Rosetta Mission Update

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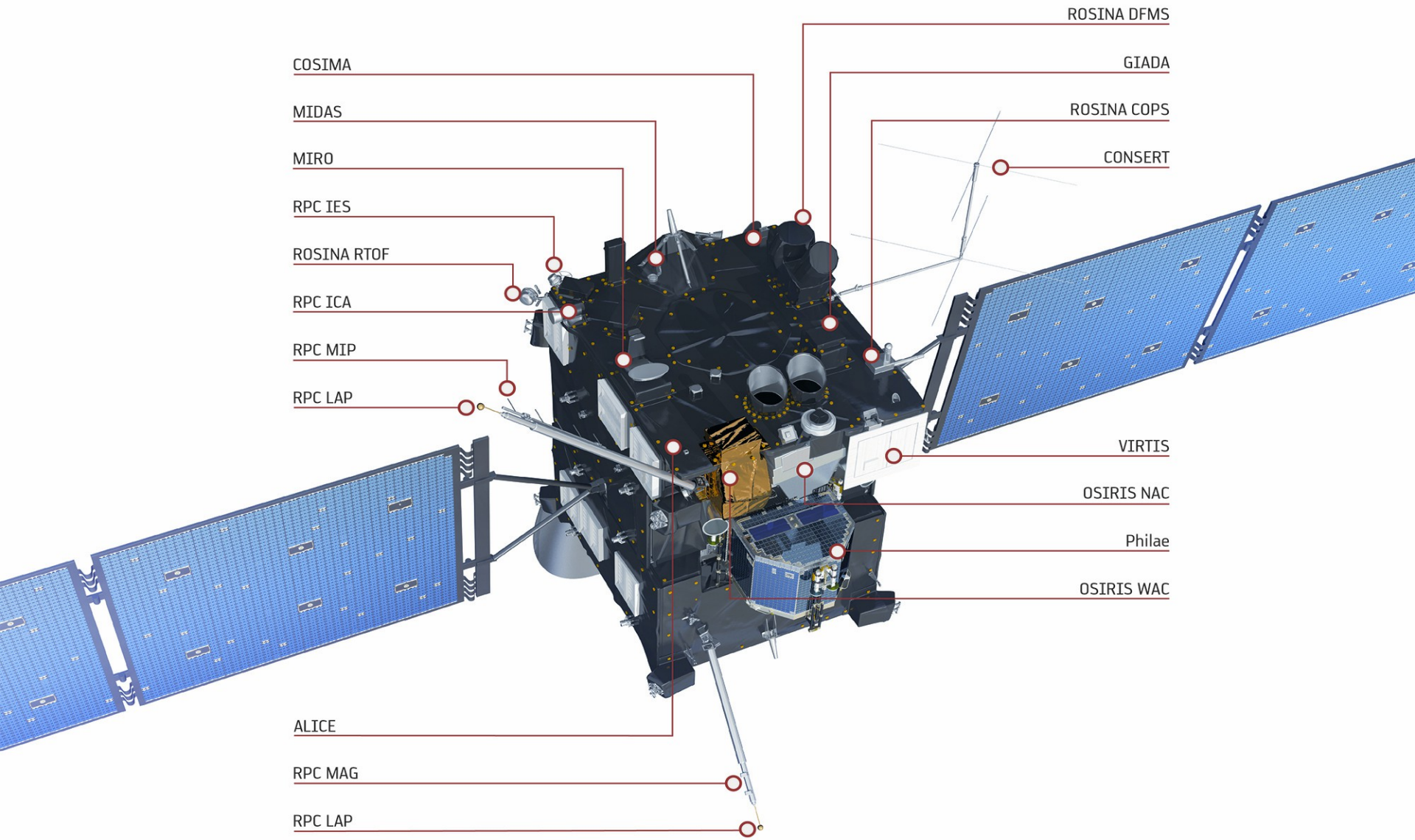
28th January 2015

Rosetta Mission

- European Space Agency mission to orbit and land on comet 67P/Churyumov-Gerasimenko
- Launched March 2004
- Arrived at comet August 2014
- Philae Lander deployed November 2014

Flight Plan Video


ROSINA DFMS
COSIMA
GIADA
MIDAS
ROSINA COPS
MIRO
CONSERT
RPC IES
ROSINA RTOF
RPC ICA
RPC MIP
RPC LAP
VIRTIS
OSIRIS NAC
Philae
OSIRIS WAC
ALICE
RPC MAG
RPC LAP

Rosetta's 11 Analysis Instruments

Alice: Ultraviolet Imaging Spectrometer – (characterising the composition of the comet nucleus and coma)

CONSERT: Comet Nucleus Sounding Experiment by Radio wave Transmission (studying the internal structure of the comet with lander Philae)

COSIMA: Cometary Secondary Ion Mass Analyser (studying the composition of the dust in the comet's coma)

GIADA: Grain Impact Analyser and Dust Accumulator (measuring the number, mass, momentum and velocity distribution of dust grains in the near-comet environment)

MIDAS: Micro-Imaging Dust Analysis System (studying the dust environment of the comet)

MIRO: Microwave Instrument for the Rosetta Orbiter (investigating the nature of the cometary nucleus, outgassing from the nucleus and development of the coma)

OSIRIS: Optical, Spectroscopic, and Infrared Remote Imaging System Camera (a dual camera imaging system consisting of a narrow angle (NAC) and wide angle camera (WAC) and operating in the visible, near infrared and near ultraviolet wavelength range)

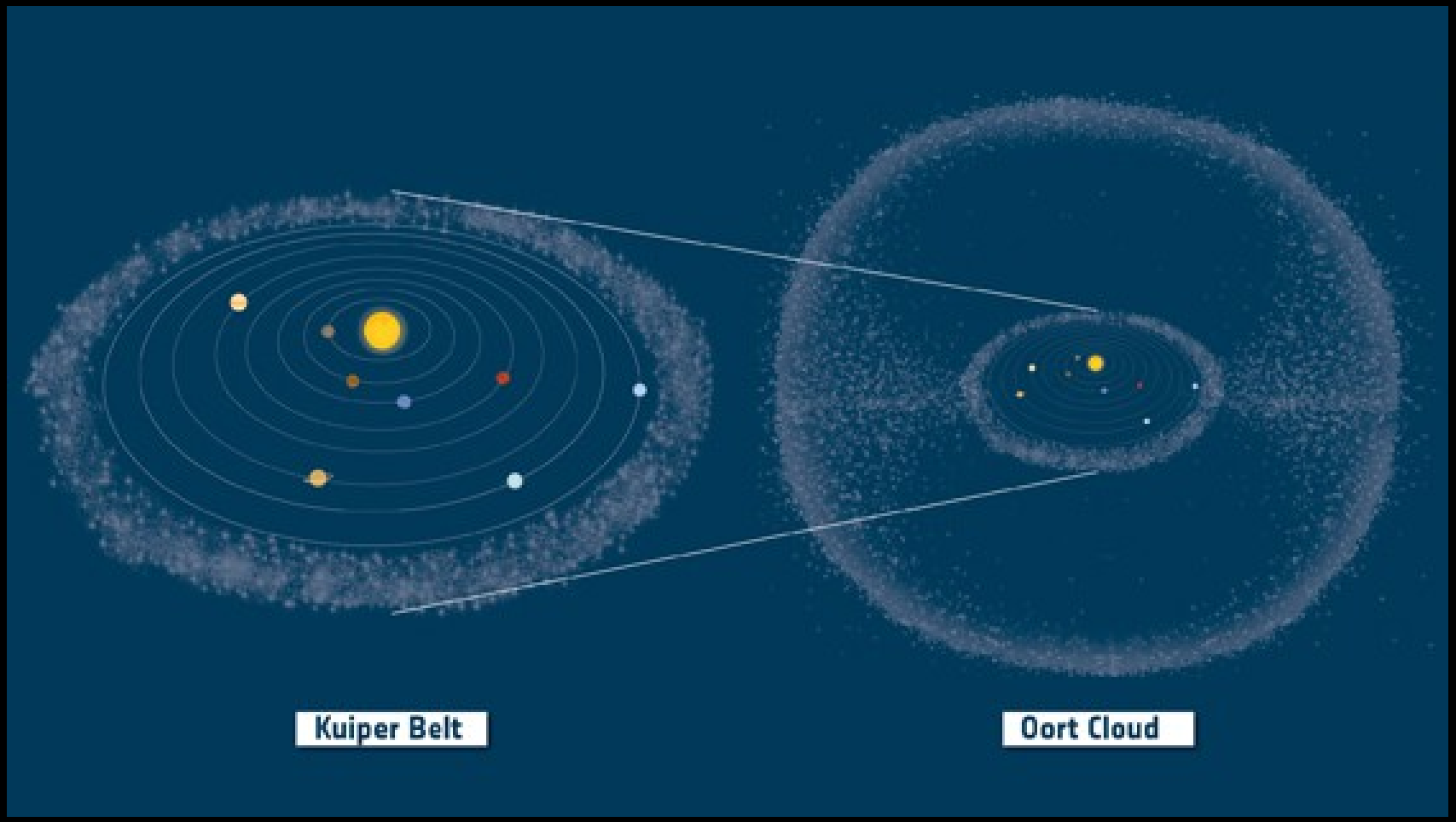
ROSINA: Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (determining the composition of the comet's atmosphere and ionosphere, and measuring the temperature, velocity and density of the gas flow, comprising: DFMS (Double-focusing mass spectrometer), RTOF (Reflectron Time-Of-Flight mass spectrometer) and COPS (Comet Pressure Sensor))

RPC: Rosetta Plasma Consortium (studying the plasma environment of the comet, comprising: ICA (Ion Composition Analyser), IES (Ion and Electron Sensor), LAP (Langmuir Probe), MAG (Fluxgate Magnetometer), MIP (Mutual Impedance Probe), PIU (Plasma Interface Unit))

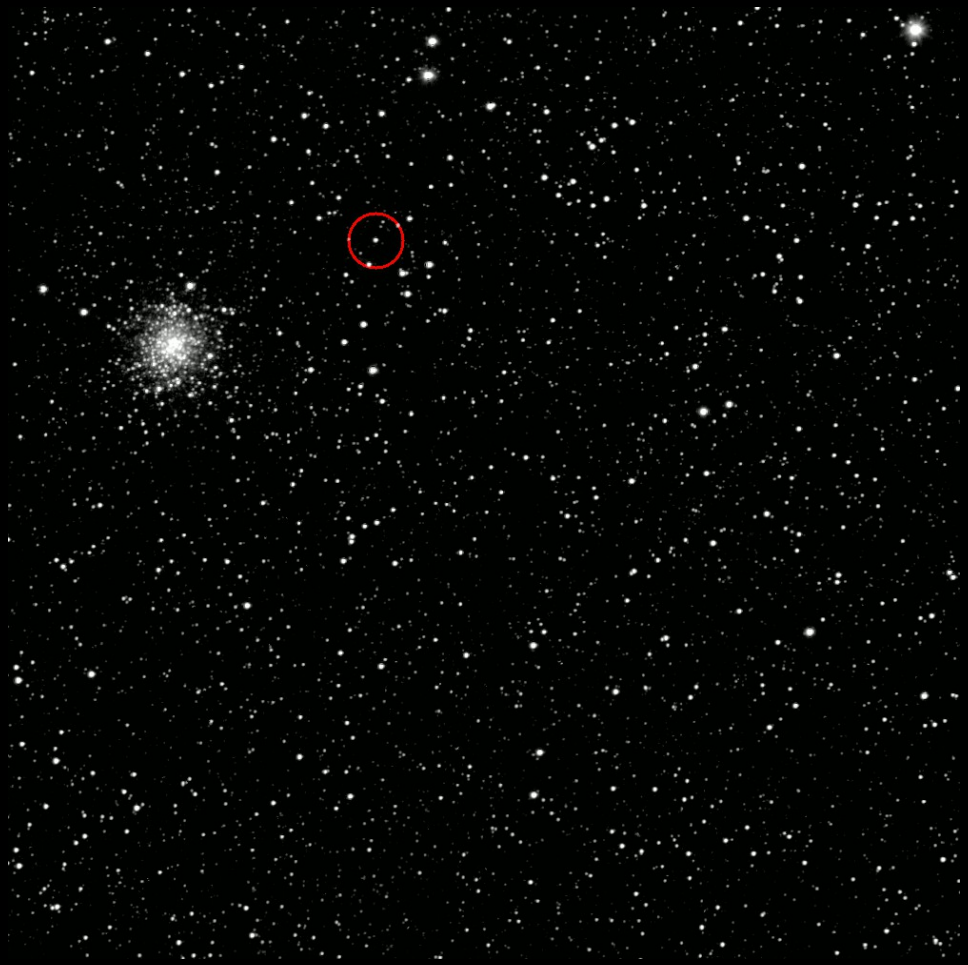
RSI: Radio Science Investigation (tracking the motion of the spacecraft to infer details of the comet environment and nucleus)

VIRTIS: Visible and Infrared Thermal Imaging Spectrometer (studying the nature of the comet nucleus and the gases in the coma)

