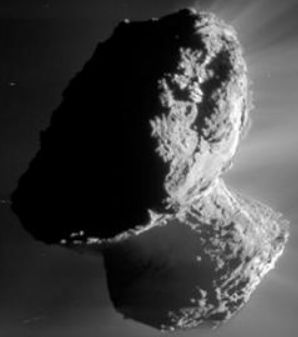

europlanet 2024
Research Infrastructure

Geology & Planetary Mapping
Winter School

Università degli Studi di Padova

Small bodies



Geological and geo-structural Mapping

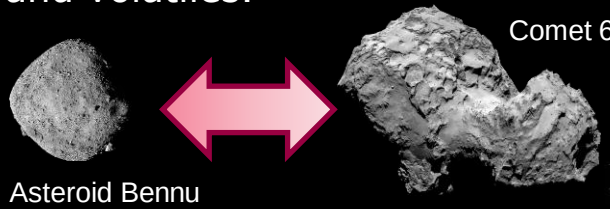
Matteo Massironi

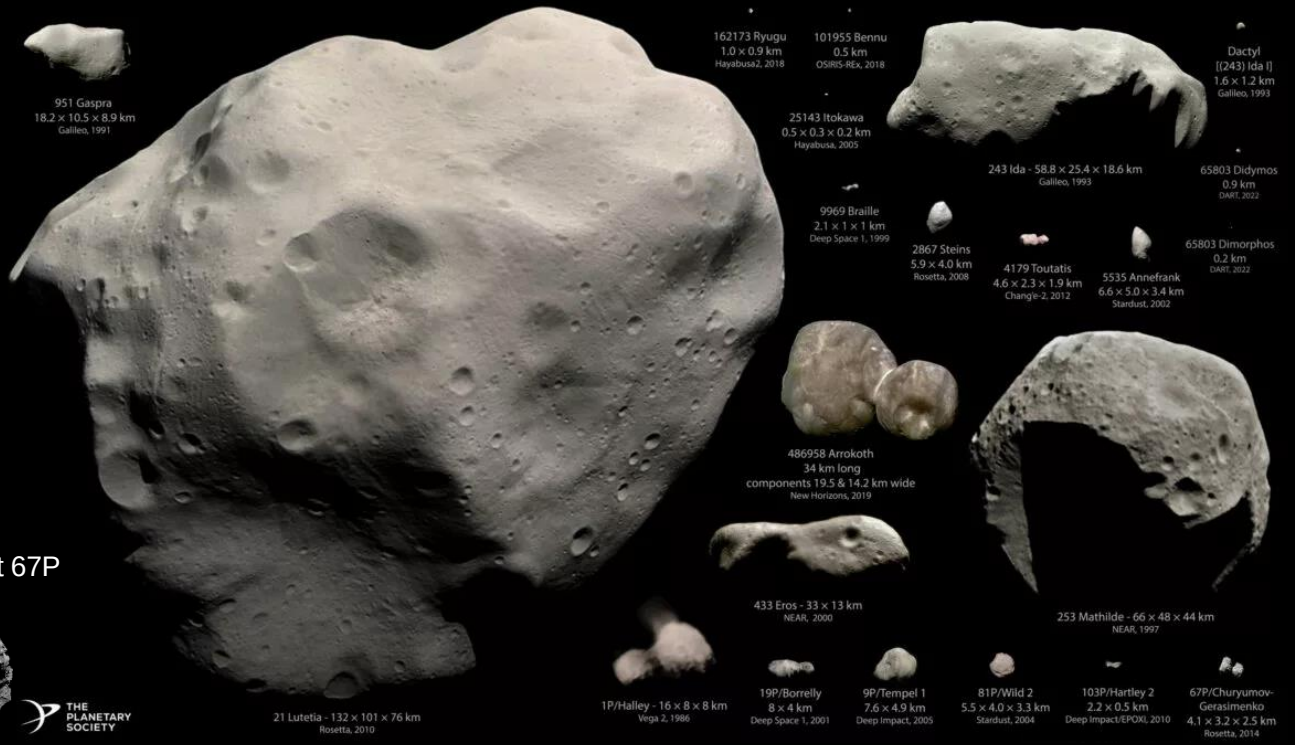
GMAP
Geological Mapping

Small bodies of the Solar System

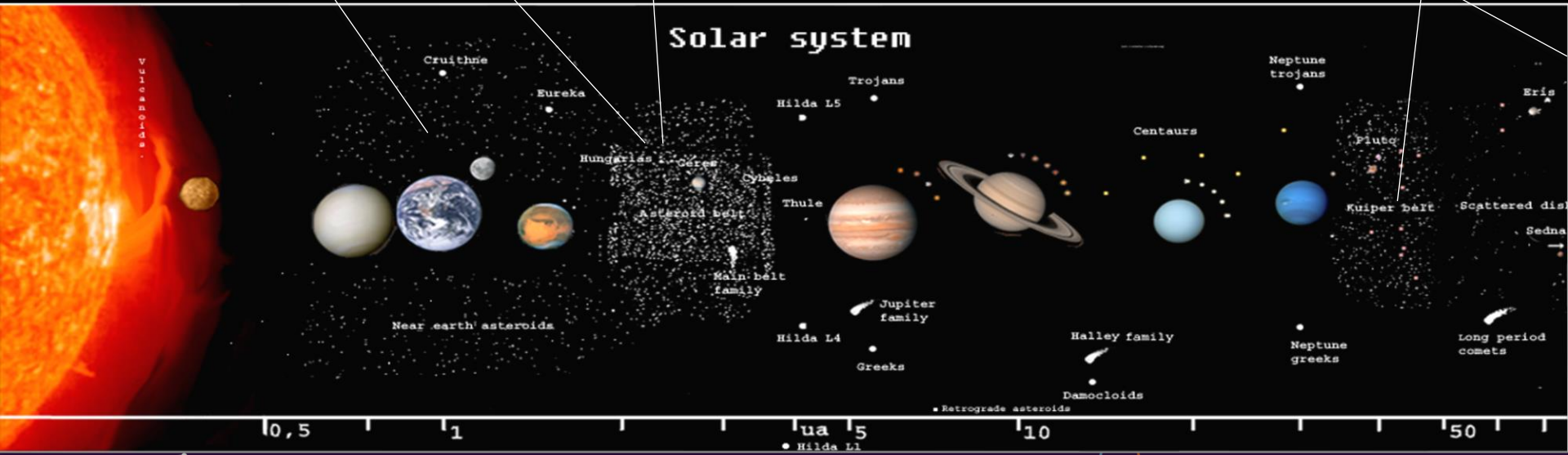
Comets are small bodies with highly elliptical orbits consisting largely of ices but also containing organics, dust and rocky material.

Asteroids largely consist of rocky material but also contain varying quantities of organics and volatiles.



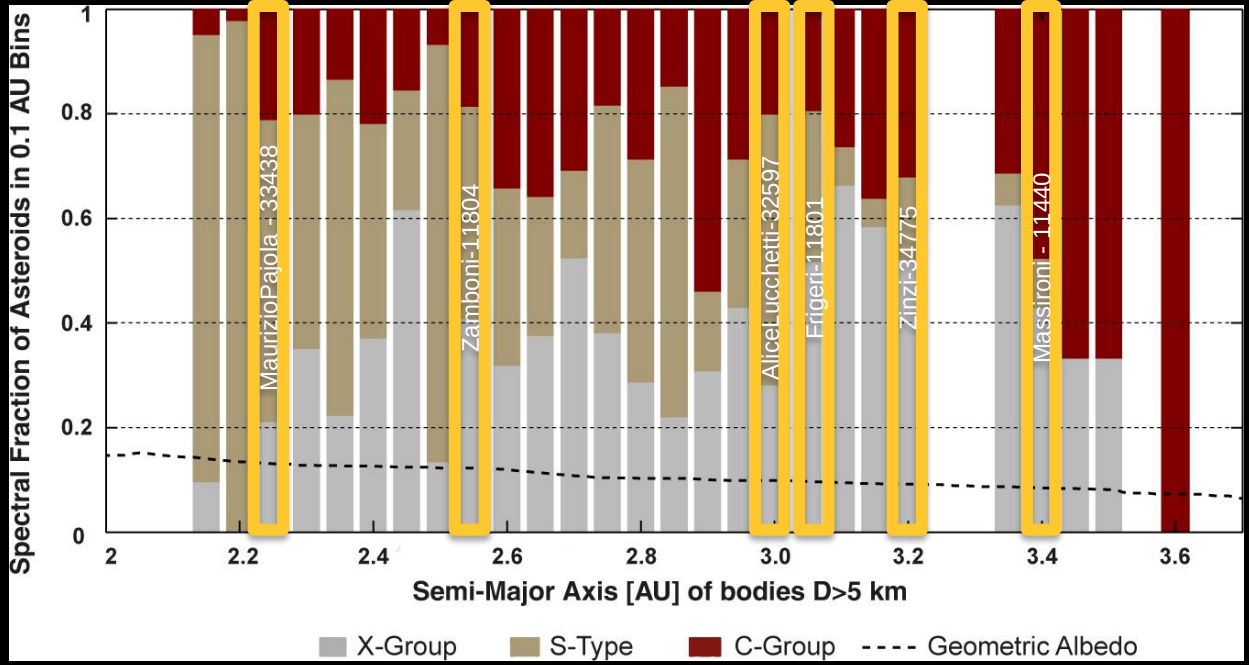


Sources and origin



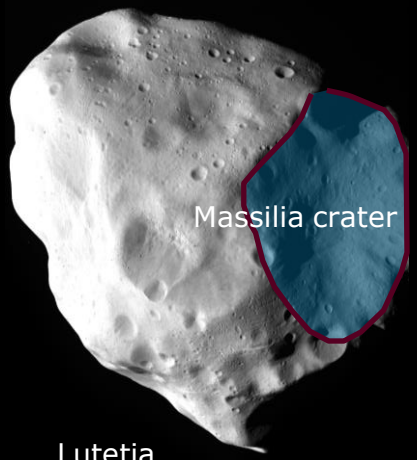
Asteroid Classification

- C-group -> dark carbonaceous objects
- S-group -> silicate stony nature
- X-group -> high abundances of metal

