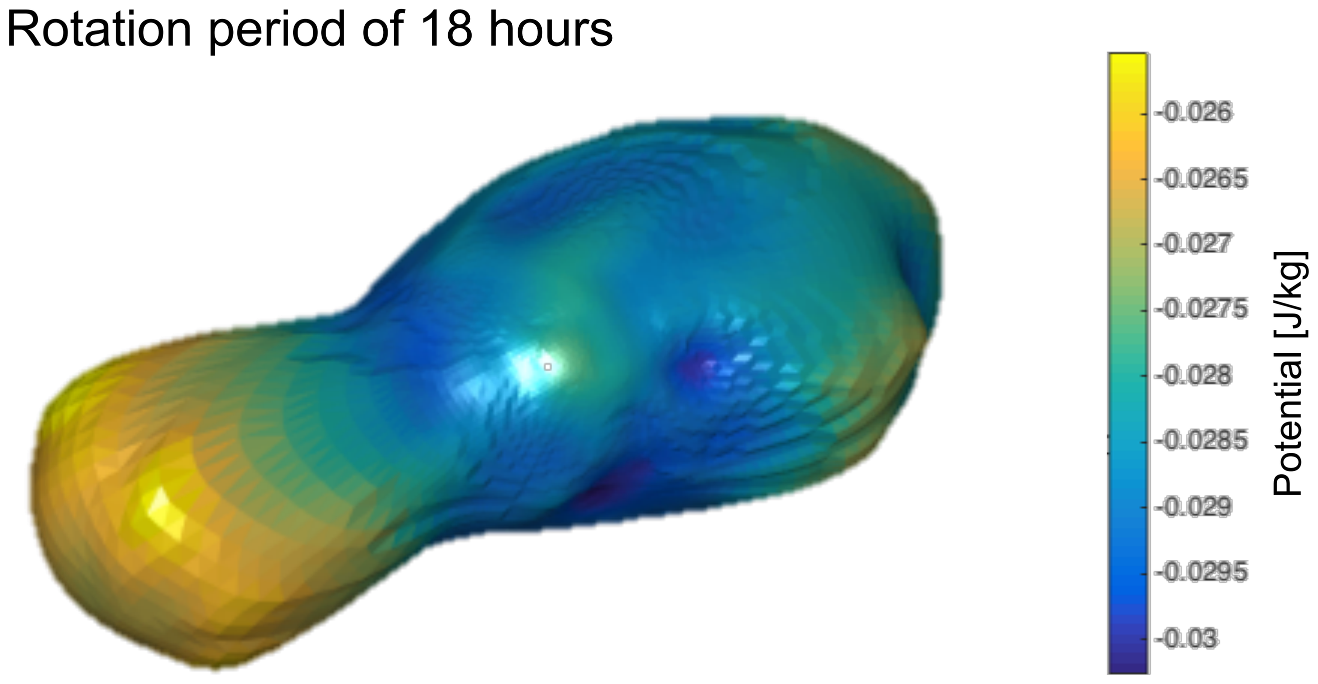
- ejection speed of 0.2 m/s.



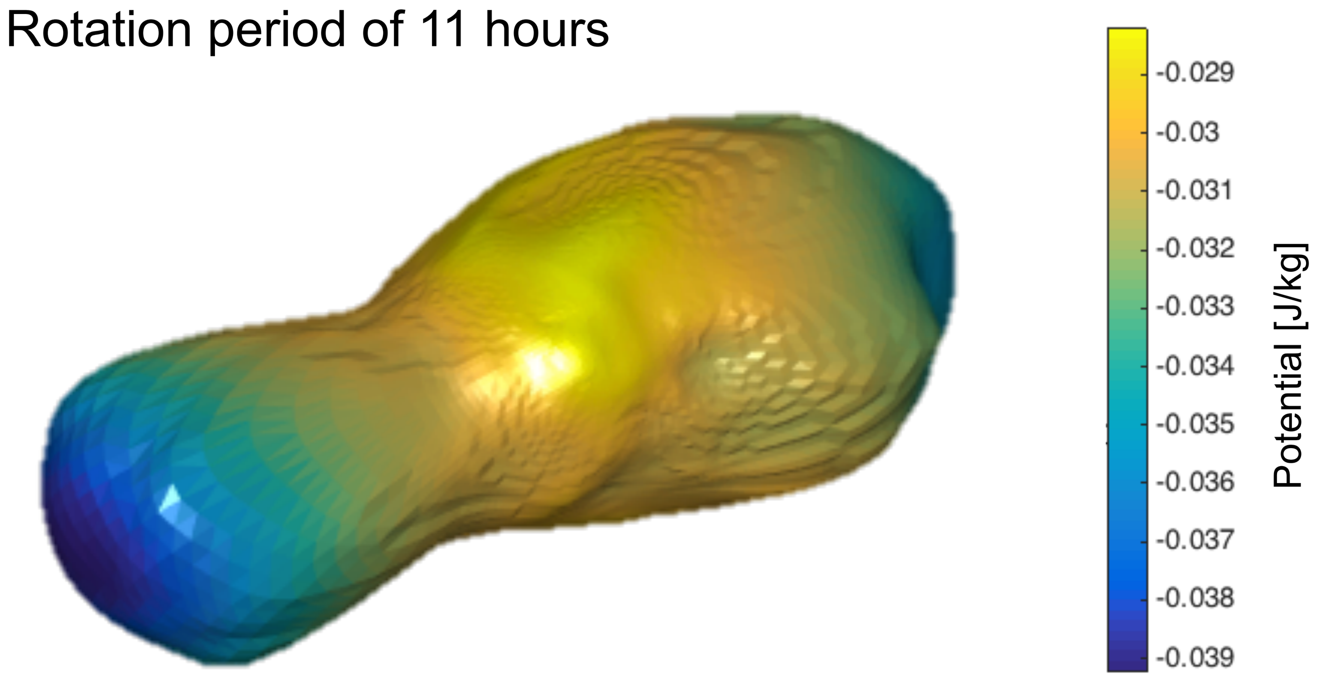
Potential on the surface (uniform rotation):

- Gravitational force can move material down potential gradients (from high to low potential), allowing deposited particles to migrate if they form fluidized flows [3]
- We evaluate the location of low potential regions at two different spin periods, as the nucleus changes its spin state dramatically [2,4].
- We find that, at the current rotation period of 18 hours [1], particles are largely deposited in potential lows, and are therefore unlikely to migrate and form the smooth waist.
- Therefore, the assumption that the waist formed from a fluizeded flow to create an equipotential surface [1,5], may be false.

- Rotation period of 18 hours



- Rotation period of 11 hours



Results and interpretation:

- Particles ejected from small lobe do not contribute to the formation of observed smooth terrains on Hartley 2.
- Particles ejected from large lobe fall equally on both the smooth waist and the semi-smooth Central Mound [5]. However, such deposition would not cause the observed morphological difference between these two terrains.
- Fluidized flows are unlikely to cause morphological difference between smooth waist and semi-smooth Central Mound, as ejected particles land in potential lows, and are therefore unlikely to flow.
- The smooth waist is therefore unlikely to be solely the result of particle deposition, although particles from the large lobe may contribute to smoothing the waist.

Reference: [1] A'Hearn et al. Science 332 (2011): 1396. [2] Belton et al. Icarus 222 (2013): 595-609. [3] Belton and Melosh Icarus 200 (2009): 280-291. [4] Drahus et al. The ApJ Letters 734 (2011): L4. [5] Bruck-Syal et al. Icarus 222 (2013): 610-624.