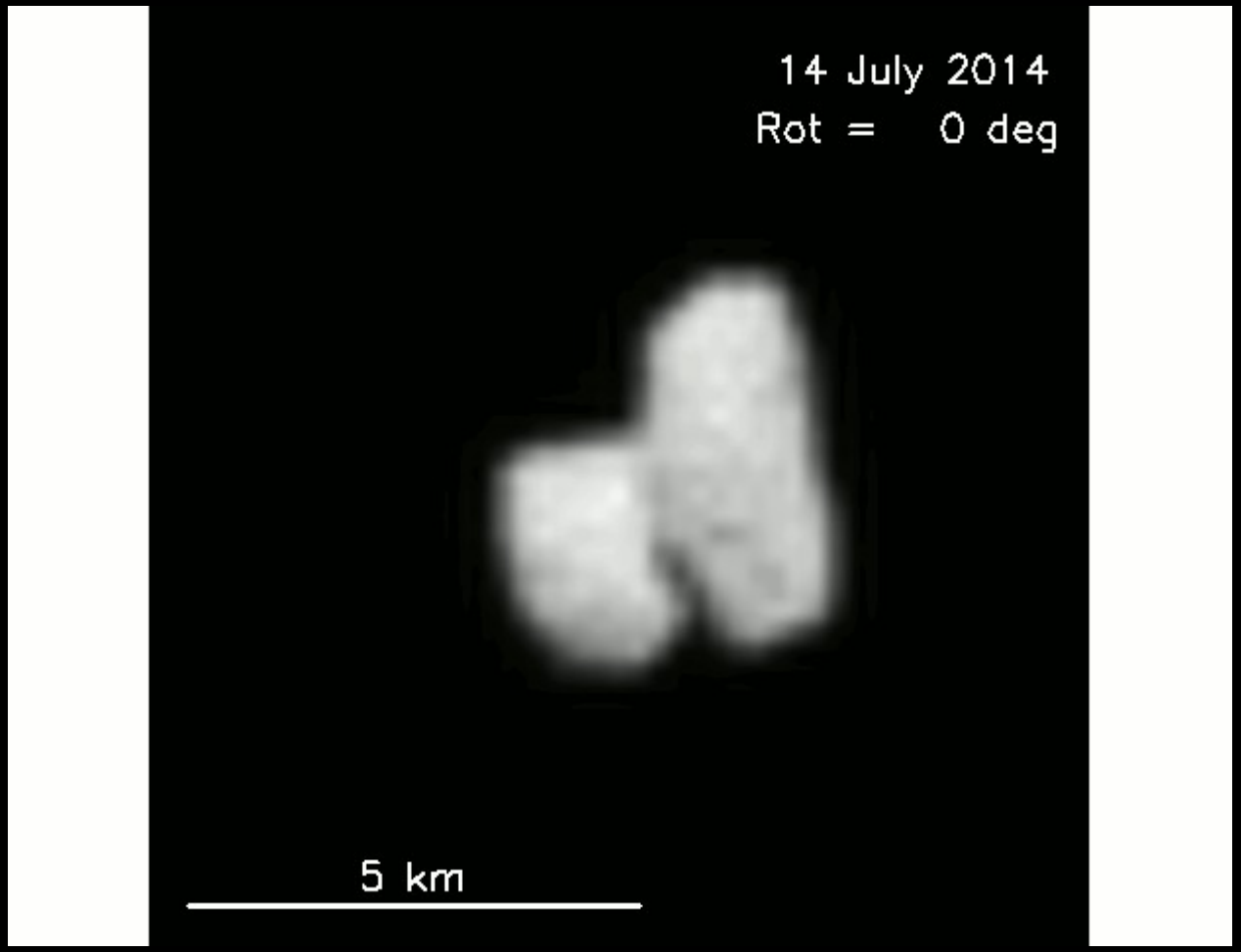
IT CAME FROM OUTER SPACE



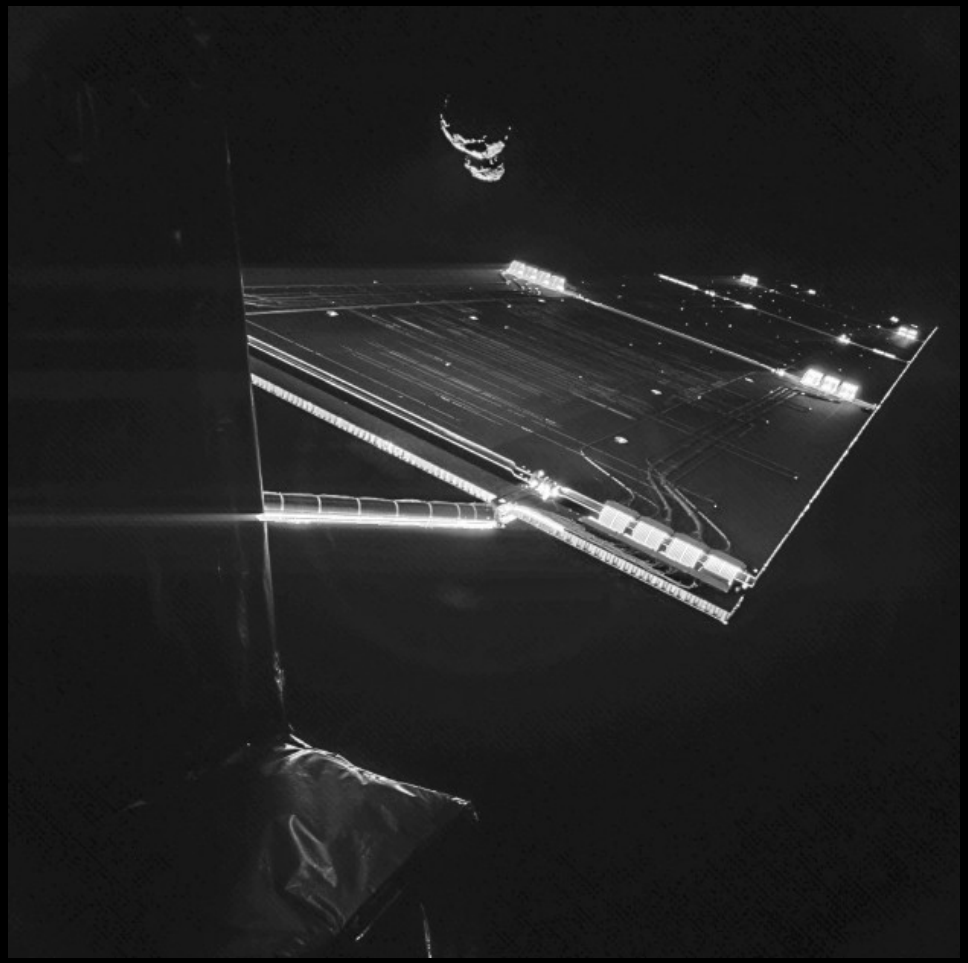
67P develops a tail March-May 2014



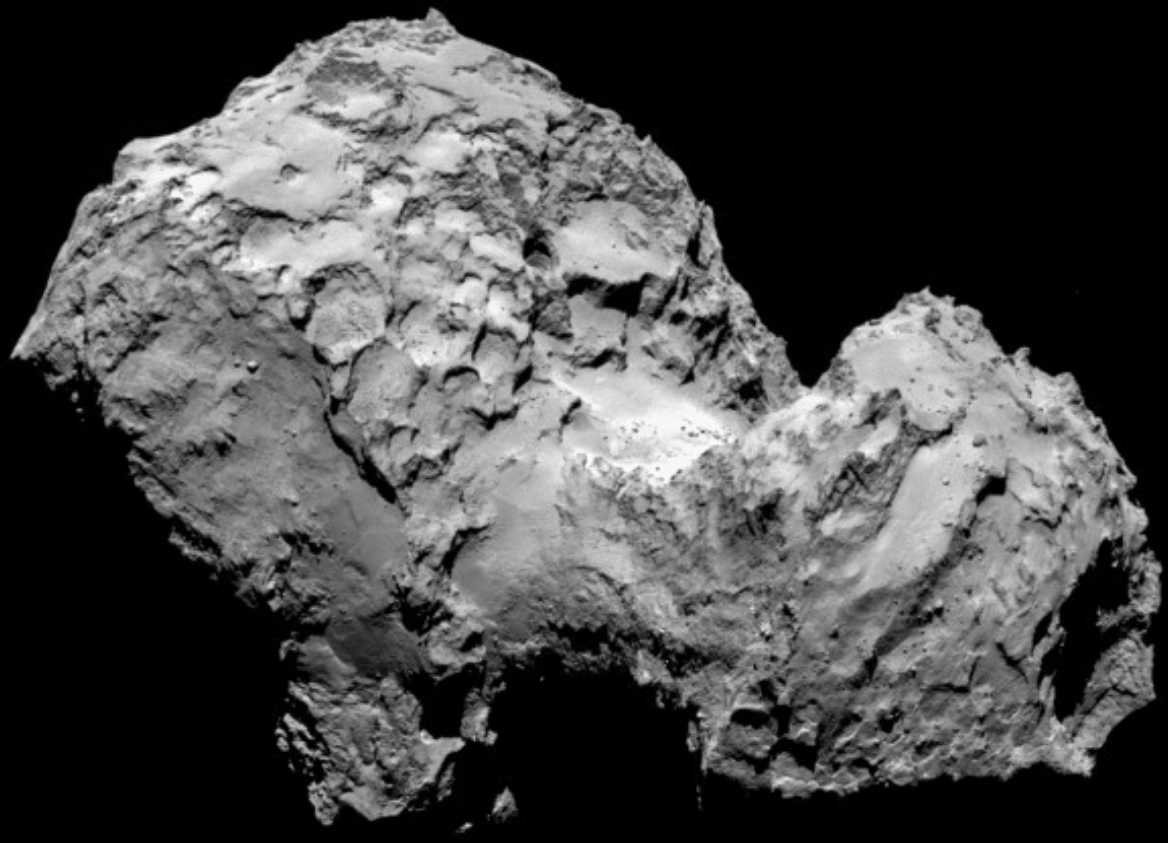
67P imaged on 14 July 2014 by the narrow angle camera of OSIRIS, Rosetta's scientific imaging system, from a distance of approximately 12 000 km



Rosetta and comet 67P

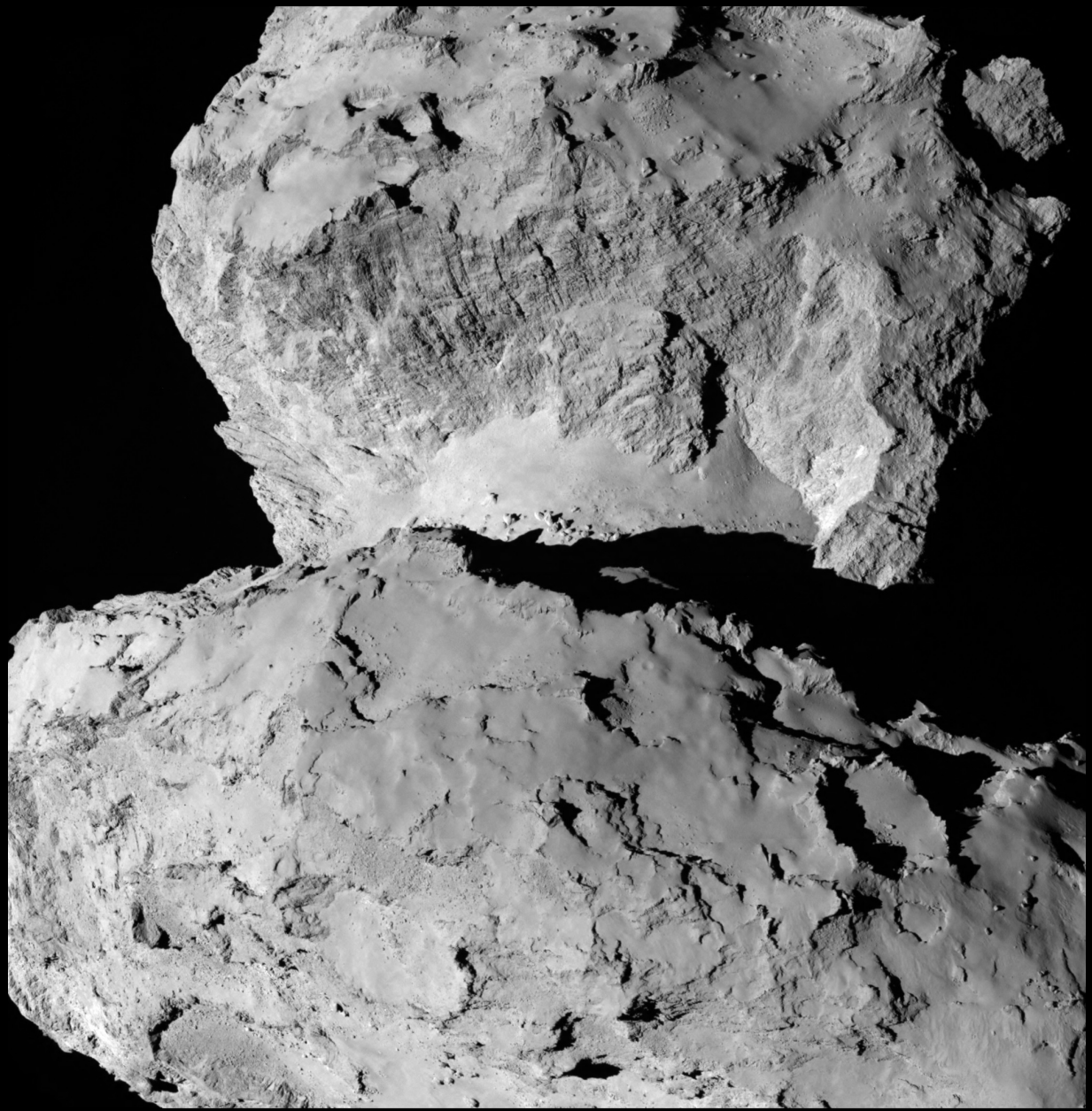


OSIRIS narrow-angle camera on 3 August 2014 from a distance of 285 km. The image resolution is 5.3 metres/pixel.



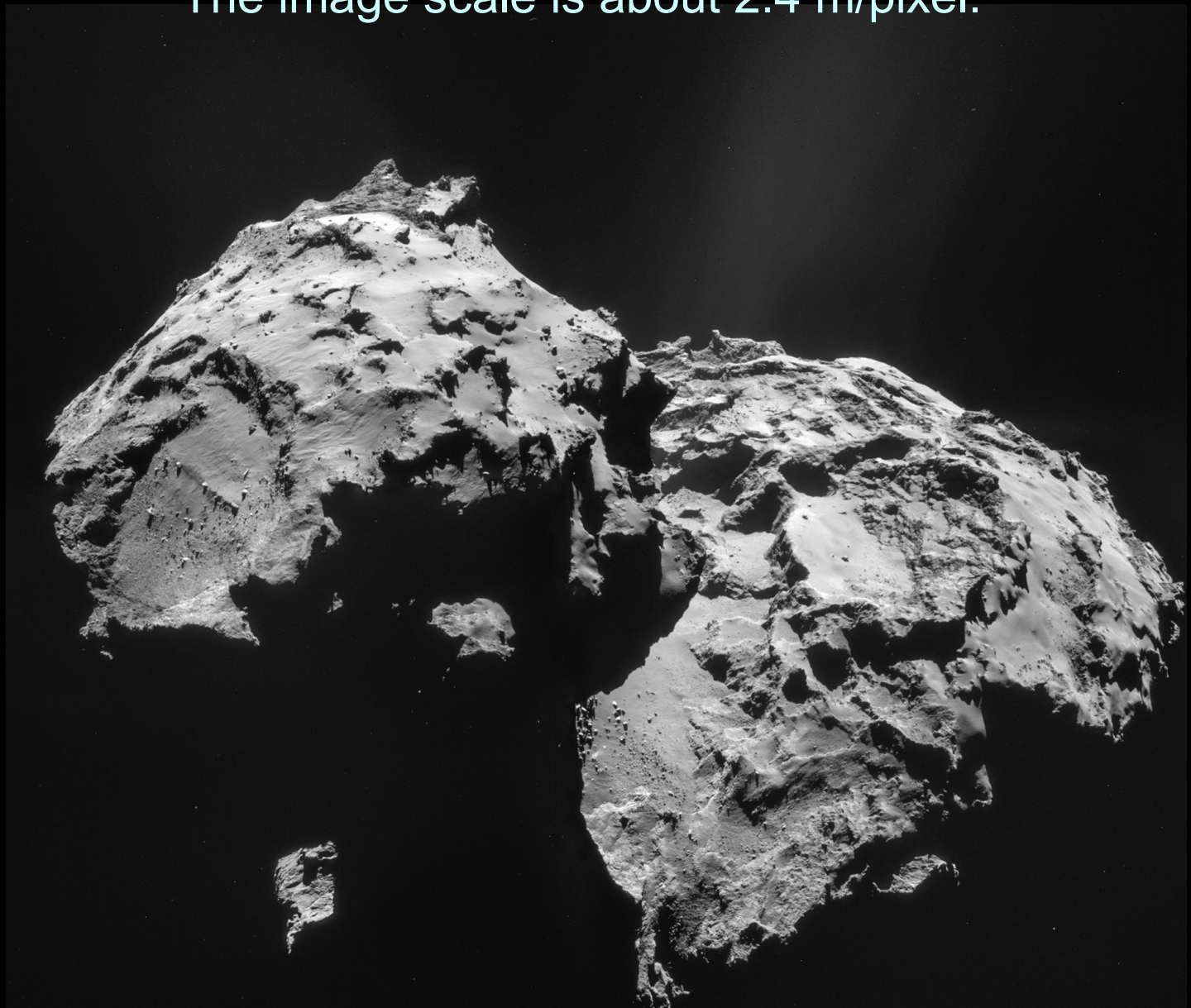
August 2014 from a distance of 285 km.
The image resolution is 5.3 metres/pixel