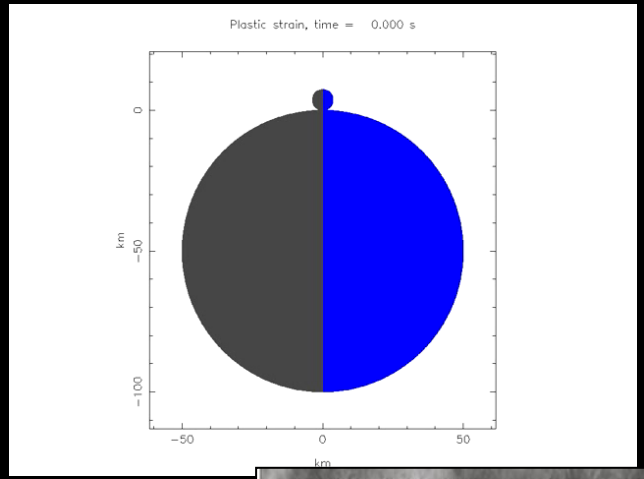


Schmedemann et al. in Rossi and Von Gasselt 2018

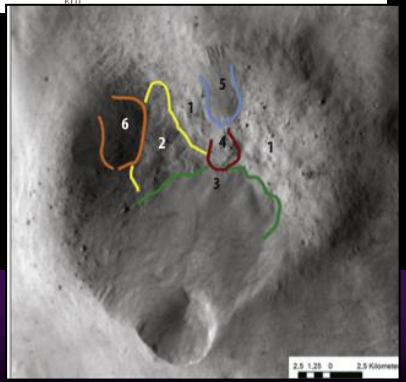
Main landforming processes on asteroids

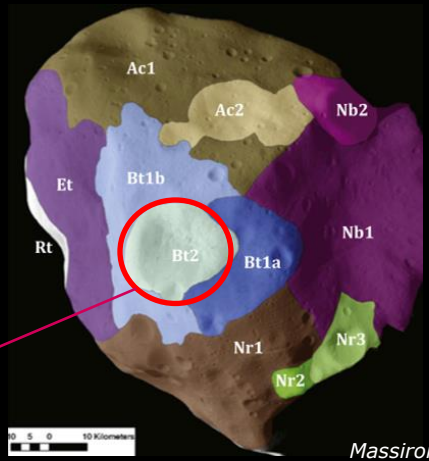


Lutetia

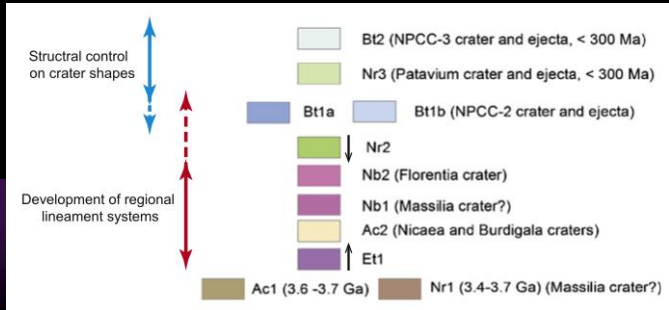


Cremonese et al. 2012

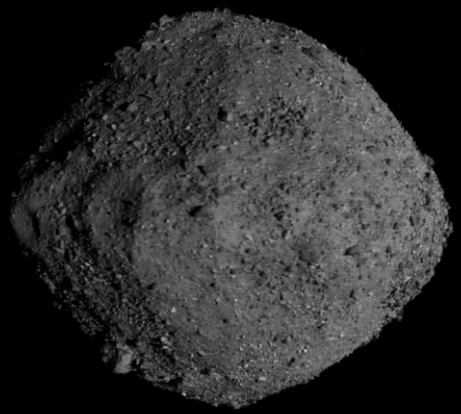




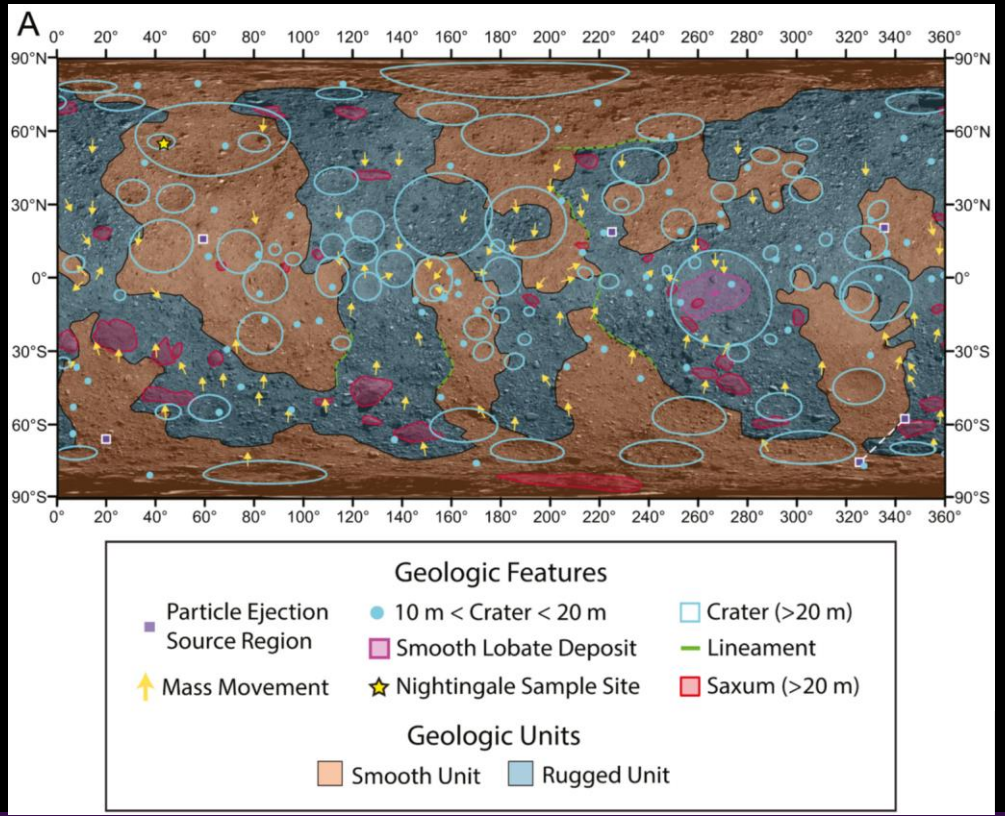
Massironi et al. 2012



Mapping rubble piles

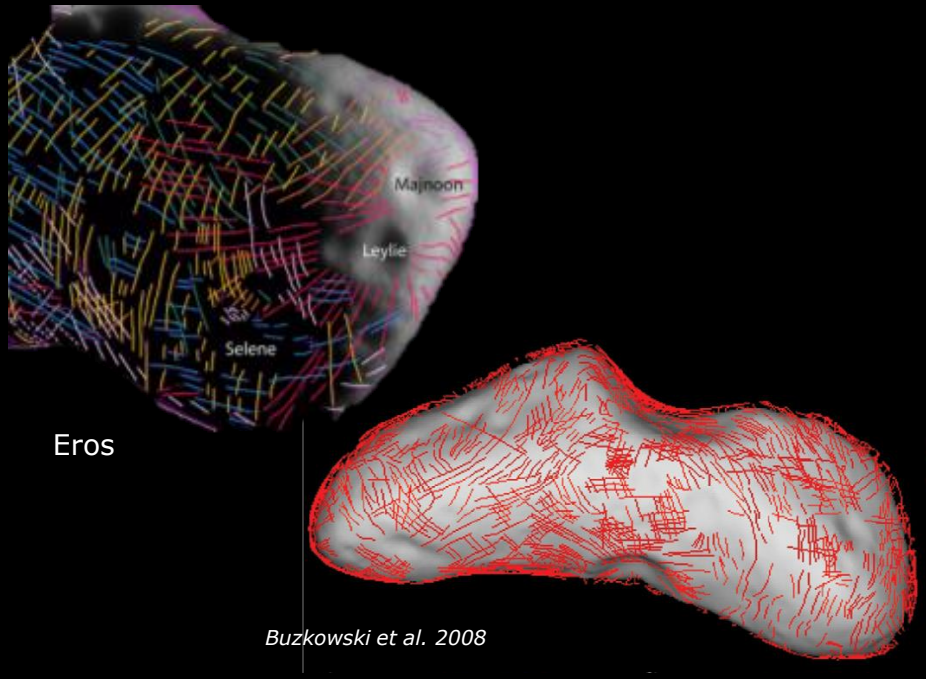


Bennu



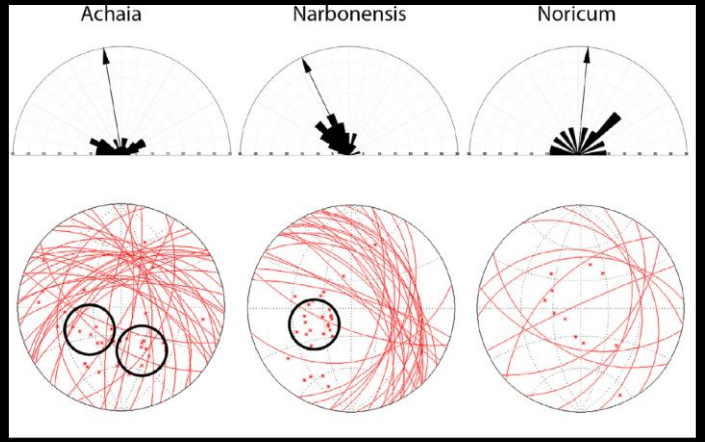
Jawin et al. 2022

Drawing and plotting lineament on small bodies



Eros

Buzkowski et al. 2008

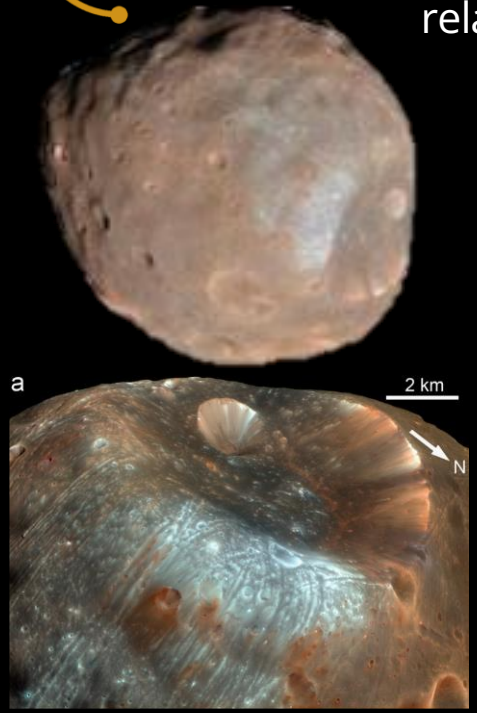


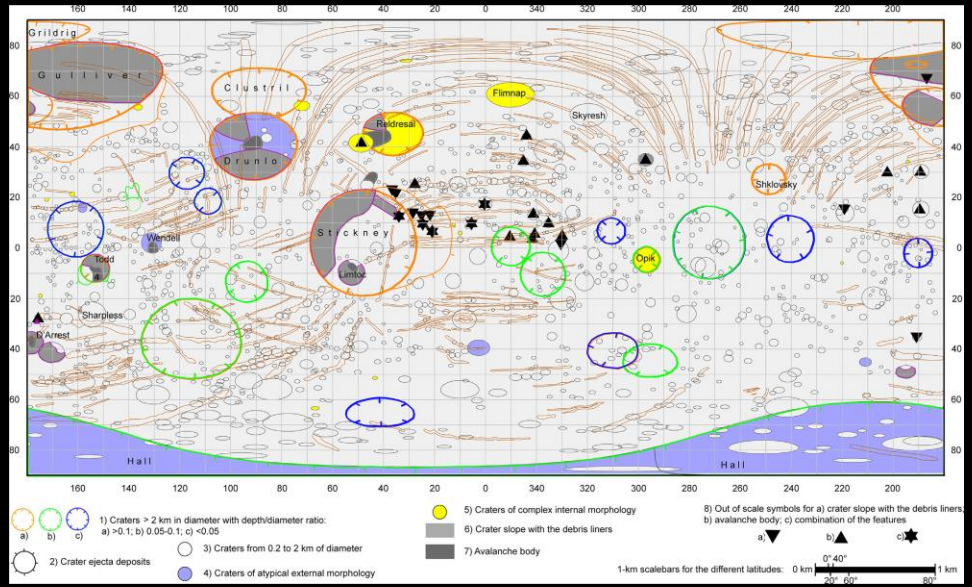
Lutetia

Besse et al. 2014

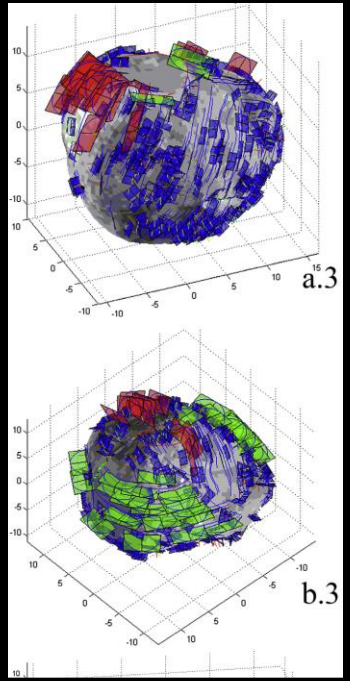
The Phobos case

Although a Martian moon it has the same geological landforms and related mapping issues of any asteroid (small body)

