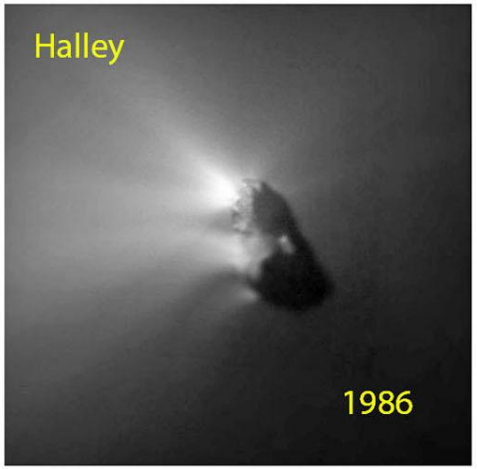
ROSETTA

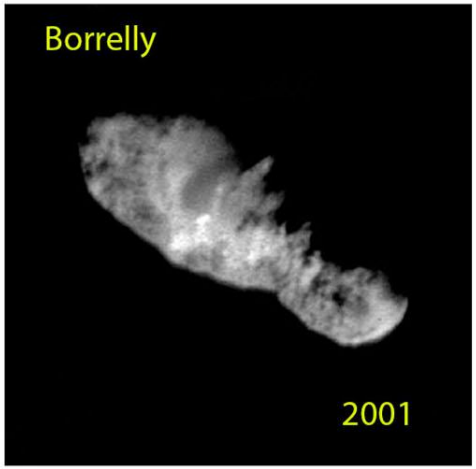
« Etude de l'émergence de l'activité d'une comète »

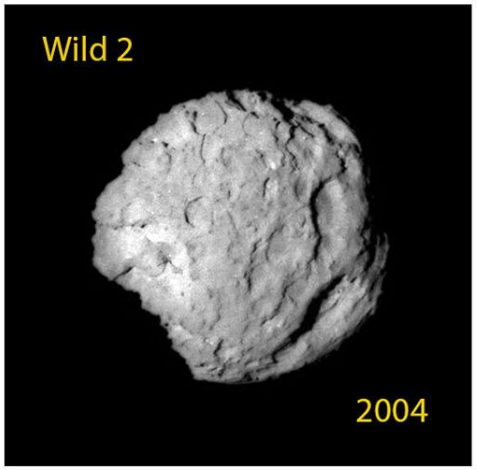
Francis Rocard, DSP/SME

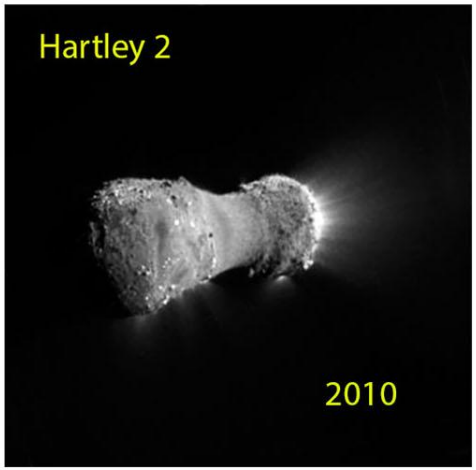
Historique

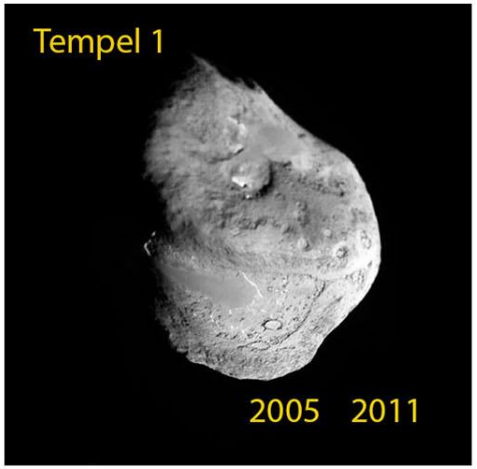
- 1991 : Après le succès de Giotto en 86, NASA et ESA étudient CNSR (comet nucleus sample return) mission très ambitieuse !
- 1993 : retrait NASA de CNSR, abandon du projet et naissance de Rosetta à l'ESA
  - la spéc de temp des échantillons était très difficiles à garantir
- Sept 1994 : choix de Rosetta comme 3ème Corner Stone du programme Horizon 2000
  - avec 2 petits landers : Roland (DLR, longue durée de vie) et Champollion (Nasa-CNES, courte durée de vie)
- 20 sept 96 : NASA annule sa participation au lander Champollion de Rosetta.
  - L'effort US est porté sur DS4-Champollion, mission au départ de retour d'échantillons cométaires puis rapidement sans retour : le CNES y participe.
- juin 99 : Nasa annule DS4-Champollion, les français montent à bord de Roland qui devient un "gros" lander de 100 kg et incorpore les expériences françaises CIVA (IAS) et Consert (IPAG)
- Roland devient **Philae**
- Mars 2003 lancement reporté en 2004 et choix de 67P