7 August from a distance of 104 km

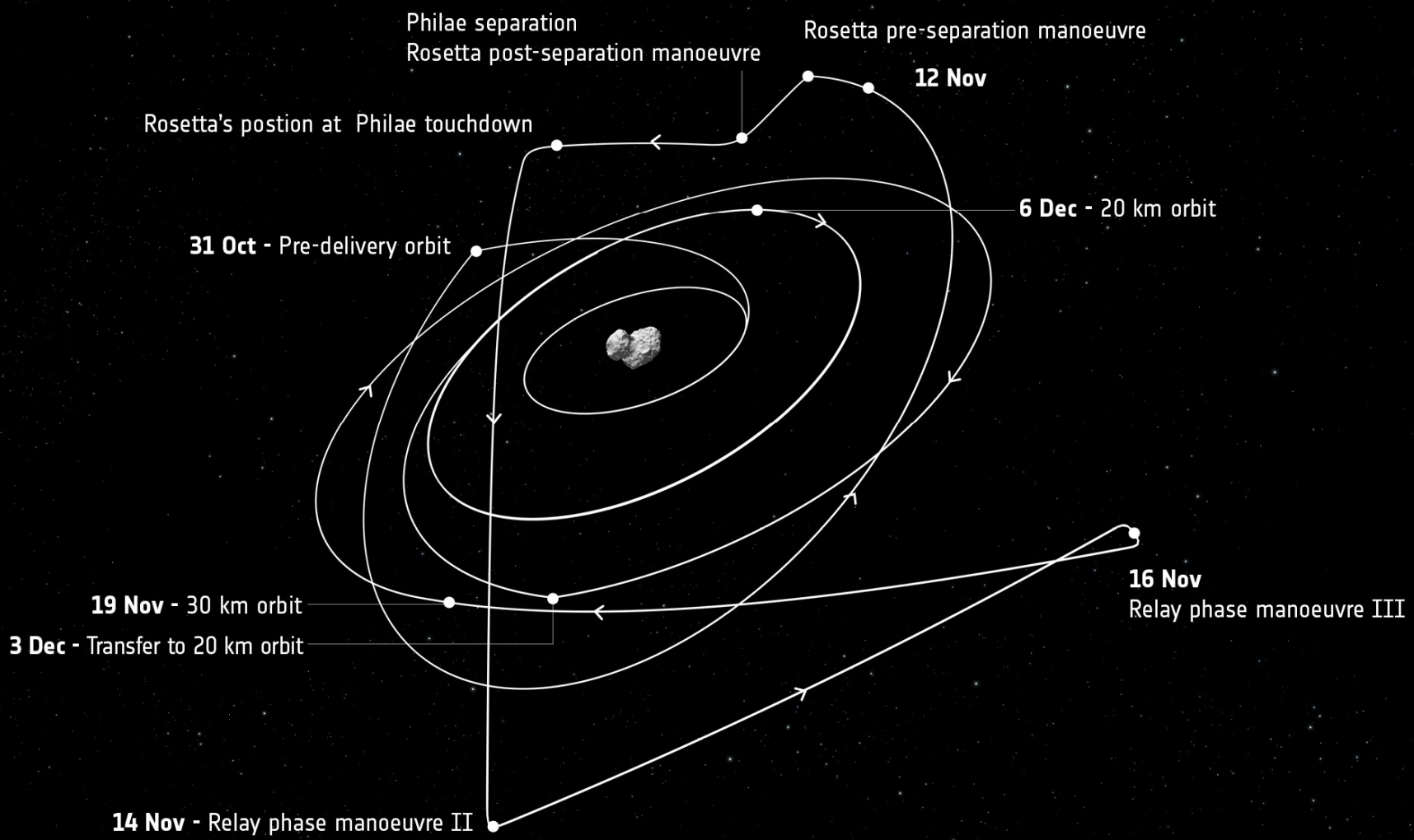



Mosaic of four images taken by Rosetta's navigation camera
(NAVCAM) on 9 December 2014 at 20.4 km
The image scale is 1.74 m/pixel.

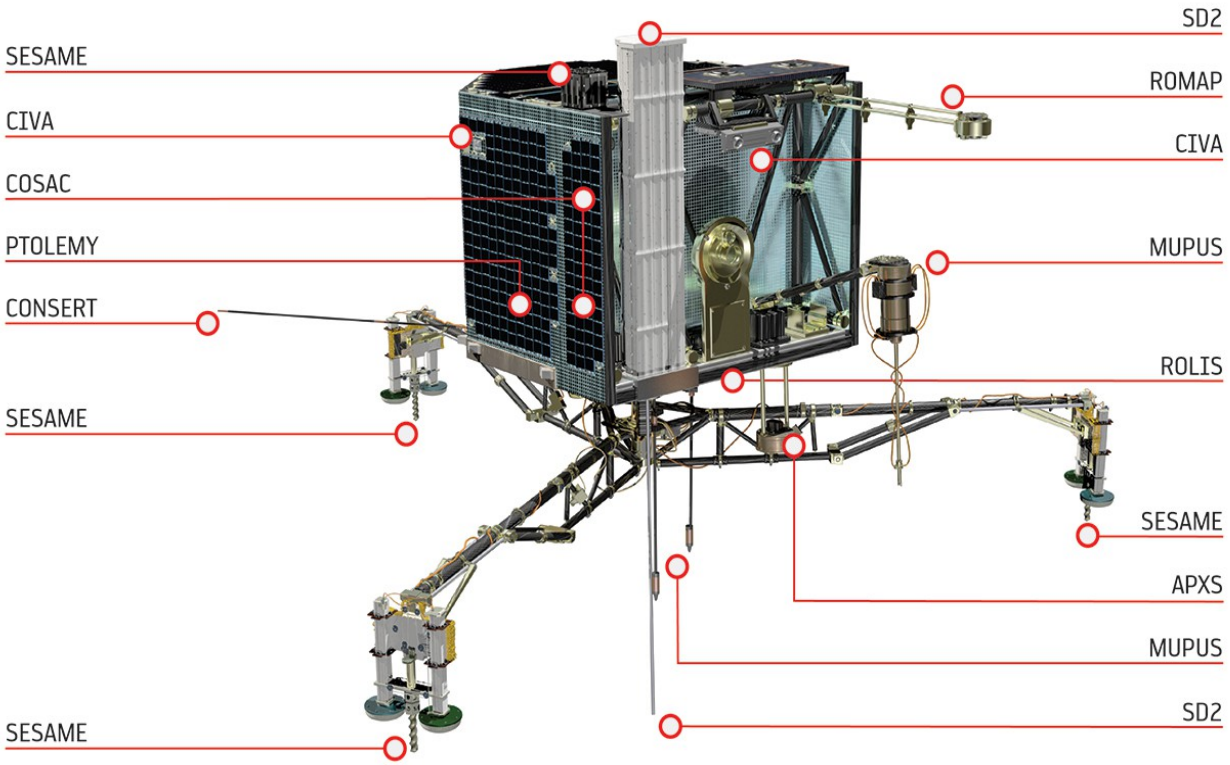
12 January 2015 at 27.9 km from the centre of comet.
The image scale is about 2.4 m/pixel.



Rosetta's trajectory around comet 67P



Philae instruments

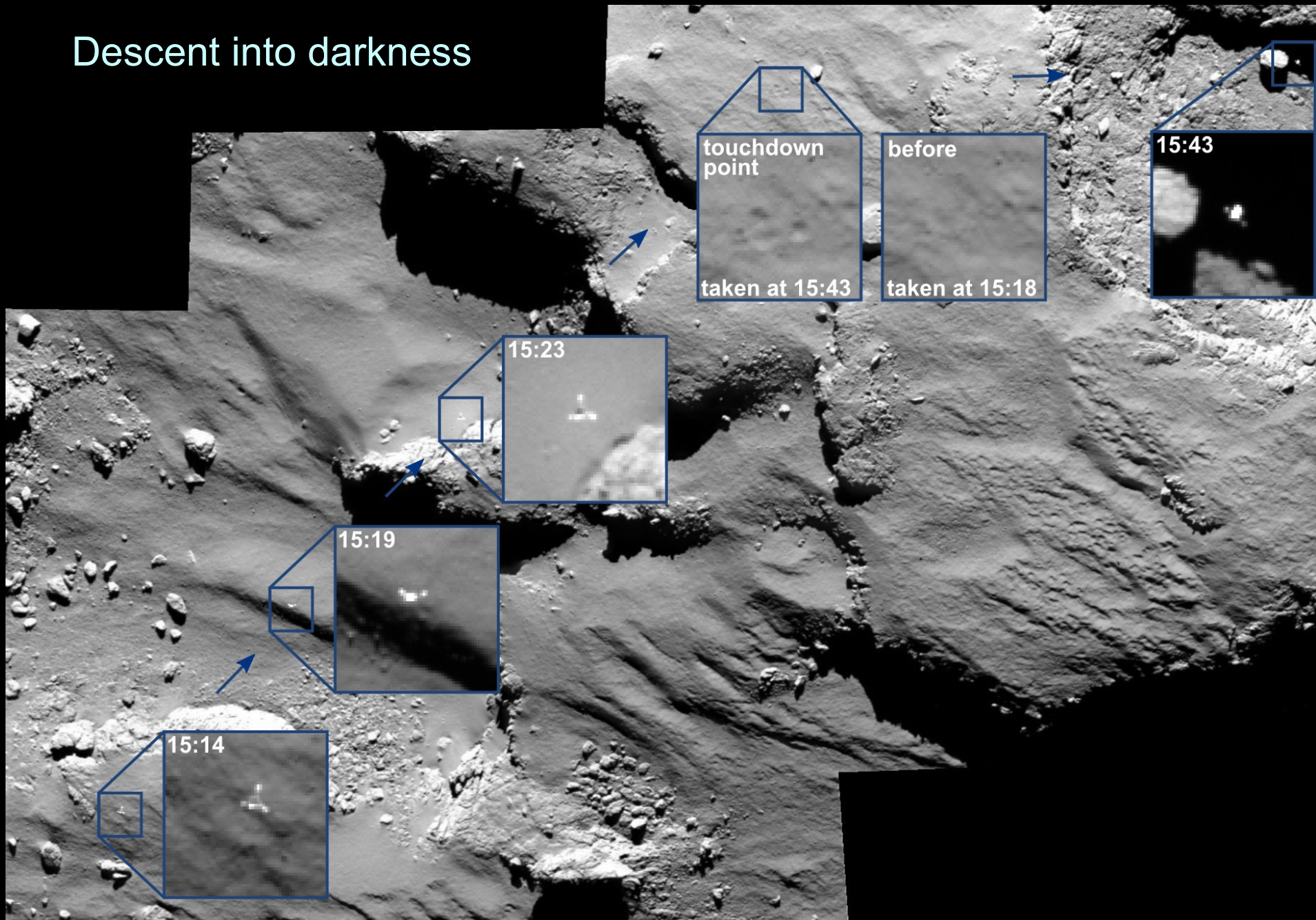


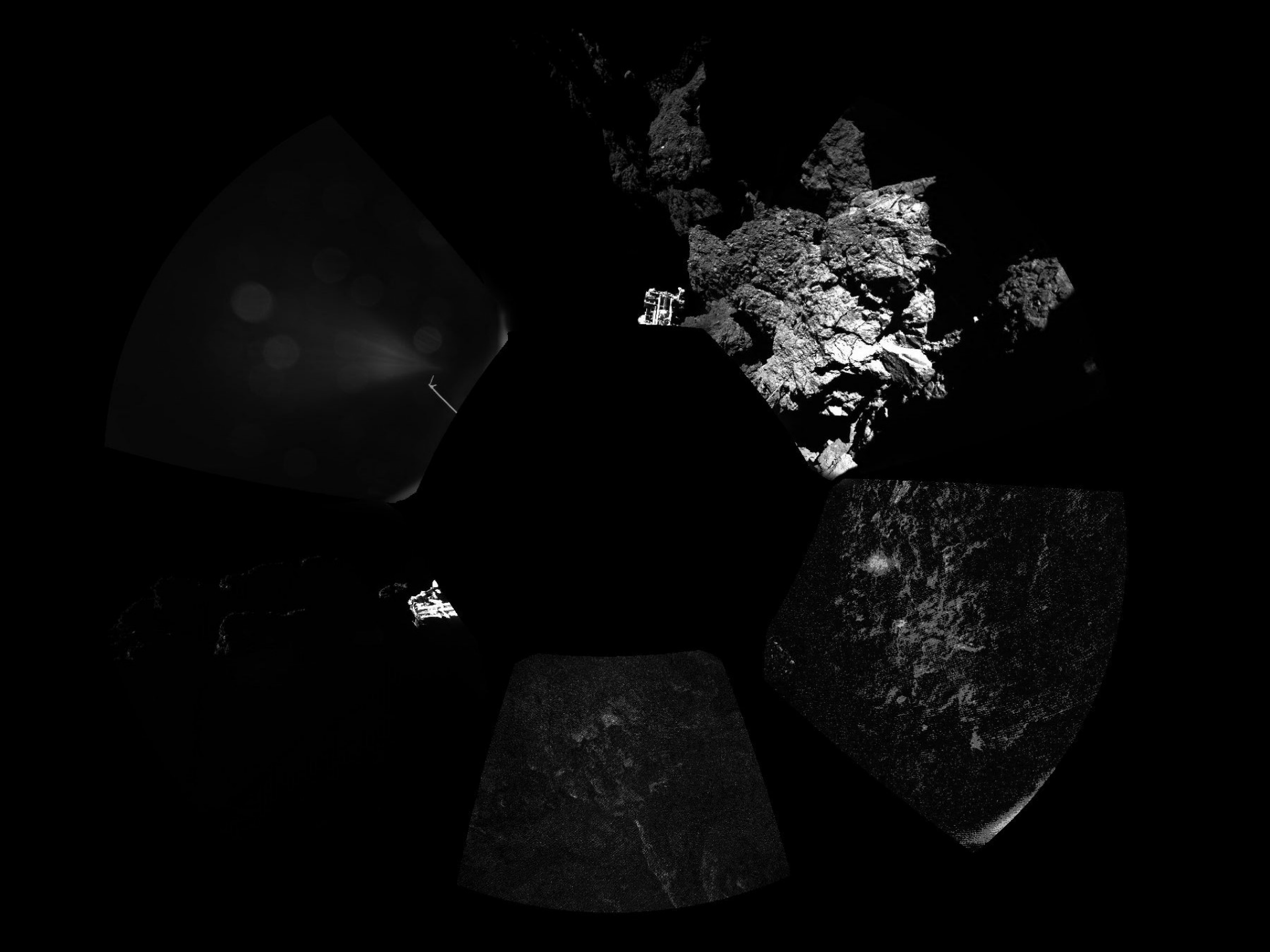
APXS: Alpha Proton X-ray Spectrometer (studying the chemical composition of the landing site and its potential alteration during the comet's approach to the Sun)
CIVA: Comet Nucleus Infrared and Visible Analyser (six cameras to take panoramic pictures of the comet surface)
CONSERT: COmet Nucleus Sounding Experiment by Radiowave Transmission (studying the internal structure of the comet nucleus with Rosetta orbiter)
COSAC: The COmetary SAmpling and Composition experiment (detecting and identifying complex organic molecules)
PTOLEMY: Using MODULUS protocol (Methods Of Determining and Understanding Light elements from Unequivocal Stable isotope compositions) to understand the geochemistry of light elements, such as hydrogen, carbon, nitrogen and oxygen.
MUPUS: MUlti-PUrpose Sensors for Surface and Sub-Surface Science (studying the properties of the comet surface and immediate sub-surface)
ROLIS: Rosetta Lander Imaging System (providing the first close-up images of the landing site)
ROMAP: Rosetta Lander Magnetometer and Plasma Monitor (studying the magnetic field and plasma environment of the comet)
SD2: Sampling, drilling and distribution subsystem (drilling up to 23 cm depth and delivering material to onboard instruments for analysis)
SESAME: Surface Electric Sounding and Acoustic Monitoring Experiment (probing the mechanical and electrical parameters of the comet)