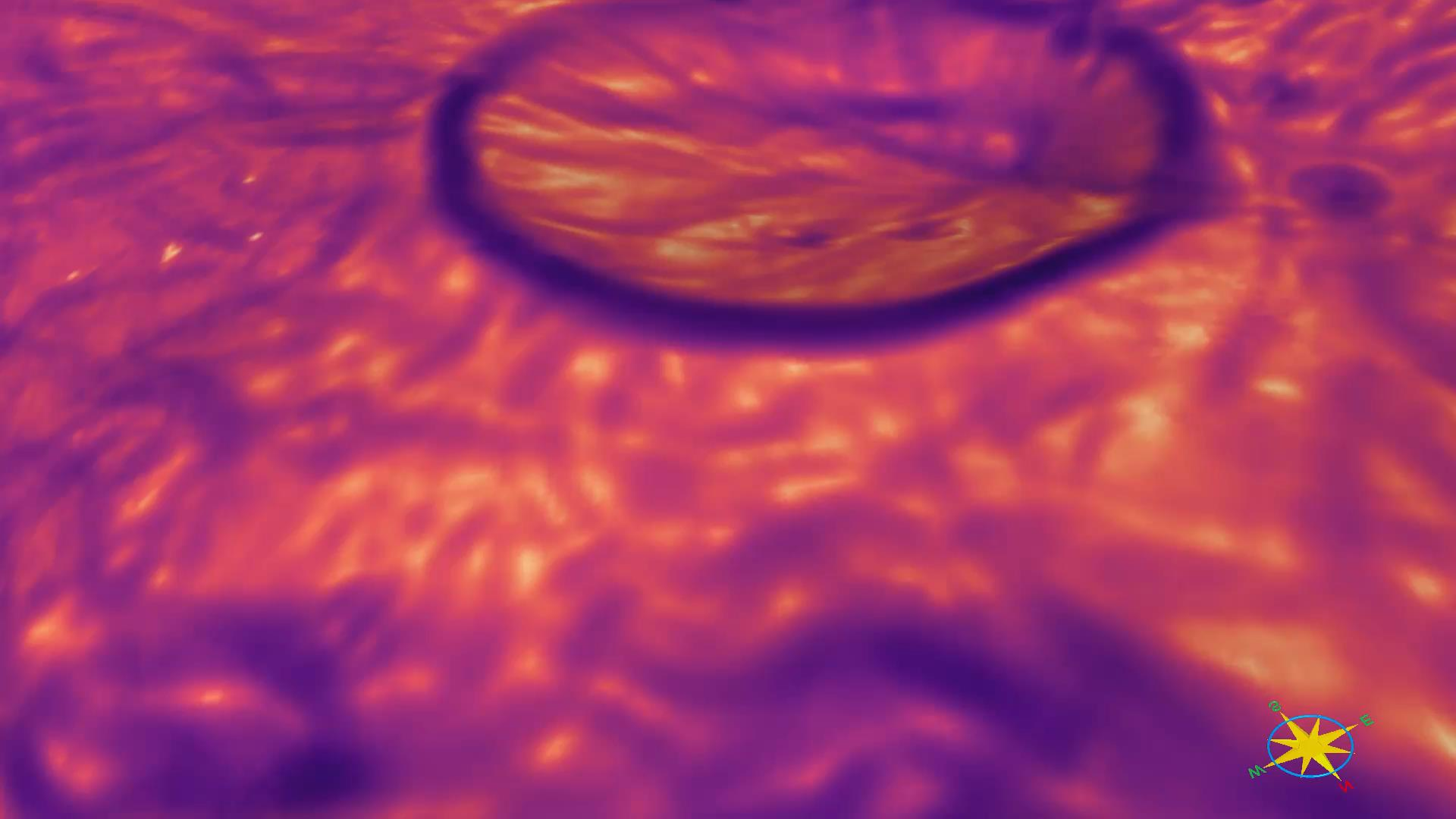




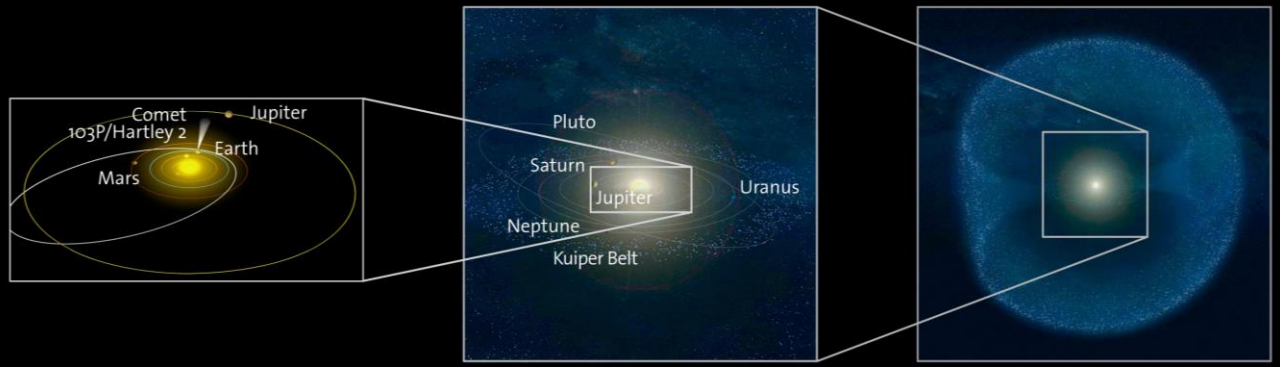
Basilevsky et al. 2014

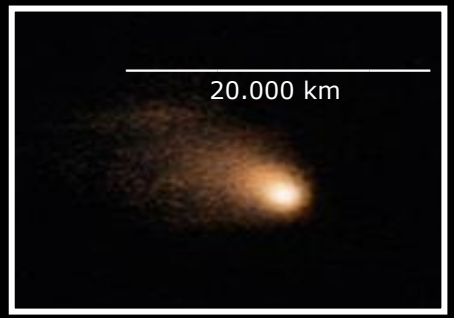


Simioni et al. 2015



Short (ugly) and Long (beautiful) period Comets





An apparently ugly
67P/Churyumov-Gerasimenko

A “beautiful” comet Halley

A “beautiful” comet Hale-Bopp

The Realms of Sublimation

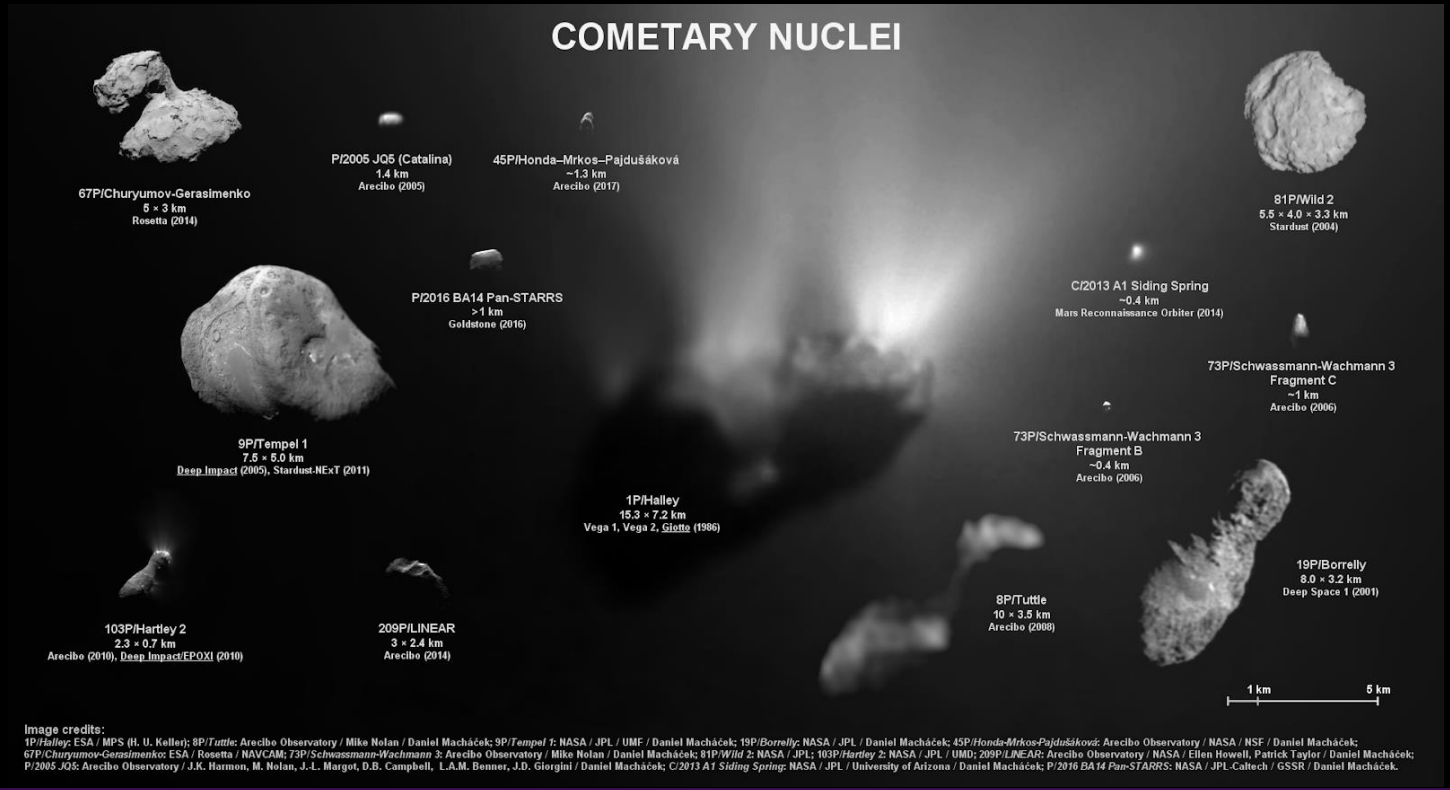


Image credits:
1P/*Halley*: ESA / MPS (H. U. Keller); 8P/*Tuttle*: Arecibo Observatory / Mike Nolan / Daniel Macháček; 9P/*Tempel 1*: NASA / JPL / UMF / Daniel Macháček; 19P/*Borrelly*: NASA / JPL / Daniel Macháček; 45P/*Honda-Mrkos-Pajdušáková*: Arecibo Observatory / NASA / NSF / Daniel Macháček; 67P/*Churyumov-Gerasimenko*: ESA / Rosetta / NAVCAM; 73P/*Schwassmann-Wachmann 3*: Arecibo Observatory / Mike Nolan / Daniel Macháček; 81P/*Wild 2*: NASA / JPL; 103P/*Hartley 2*: NASA / JPL / UMD; 209P/*LINEAR*: Arecibo Observatory / NASA / Ellen Howell, Patrick Taylor / Daniel Macháček; P/*2005 JQ5*: Arecibo Observatory / J.K. Harmon, M. Nolan, J.-L. Margot, D.B. Campbell, L.A.M. Benner, J.D. Giorgini / Daniel Macháček; C/*2013 A1 Siding Spring*: NASA / JPL / University of Arizona / Daniel Macháček; P/*2016 BA14 Pan-STARRS*: NASA / JPL-Caltech / GSSR / Daniel Macháček.