Halley
1986


Borrelly
2001

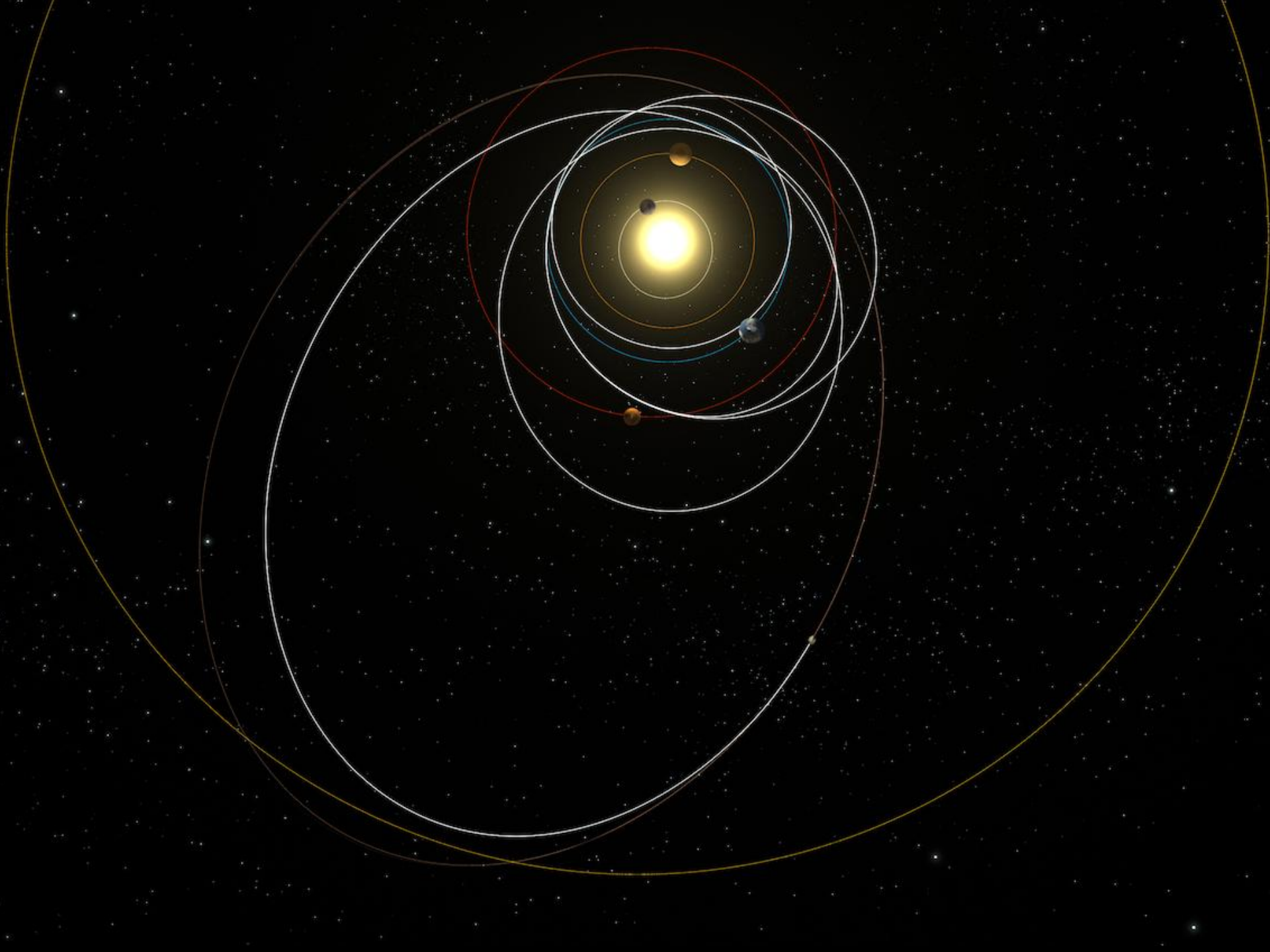

Wild 2
2004


Hartley 2
2010

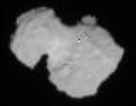

Tempel 1
2005 2011

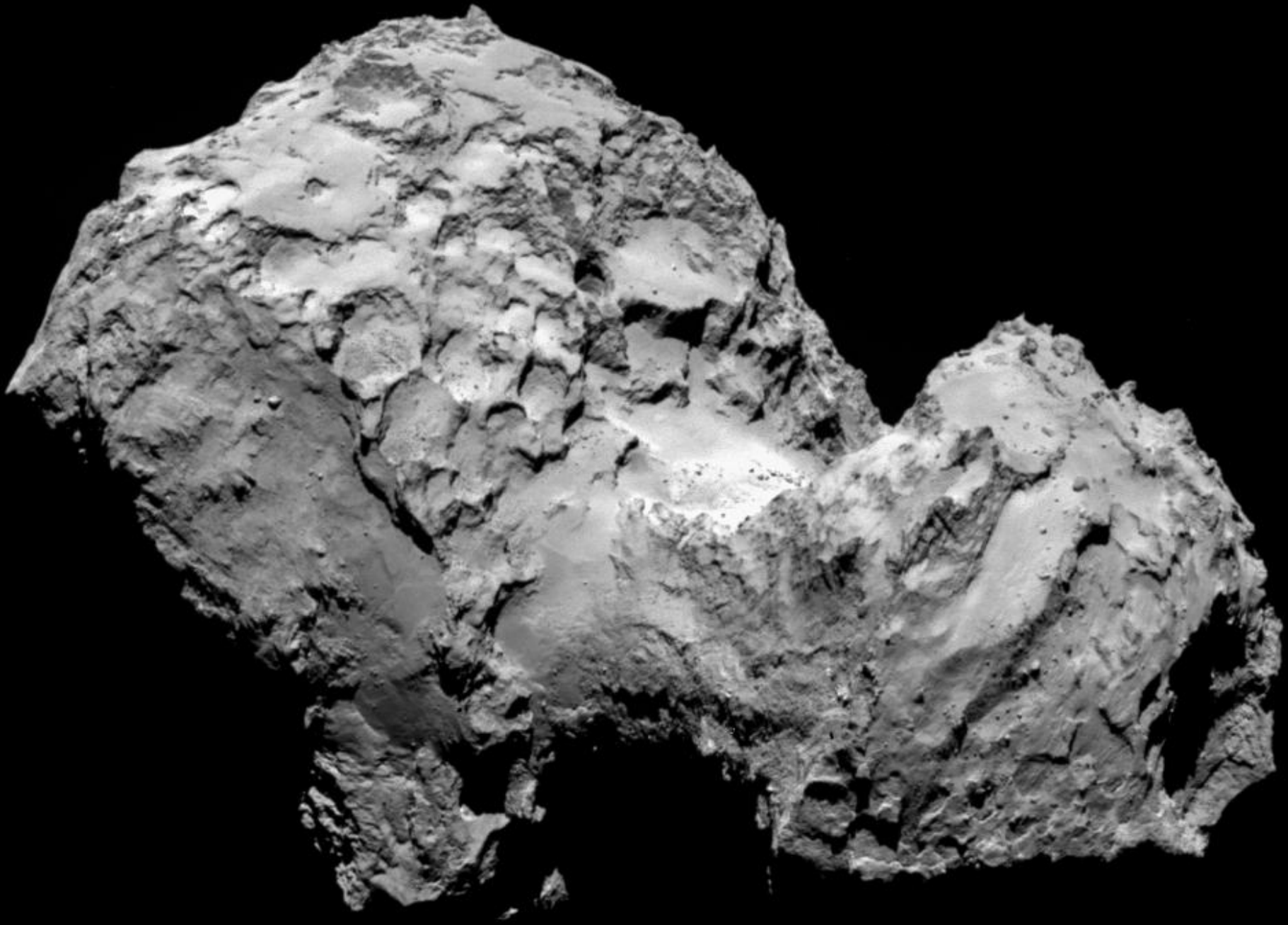

Churyumov-Gerasimenko
2014

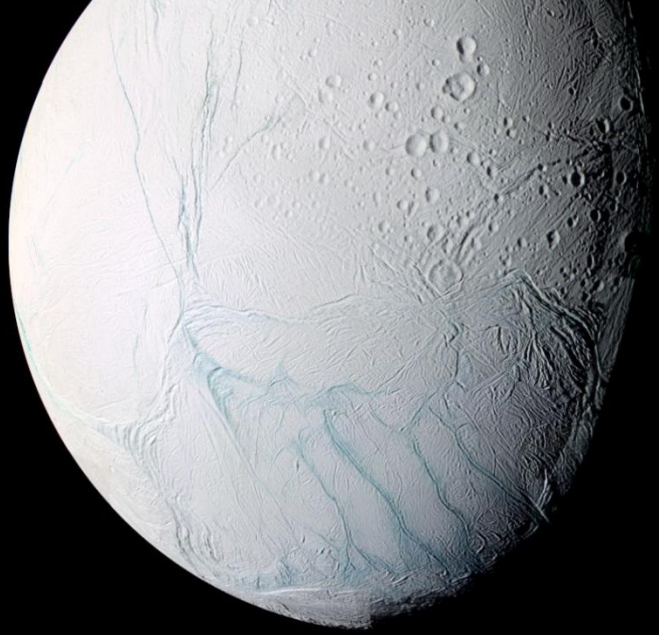

esa

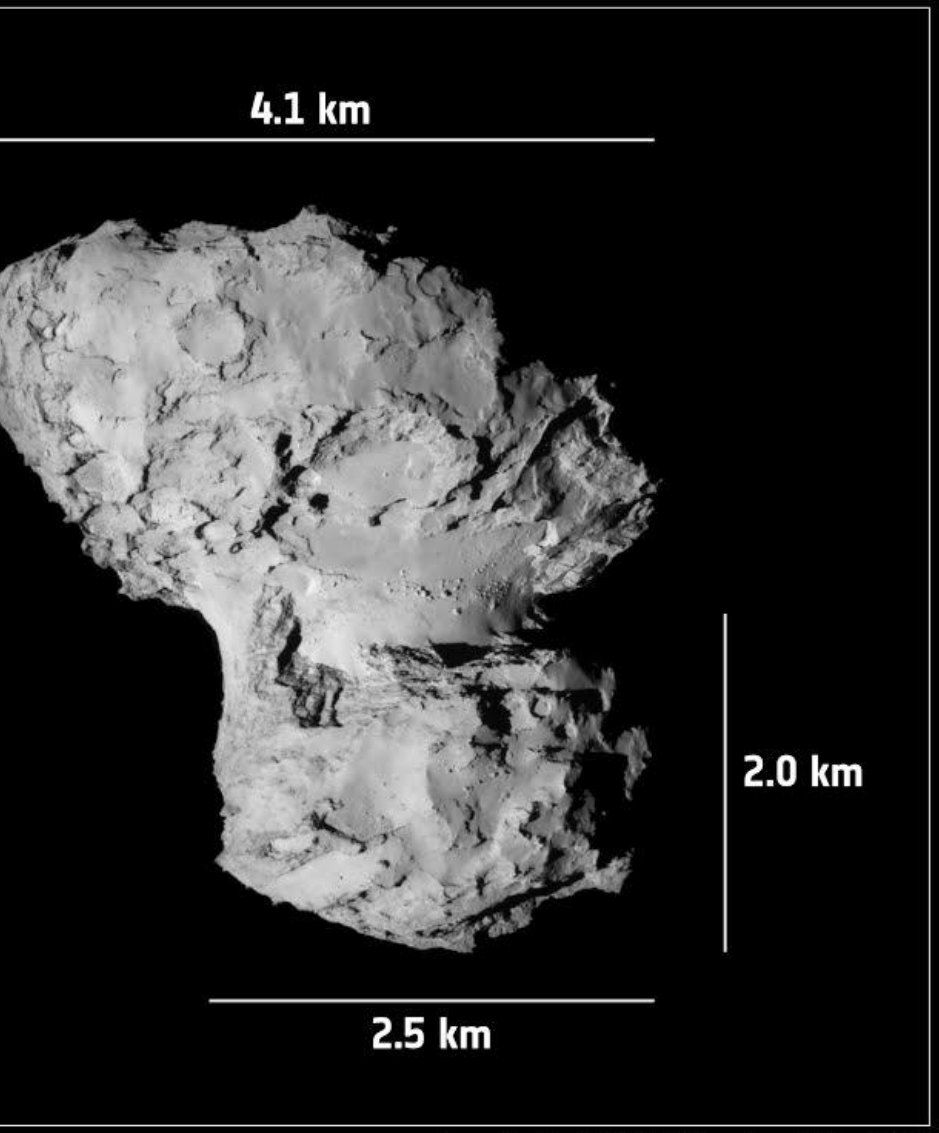


67P









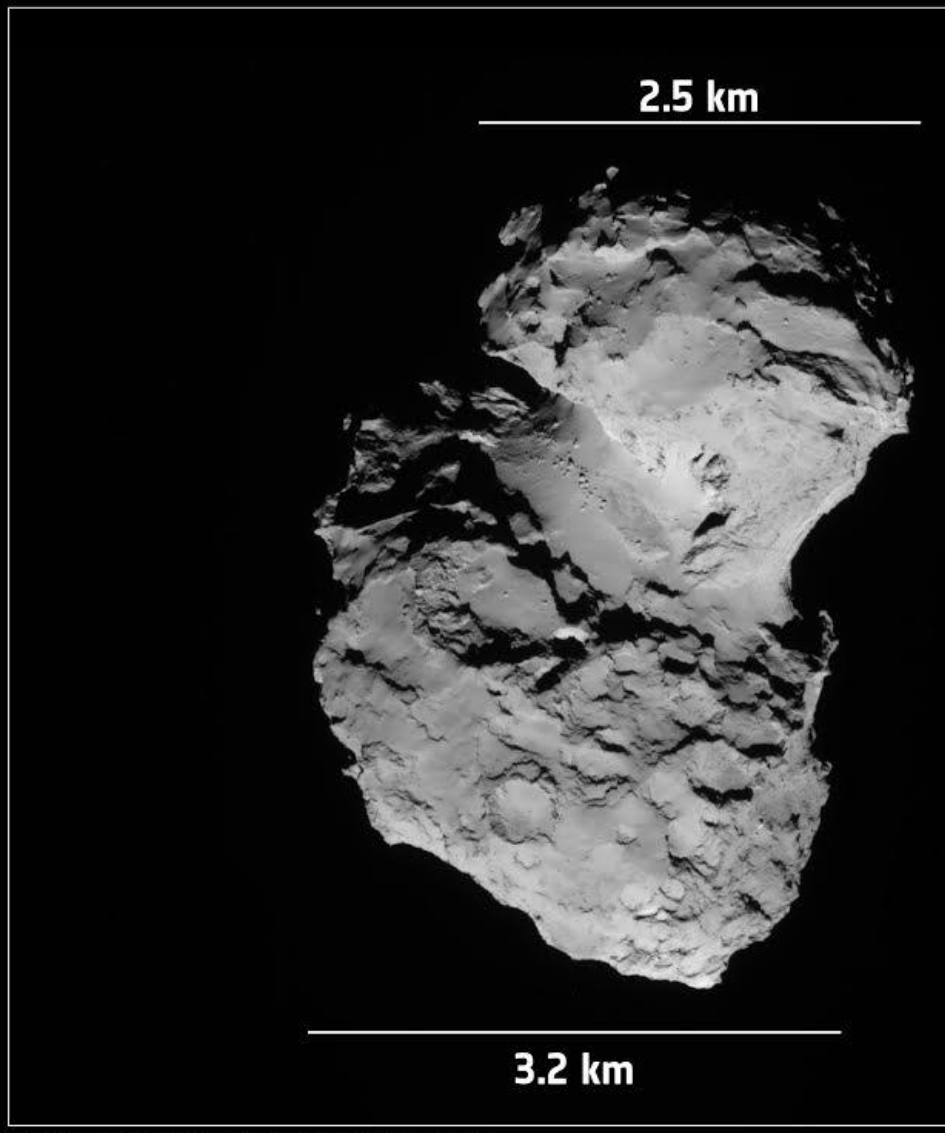
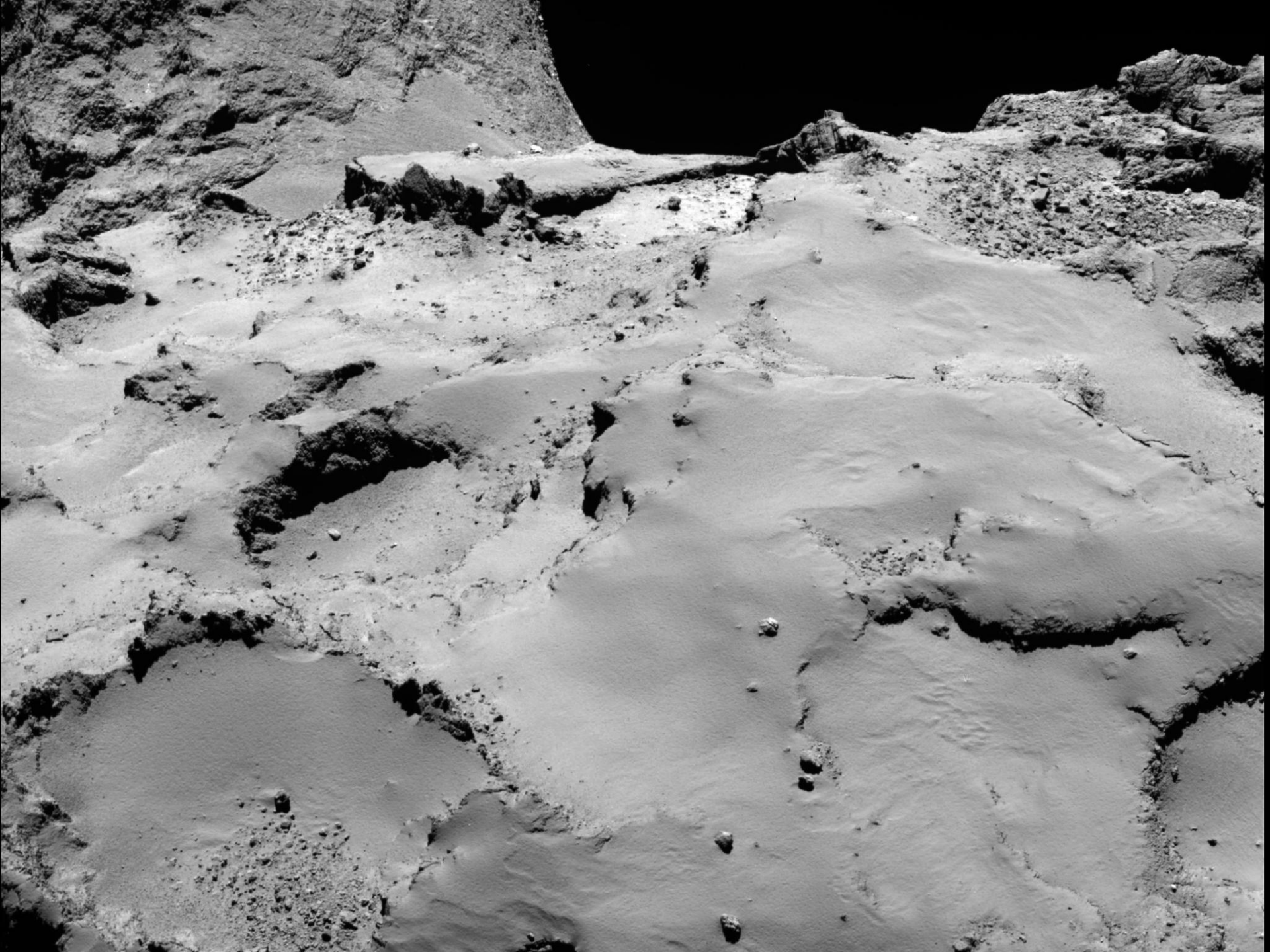
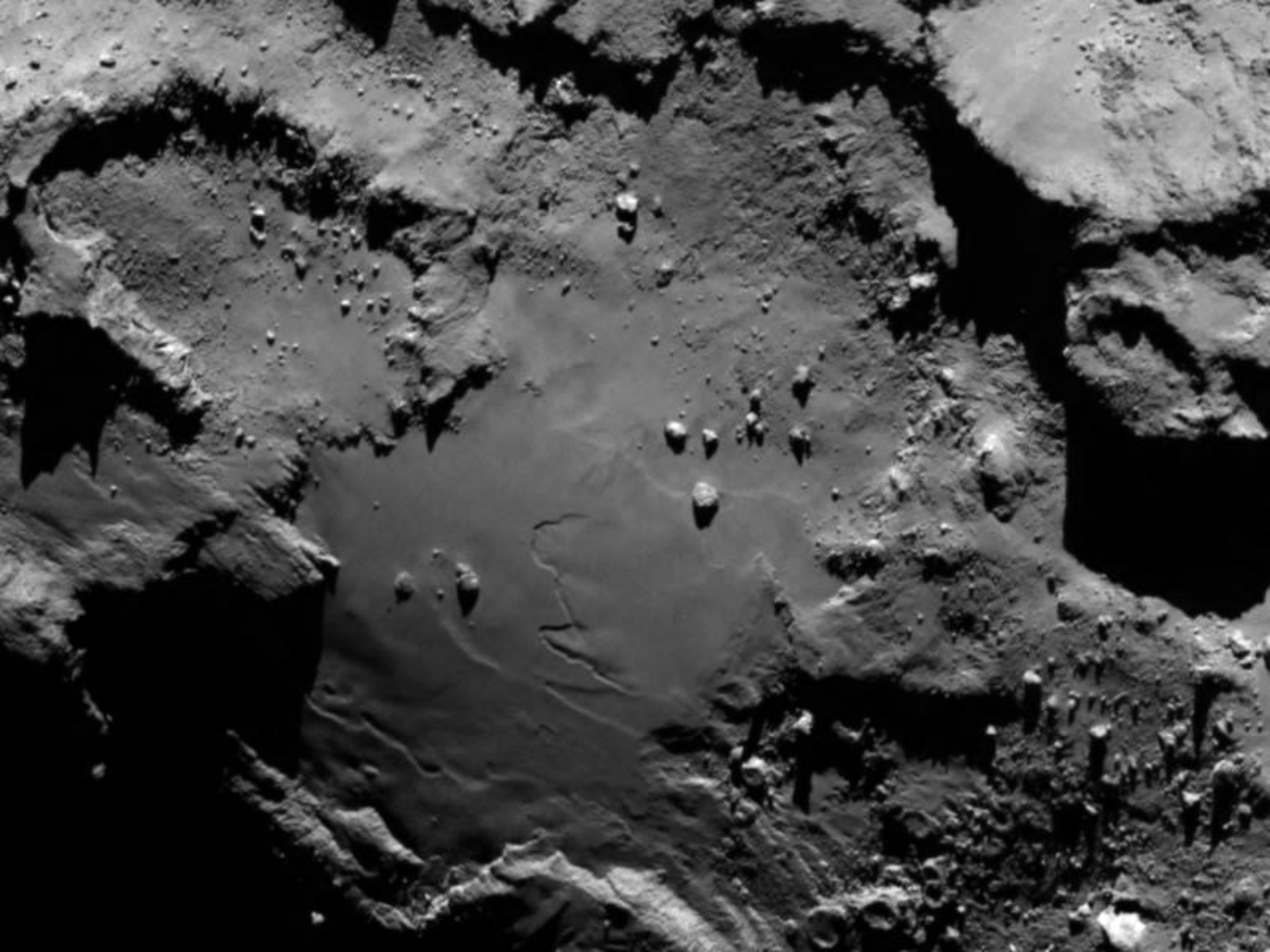
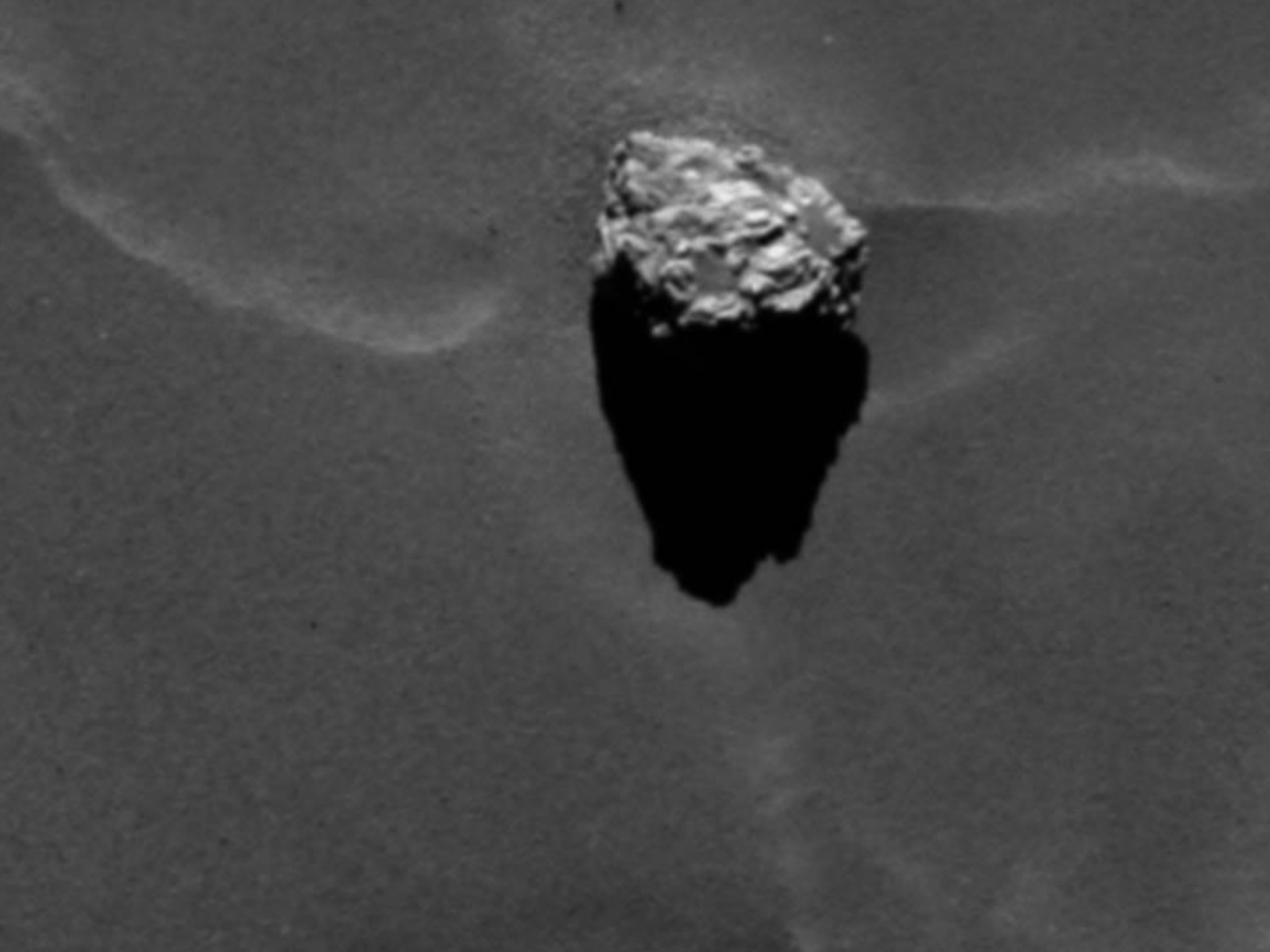
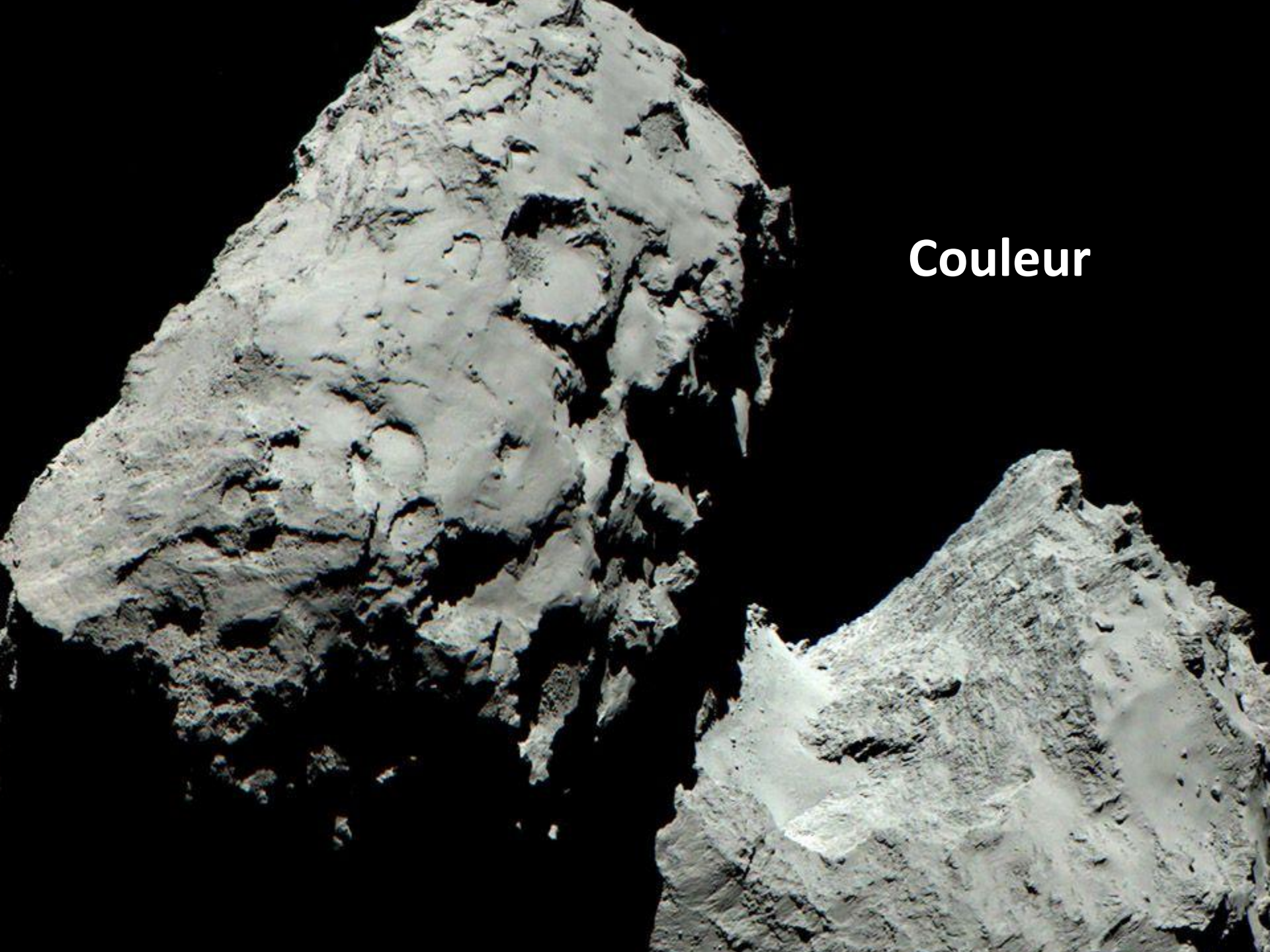


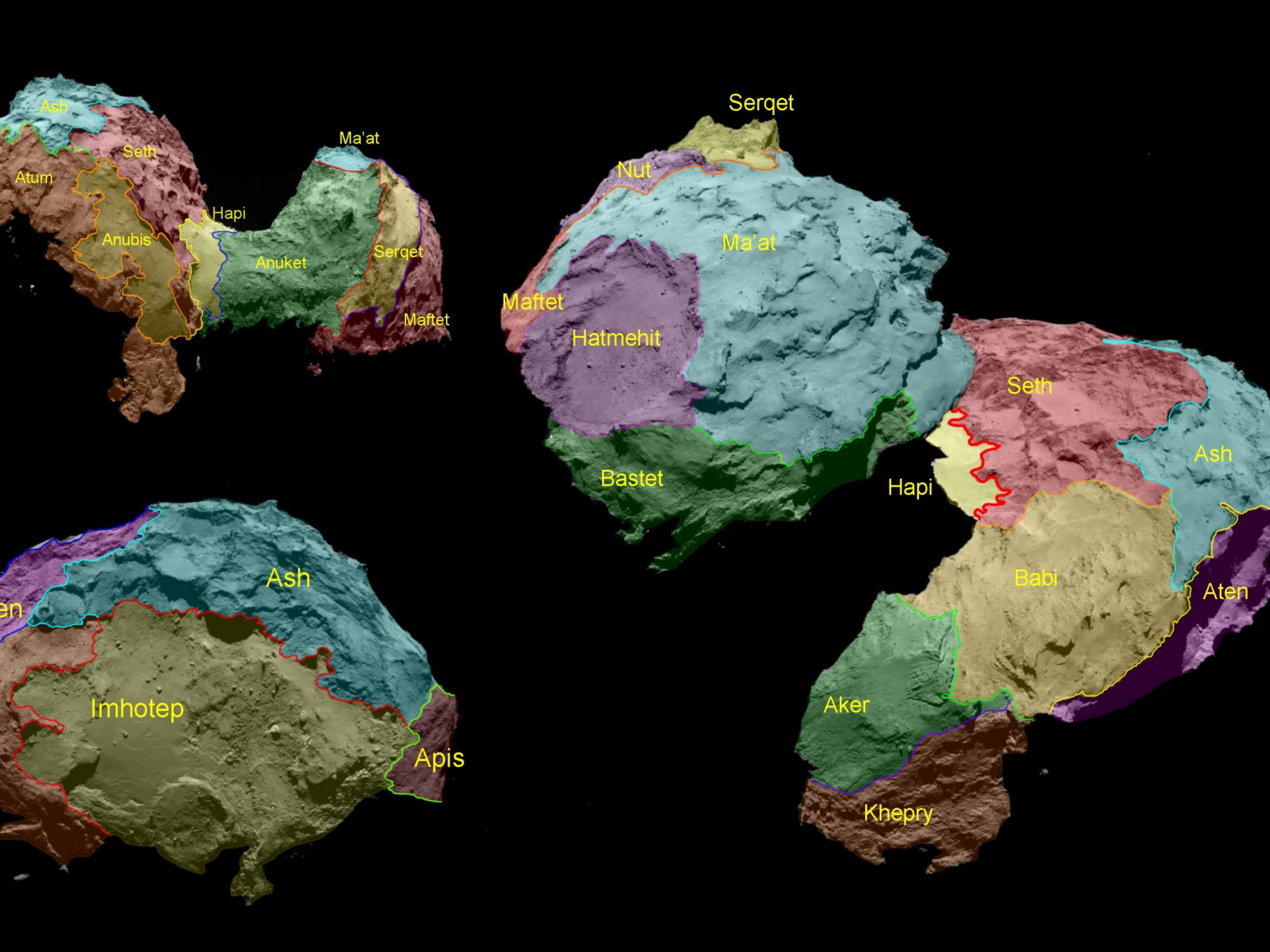
Image: ESA/Rosetta/NAVCAM; Dimensions: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