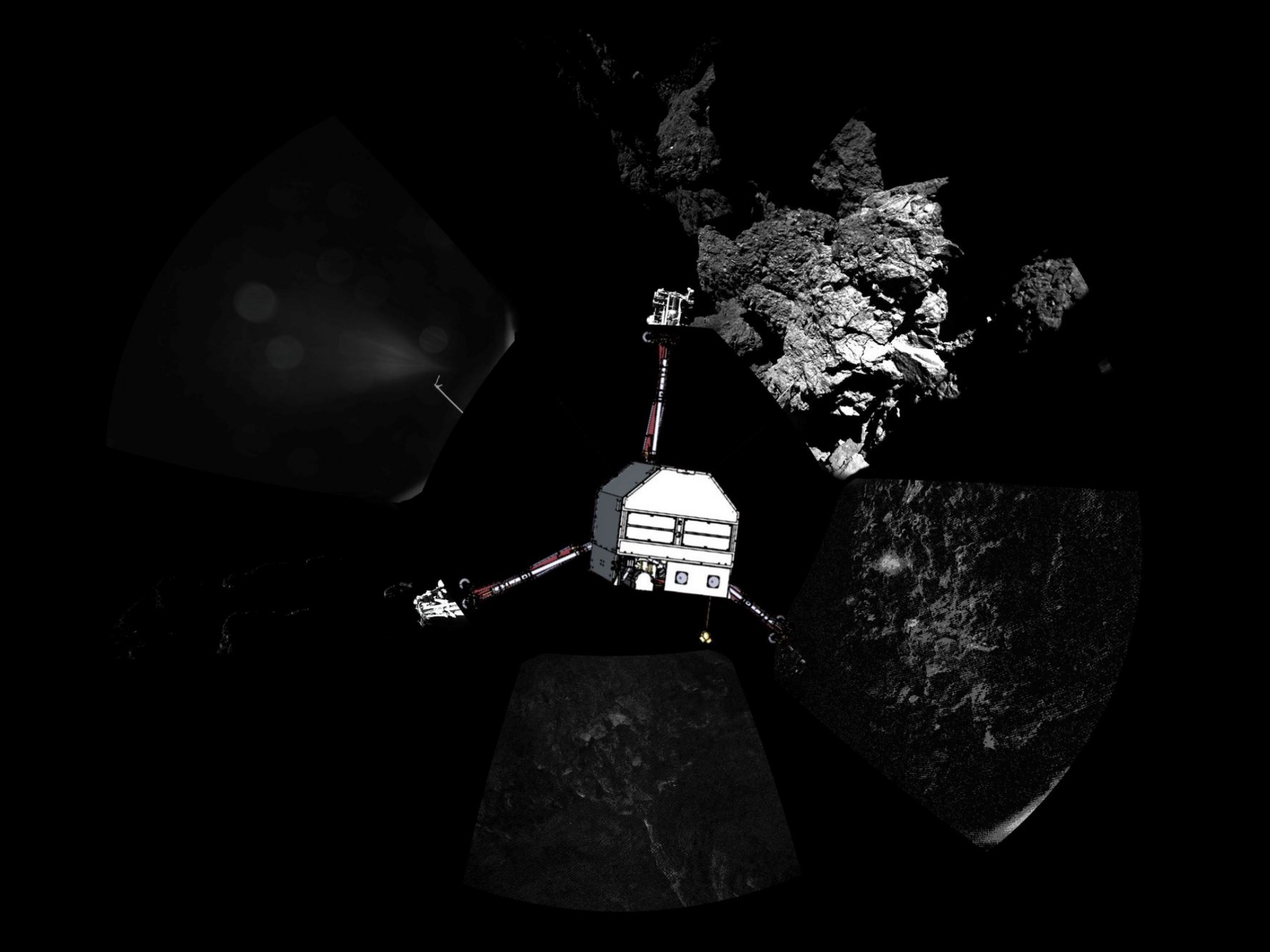
Philae descends to the surface. November 2014

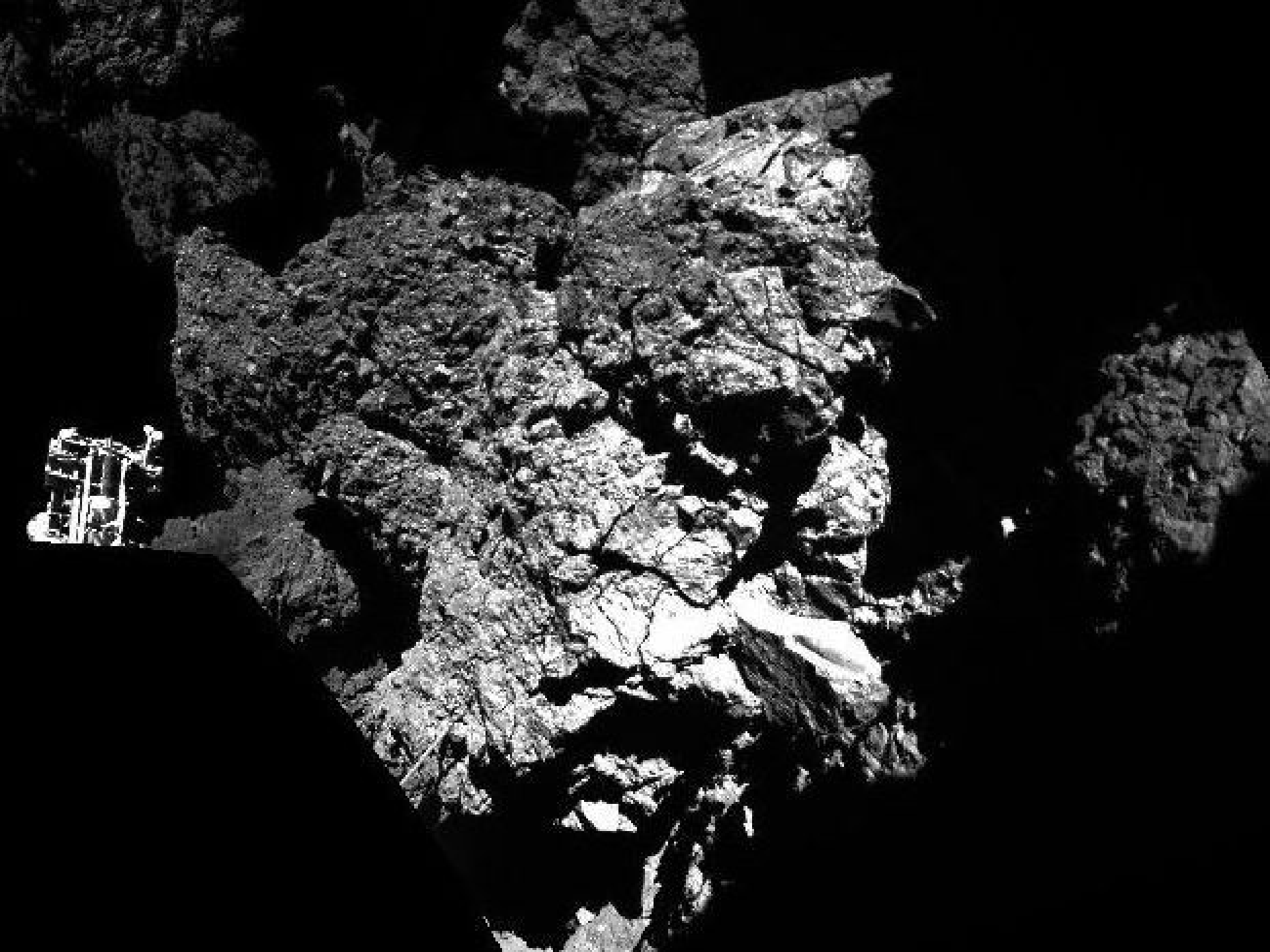
This image was taken by Philae's down-looking descent ROLIS imager when it was about 40 m above the surface

Descent into darkness









→ COMET 67P/CHURYUMOV–GERASIMENKO'S VITAL STATISTICS

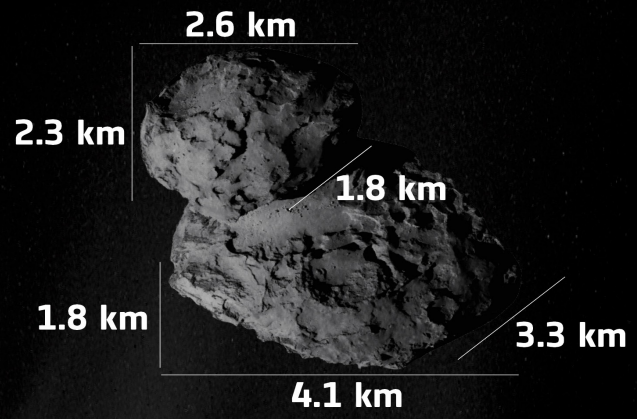
esa

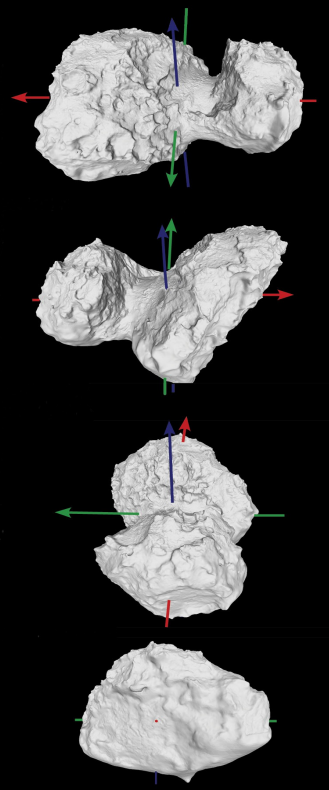
21.4 km³
Volume

1.0 × 10¹³ kg
Mass

470 kg/m³
Density

70–80%
Porosity





Rotation period
12.4043 hours

Spin axis:
69.3°
Right Ascension

64.1°
Declination

52°
Obliquity of the comet's rotational axis

4
Dust/gas ratio

5.3 × 10⁻⁴
D/H ratio

Average water vapour production
300 ml/s → June 2014
600 ml/s → July 2014
1200 ml/s → August 2014

–93°C to –43°C
Surface temperature

–243°C to –113°C
Subsurface temperature

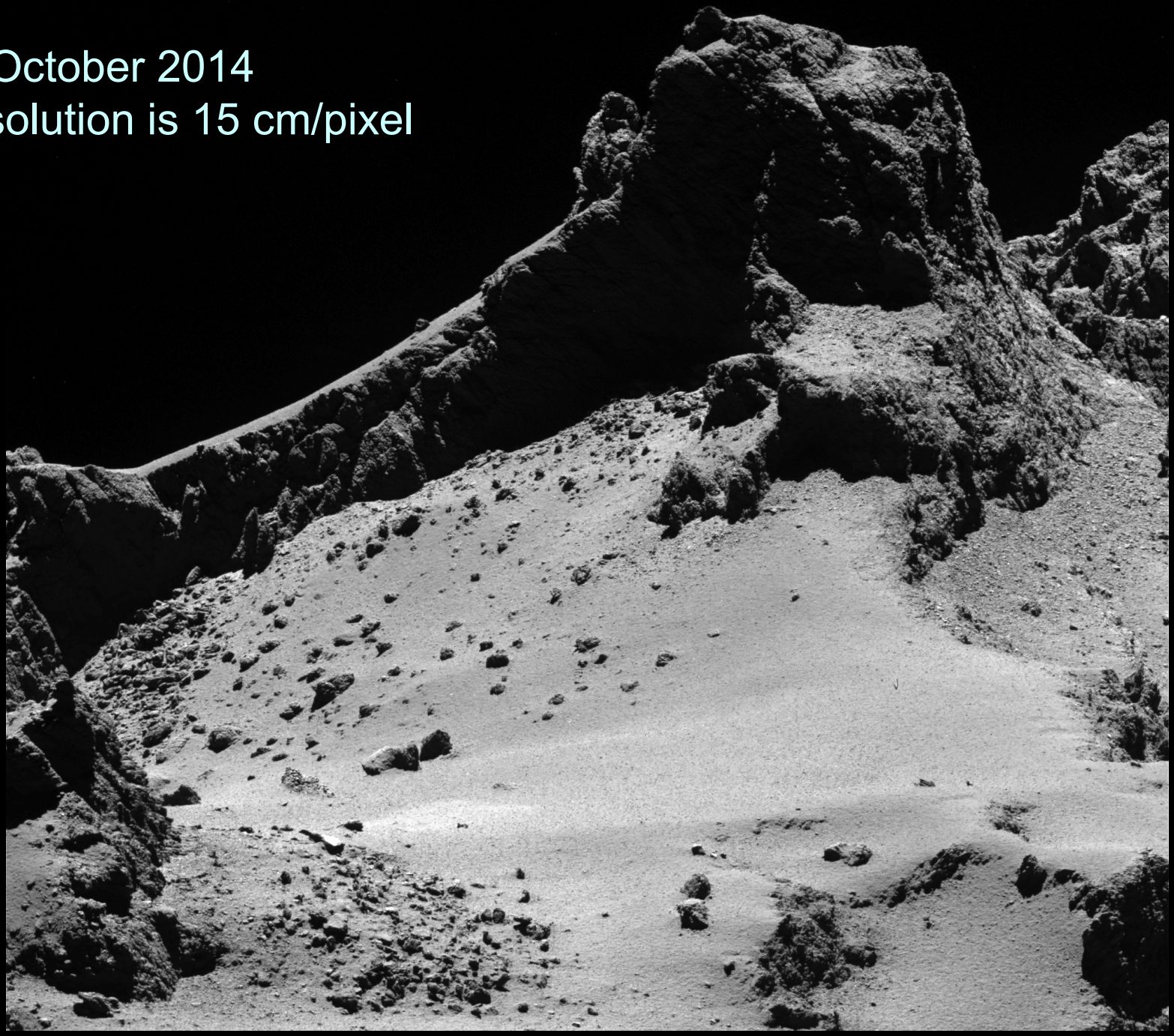
6%
Average albedo

Rotation/shape model: OSIRIS; surface temperature: VIRTIS; subsurface temperature: MIRO; water production rate: MIRO; D/H: ROSINA; dust/gas: GIADA, MIRO, ROSINA; volume: OSIRIS; mass: RSI; density: RSI/OSIRIS; albedo: OSIRIS, VIRTIS; comet images: NavCam