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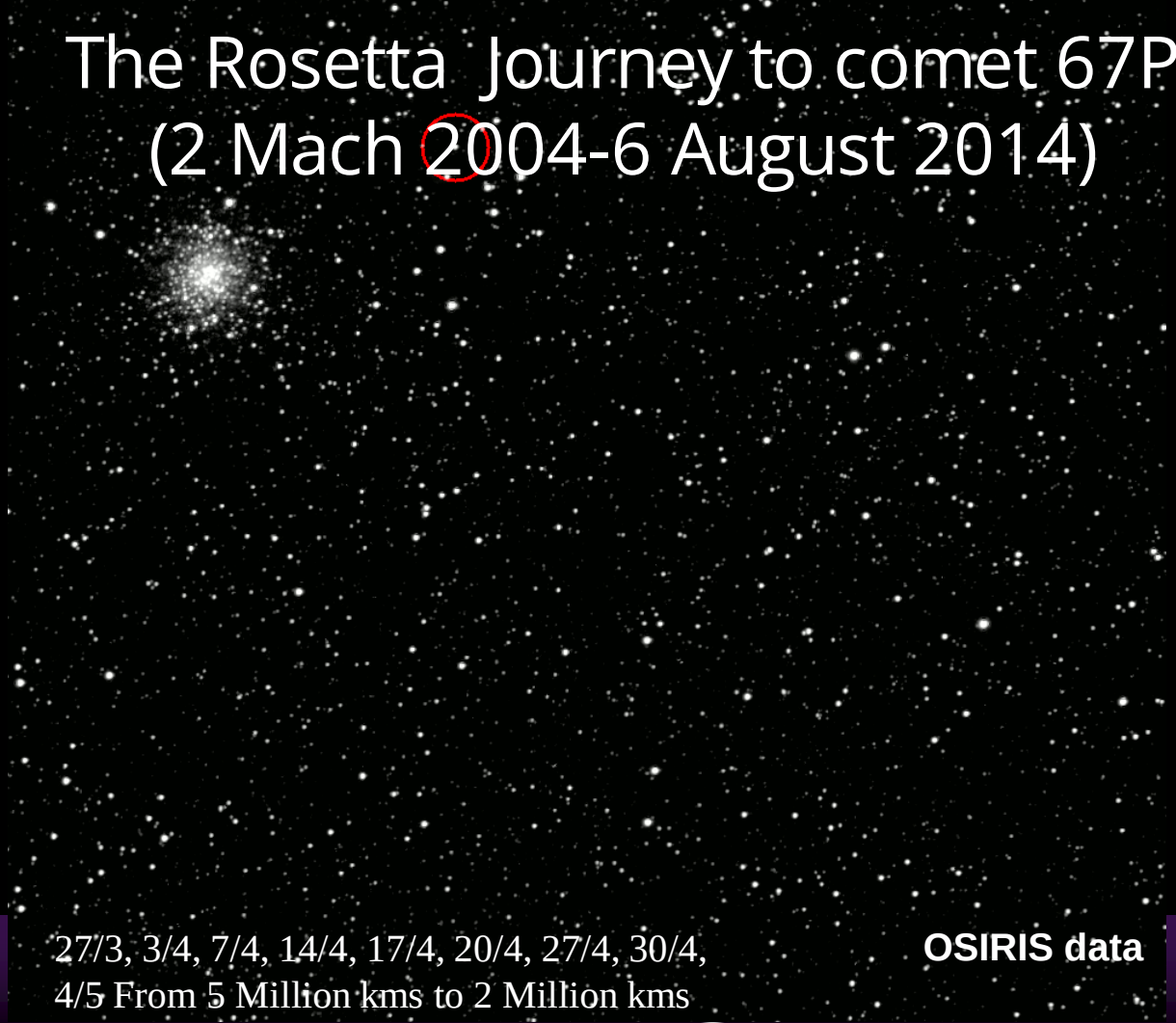
The Rosetta Journey to comet 67P (2 Mach 2004-6 August 2014)



27/3, 3/4, 7/4, 14/4, 17/4, 20/4, 27/4, 30/4,
4/5 From 5 Million kms to 2 Million kms

OSIRIS data

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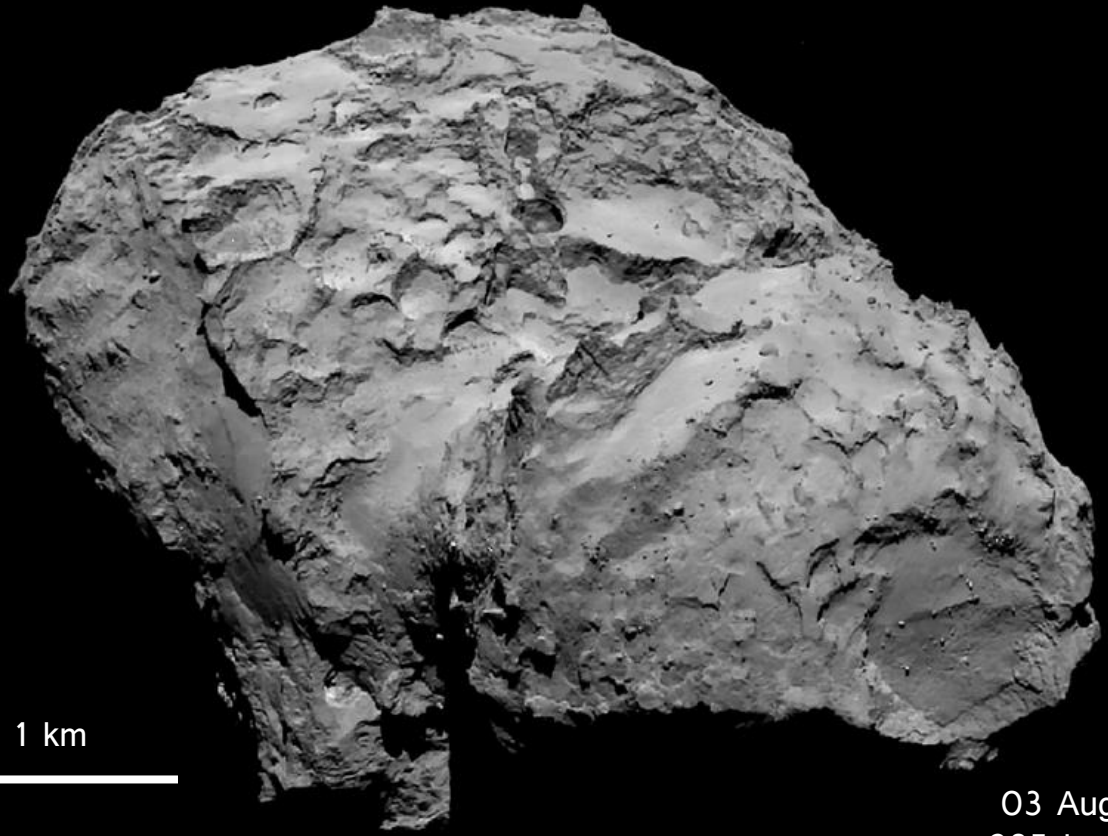
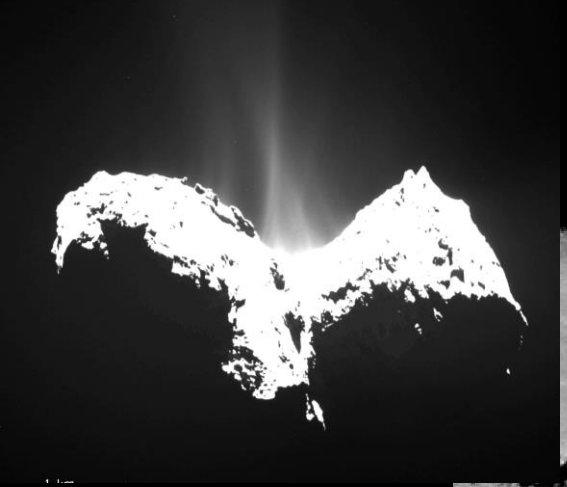
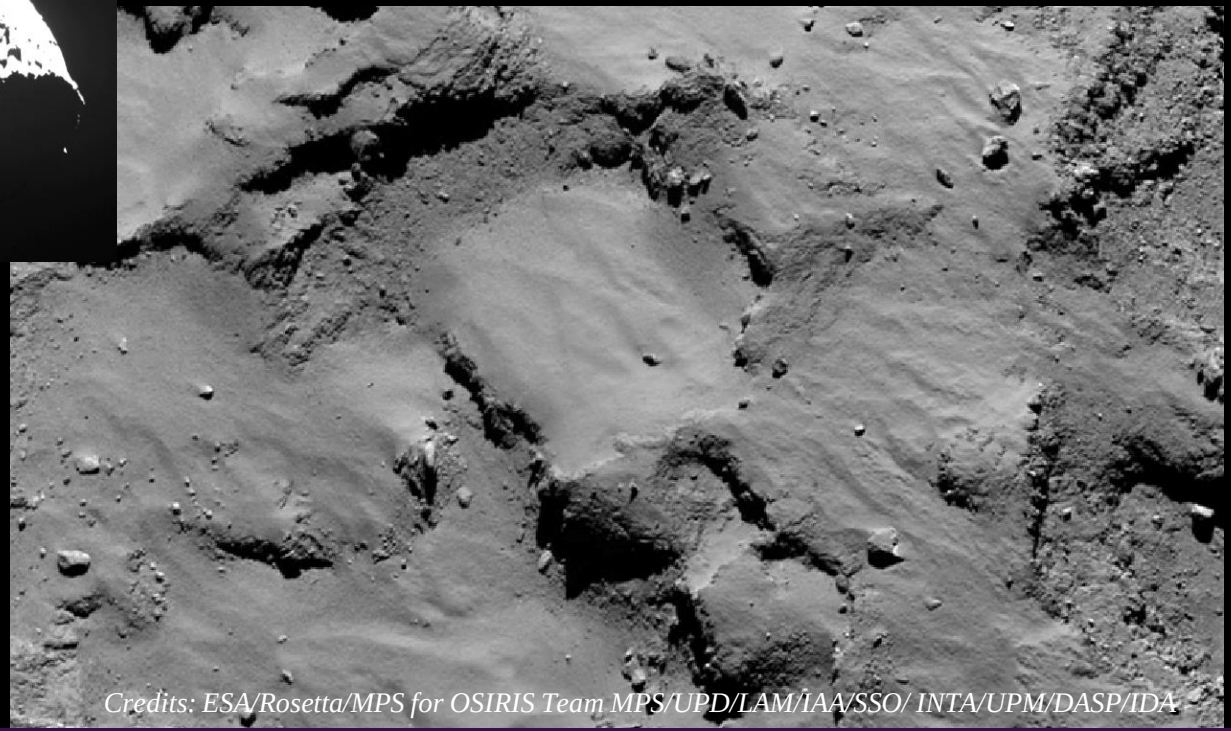
03 August 2014
Rosetta meet 67P/CG



03 August 2014
285 km 5.5 m/px

Cometary landforms: Outcrops, Airfalls and Taluses

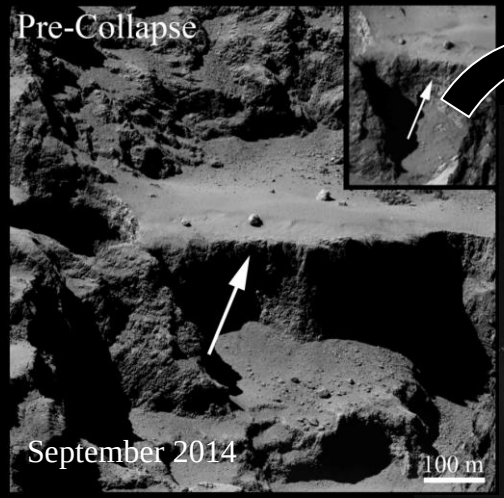


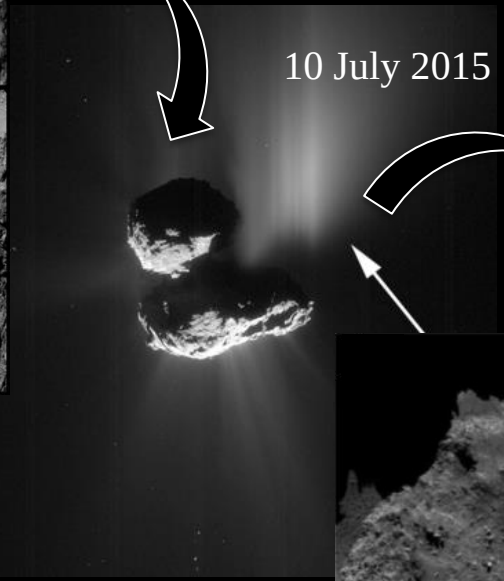


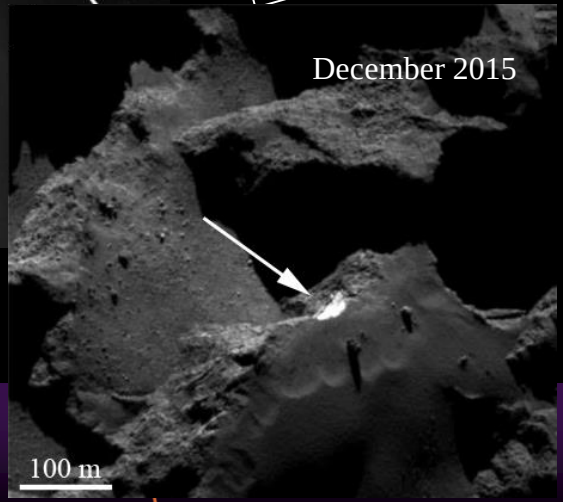
Credits: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/ INTA/UPM/DASP/IDA