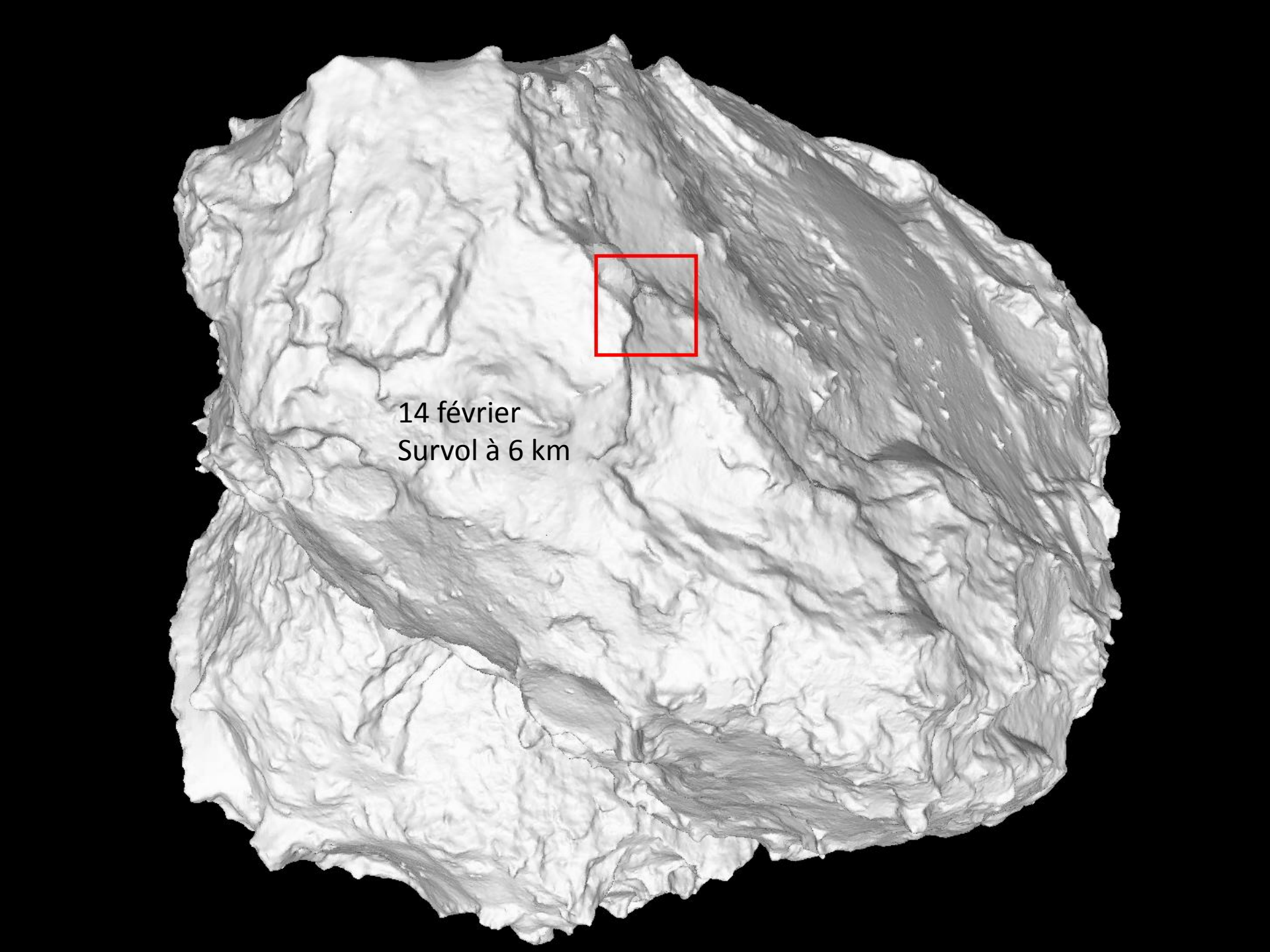


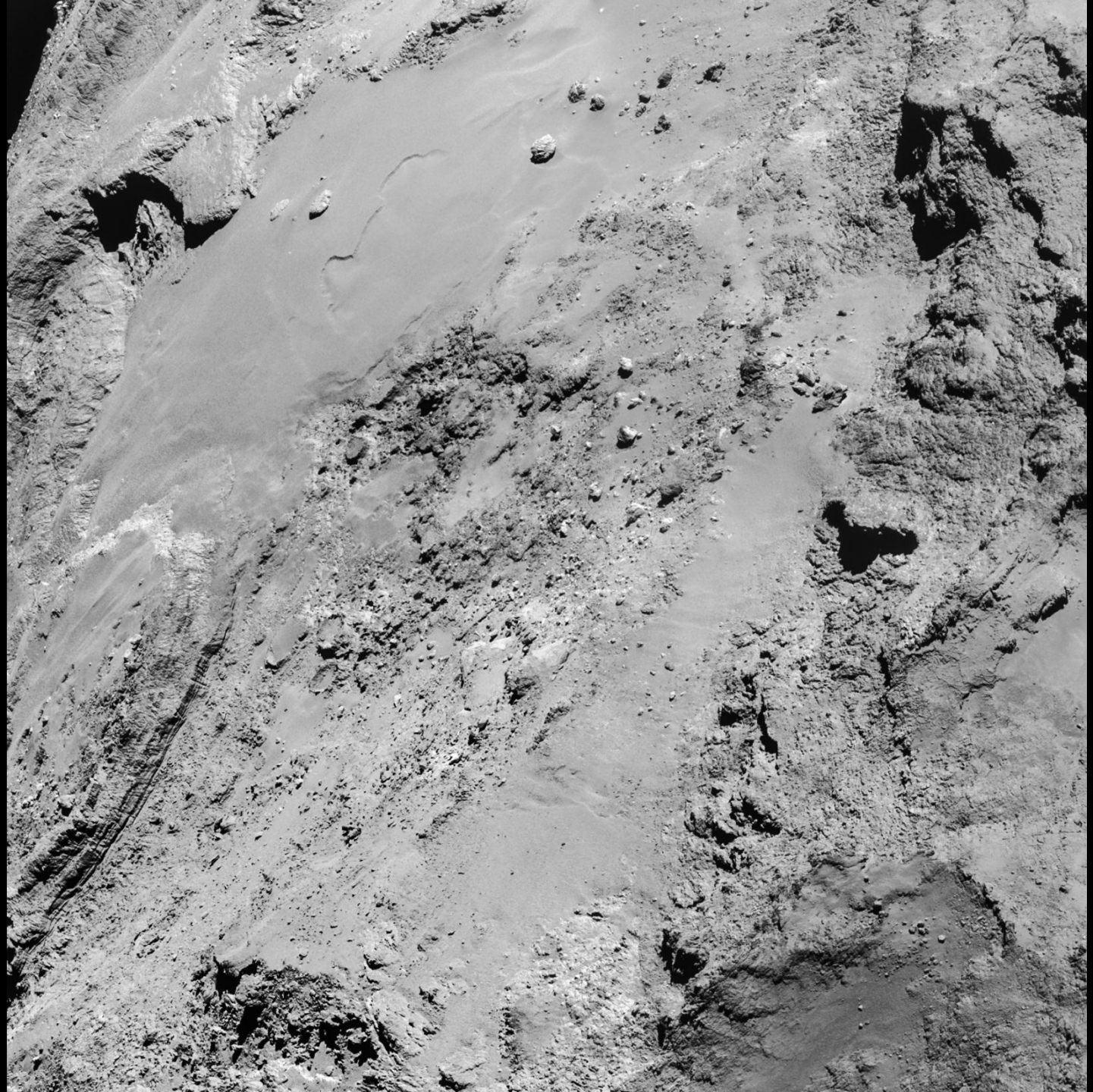


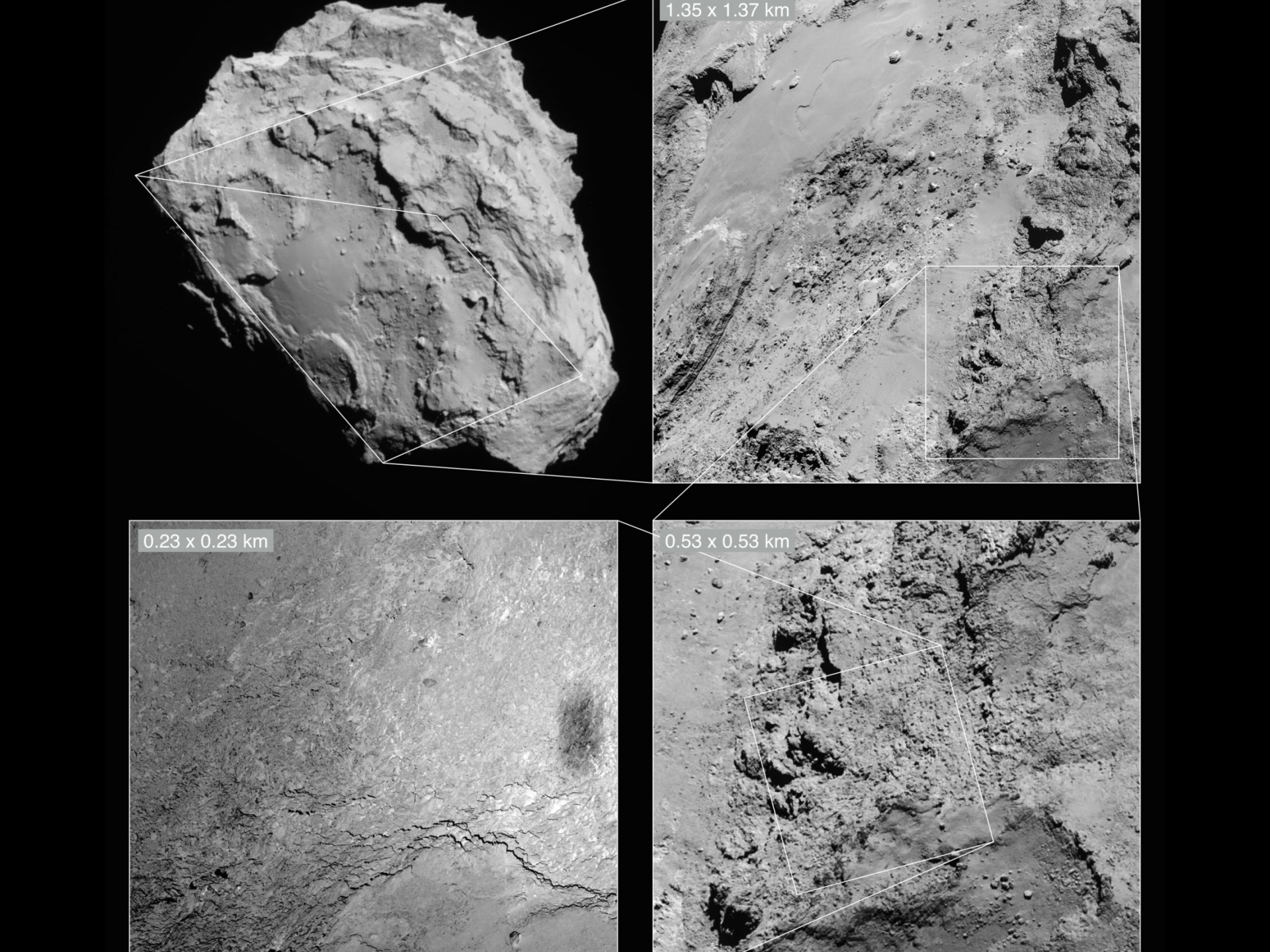



Couleur


Ash
Seth
Atum
Ma'at
Hapi
Anubis
Anuket
Serqet
Maftet
Serqet
Nut
Ma'at
Maftet
Hatmehit
Bastet
Seth
Ash
Hapi
Babi
Aten
Aker
Khepry
Ash
Imhotep
Apis