Data based on values published in January 2015

Very low albedo ~6%

14 October 2014
Resolution is 15 cm/pixel



An activist uses science to fight animal research *p. 366*

A battle of principles in the e-cigarettes debate *p. 375*

Counting molecular garbage chutes in intact neurons *p. 419*

Science

$10
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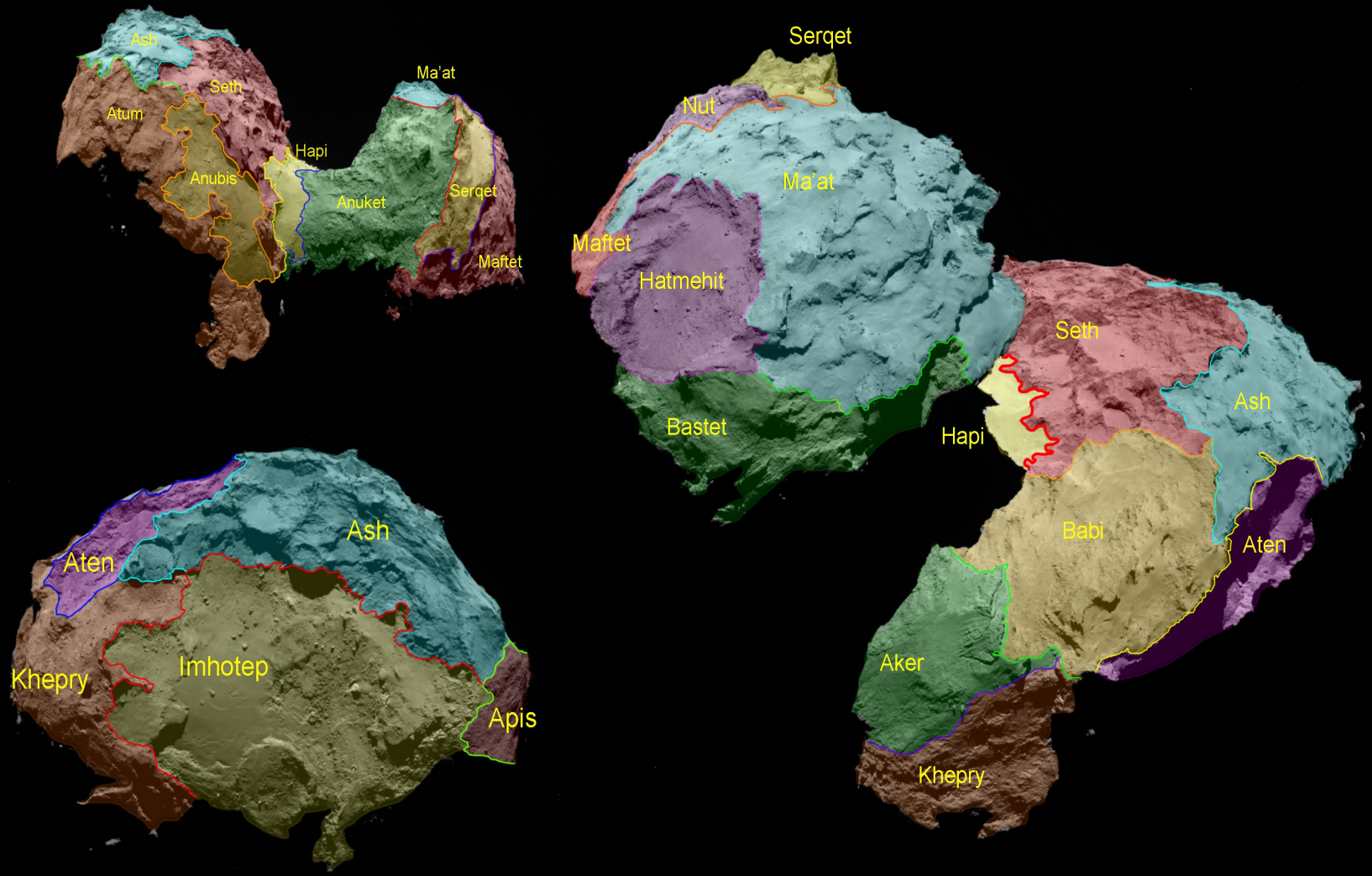
Catching a comet

Rosetta follows a relic of the early solar system toward the Sun

pp. 358 & 387

Different surface types



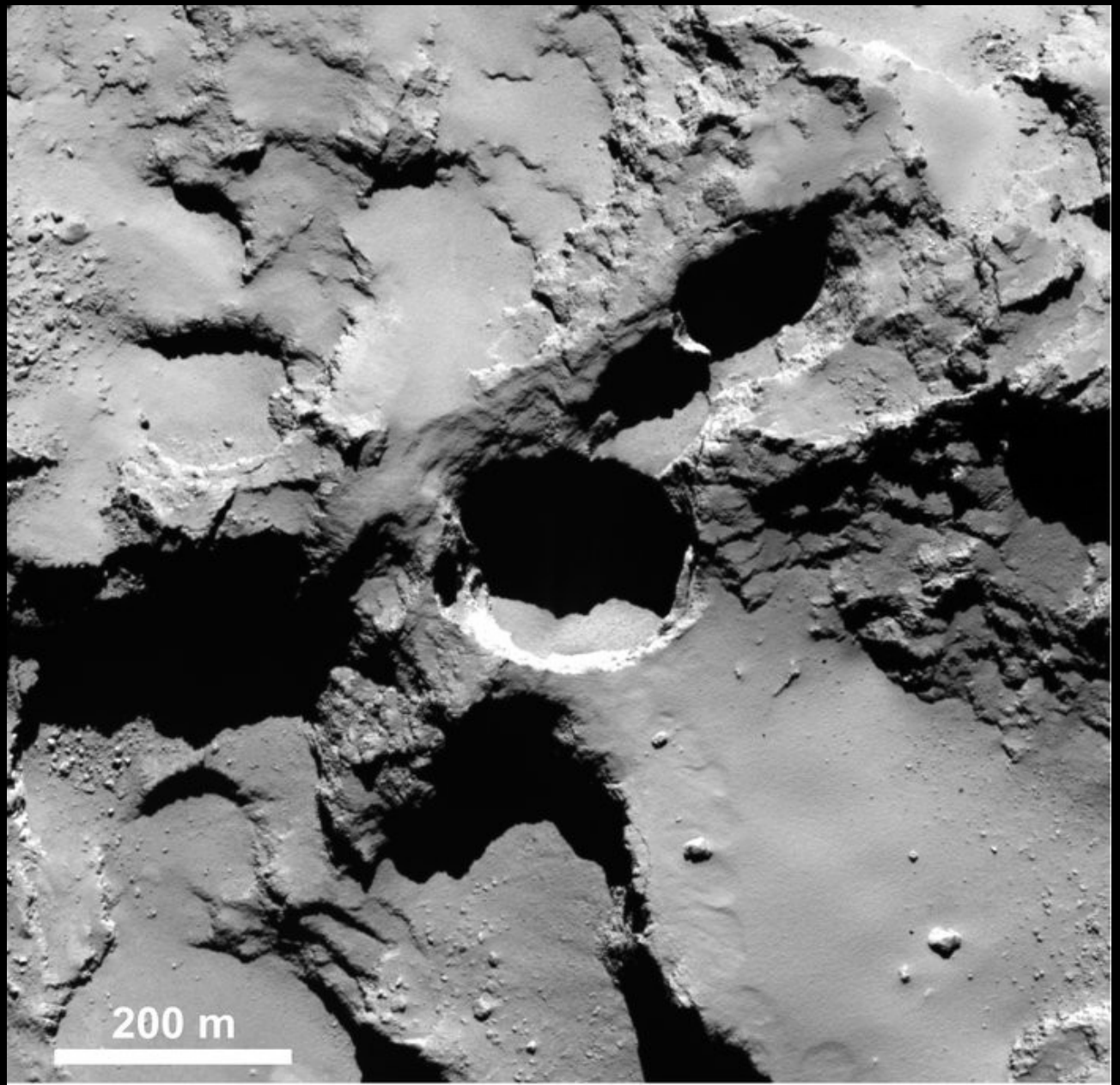
The 19 regions identified are separated by distinct geomorphological boundaries

Regions are grouped according to the type of terrain dominant within each region.

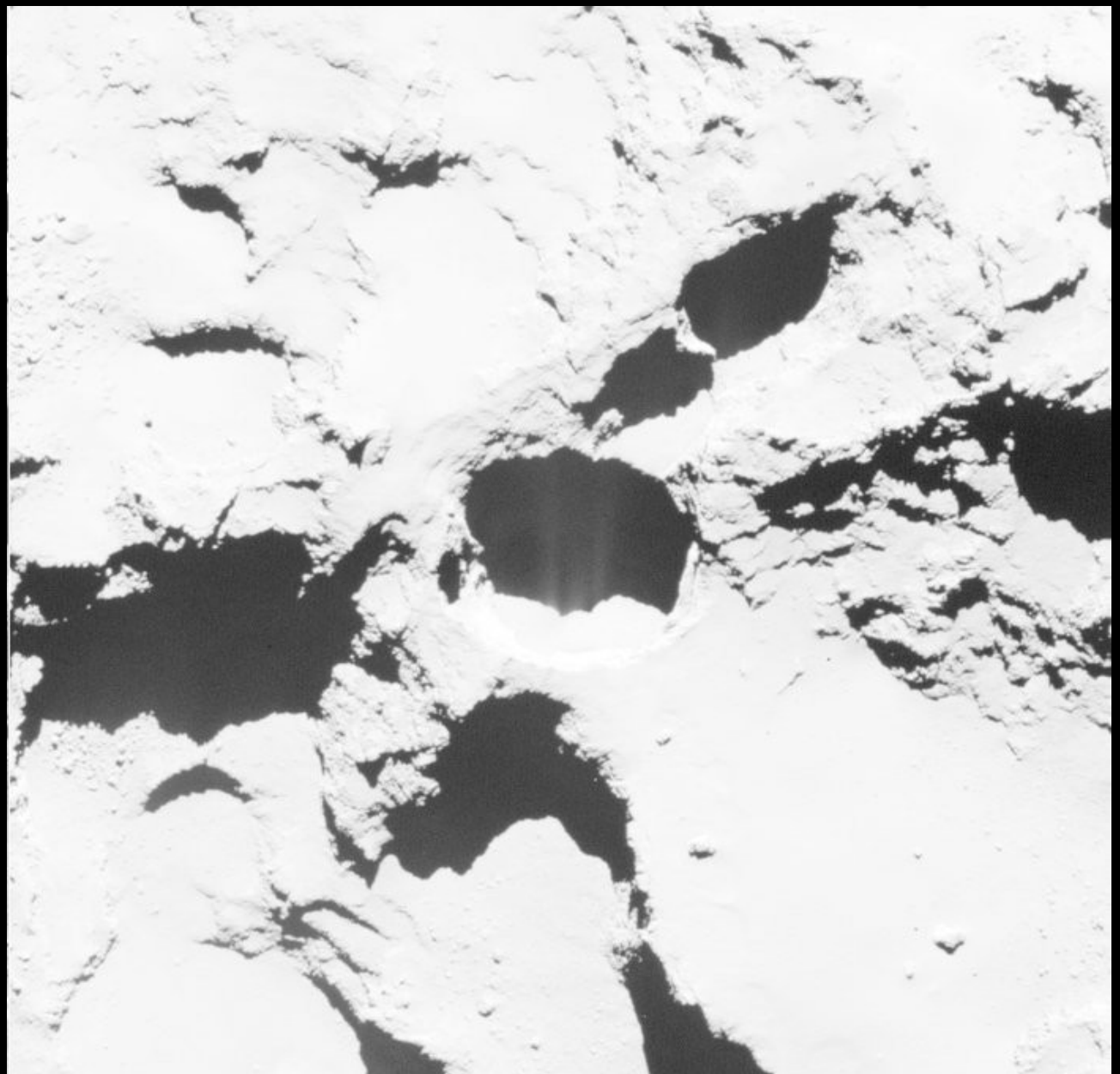
Five basic categories of terrain type have been determined:

- Dust-covered (Ma'at, Ash and Babi)
- Brittle materials with pits and circular structures (Seth)
- Large-scale depressions (Hatmehit, Nut and Aten)
- Smooth terrains (Hapi, Imhotep and Anubis)
- Exposed, more consolidated ('rock-like') surfaces (Maftet, Bastet, Serqet, Hathor, Anuket, Khepry, Aker, Atum and Apis).

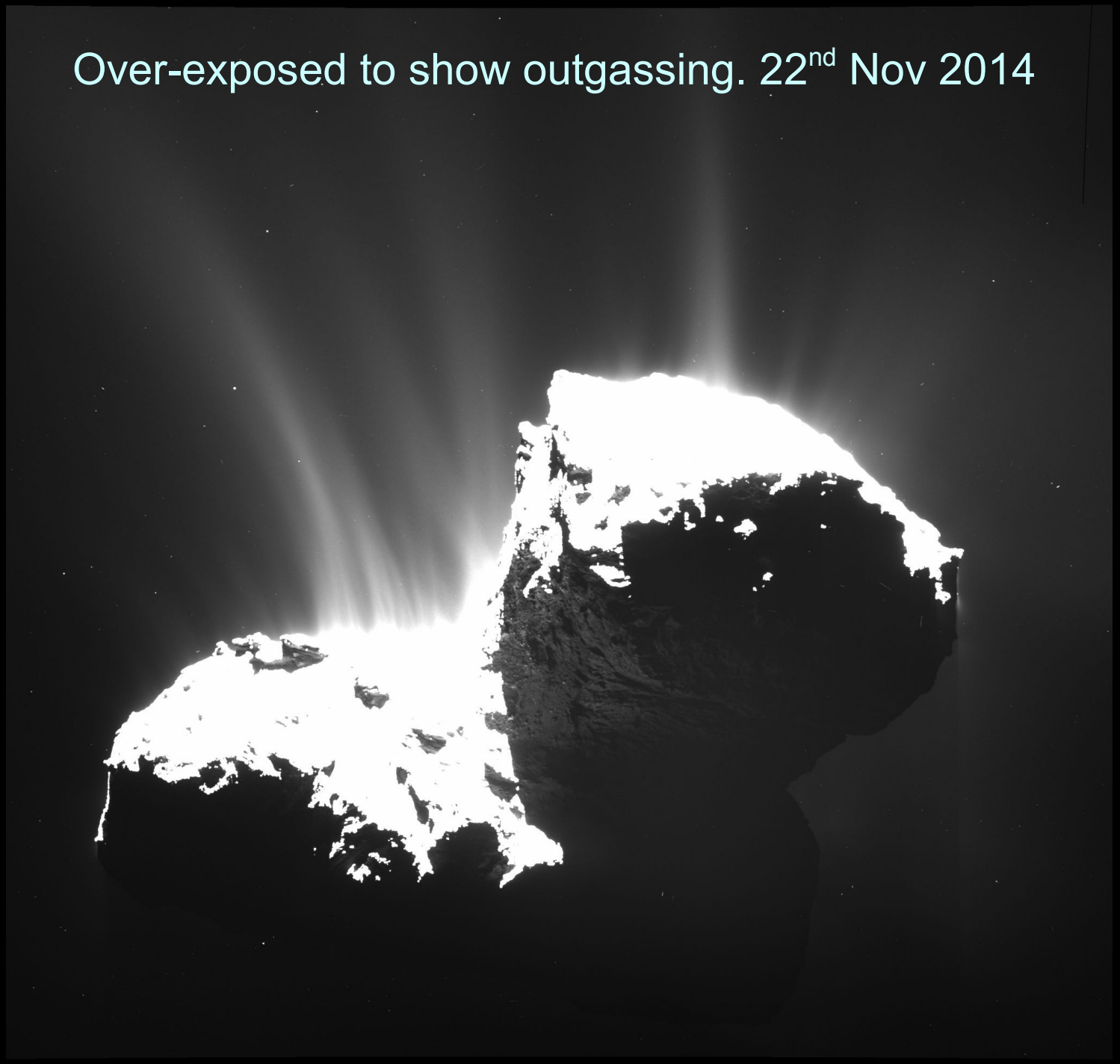
Active pit detected in Seth region. 28 August 2014