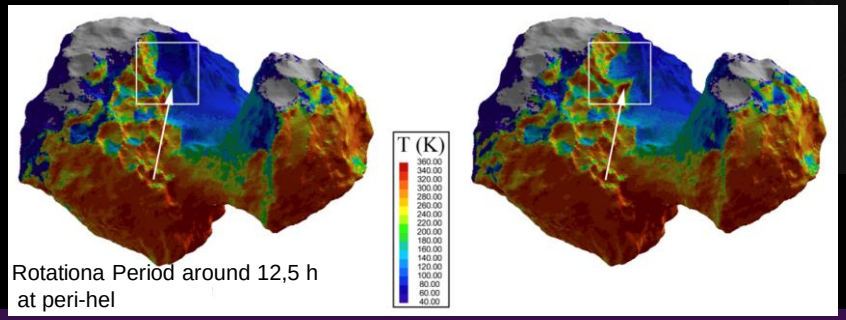

NAC 05-Sep-2015

Outburst and Gravittional collapses









Pajola M. et al. 2017

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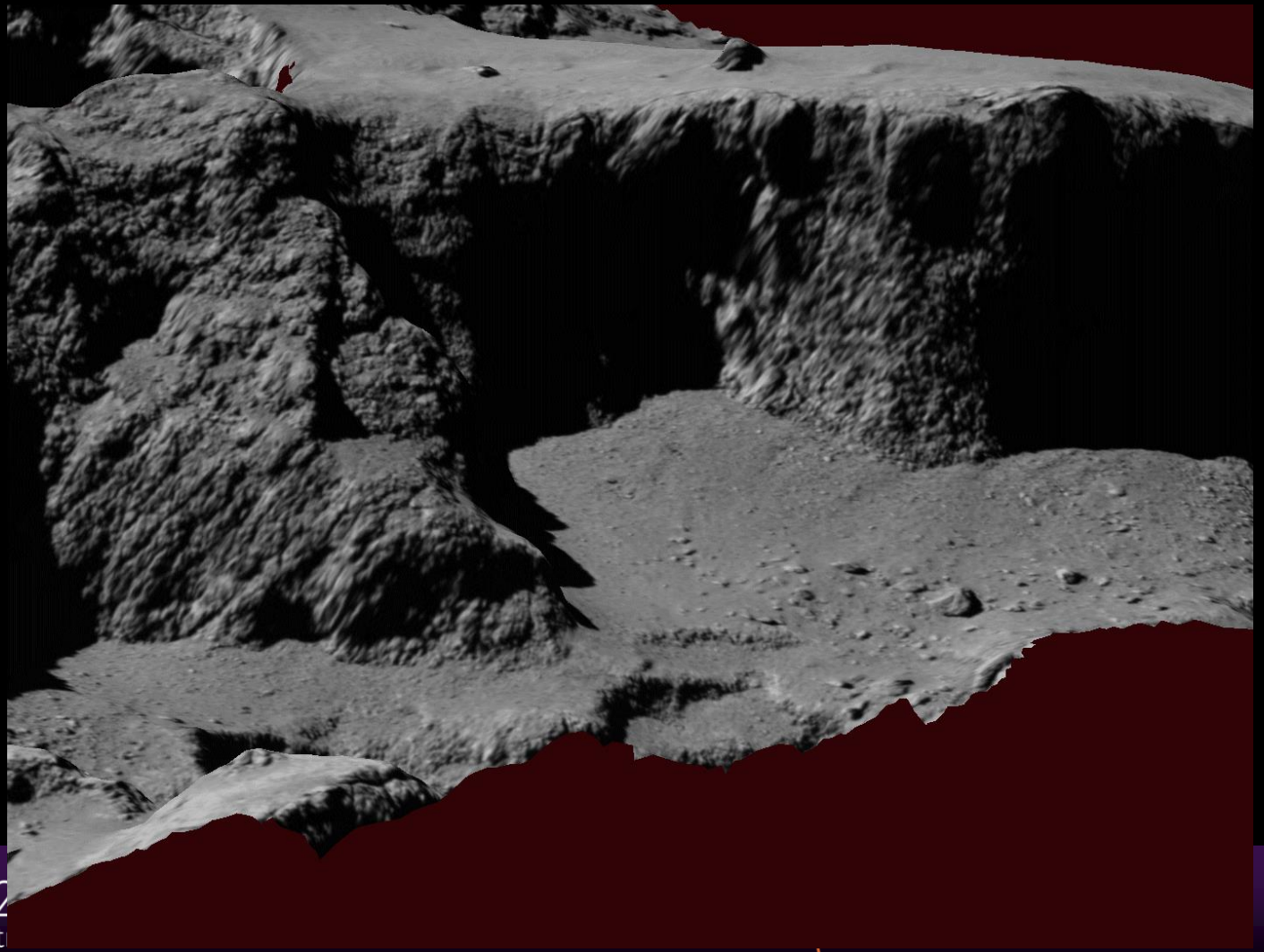

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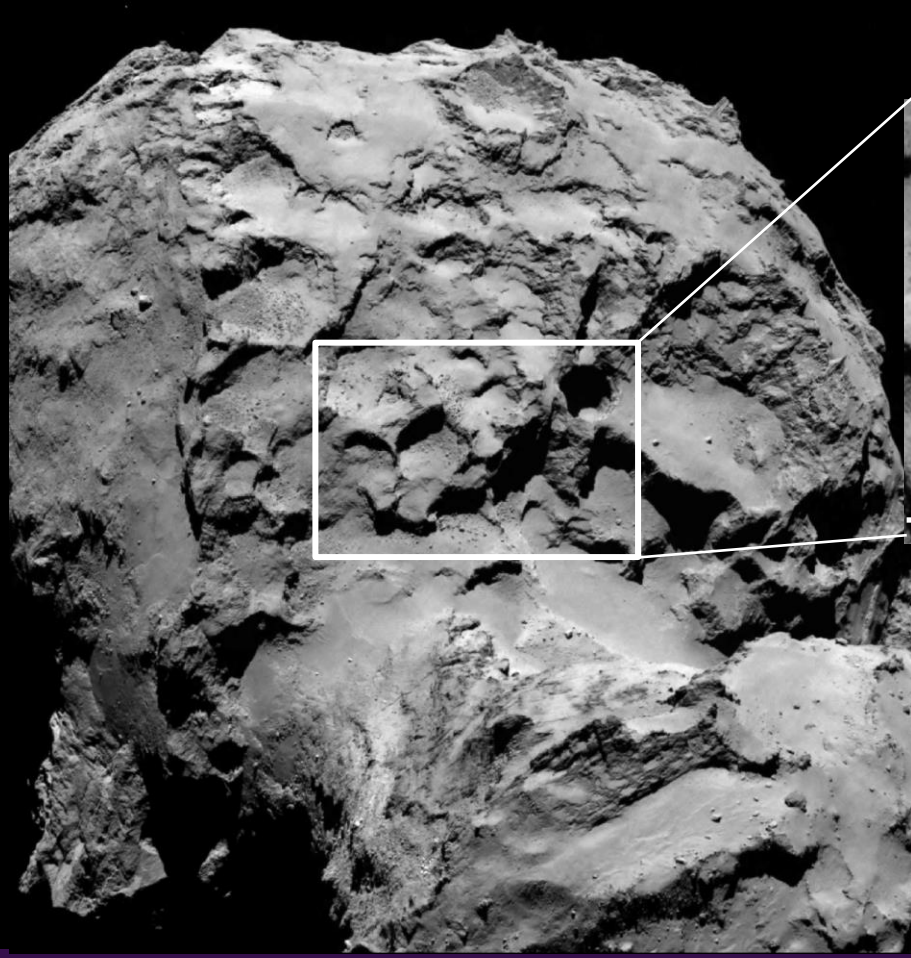
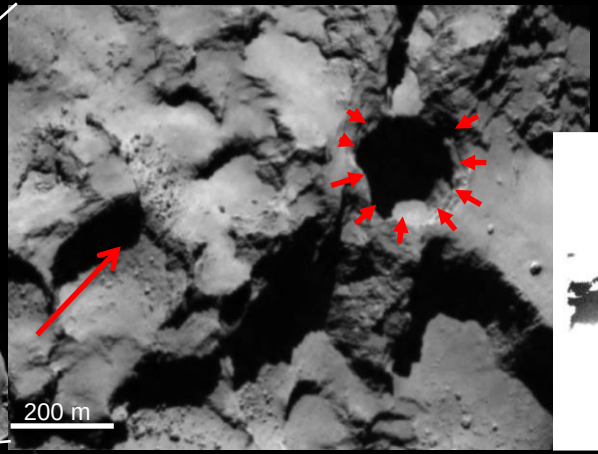
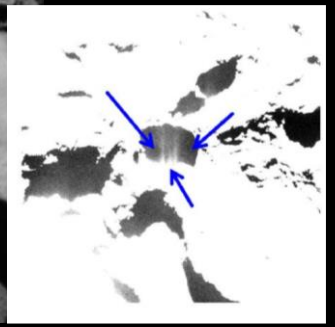
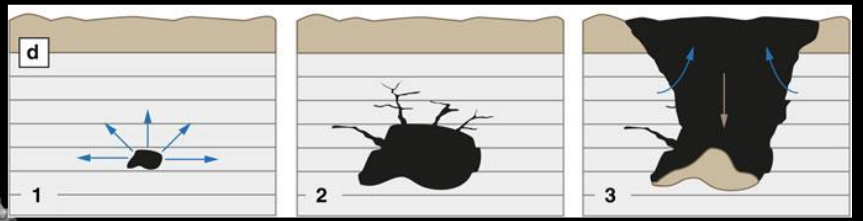
Active Pits