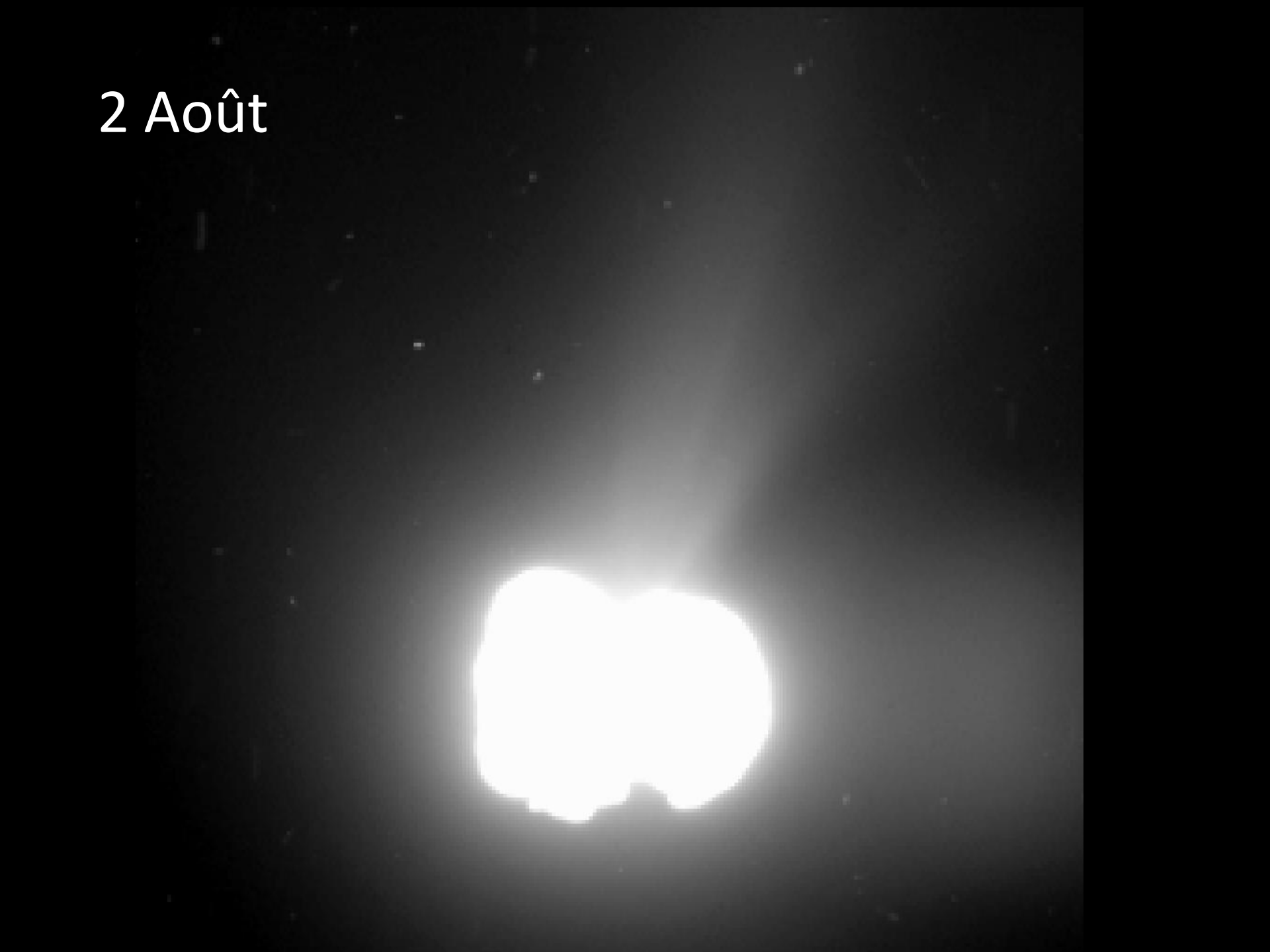

14 février
Survol à 6 km



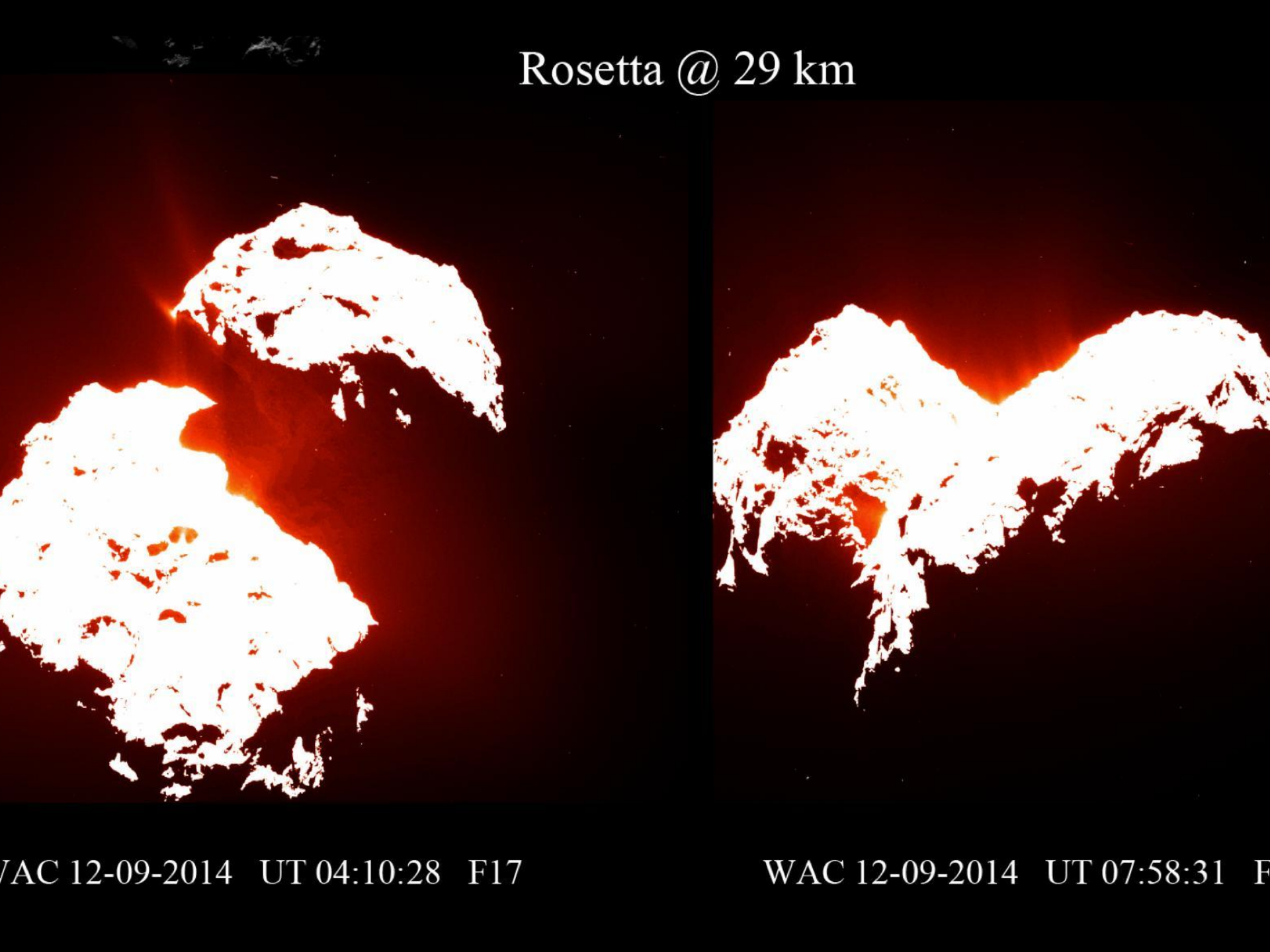

1.35 x 1.37 km
0.23 x 0.23 km
0.53 x 0.53 km

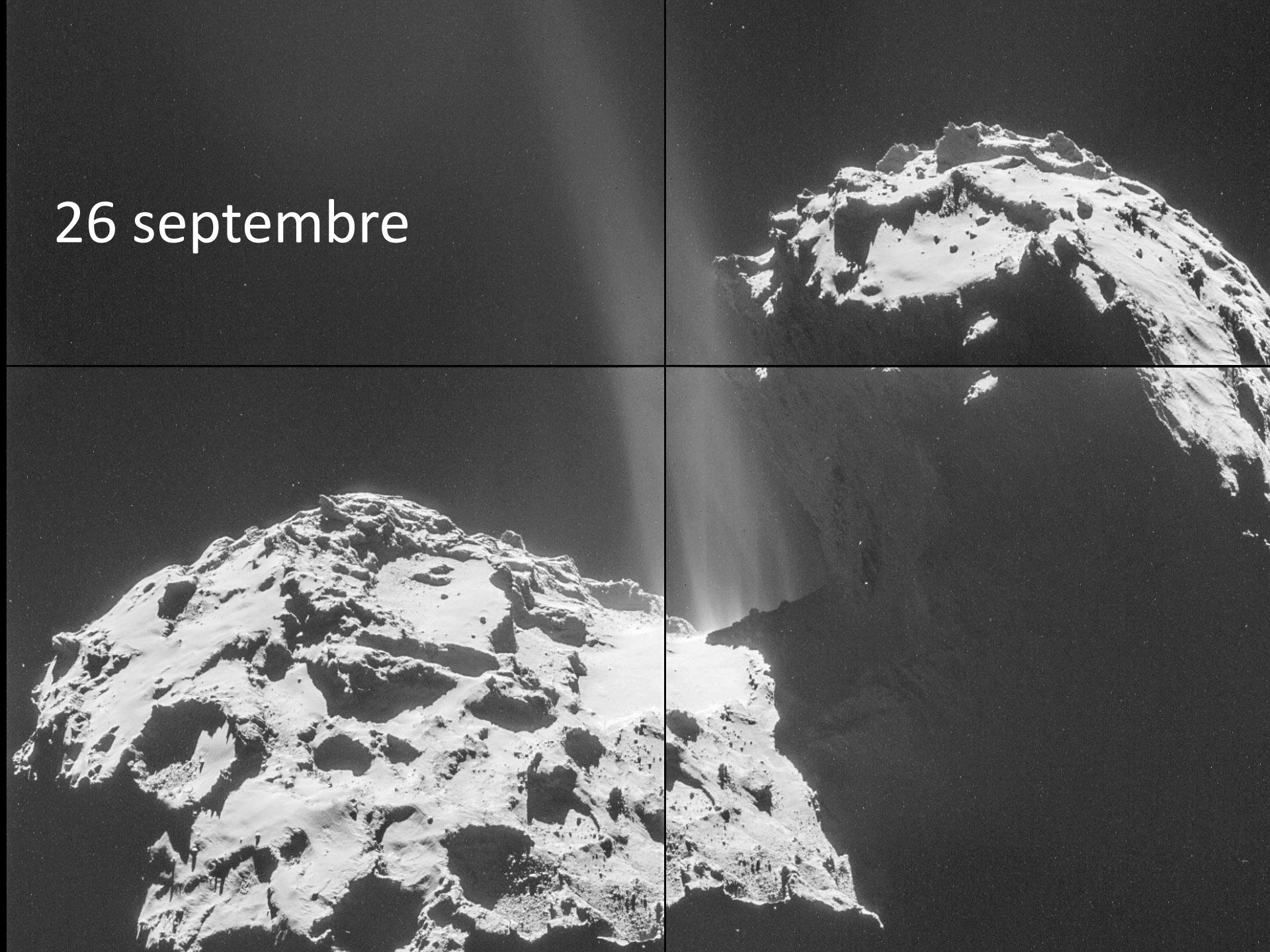
ACTIVITE

2 Août

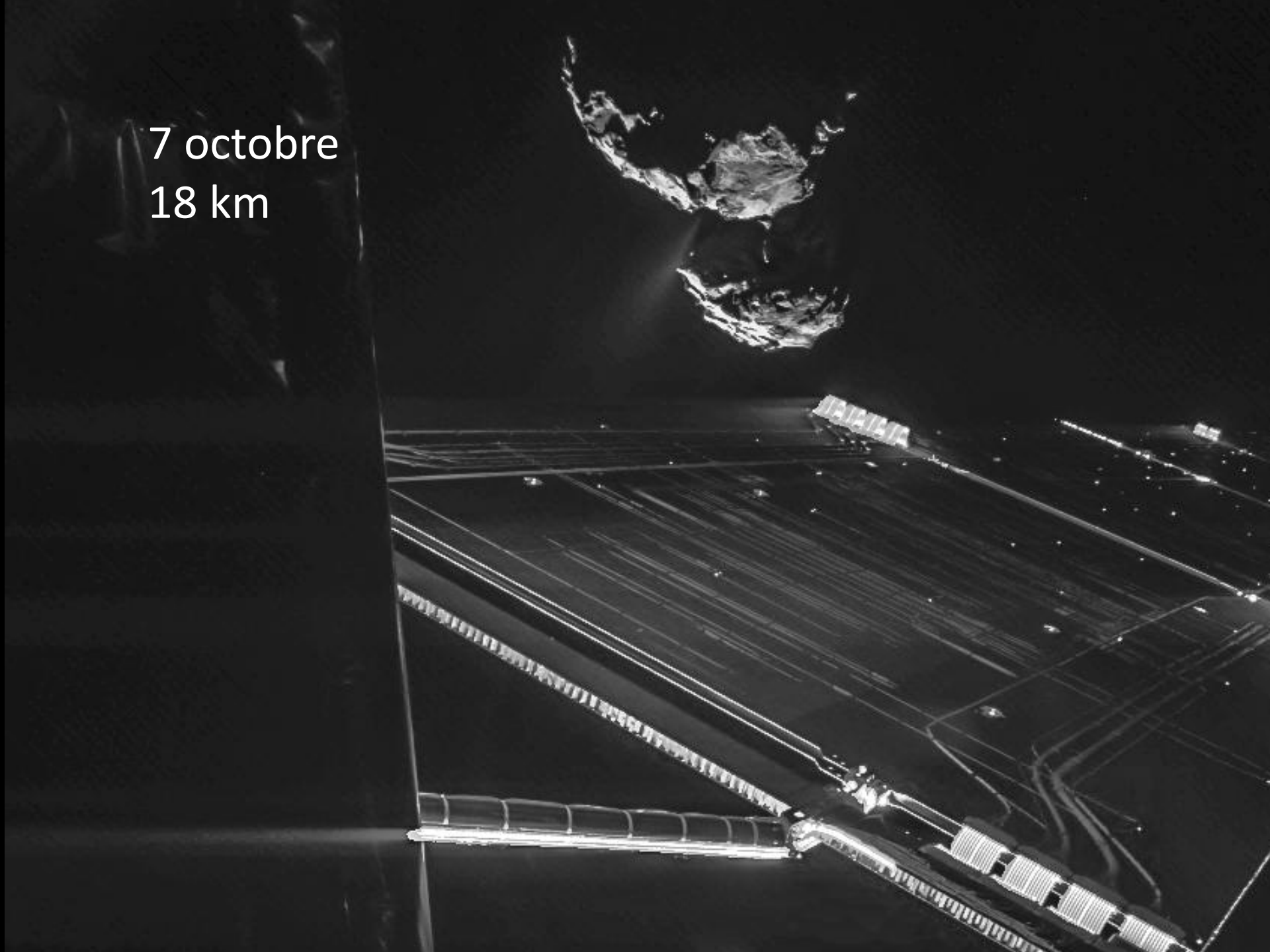


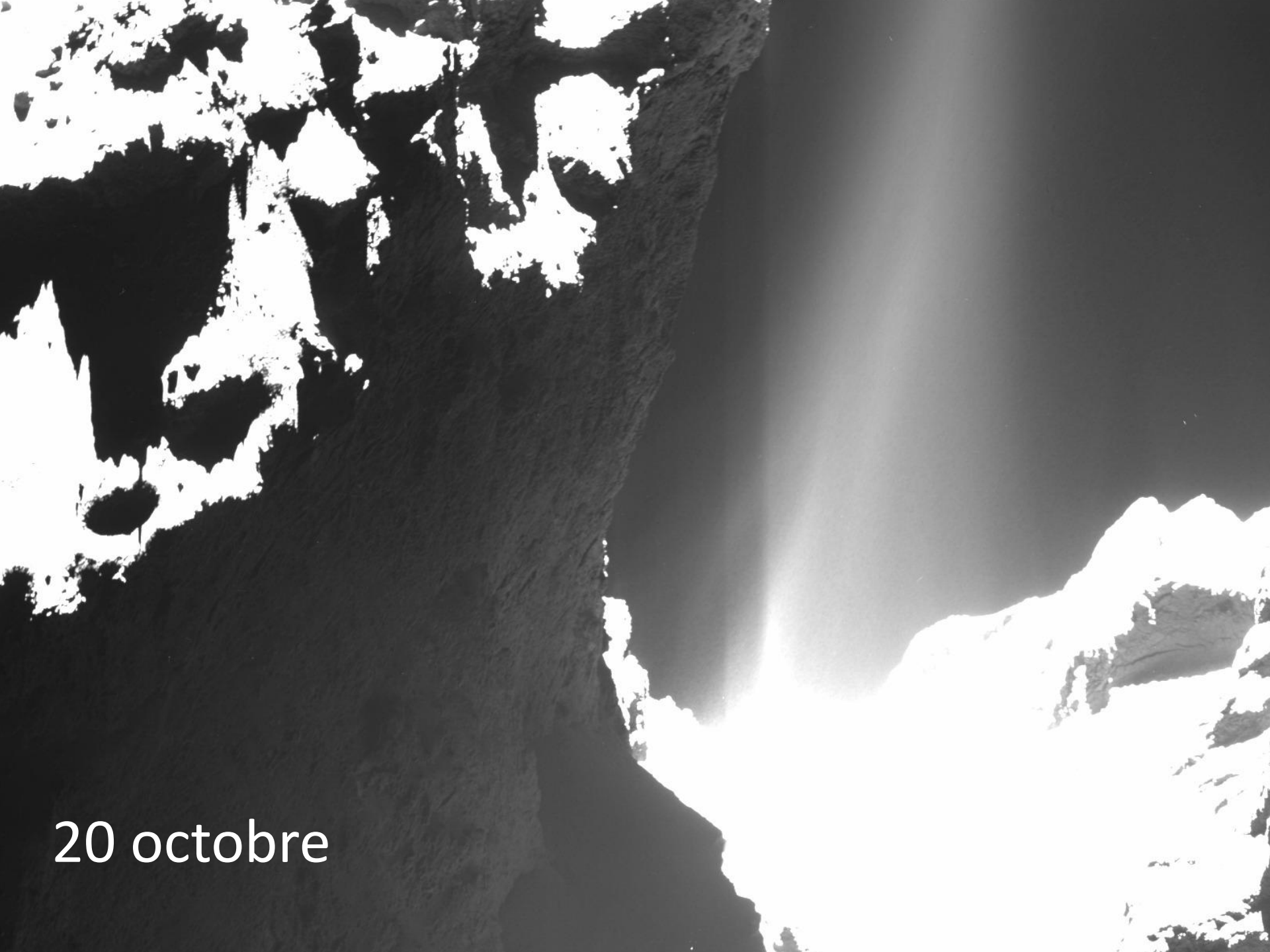
11 Août


Rosetta @ 29 km
VAC 12-09-2014 UT 04:10:28 F17
WAC 12-09-2014 UT 07:58:31 F


26 septembre


7 septembre
30 km


7 octobre
18 km

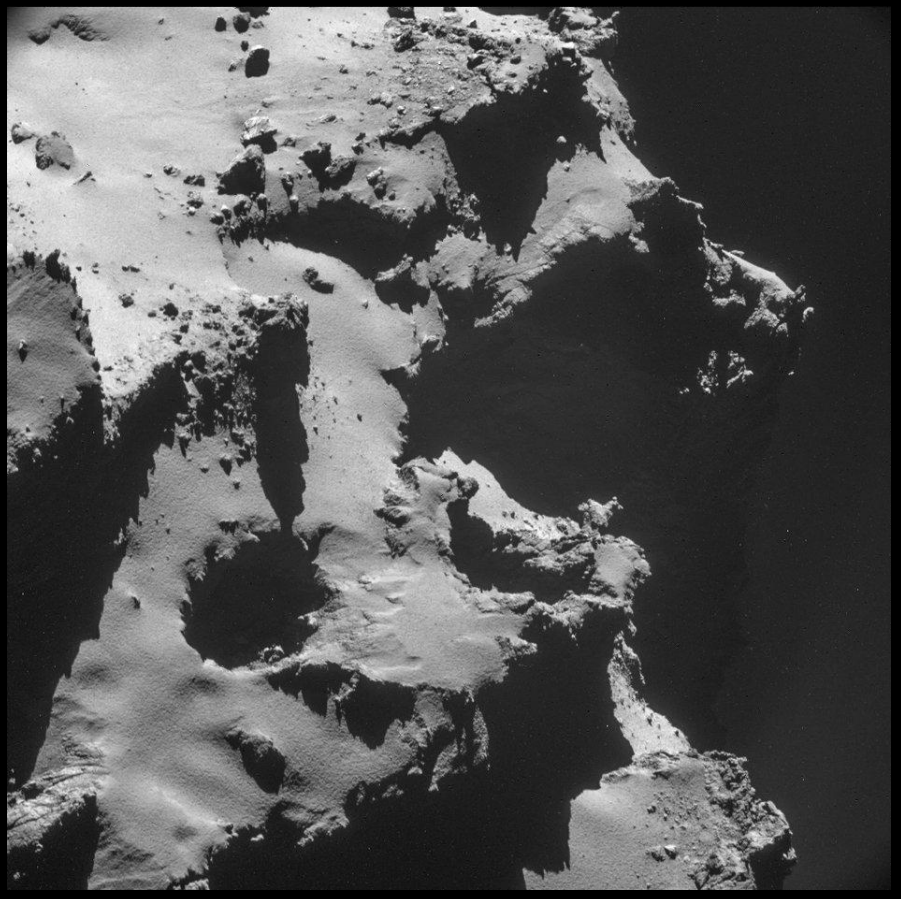

20 octobre

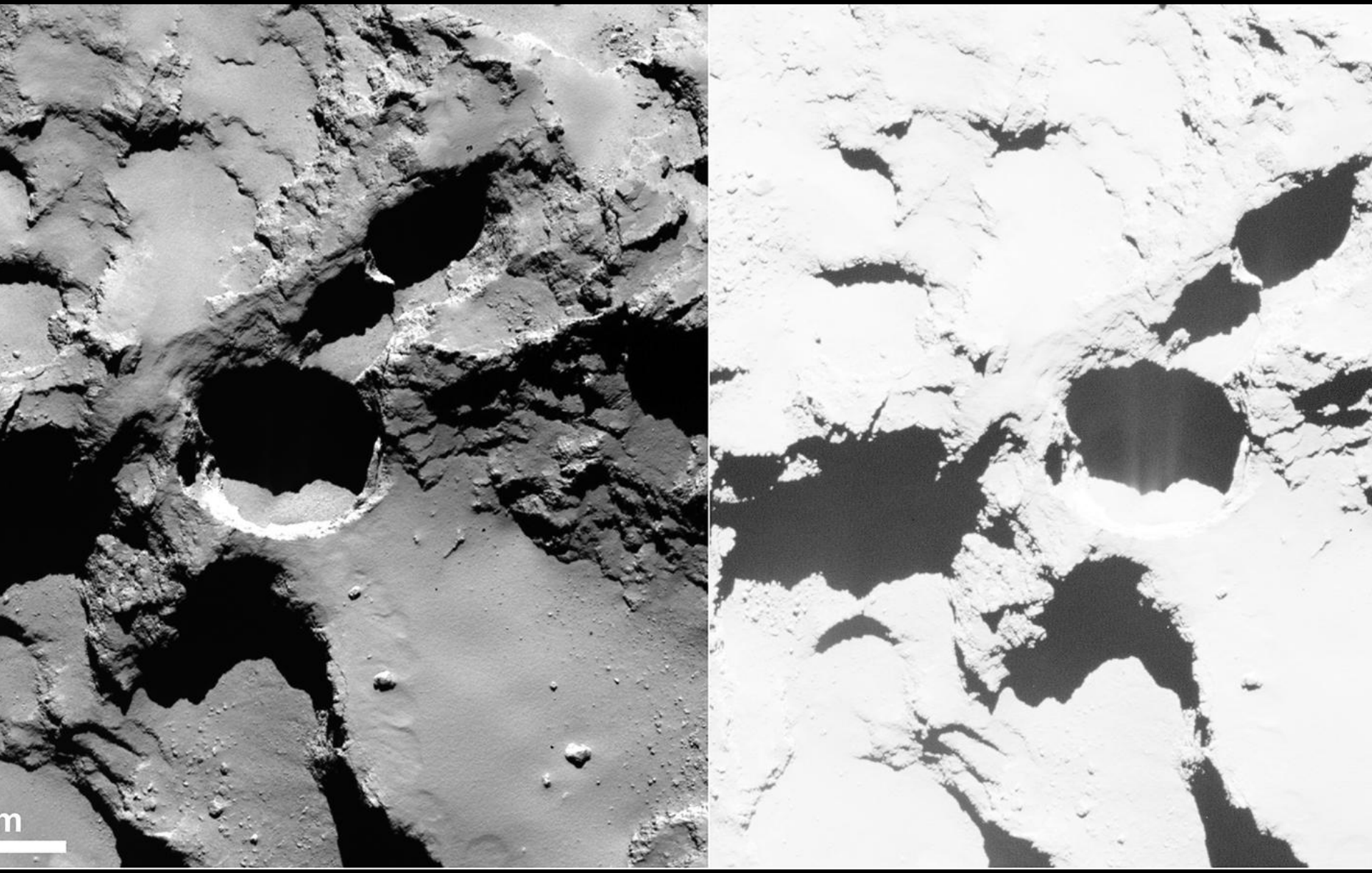
23 octobre

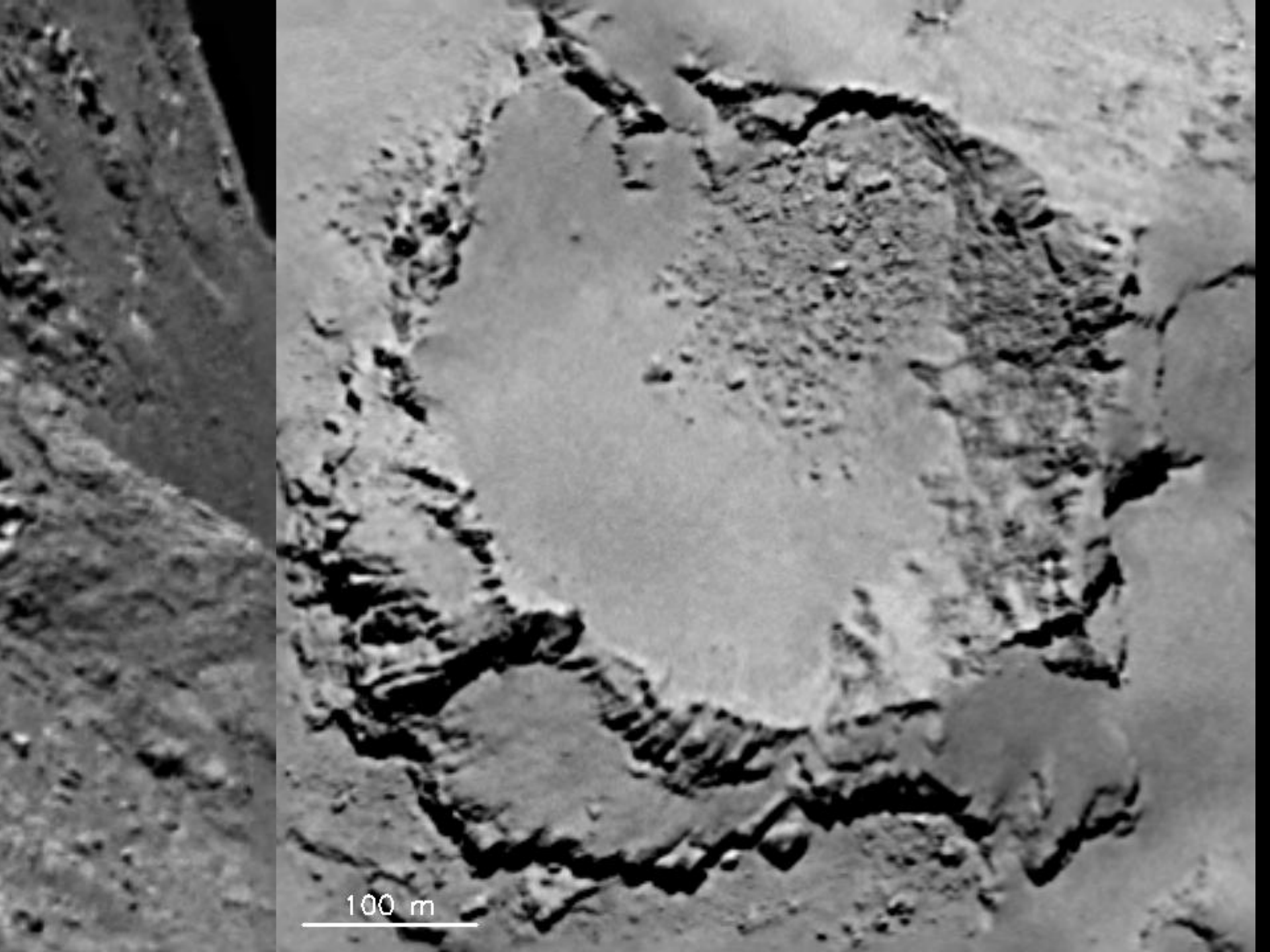

22 novembre

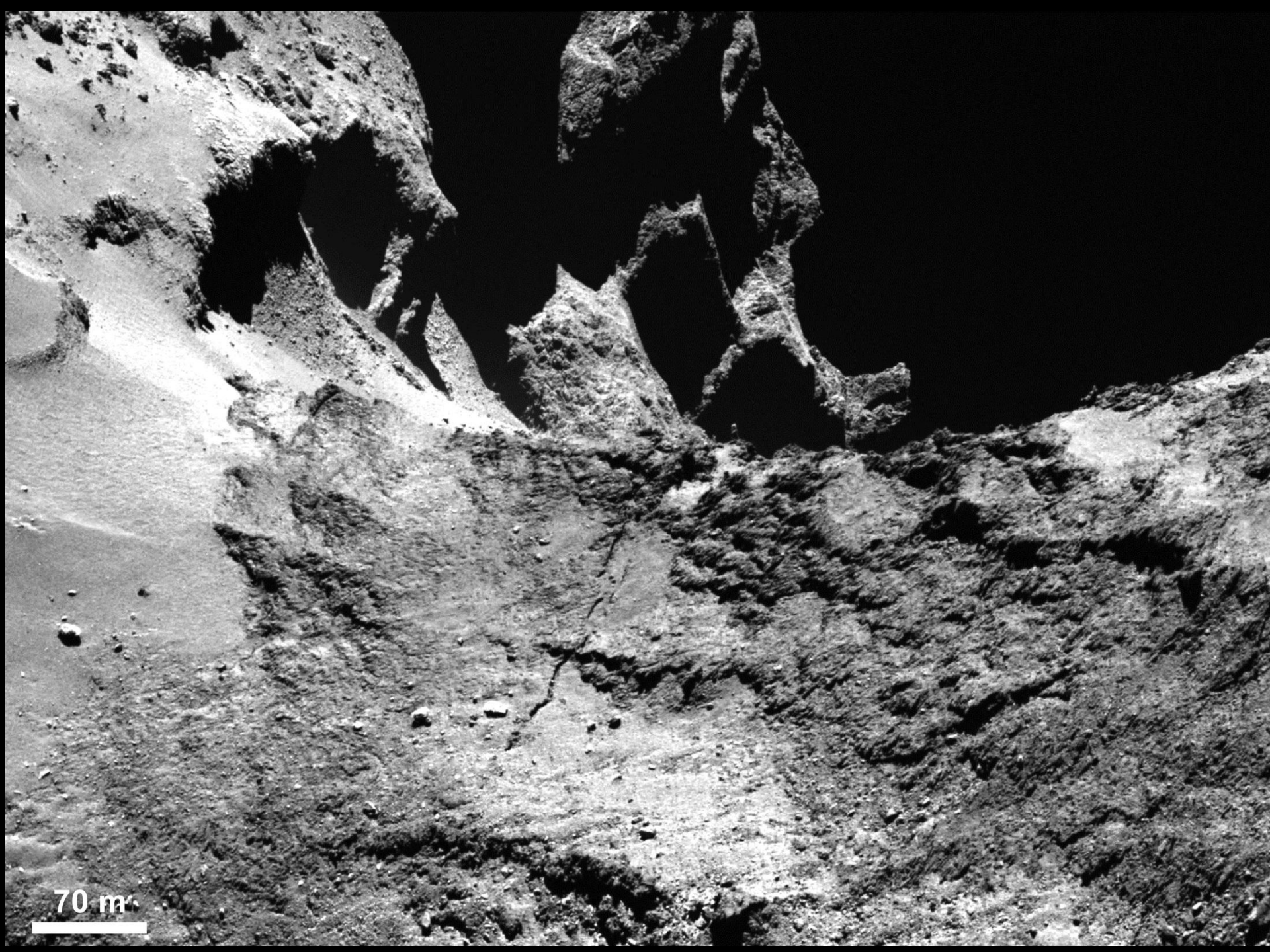

31 janvier

Des trous mystérieux !