Enhanced image showing activity



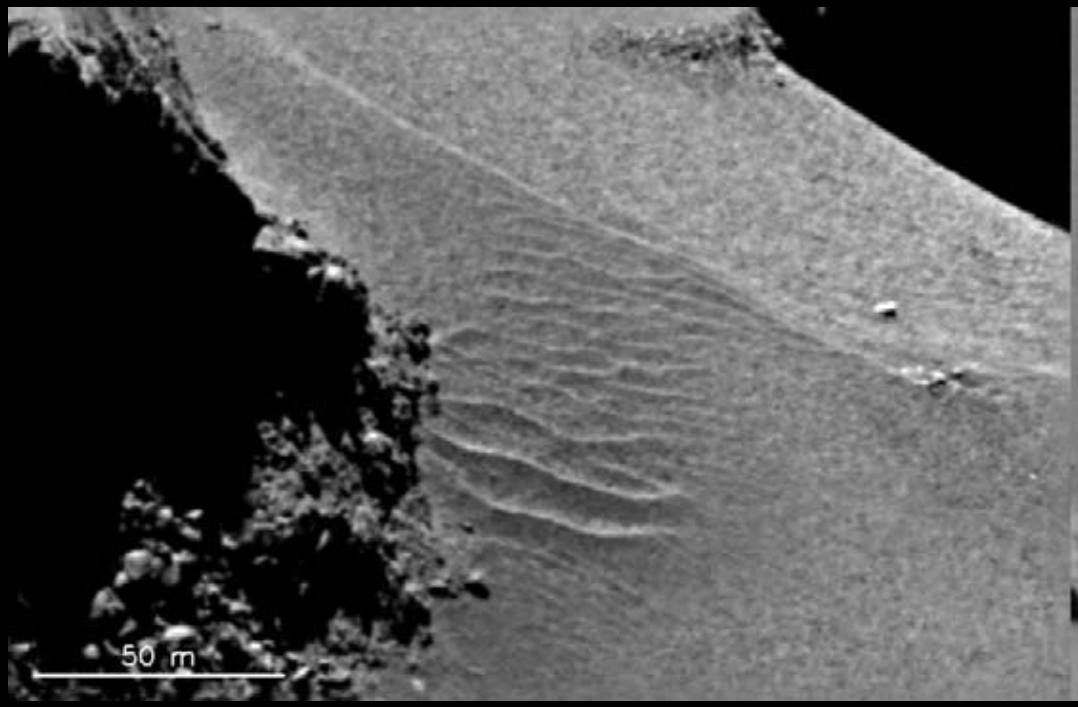
Over-exposed to show outgassing. 22nd Nov 2014

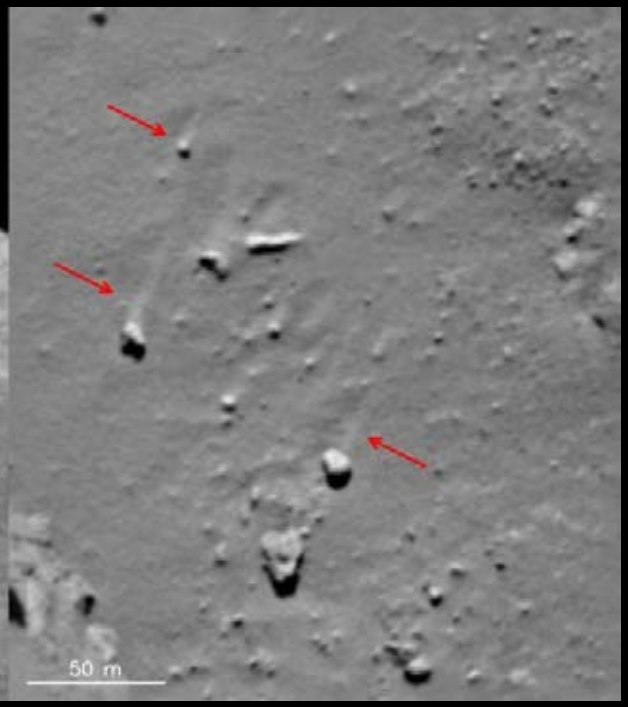


Possible aeolian transport

Aeolian ripples in the Hapi region

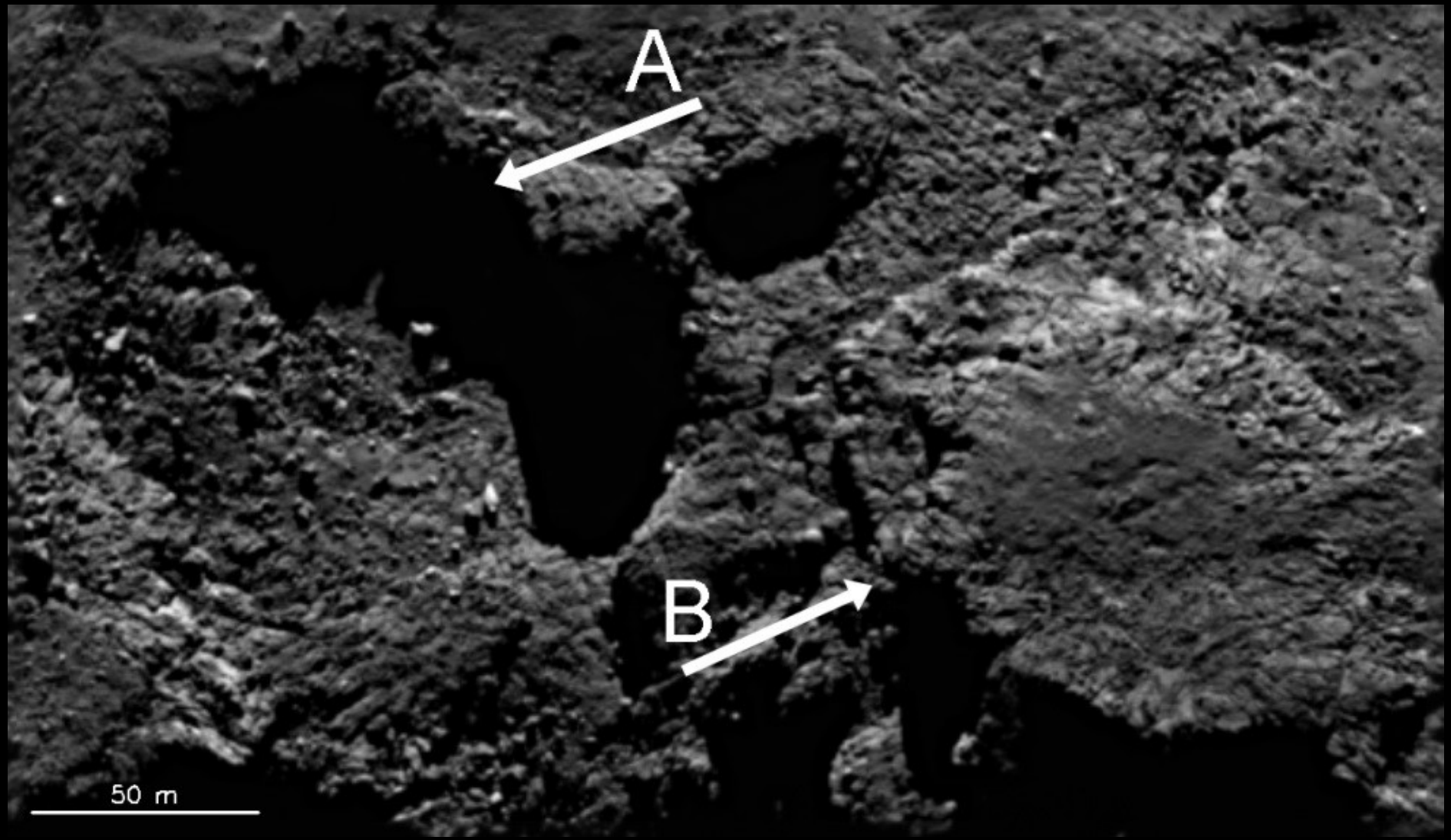
Wind tails behind rocks in the Hapi region.





Quasi-linear cracks in Anuket which extend from Hapi around the neck.

Block ejected by gas eruption?
Maftet region

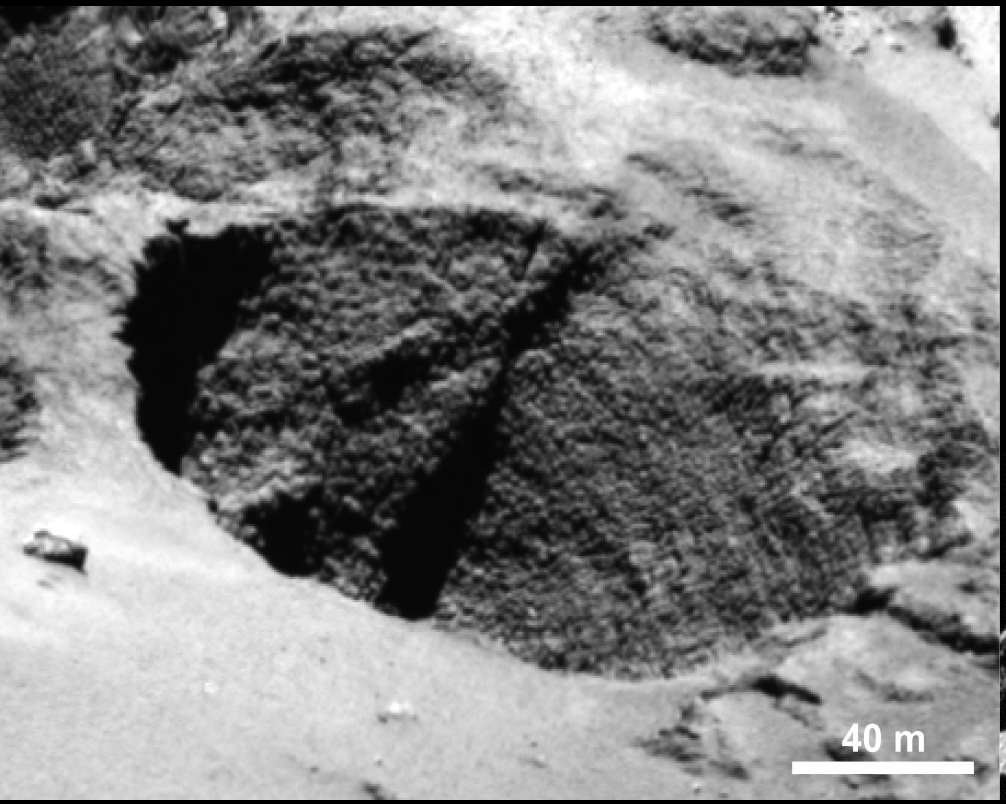


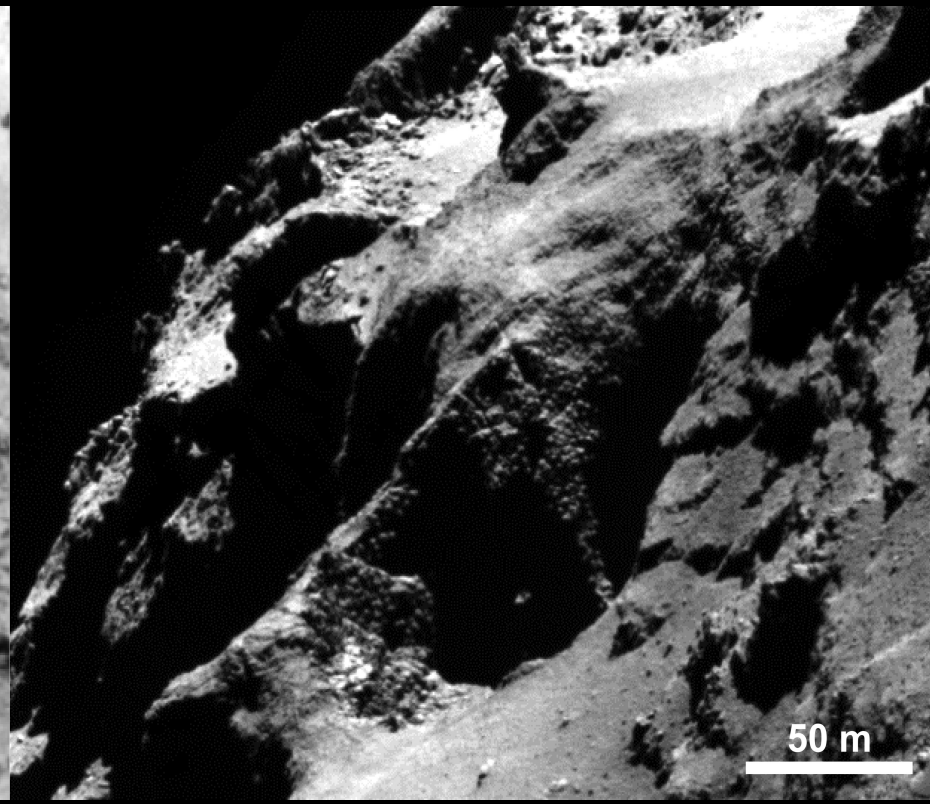
Fluidised flow in Maftet region?

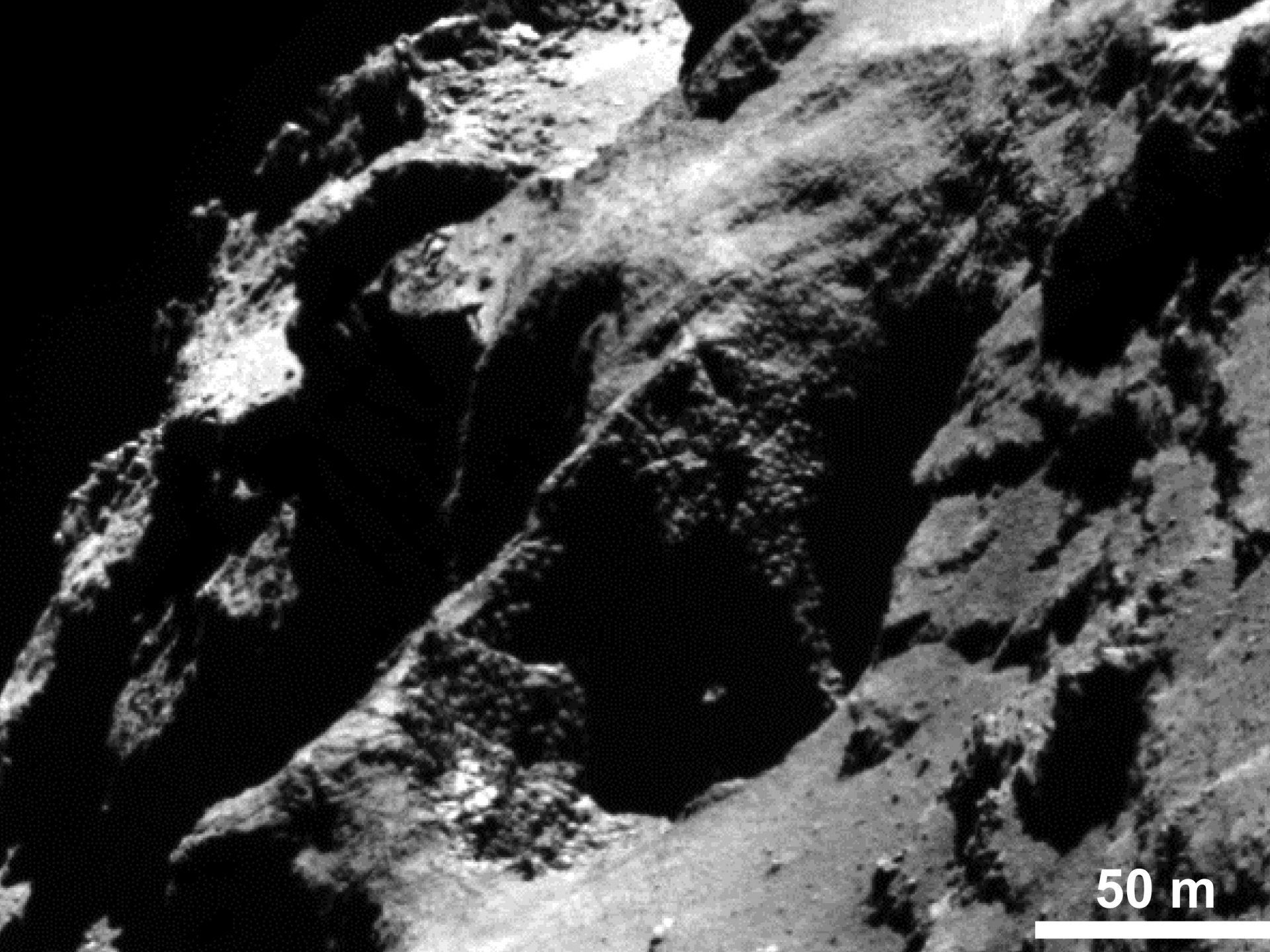
Close-ups of a curious surface texture nicknamed 'goosebumps'.