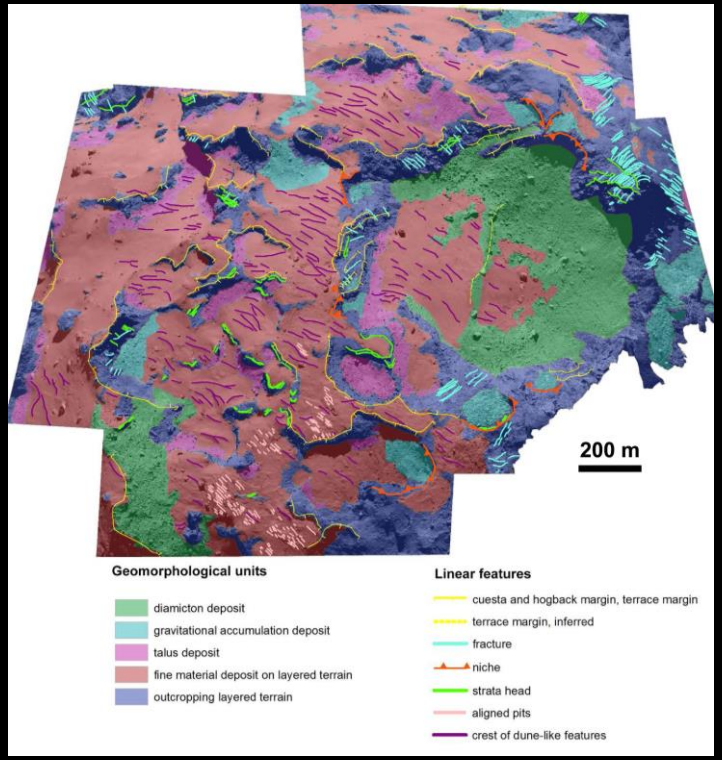
Vincent et al. 2015

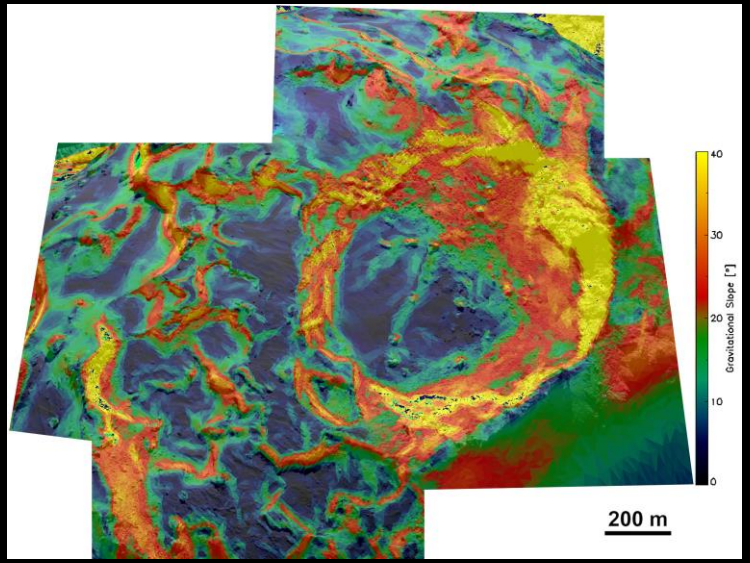


500 m

Schmedemann et al. in Rossi and Von Gasselt 2018

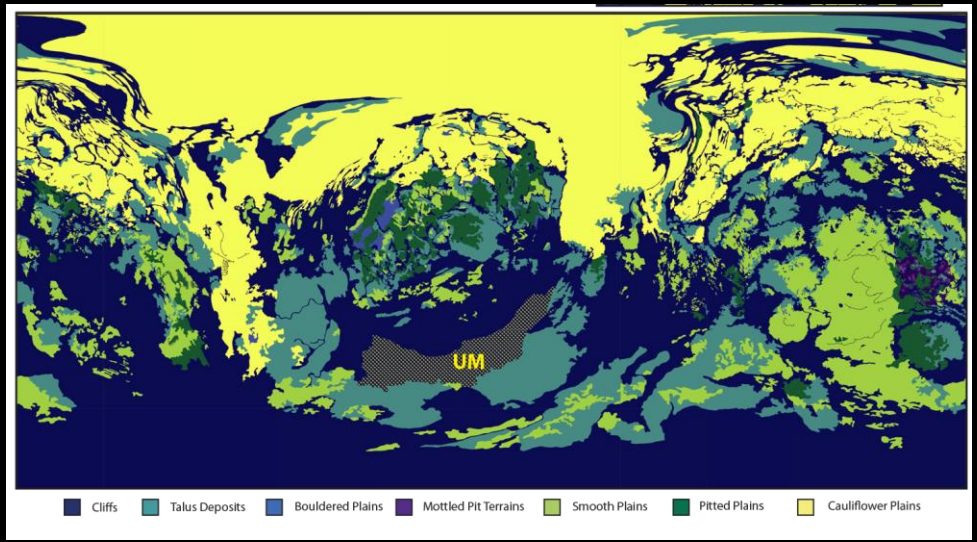
Local geological maps

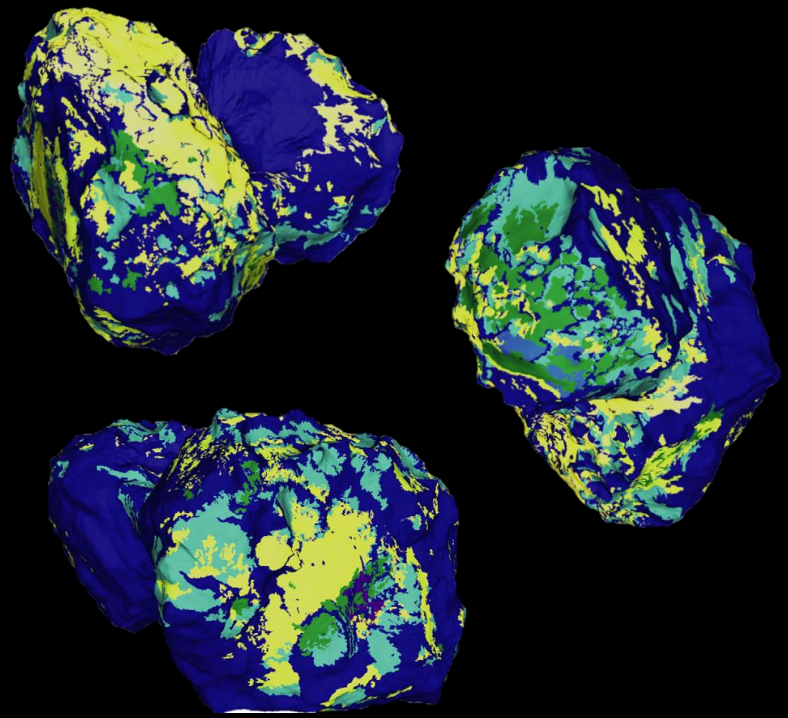




La Forgia et al. 2015

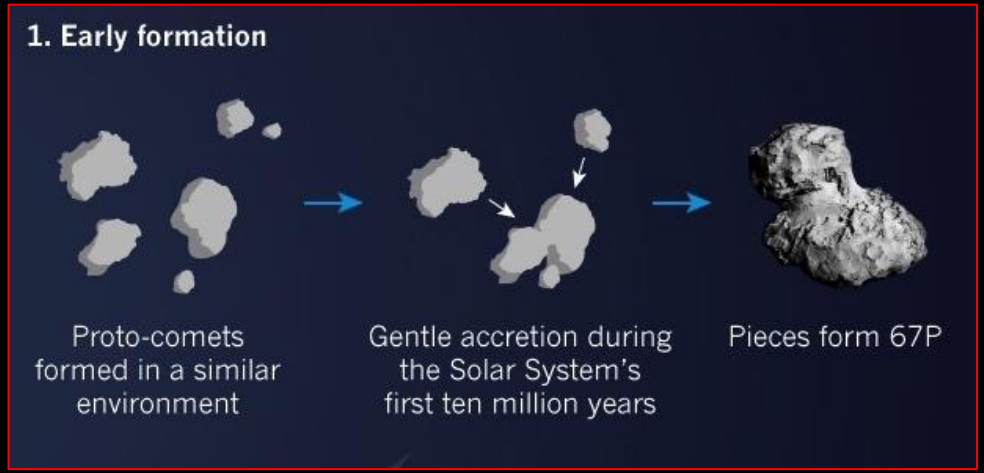
Global Geological Maps

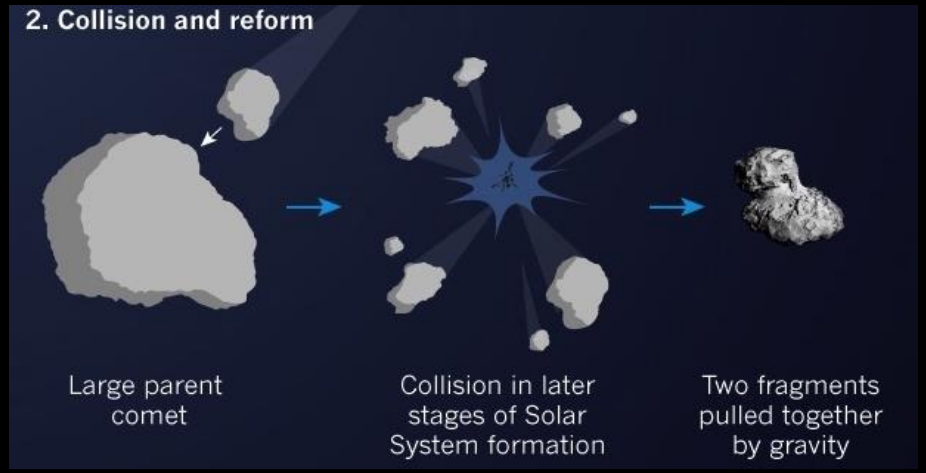




Birch et al. 2017

How the lobes formed?