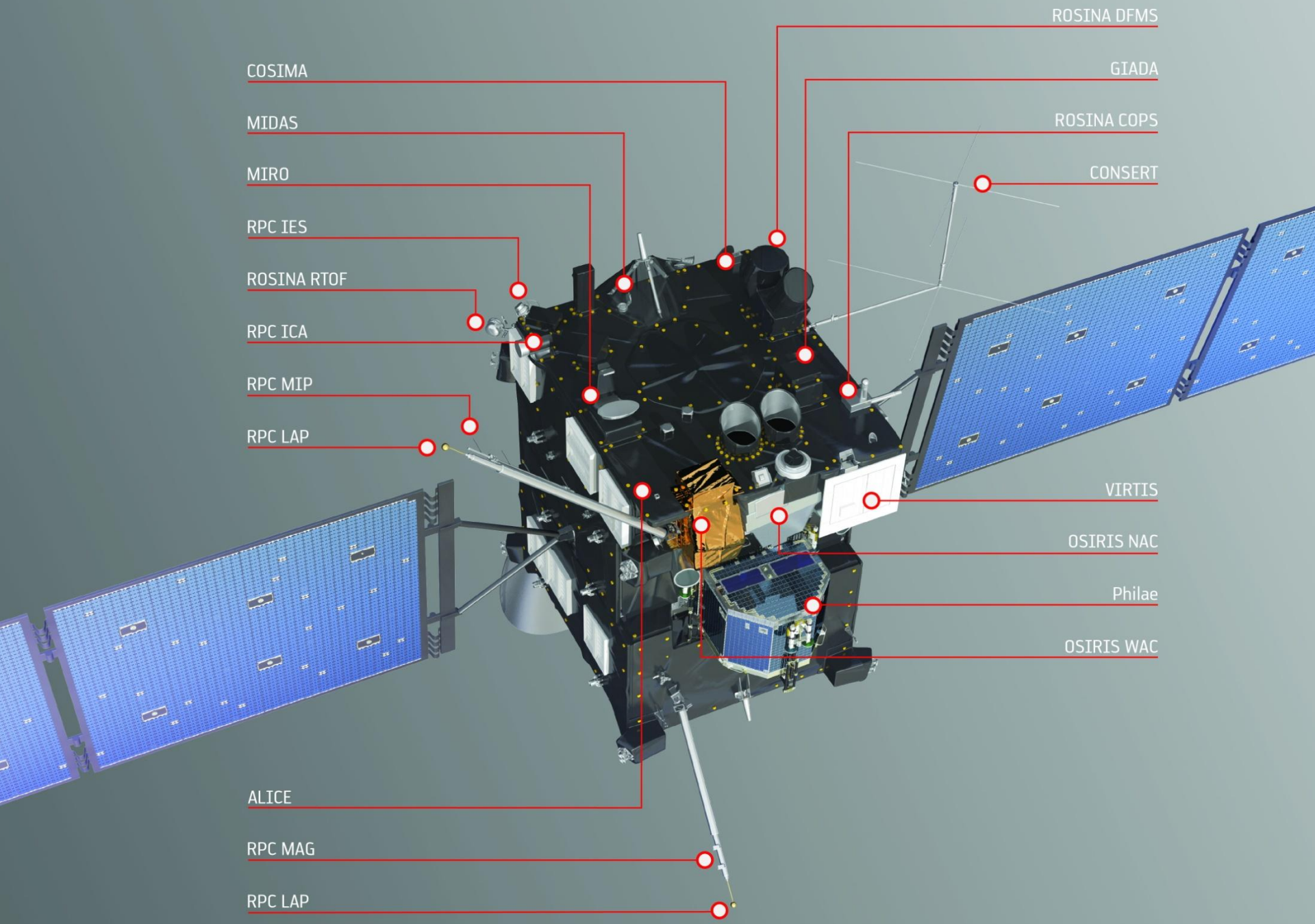


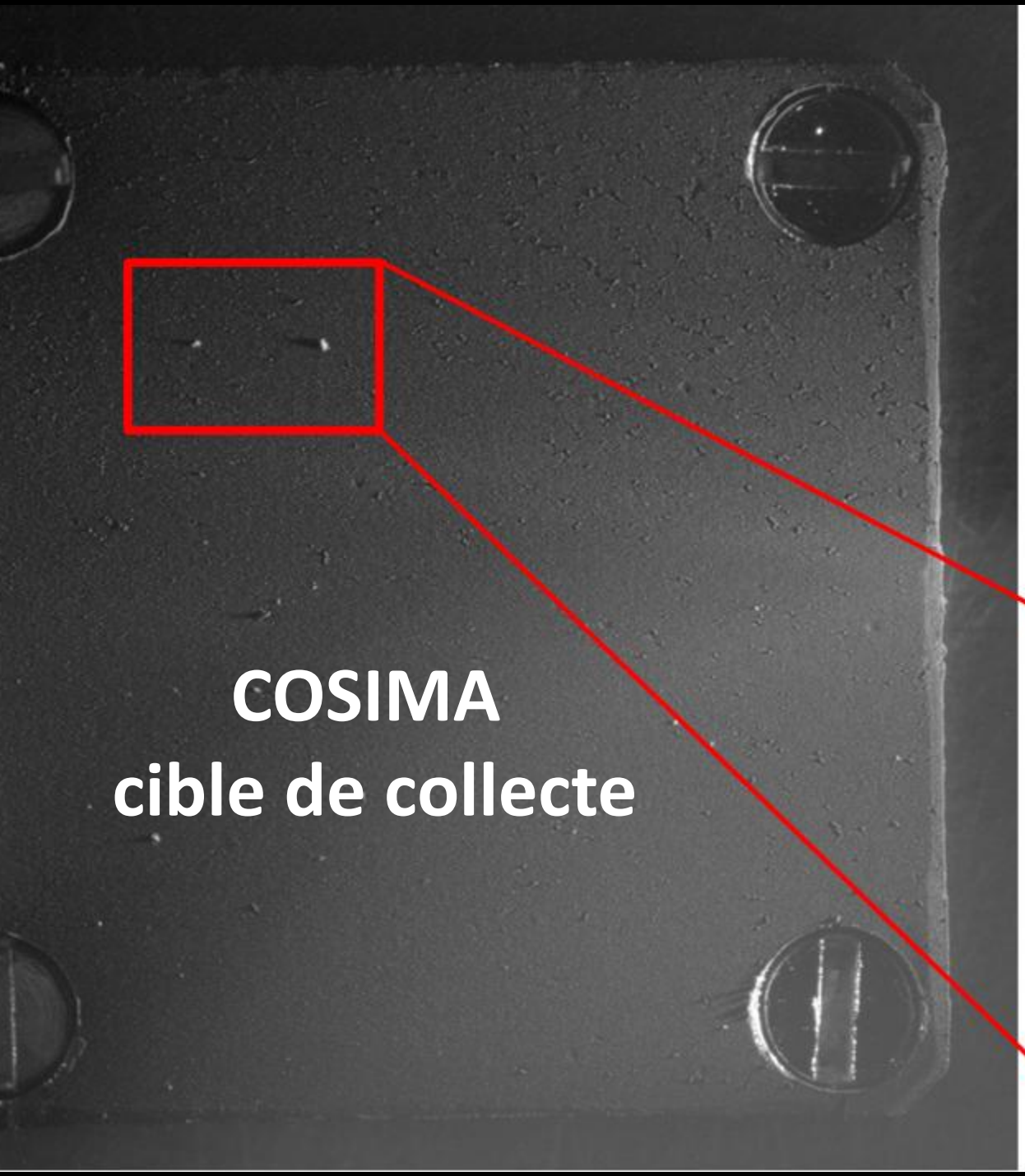



100 m

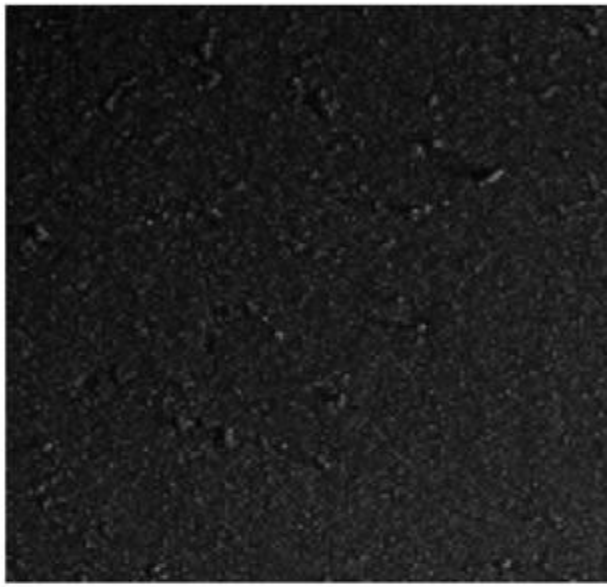

70 m

Quelques Résultats scientifiques

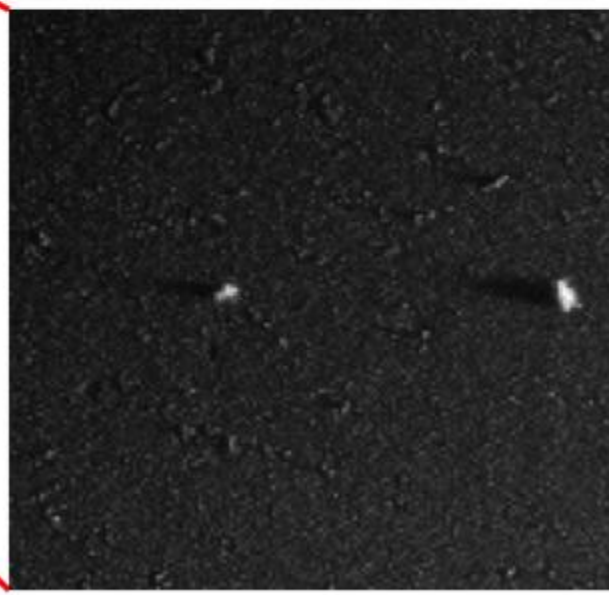

ROSINA DFMS
GIADA
ROSINA COPS
CONSERT
COSIMA
MIDAS
MIRO
RPC IES
ROSINA RTOF
RPC ICA
RPC MIP
RPC LAP
VIRTIS
OSIRIS NAC
Philae
OSIRIS WAC
ALICE
RPC MAG
RPC LAP



17/08/2014



24/08/2014



3D0, P LED

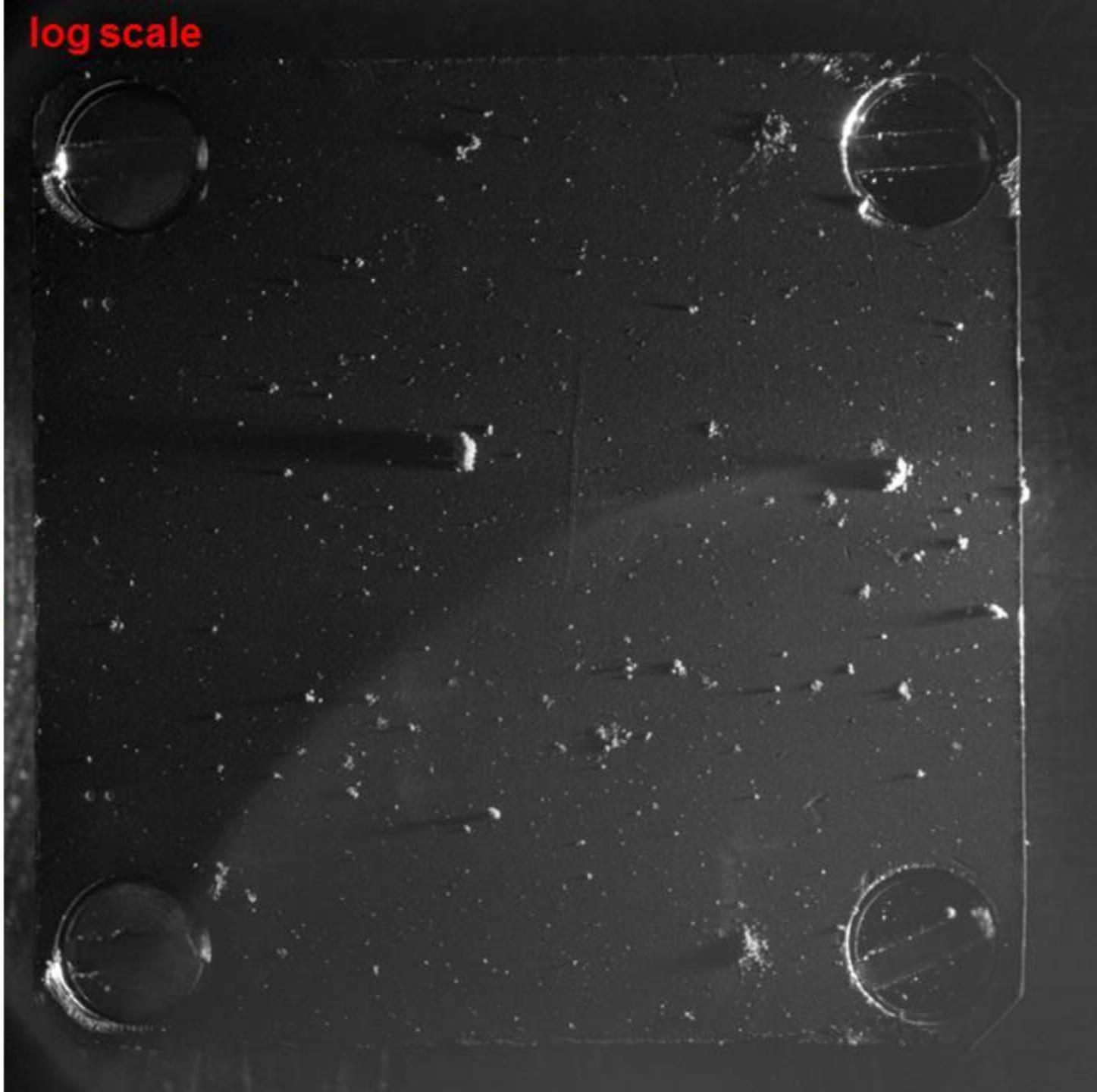
November 21nd

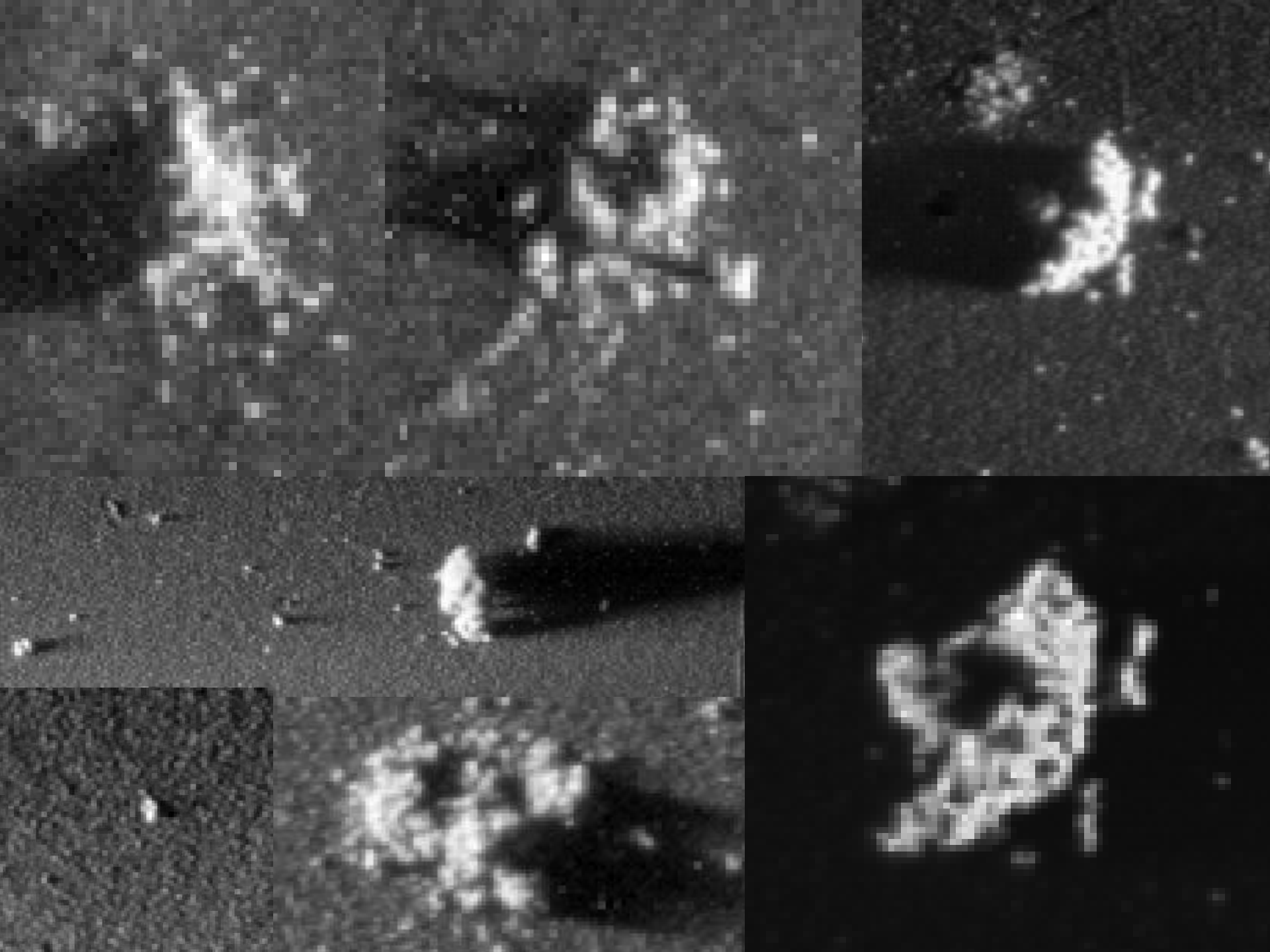
(15 weeks of exposure)

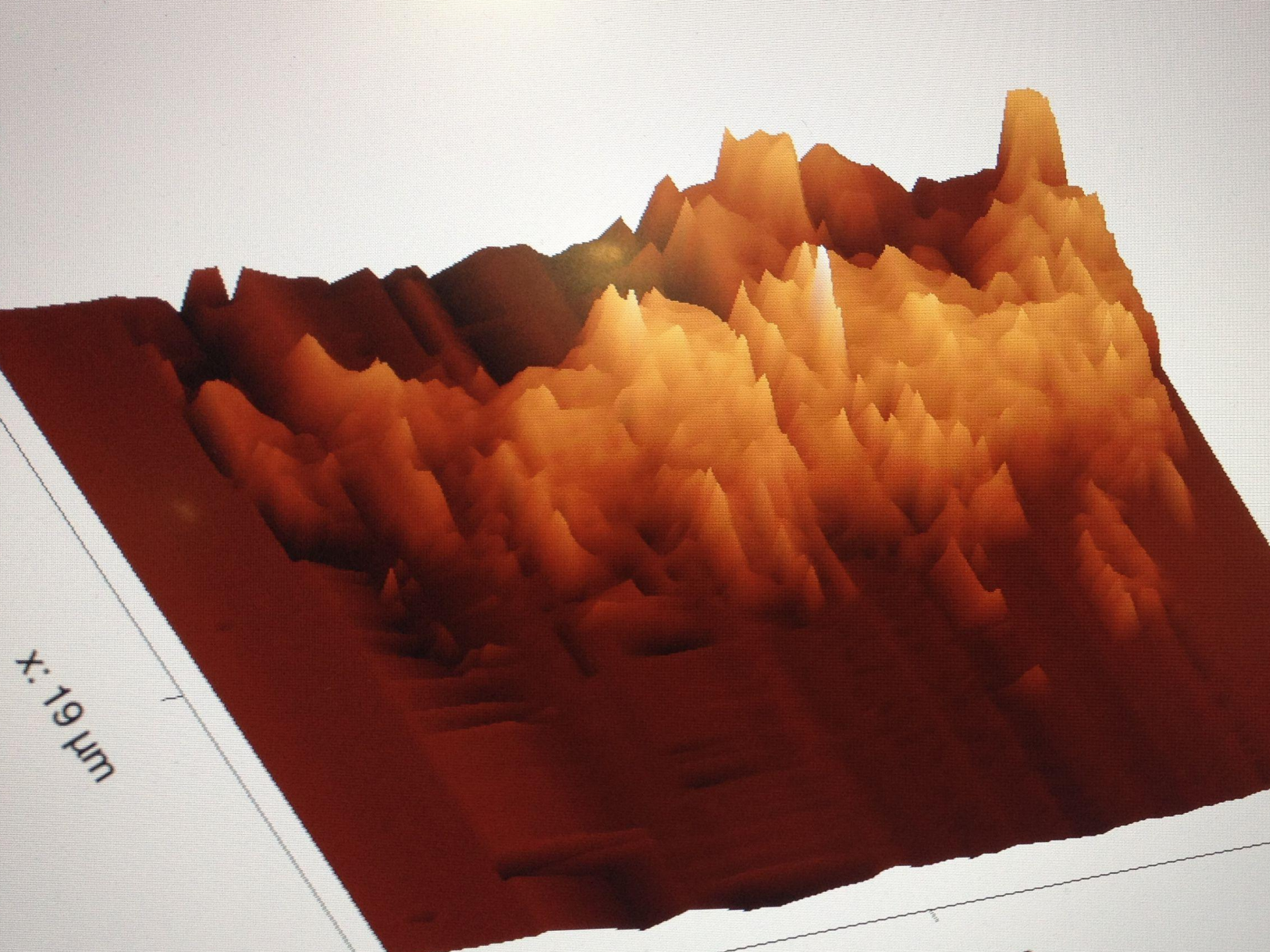
~ 1000 detections

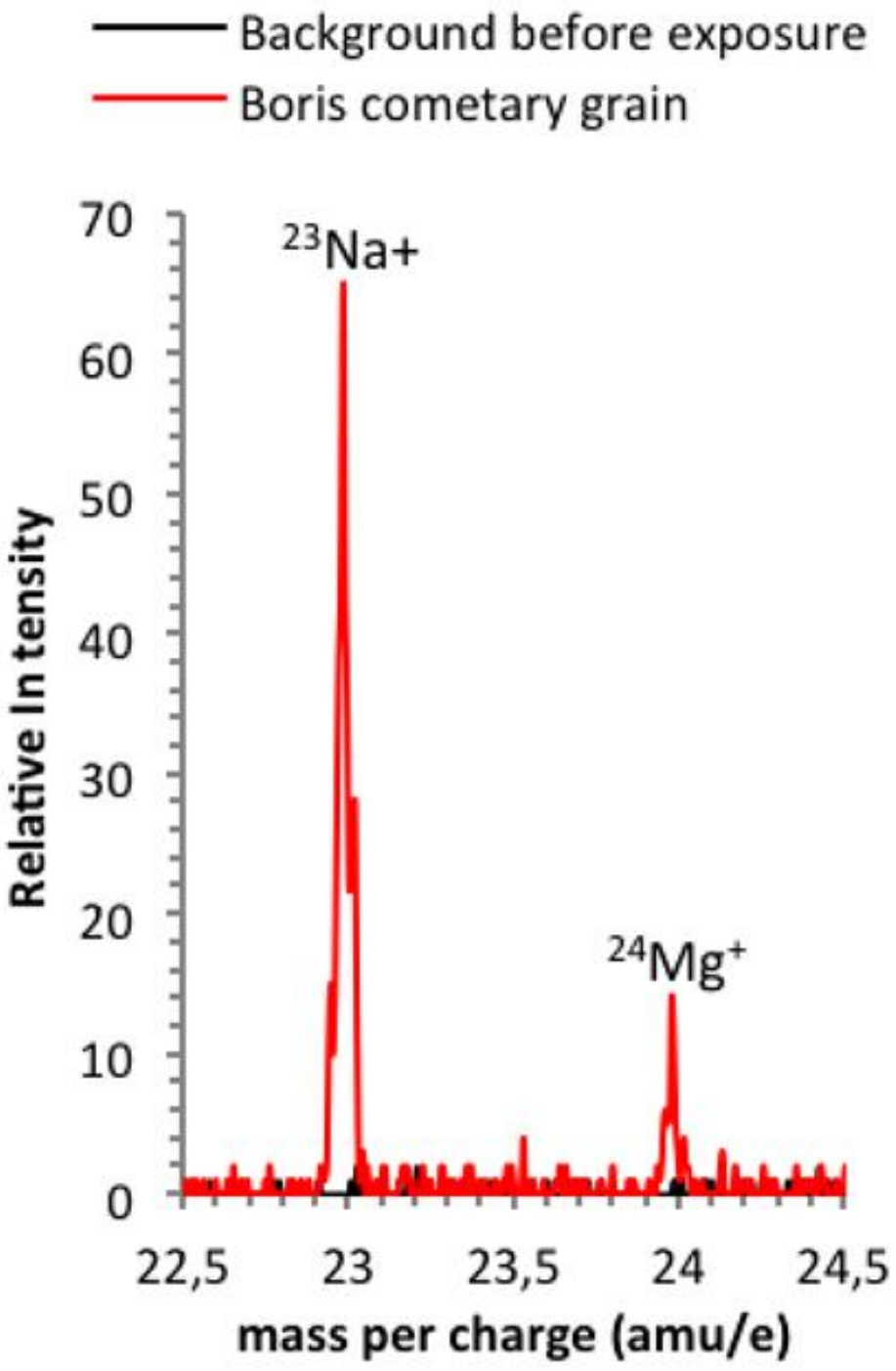
1% of the area is covered

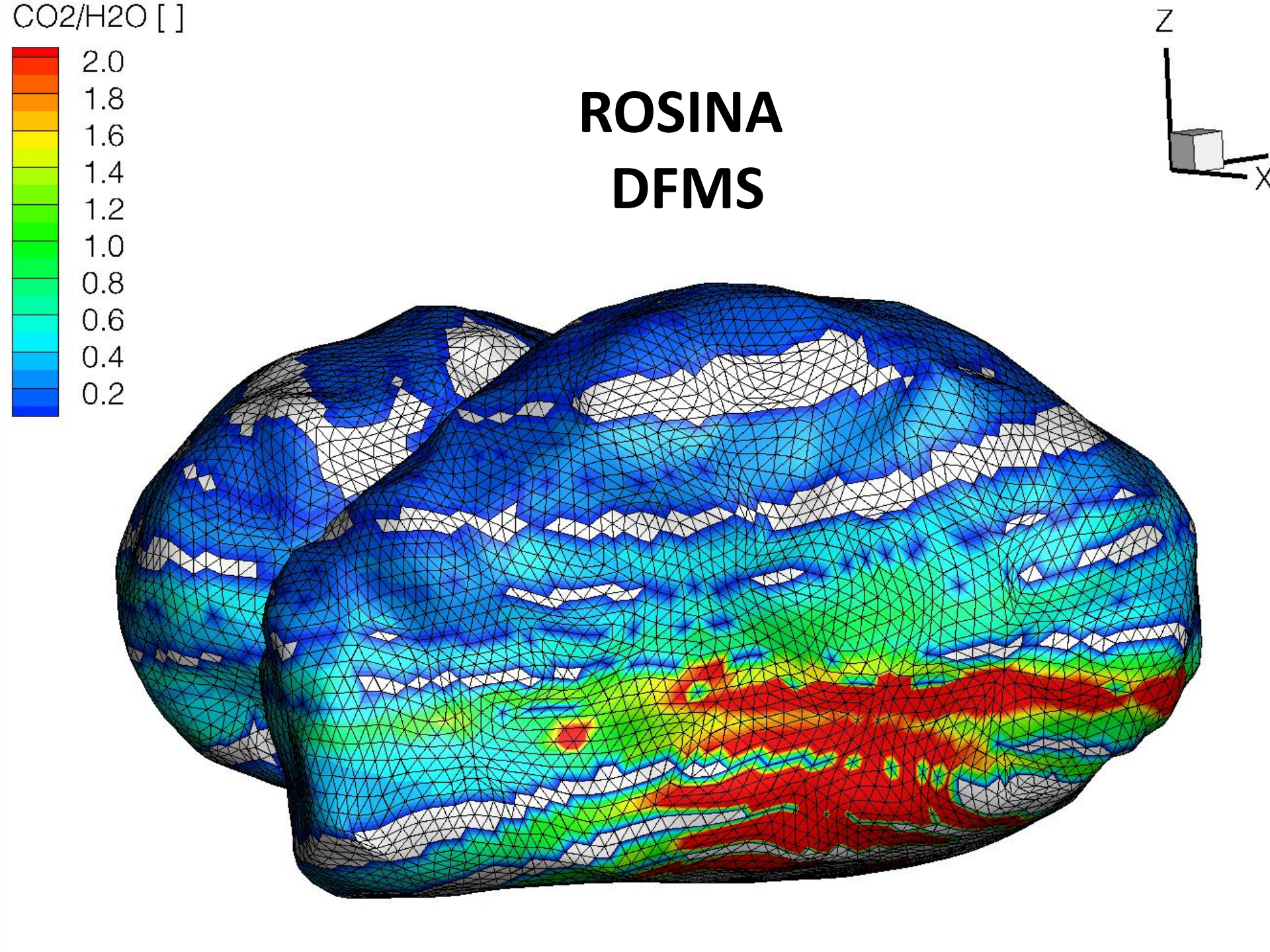
The log scale Is misleading: Scattering efficiency from 1 to 10






x: 19 µm


Background before exposure
Boris cometary grain
70
60
50
40
30
20
10
0
Relative In tensity
$^{23}Na+$
$^{24}Mg^{+}$
22,5
23
23,5
24
24,5
mass per charge (amu/e)