The characteristic scale of all the bumps seen on Comet 67P/Churyumov–Gerasimenko by the OSIRIS narrow-angle camera is approximately 3 m, extending over regions greater than 100 m.

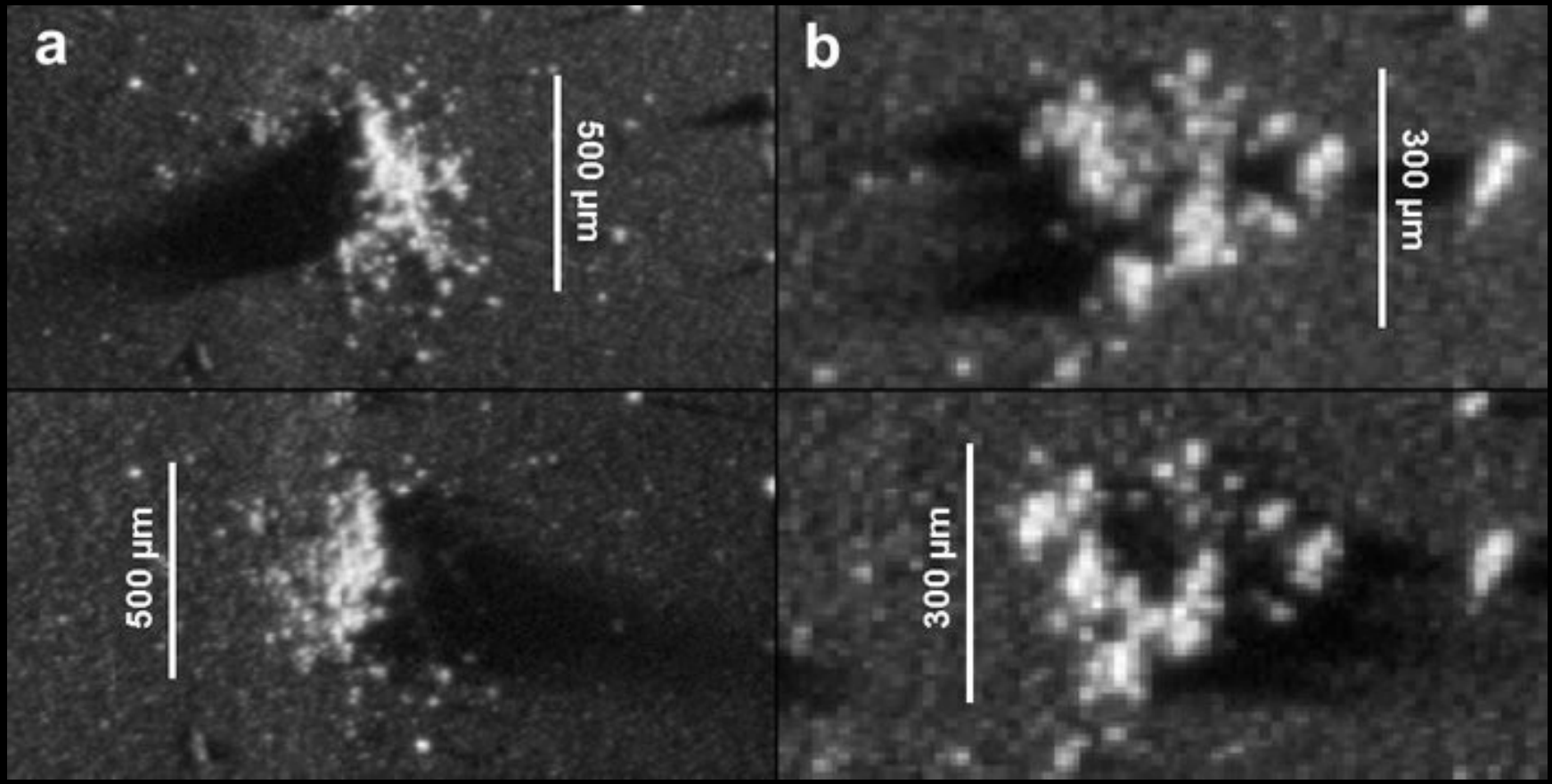
They are seen on very steep slopes and on exposed cliff faces, but their formation mechanism is yet to be explained






50 m

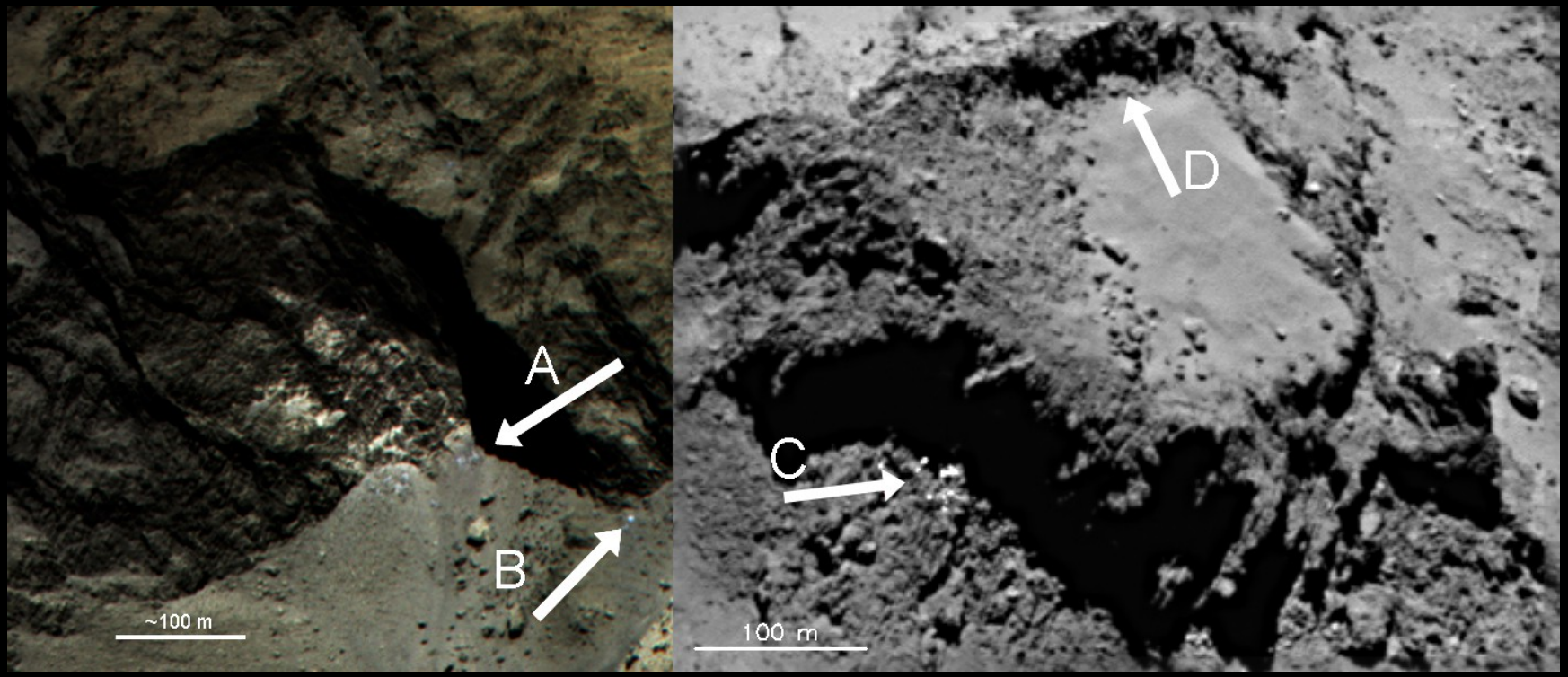
Fluffy dust grains collected by Rosetta's
COmetary Secondary Ion Mass Analyser (COSIMA)
Low ice content means they collapsed on impact



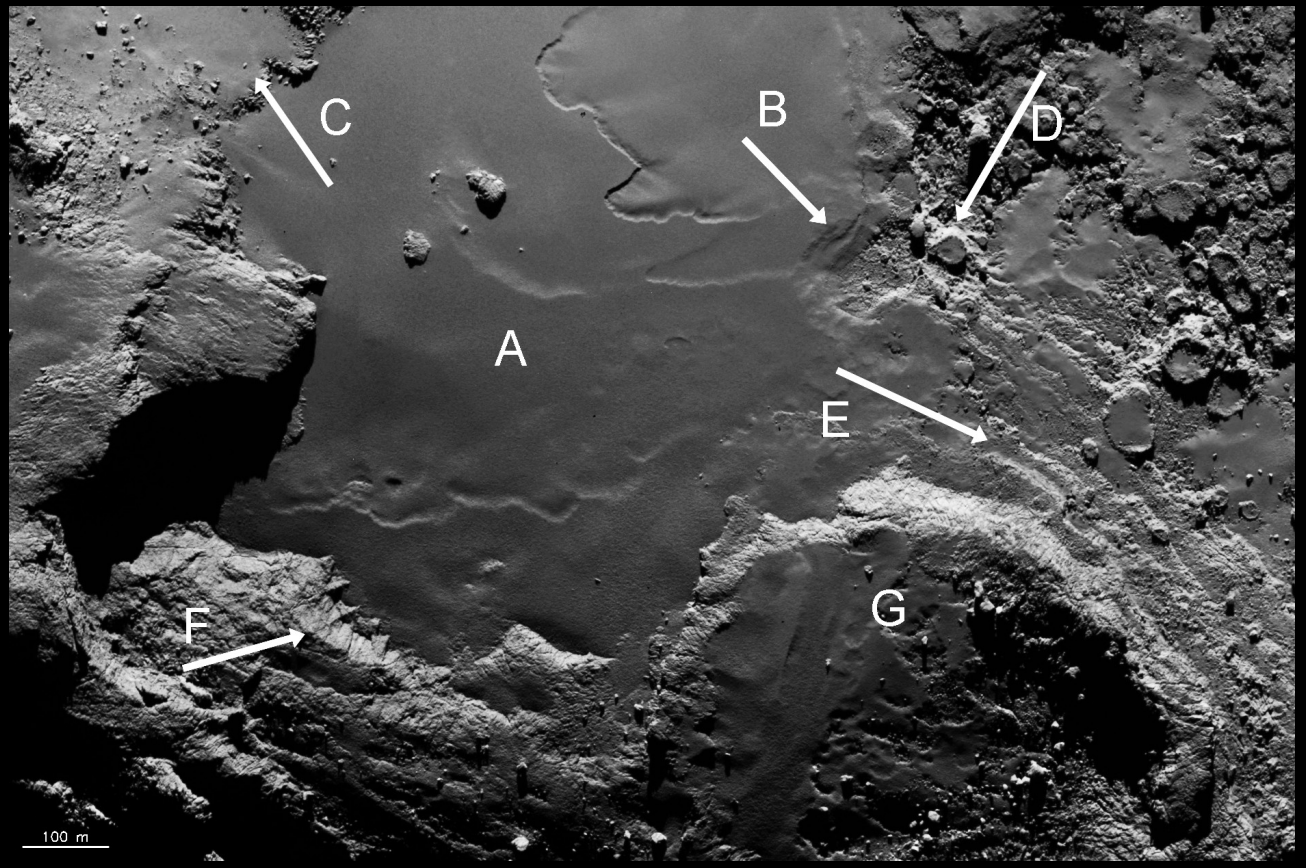
A&B (Colour image) - material 20% brighter and bluer than the surroundings may be evidence of recently exposed ice.

C - Bright, highly reflective metre□size boulders at the Ash-Khepry boundary

D - An example of brittle fracturing



Part of the Imhotep region



A - smooth terrain

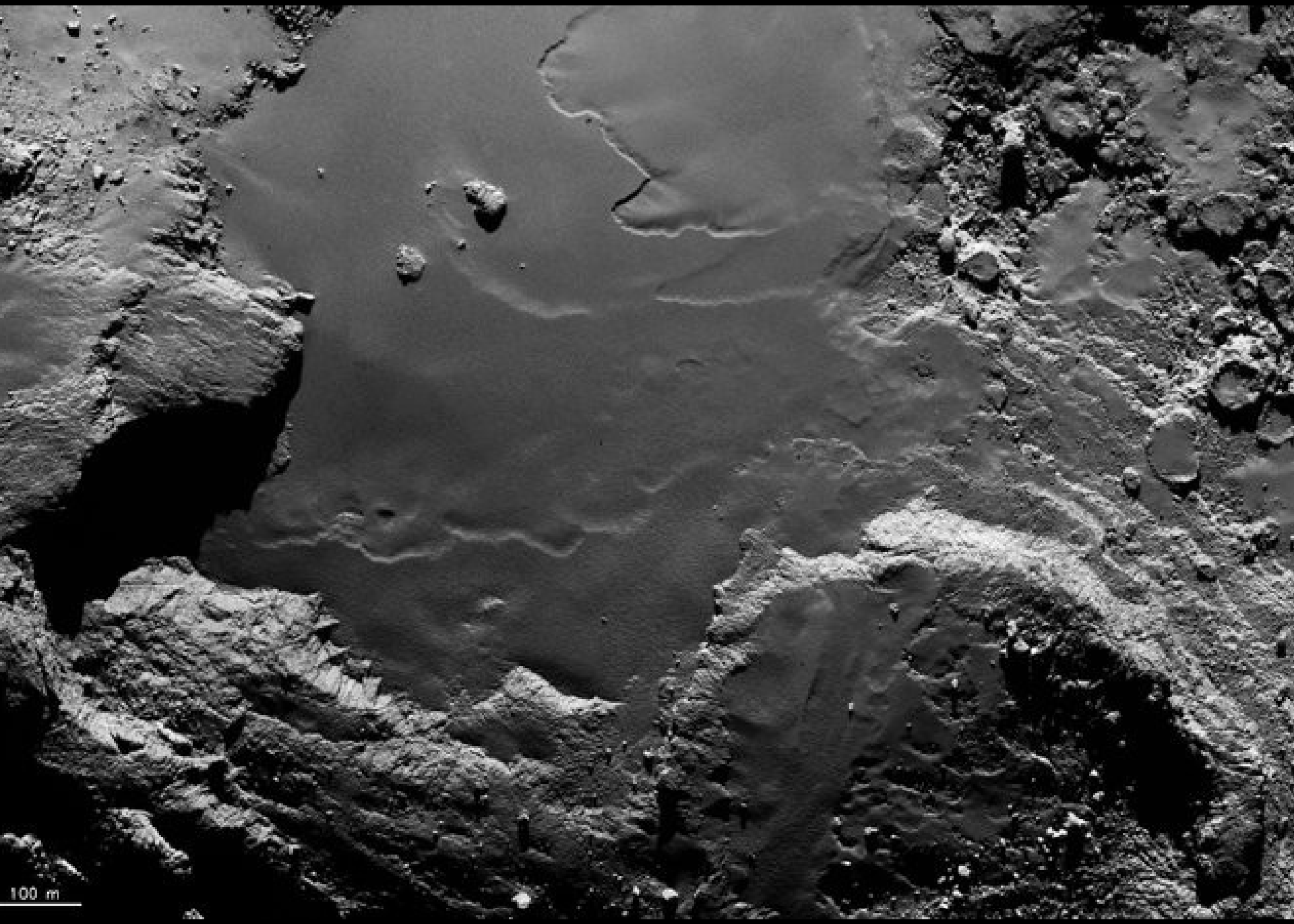
B - layering of this material at its margin