GMAP
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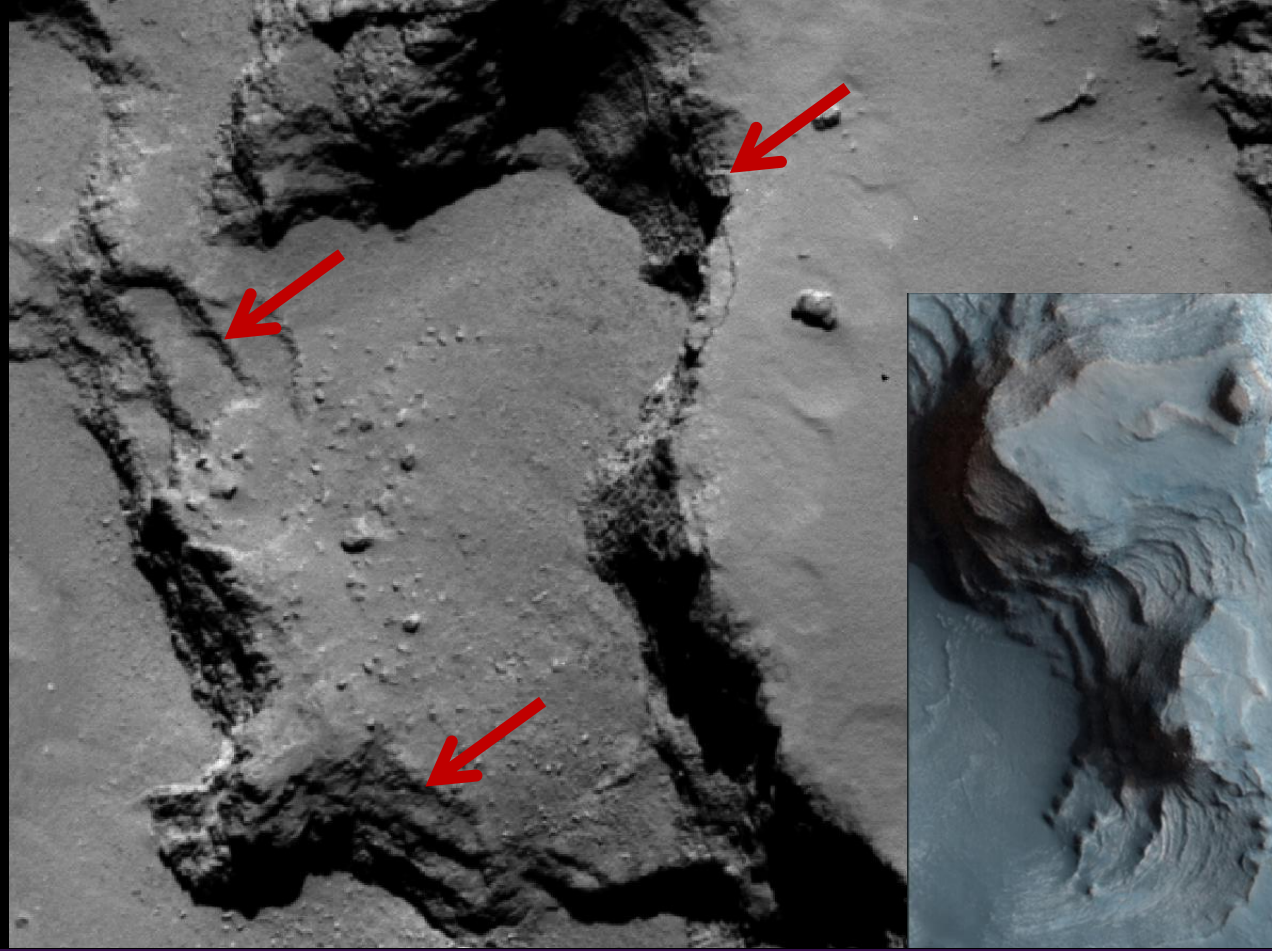
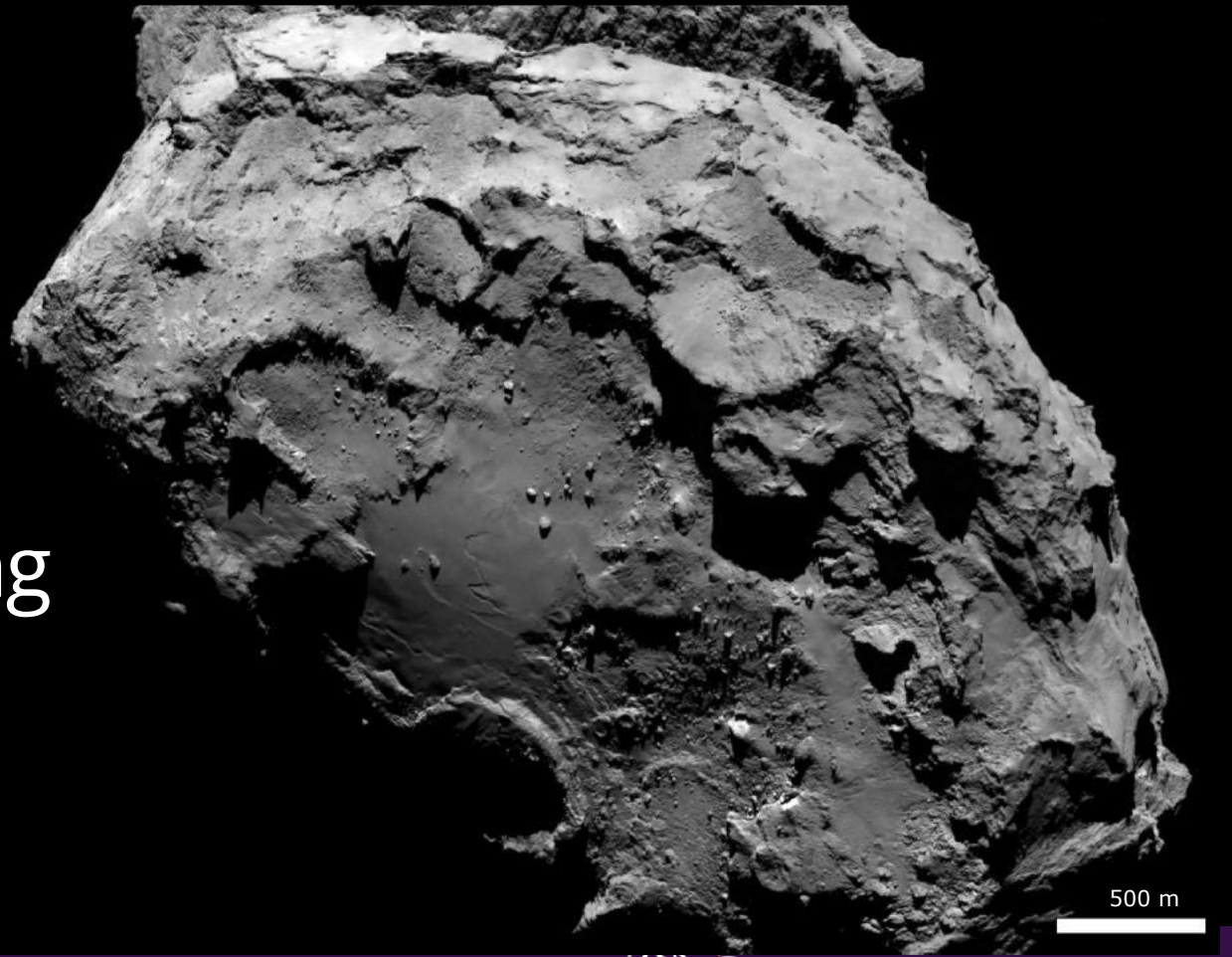
Stair-case terraces