CO2/H2O [ ]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Z
X
ROSINA
DFMS

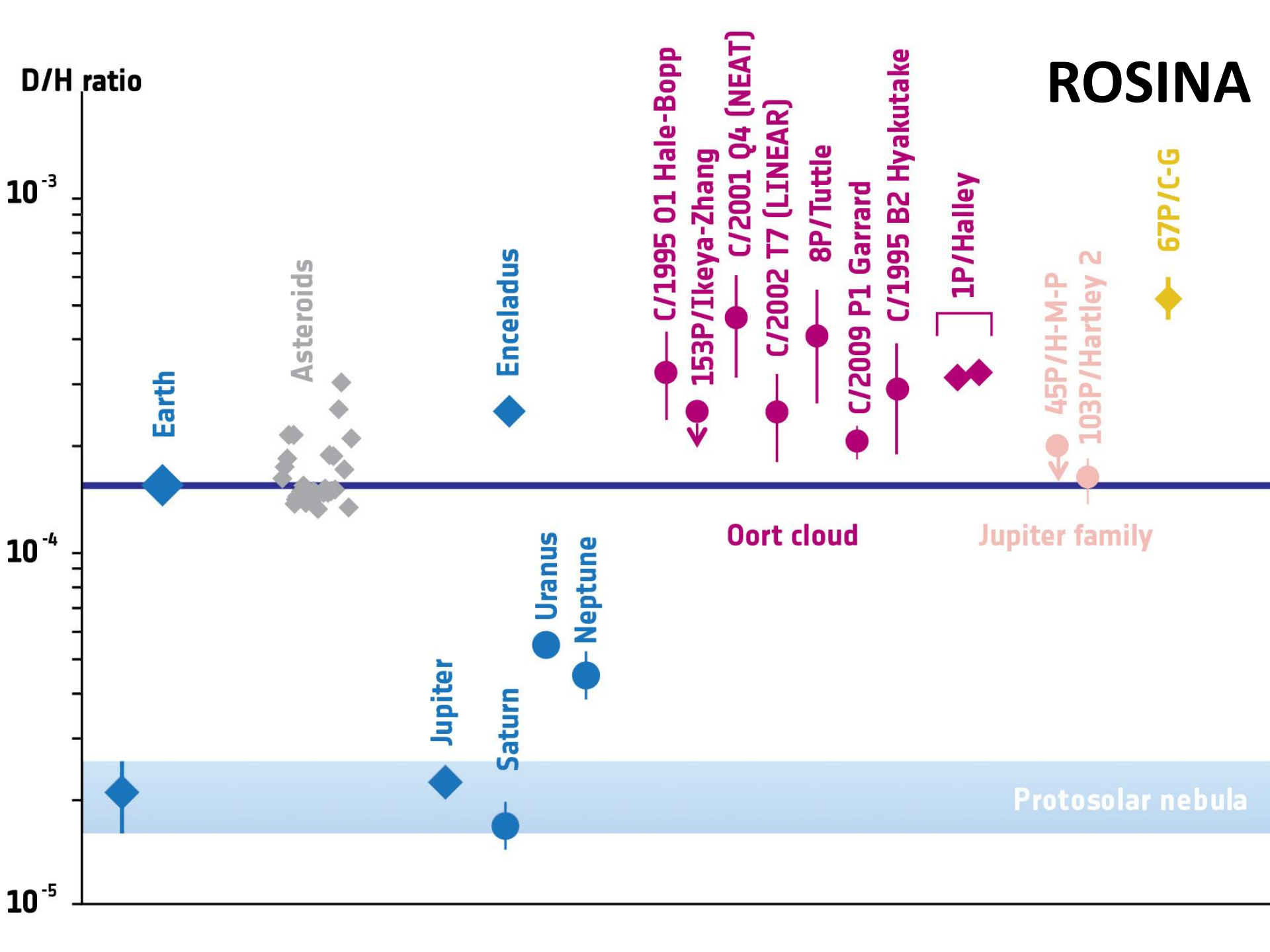
LES ODEURS DE LA COMÈTE 67P

Le « parfum » de la comète Churuymov-Gerasimenko est plutôt fort.

Rosina (spectromètre de masse du gaz) a détecté en premier lieu : l'eau, le monoxyde de carbone, le dioxyde de carbone et le méthane.

Plus des gaz odorants :

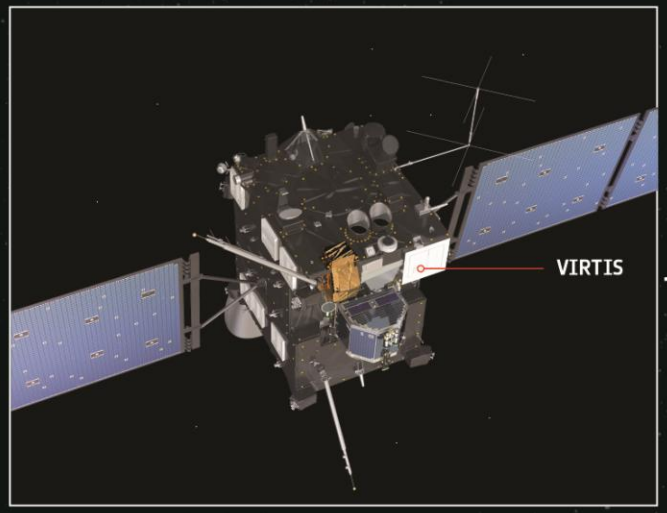
- H_2S hydrogène sulfuré ► une odeur d'œuf pourri
- NH_3 ammoniaque ► odeur d'écuries
- H_2CO formaldéhyde ►odeur âcre & suffocante
- HCN cyanure d'hydrogène ► arôme d'amande amère
- CH_3OH méthanol ► un relent d'alcool
- SO_2 dioxyde de soufre ►une arôme vinaigrée
- CS_2 sulfure de carbone ►un soupçon de parfum doux et aromatique


ROSINA
D/H ratio
10-3
10-4
10-5
Earth
Asteroids
Enceladus
C/1995 O1 Hale-Bopp
153P/Ikeya-Zhang
C/2001 Q4 (NEAT)
C/2002 T7 (LINEAR)
8P/Tuttle
C/2009 P1 Garrard
C/1995 B2 Hyakutake
1P/Halley
45P/H-M-P
103P/Hartley 2
67P/C-G
Oort cloud
Jupiter family
Jupiter
Saturn
Uranus
Neptune
Protosolar nebula

First VIRTIS measurements reveal a temperature of -70°C suggesting that the surface of comet 67P/Churyumov-Gerasimenko is predominantly covered by dust

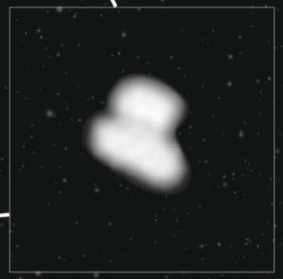
Sun

553.5 million km



The observations were made by VIRTIS between 13 and 21 July 2014

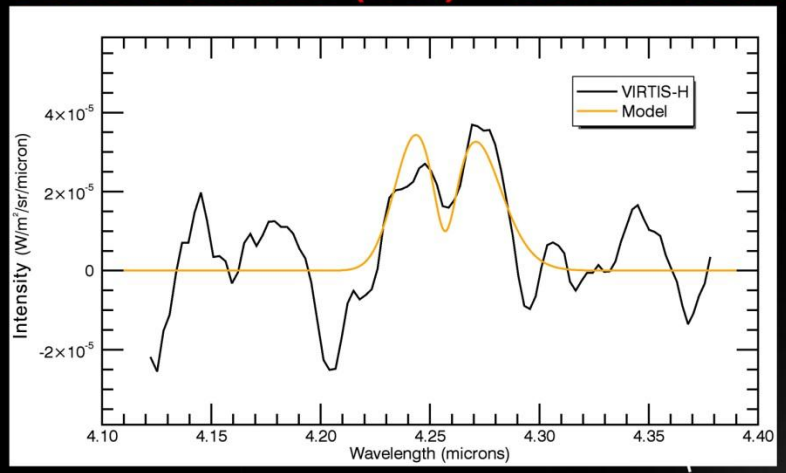
≈ 14 000 - 5 000 km



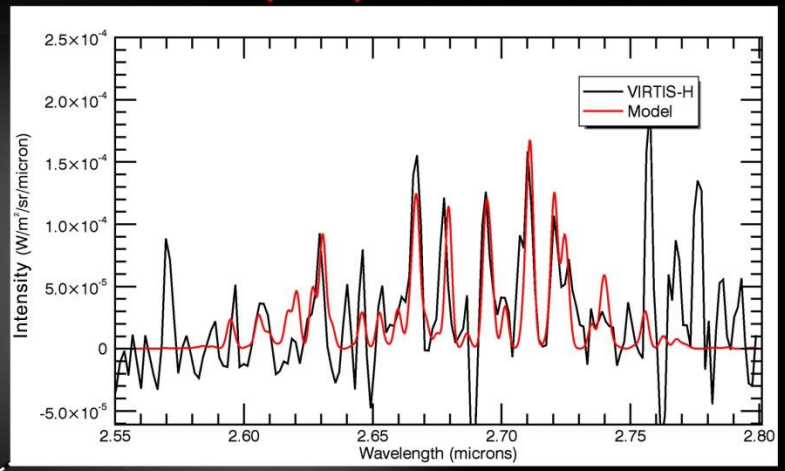
NAVCAM image of comet 67P/C-G on 23 July 2014