C - smooth material on topographically higher surfaces

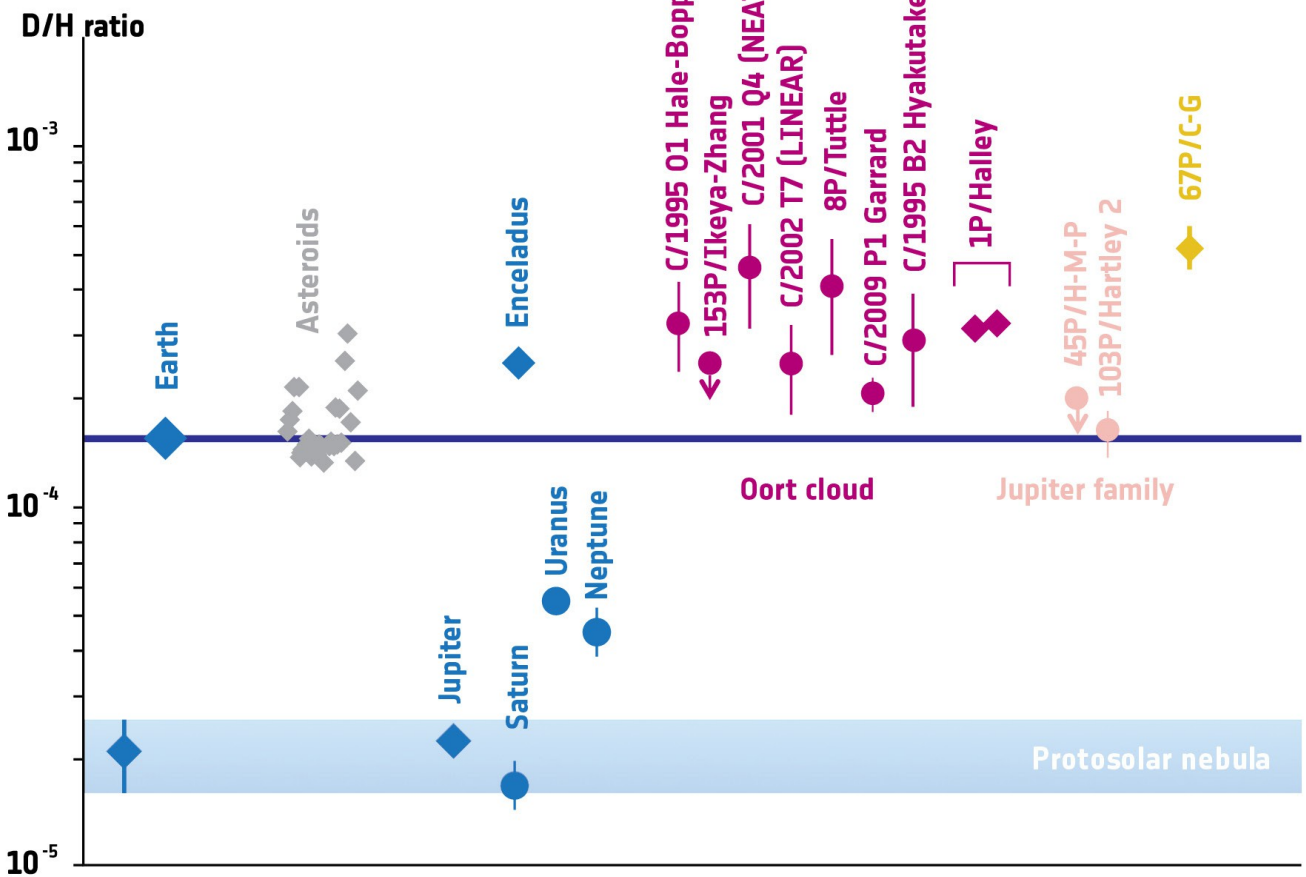
D - circular structures

E - layered consolidated material rising towards a 650 m-diameter raised semicircular structure (G)

F - Fracturing of consolidated material is evident throughout


100 m

Deuterium/Hydrogen ratio



SCIENCE Magazine Jan 2015

- 67/P papers available for free download at http://www.sciencemag.org/site/special/rosetta/
- Some titles and headlines from the abstracts…

On the nucleus structure and activity of comet 67P/Churyumov-Gerasimenko

- The nucleus has a bulk density less than half that of water.
- Activity at a distance from the Sun of >3 astronomical units is predominantly from the neck, where jets have been seen consistently.
- The nucleus rotates about the principal axis of momentum with period 12.4 hours.
- The surface morphology suggests that the removal of larger volumes of material, possibly via explosive release of subsurface pressure or via creation of overhangs by sublimation, may be a major mass loss process.
- The shape raises the question of whether the two lobes represent a contact binary formed 4.5 billion years ago, or a single body where a gap has evolved via mass loss.

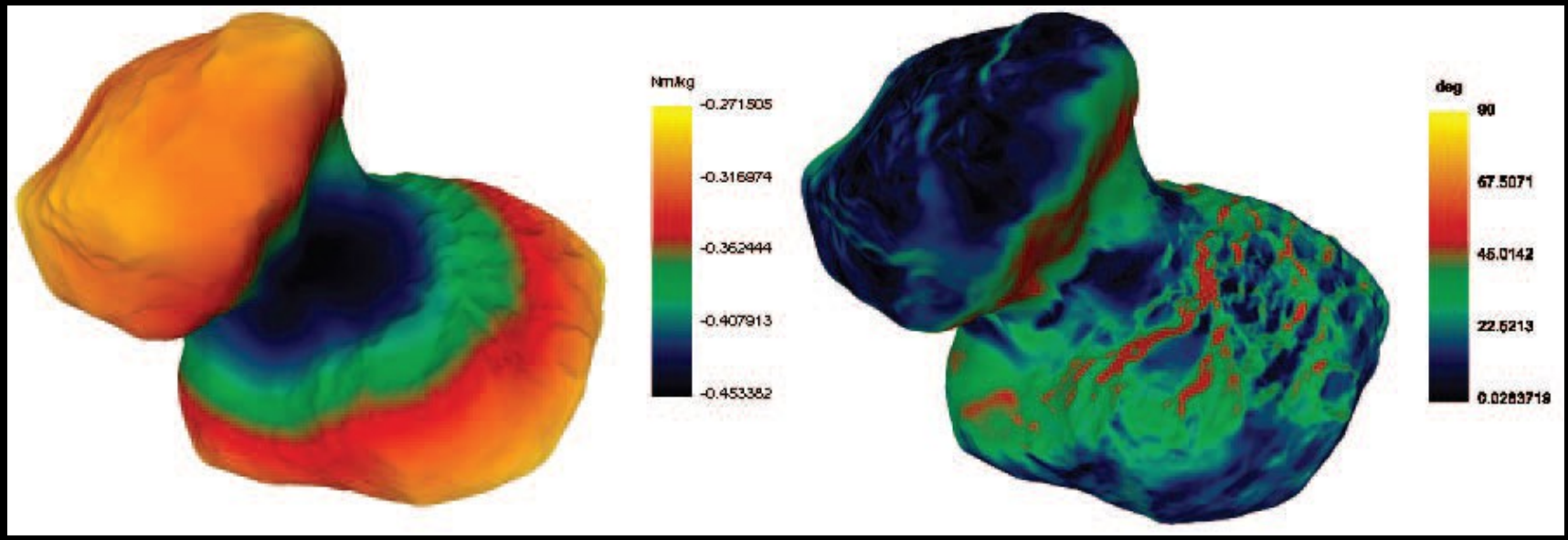
Dust measurements in the coma of comet 67P/Churyumov-Gerasimenko inbound to the Sun

- Dust/gas mass ratio of 4 ±2 averaged over the sunlit nucleus surface.
- A cloud of larger grains also encircles the nucleus in bound orbits from the previous perihelion.
- The largest orbiting clumps are meter-sized, confirming the dust/gas ratio of 3 inferred at perihelion from models of dust comae and trails.

The organic-rich surface of comet 67P/ Churyumov-Gerasimenko as seen by VIRTIS/Rosetta

- Nonvolatile organic macromolecular materials: a complex mixture of various types of carbon-hydrogen and/or oxygen-hydrogen chemical groups, with little contribution of nitrogen-hydrogen groups
- In active areas, the changes in spectral slope and absorption feature width may suggest small amounts of water ice
- However, no ice-rich patches are observed, indicating a generally dehydrated nature for the surface currently illuminated by the Sun

On the nucleus structure and activity of comet 67P/Churyumov-Gerasimenko

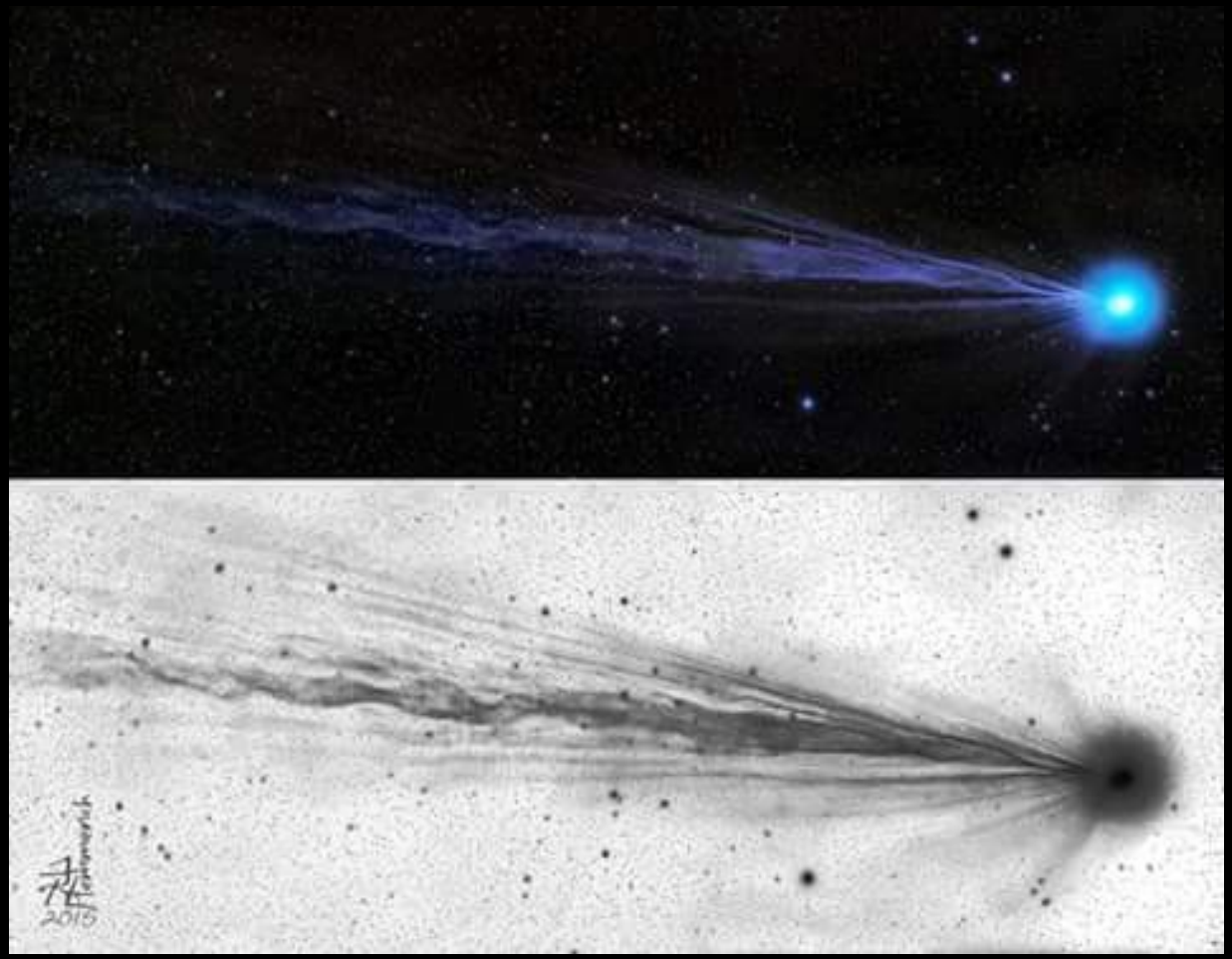


Gravitational field.

Left: The effective gravitational potential at the surface, including the centrifugal term due to rotation of the nucleus

Right: The slope of the terrain relative to local gravity.

Very briefly – Comet 2014 Q2 Lovejoy

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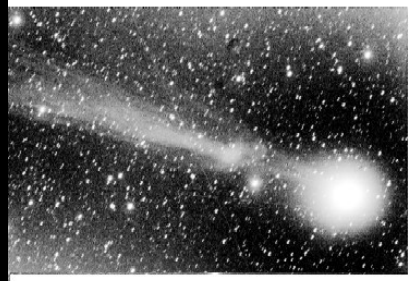
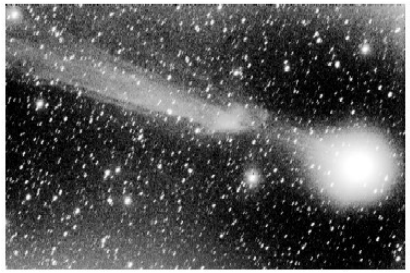
2014 Q2 (Lovejoy) - The Plasma Bubble

Night of the 8th January 2015



2015-01-08T18:48:40

The bubble is 37 arc minutes from the coma centre



2015-01-08T19:50:45

The Bubble is 41.5 arc minutes from the coma centre

2015-01-08T20:34:24

The Bubble is 44 arc minutes from the coma centre

2015-01-08T21:42:46

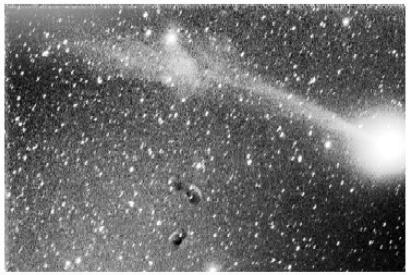
The Bubble is 48.5 arc minutes from the coma centre

2015-01-08T22:63:41

The Bubble is 55 arc minutes from the coma centre

2015-01-08T23:51:59

The Bubble is 59.5 arc minutes from the coma centre



2015-01-09T01:10:57

The Bubble is 66 arc minutes from the coma centre

Each image is a stack of 10 x 30 second exposures

104.4x77.6 arc mins

0.105m Ref F4 ST8 1x1 bin unfiltered

SON@OSC Tony Angel & Caisey Harlingten 36.877222, -3.249722 MPC Z85

Credits

- All information and images about comet 67/P courtesy of the European Space Agency, and Science Magazine
- 3 images of comet Lovejoy provided by Neil Norman and used with permission
- 1 image of comet Lovejoy provided by David Murton

- And finally – a short film - Ambition