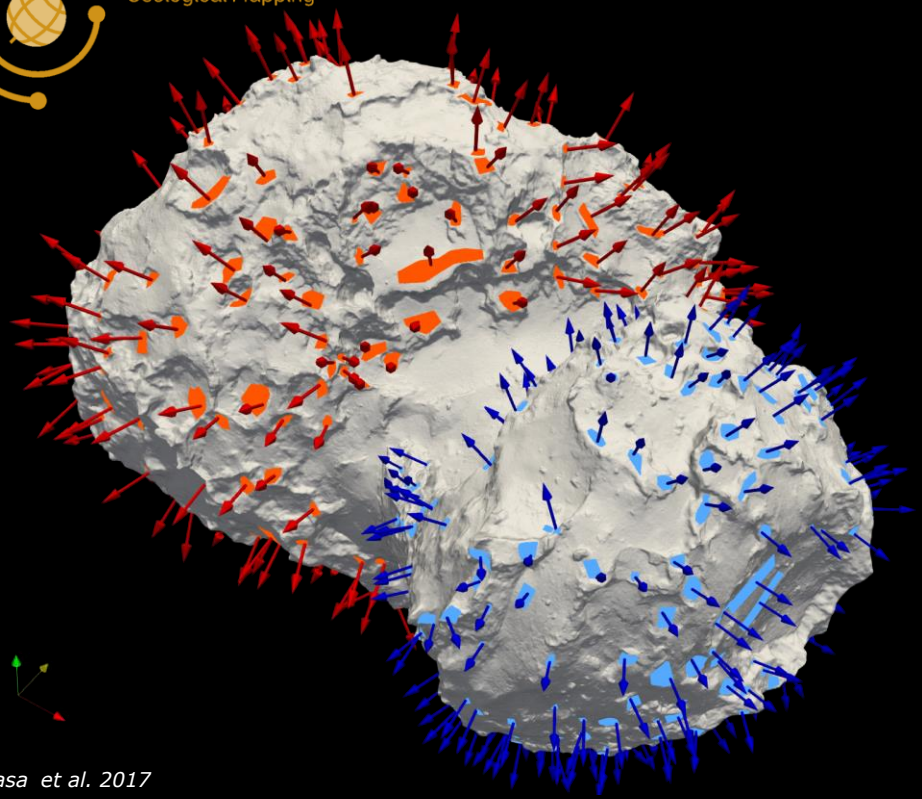


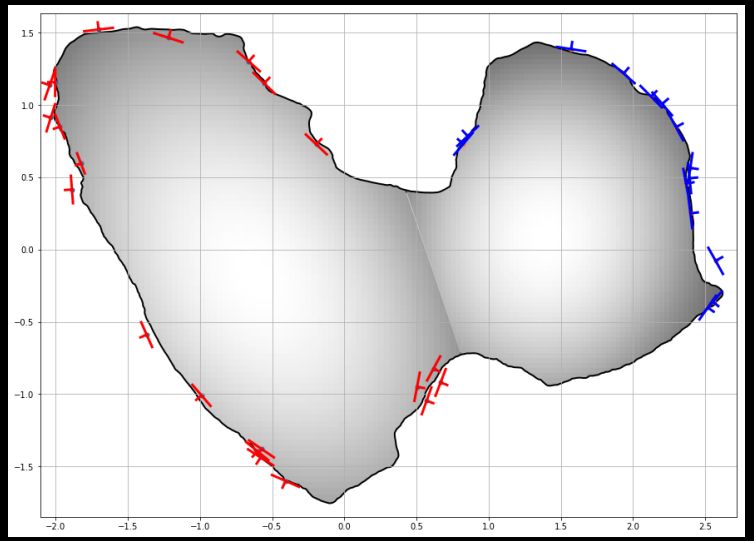
GMAP
Geological Mapping

Regional layering



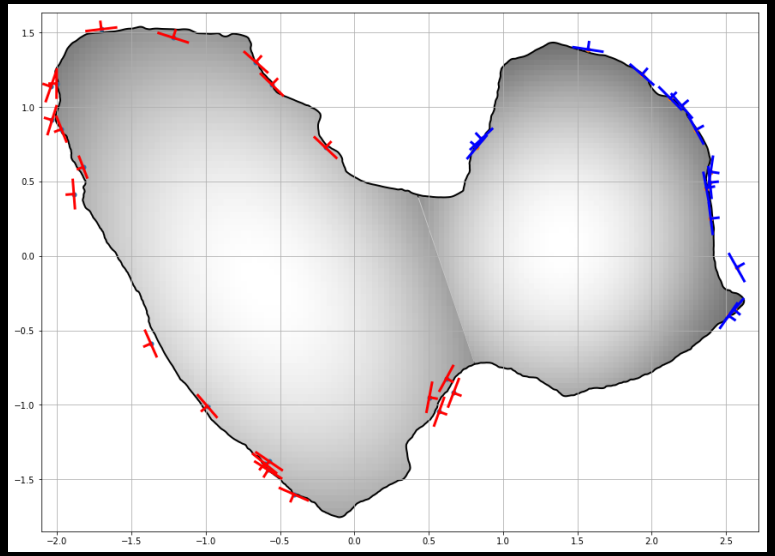
Strata Measurements

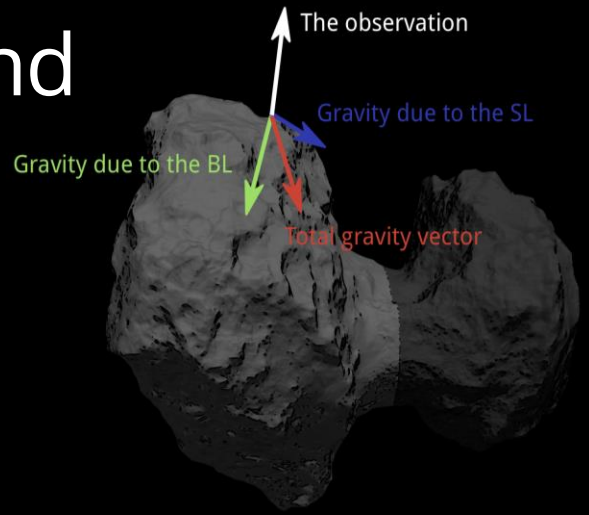


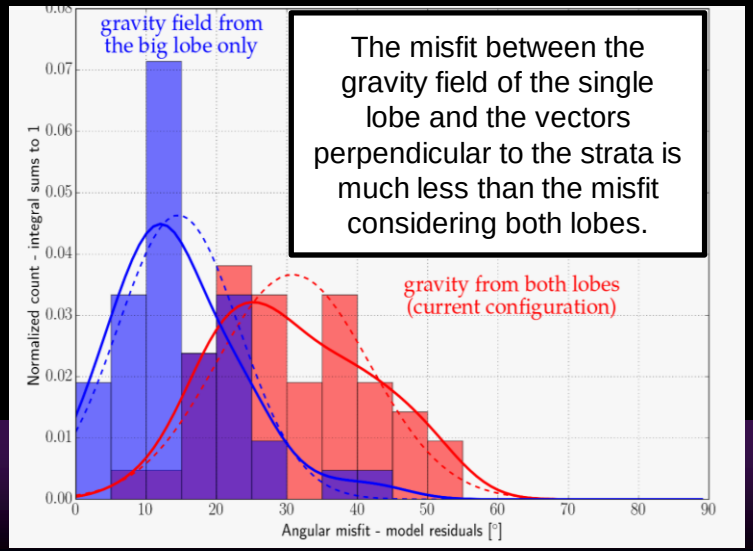


Penasa et al. 2017

Layer attitudes and gravity field



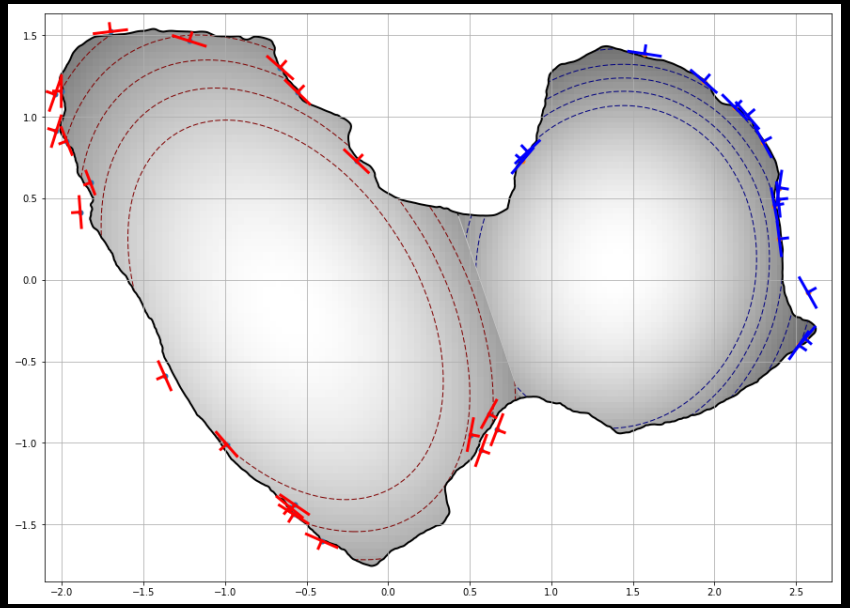


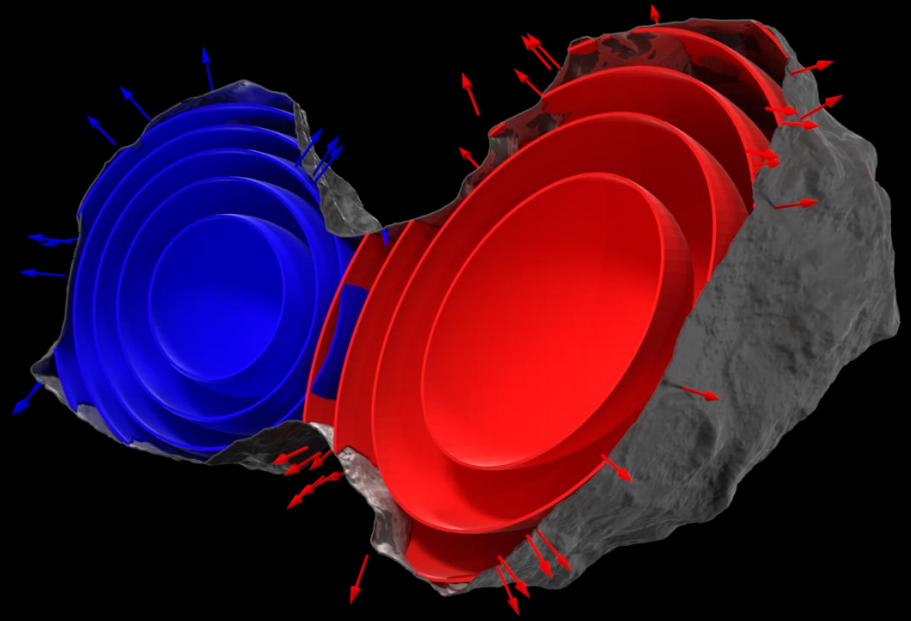


The misfit between the gravity field of the single lobe and the vectors perpendicular to the strata is much less than the misfit considering both lobes.

Penasa et al. 2017

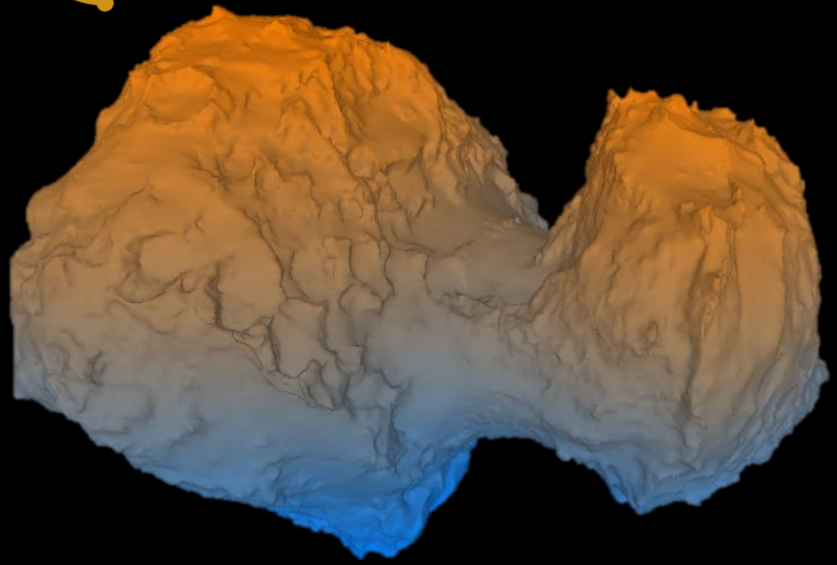
Implications: two single bodies with independent layering



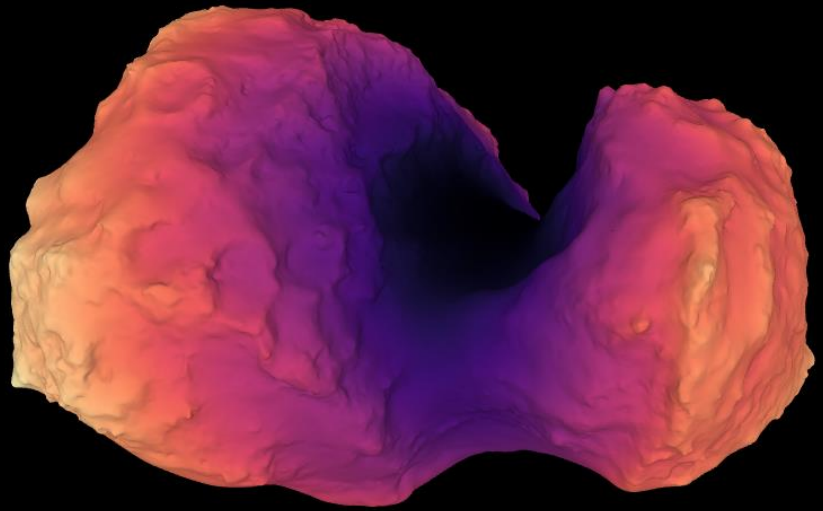


Penasa et al. 2017

Let’s practice through VRGS



Shape Model



Gravity potential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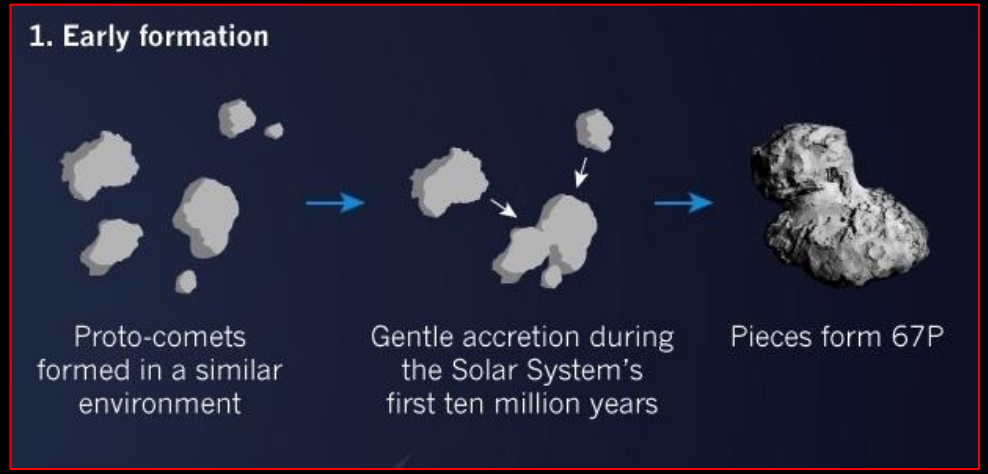
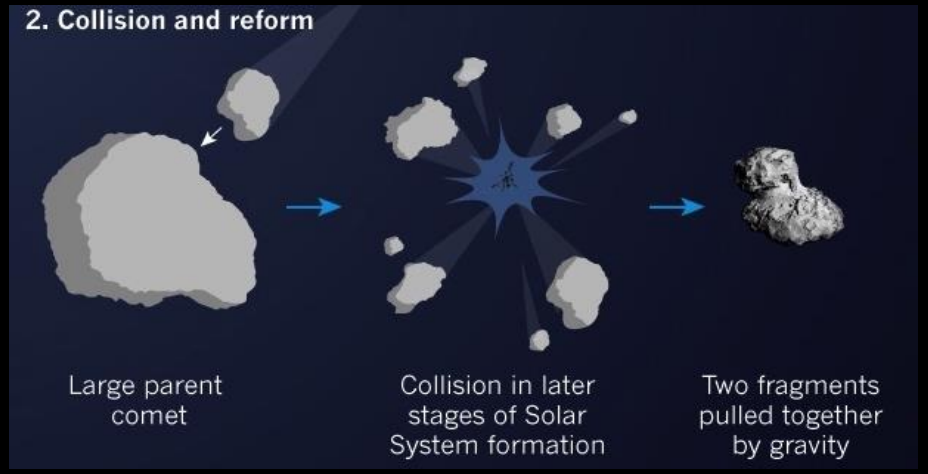
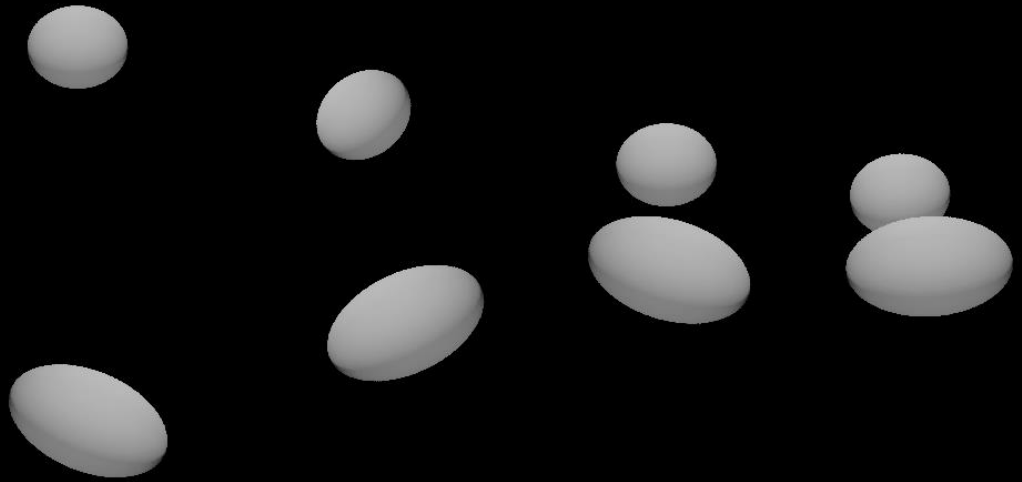
Further Implications: an early aggregation





Further Implications: A gentle joining



Further implications: Avoiding catastrophic collisions

67P should have escaped catastrophic collisions during the Solar System evolution

Nice Model
Credit: Hal Levison,
Southwest Research Institute,
Boulder, Colorado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