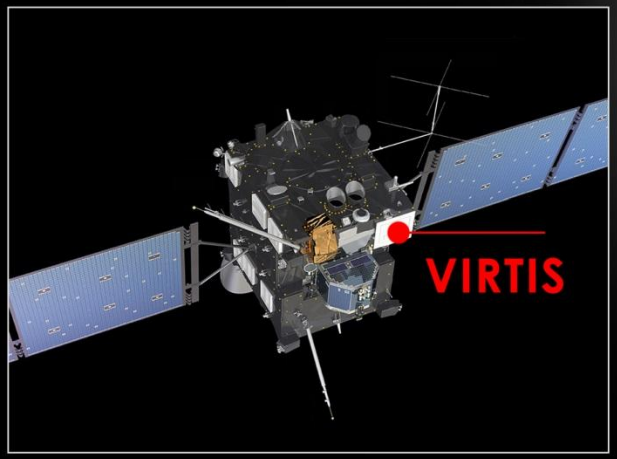
www.esa.int

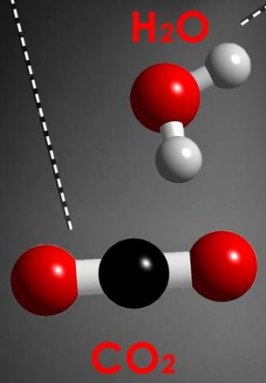
Carbon dioxide (CO_2) - October 2014

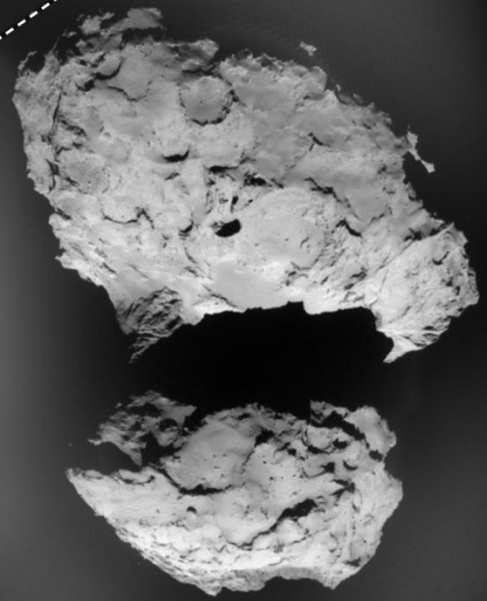


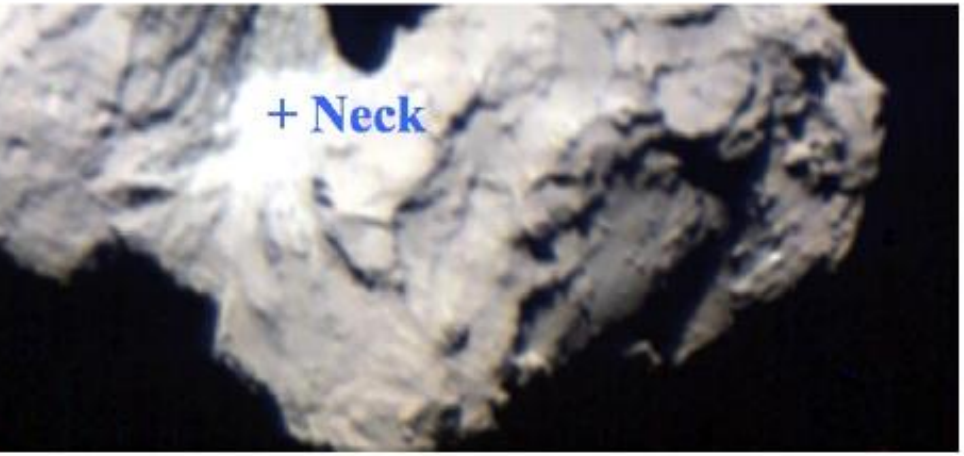
Water (H_2O) - October 2014

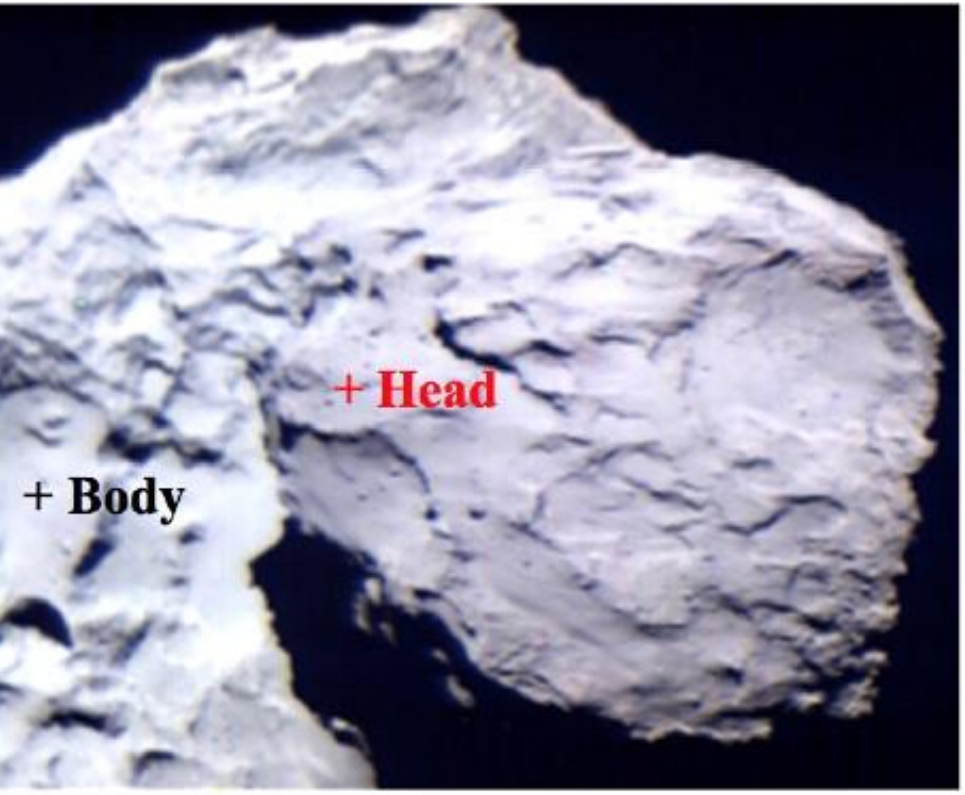


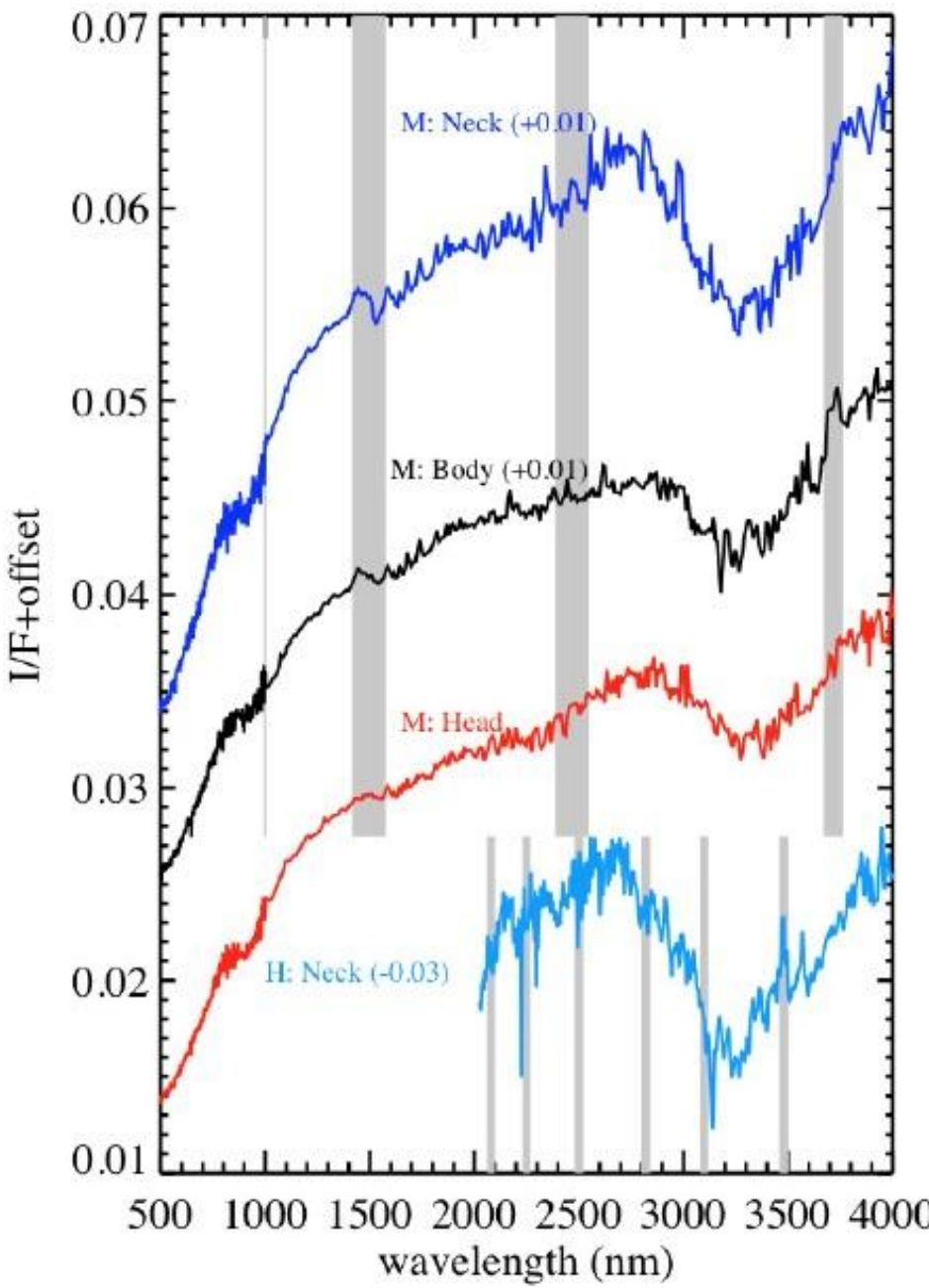




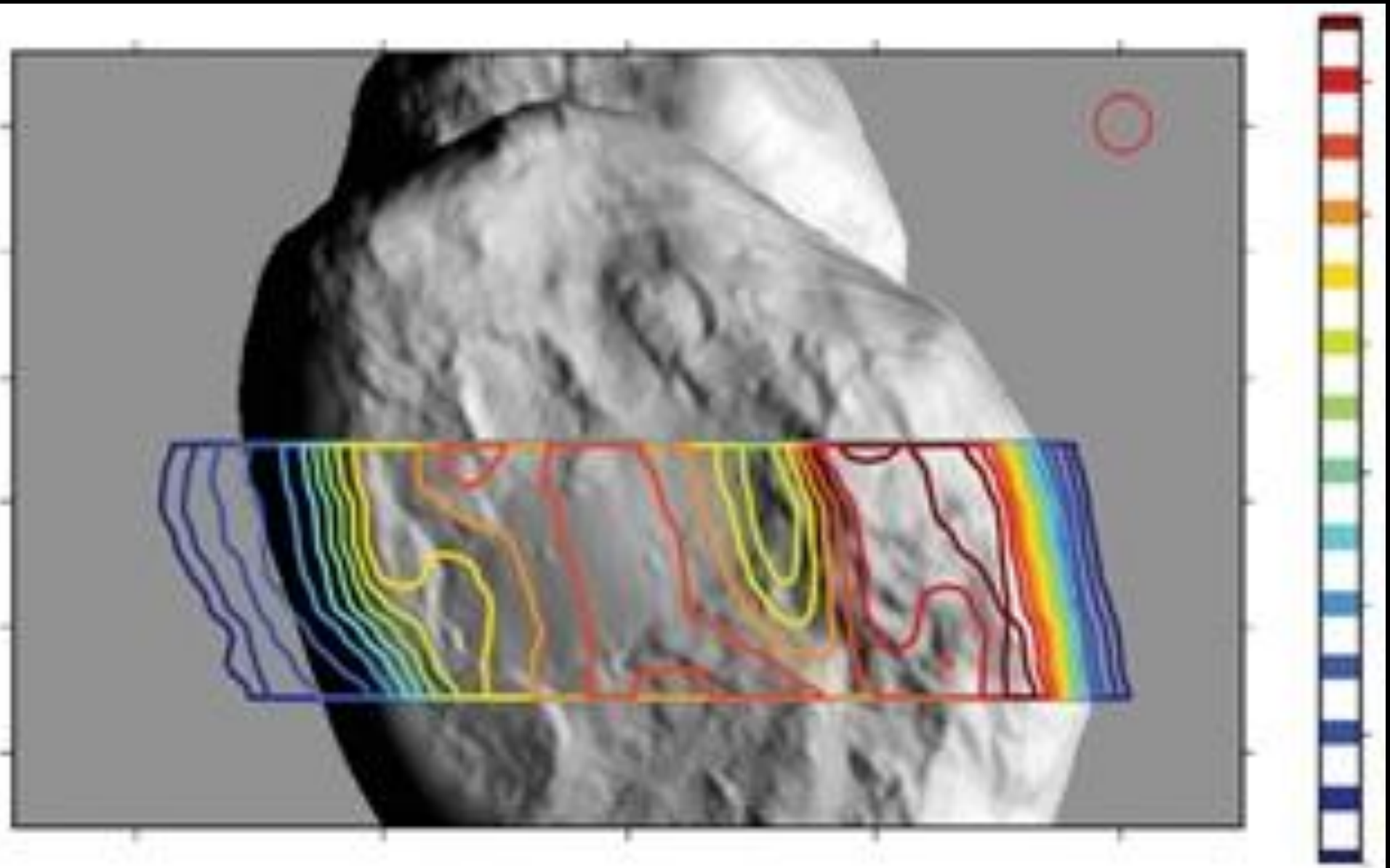


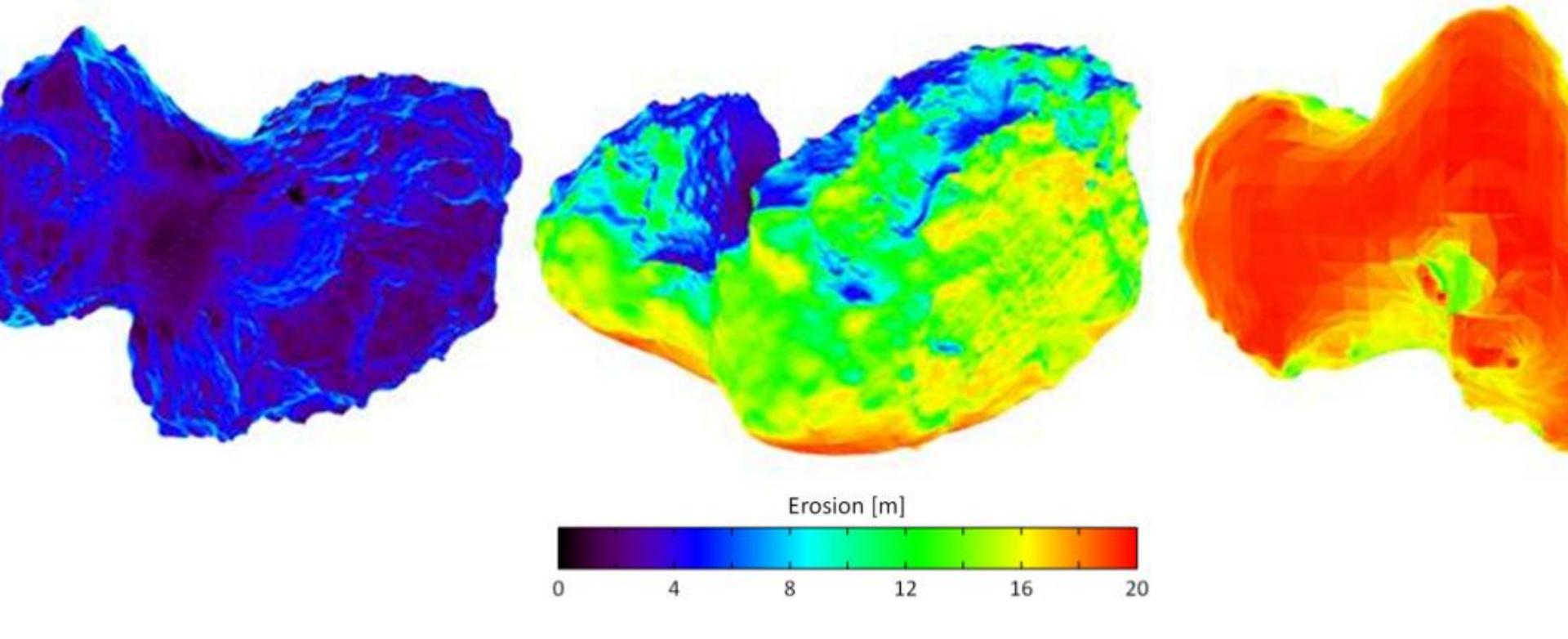

+ Neck

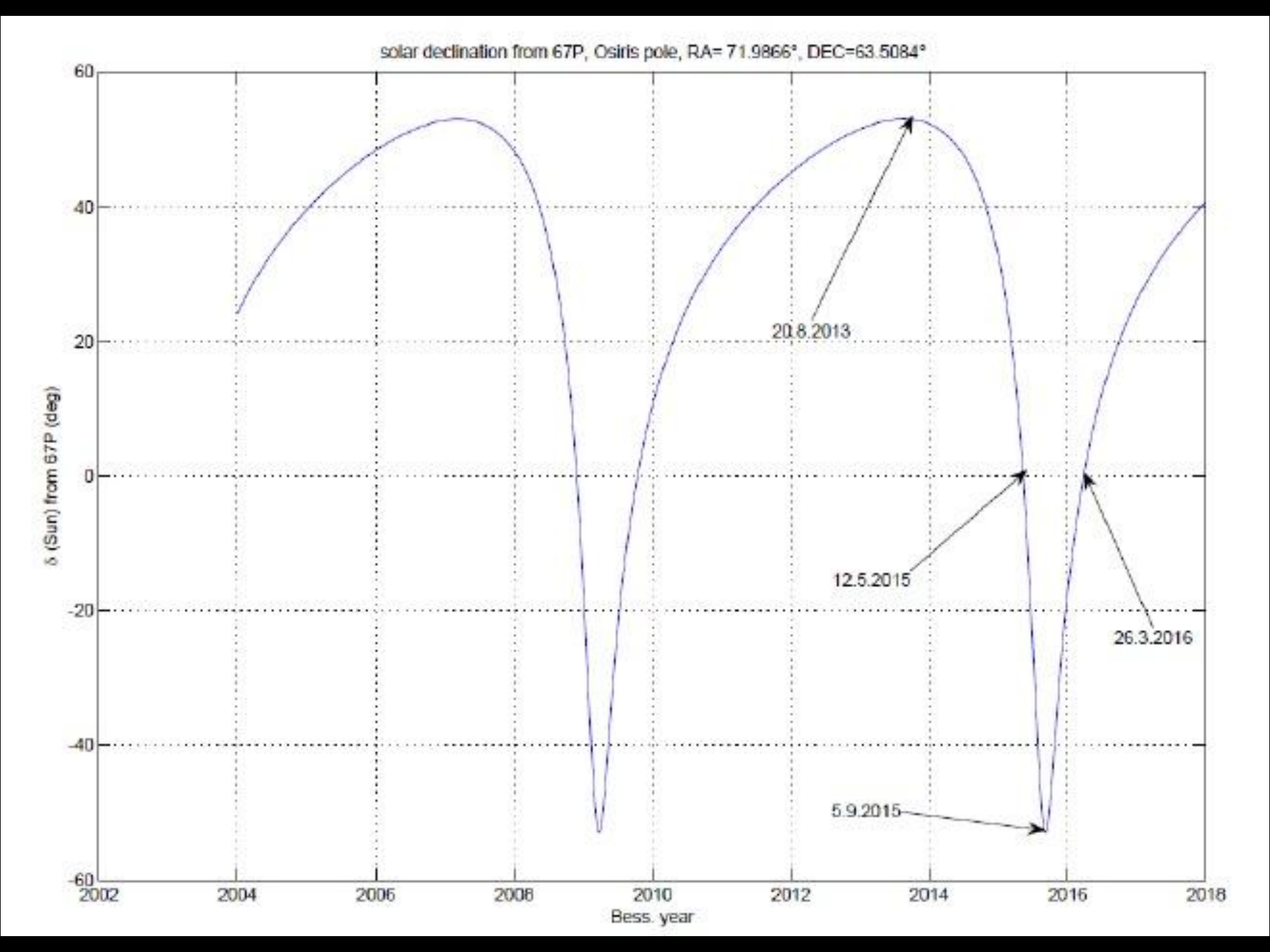

+ Head
+ Body

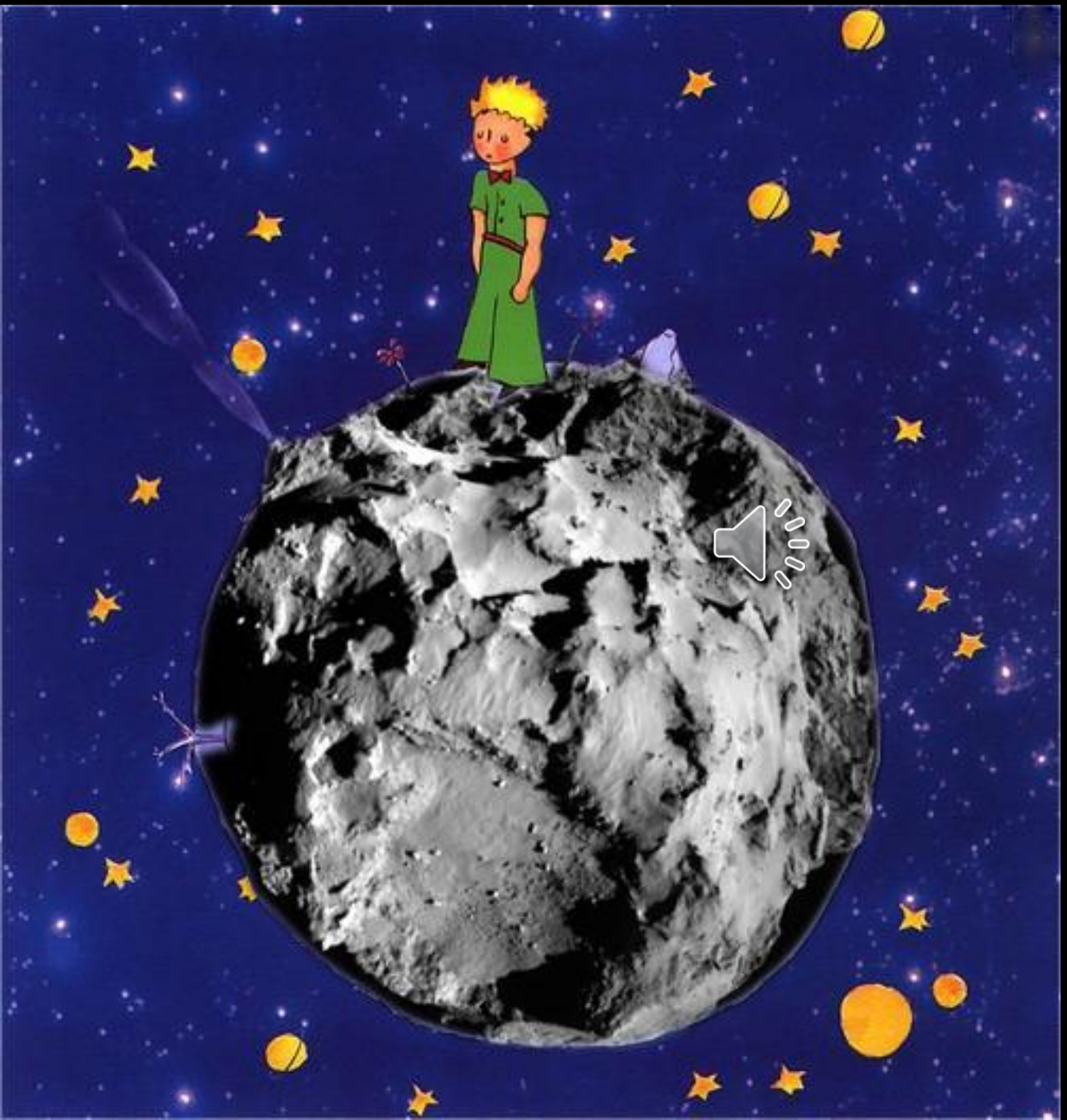

0.07
0.06
0.05
0.04
0.03
0.02
0.01
I/F+offset
M: Neck (+0.01)
M: Body (+0.01)
M: Head
H: Neck (-0.03)
500
1000
1500
2000
2500
3000
3500
4000
wavelength (nm)

MIRO
Température proche de la surface




Erosion [m]
0
4
8
12
16
20


solar declination from 67P, Osiris pole, RA= 71.9866°, DEC=63.5084°
δ (Sun) from 67P (deg)
Bess. year
60
40
20
0
-20
-40
-60
2002
2004
2006
2008
2010
2012
2014
2016
2018
20.8.2013
12.5.2015
26.3.2016
5.9.2015



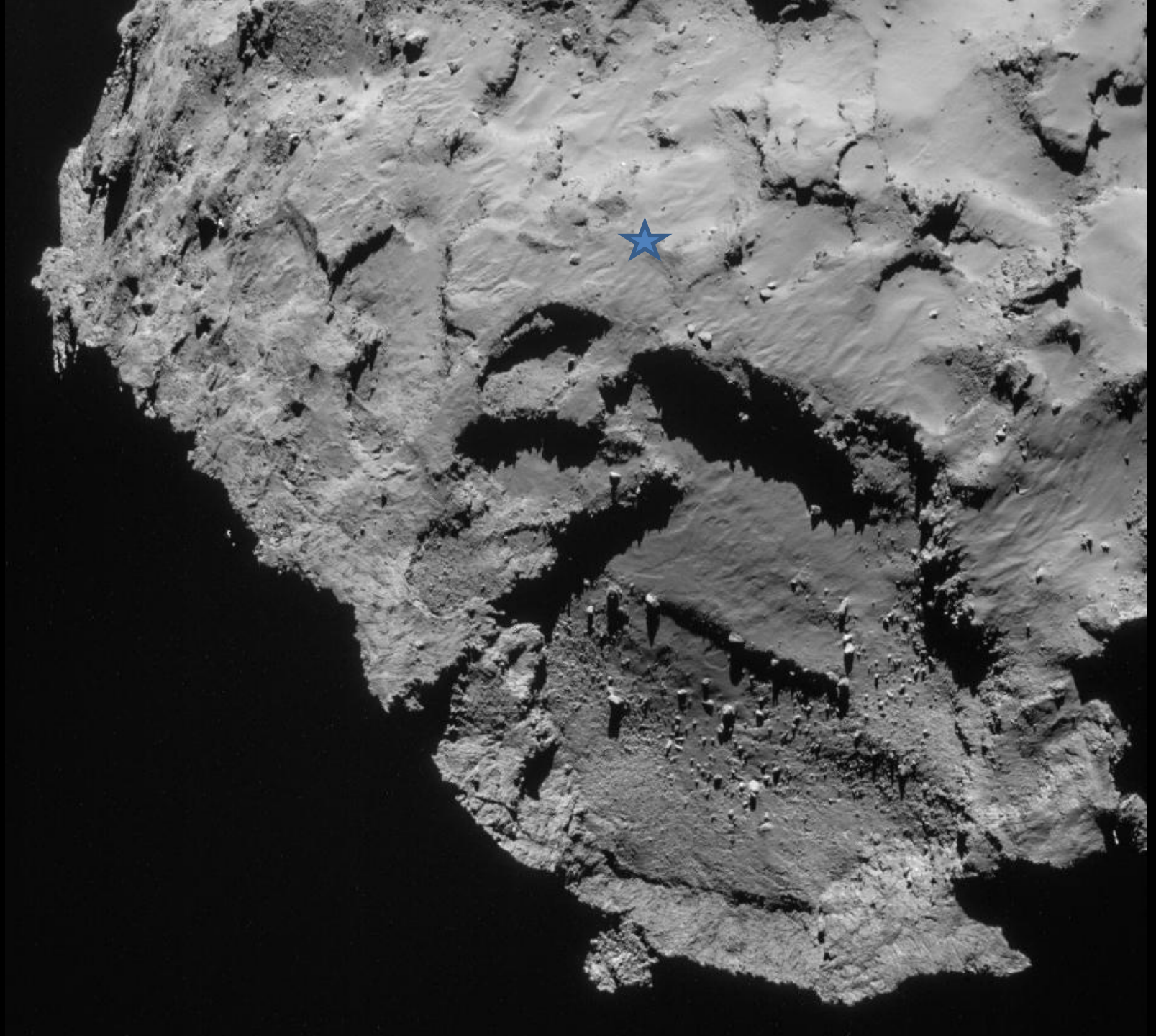
RPC-MAG

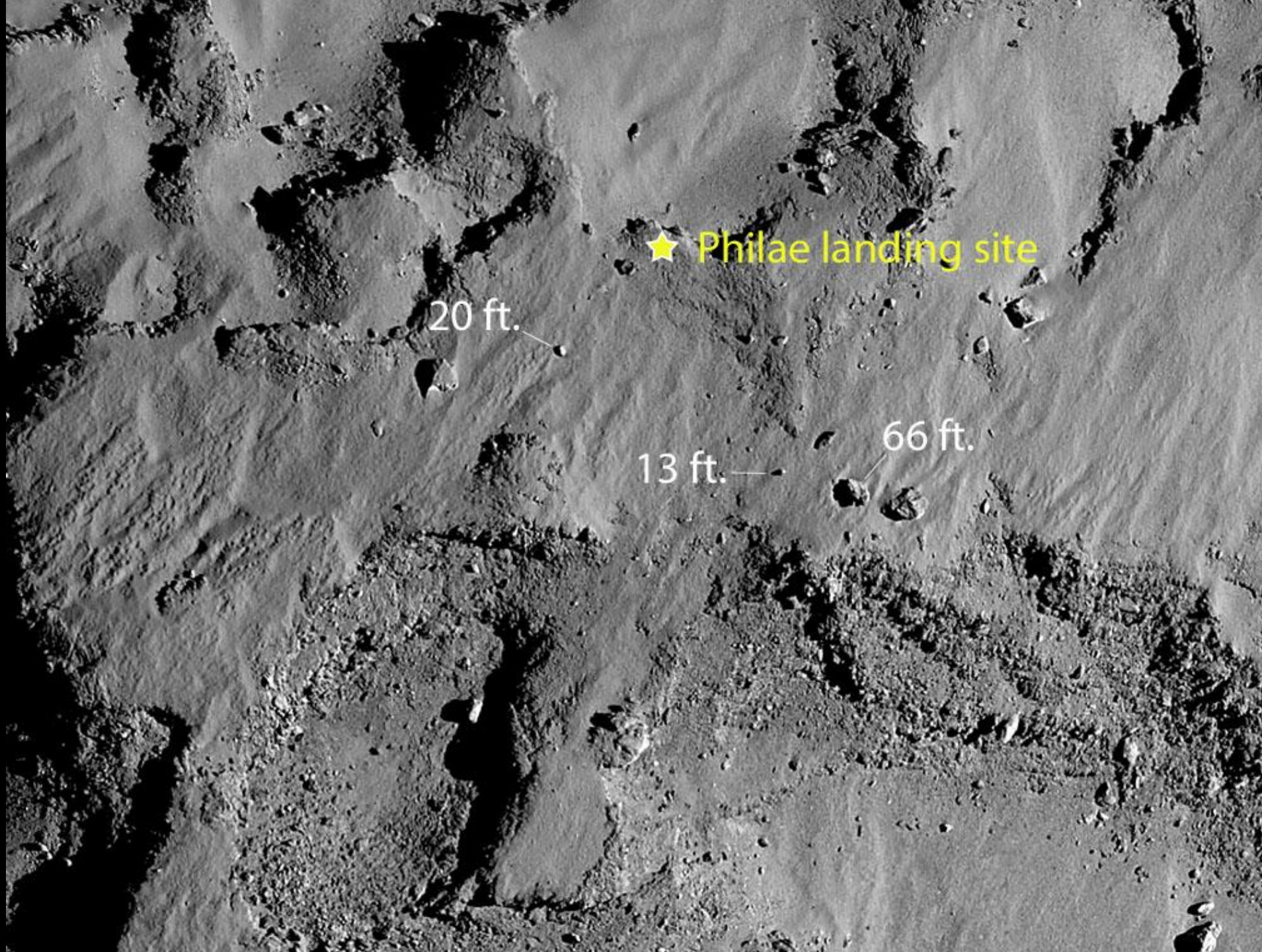
“son” accéléré 10.000 fois

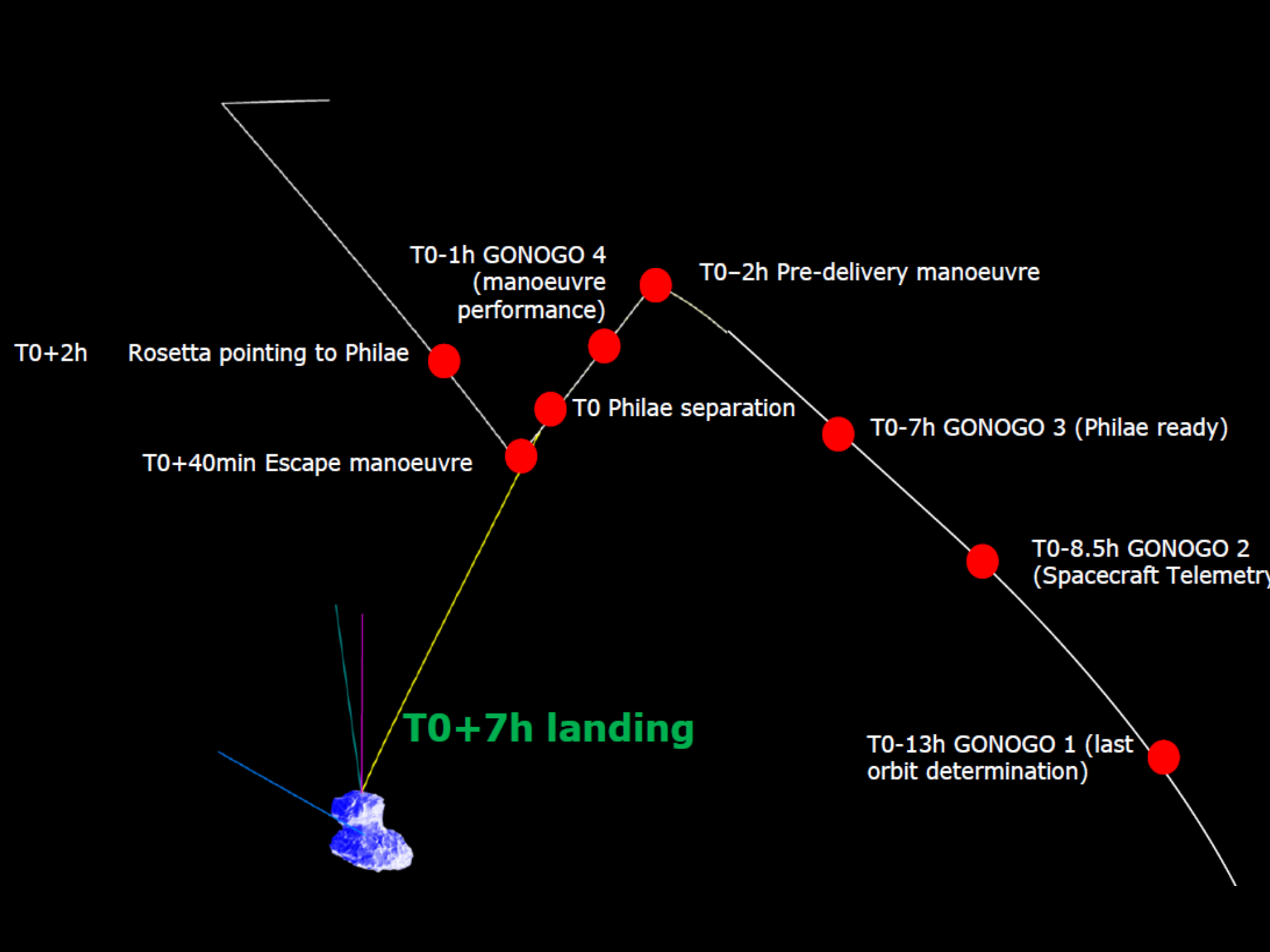
Période 20-25 sec

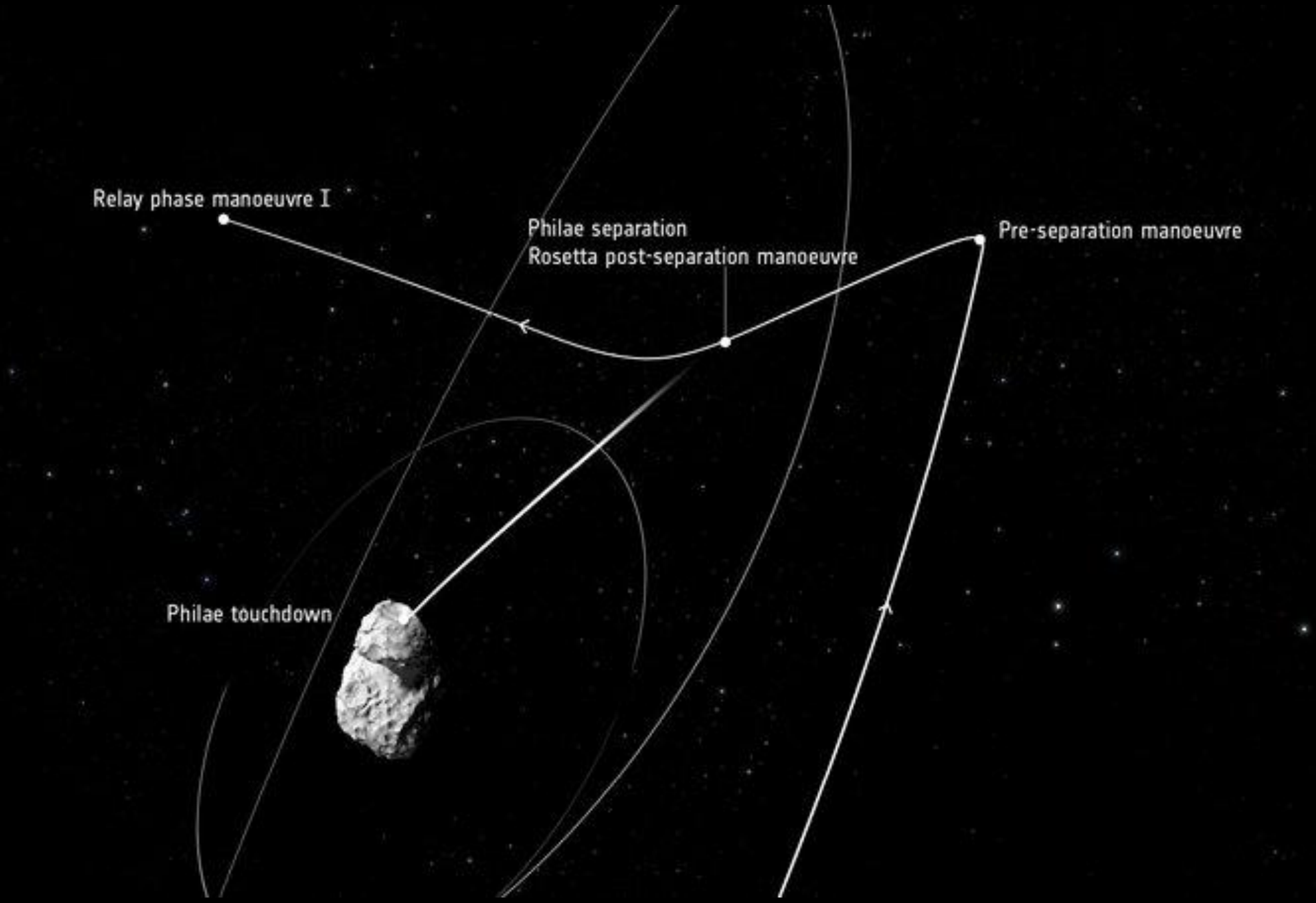
Philae

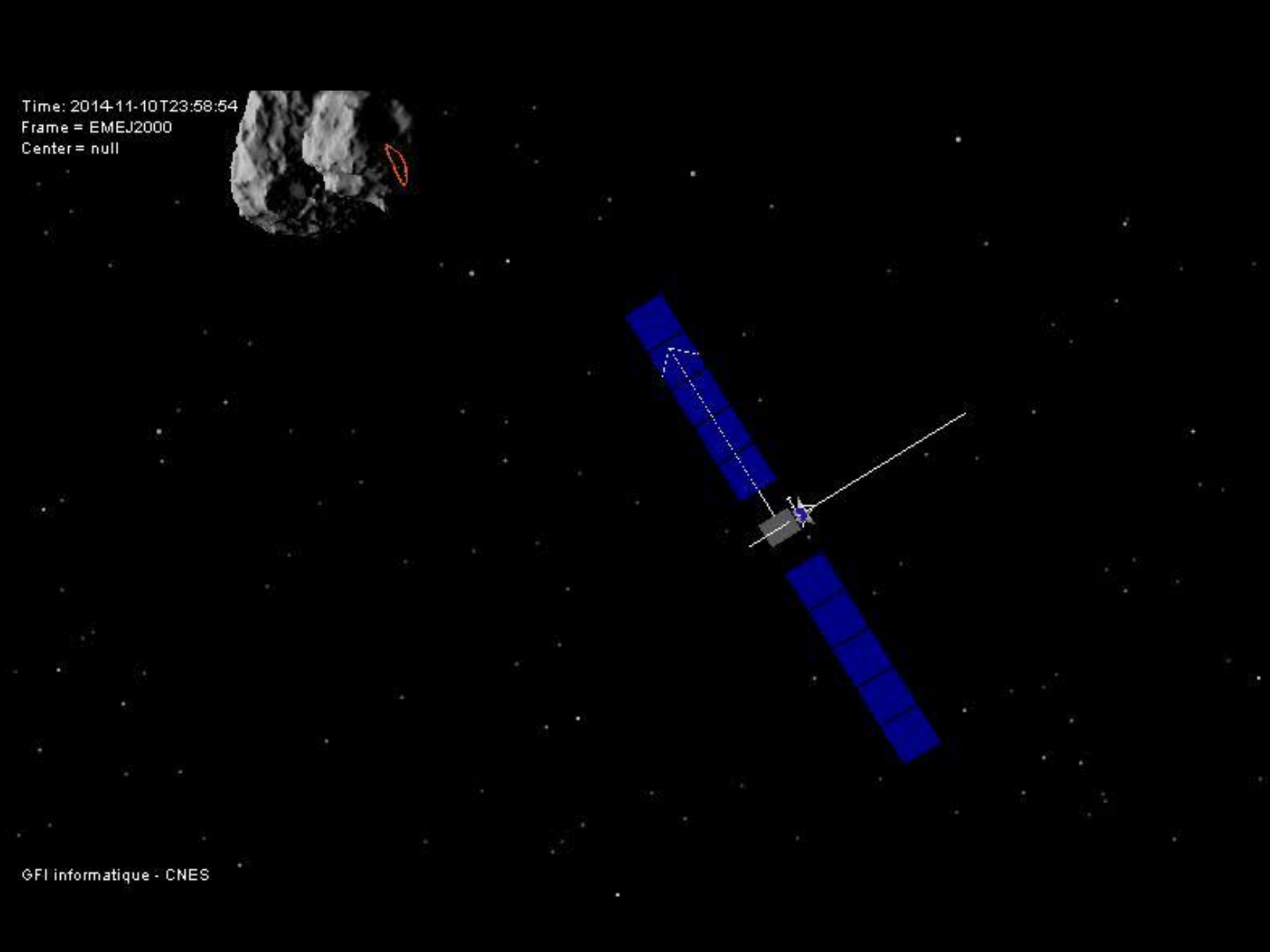
Atterrissage sur la comète !

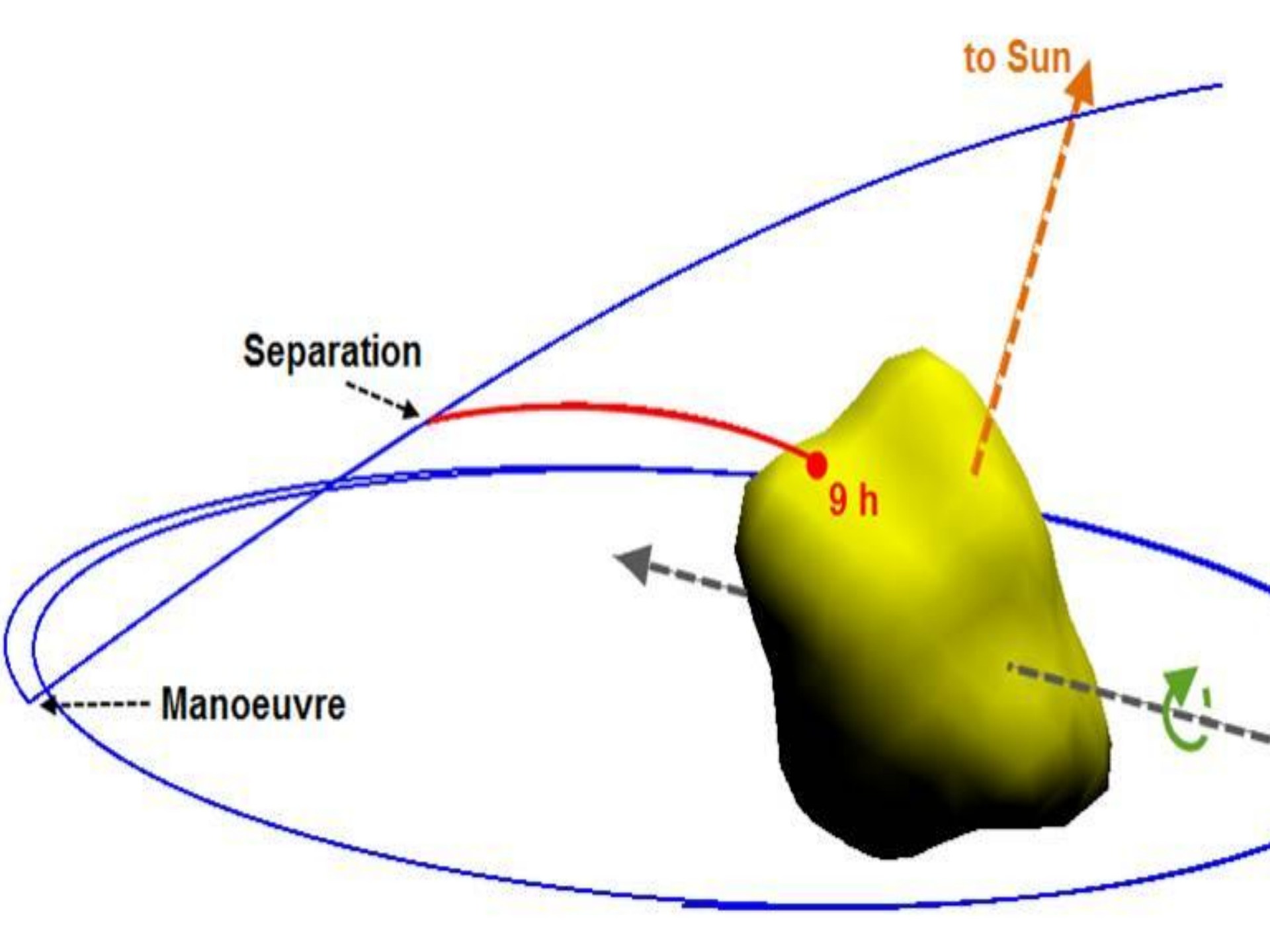


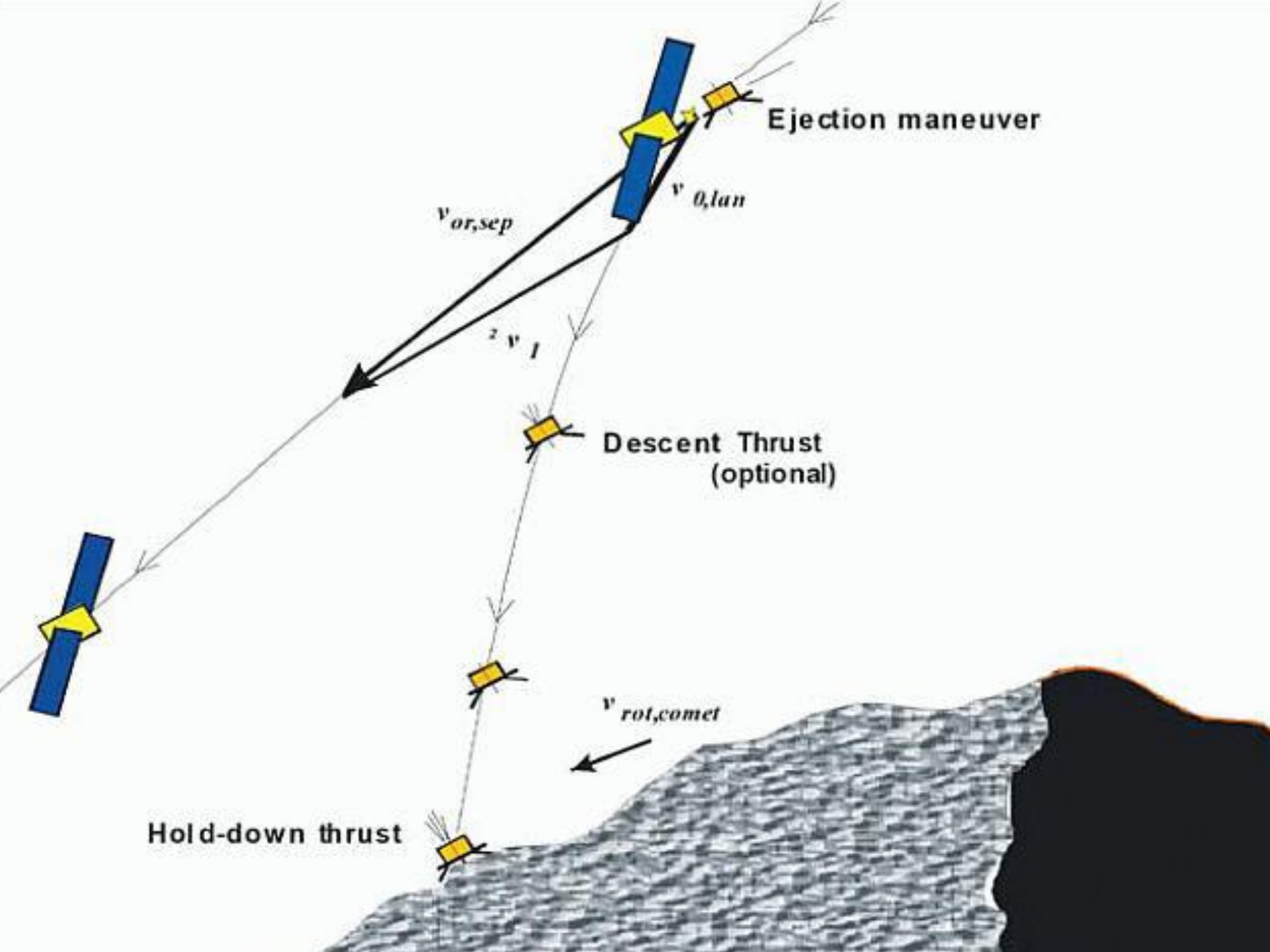

Philae landing site
20 ft.
66 ft.
13 ft.

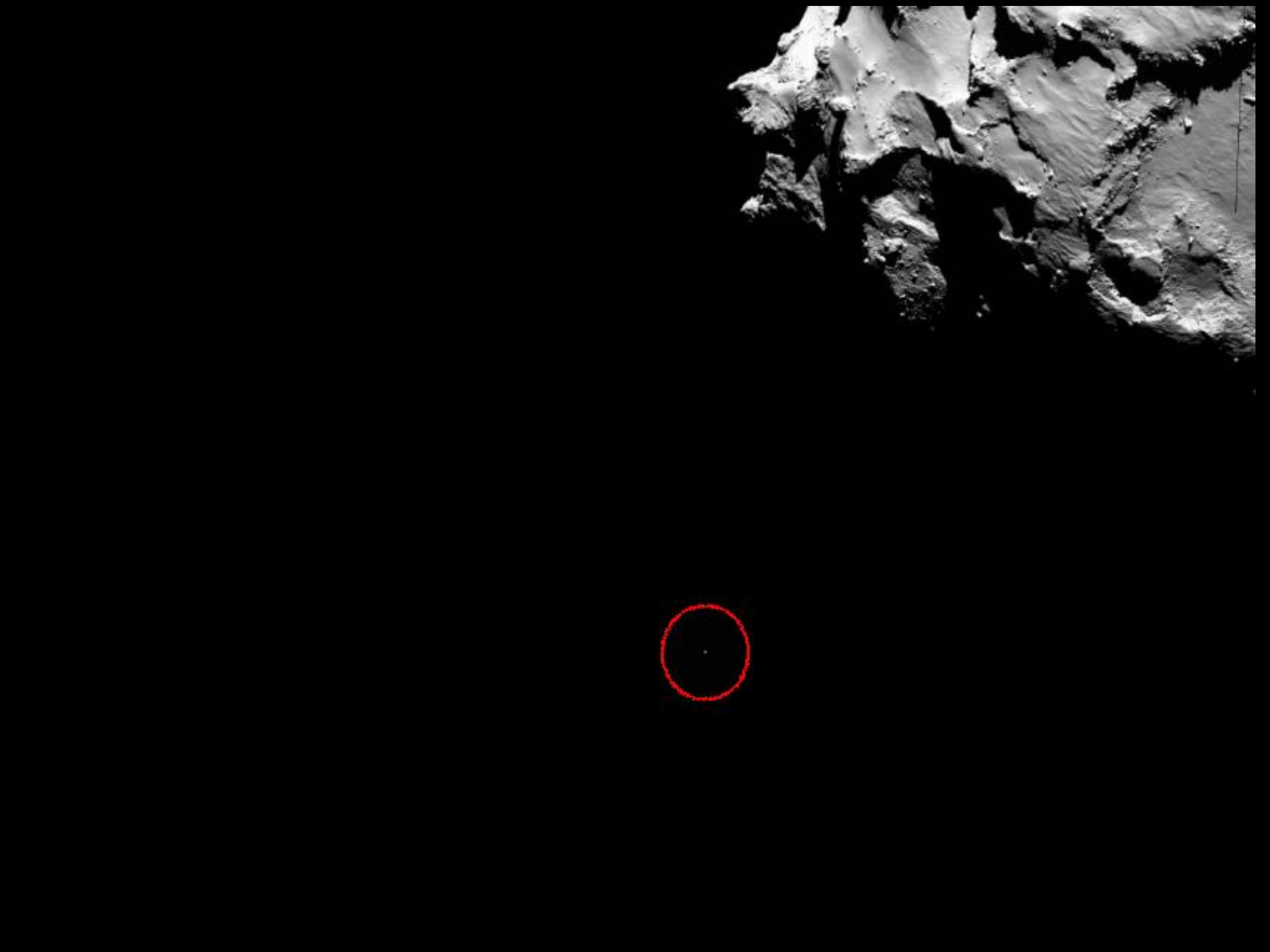

T0-1h GONOGO 4
(manoeuvre
performance)
T0–2h Pre-delivery manoeuvre
T0+2h
Rosetta pointing to Philae
T0 Philae separation
T0-7h GONOGO 3 (Philae ready)
T0+40min Escape manoeuvre
T0-8.5h GONOGO 2
(Spacecraft Telemetry
T0+7h landing
T0-13h GONOGO 1 (last
orbit determination)


Relay phase manoeuvre I
Philae separation
Rosetta post-separation manoeuvre
Pre-separation manoeuvre
Philae touchdown


Time: 2014-11-10T23:58:54
Frame = EMEJ2000
Center = null
GFI informatique - CNES

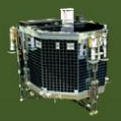

to Sun
Separation
9 h
Manoeuvre


Ejection maneuver
$v_{0,lan}$
$v_{or,sep}$
$^2v_1$
Descent Thrust
(optional)
$v_{rot,comet}$
Hold-down thrust



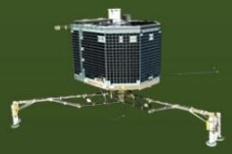
09:03 GMT/10:03 CET
(Time signal expected on Earth)

Separation



~7 hours

Descent



CIVA Farewell images

CONSERT Descent trajectory, gravity, surface & subsurface properties

ROLIS Descent images

ROMAP Magnetic field measurements

SESAME Dust & plasma measurements

16:00 GMT/17:00 CET
(Time signal expected on Earth)

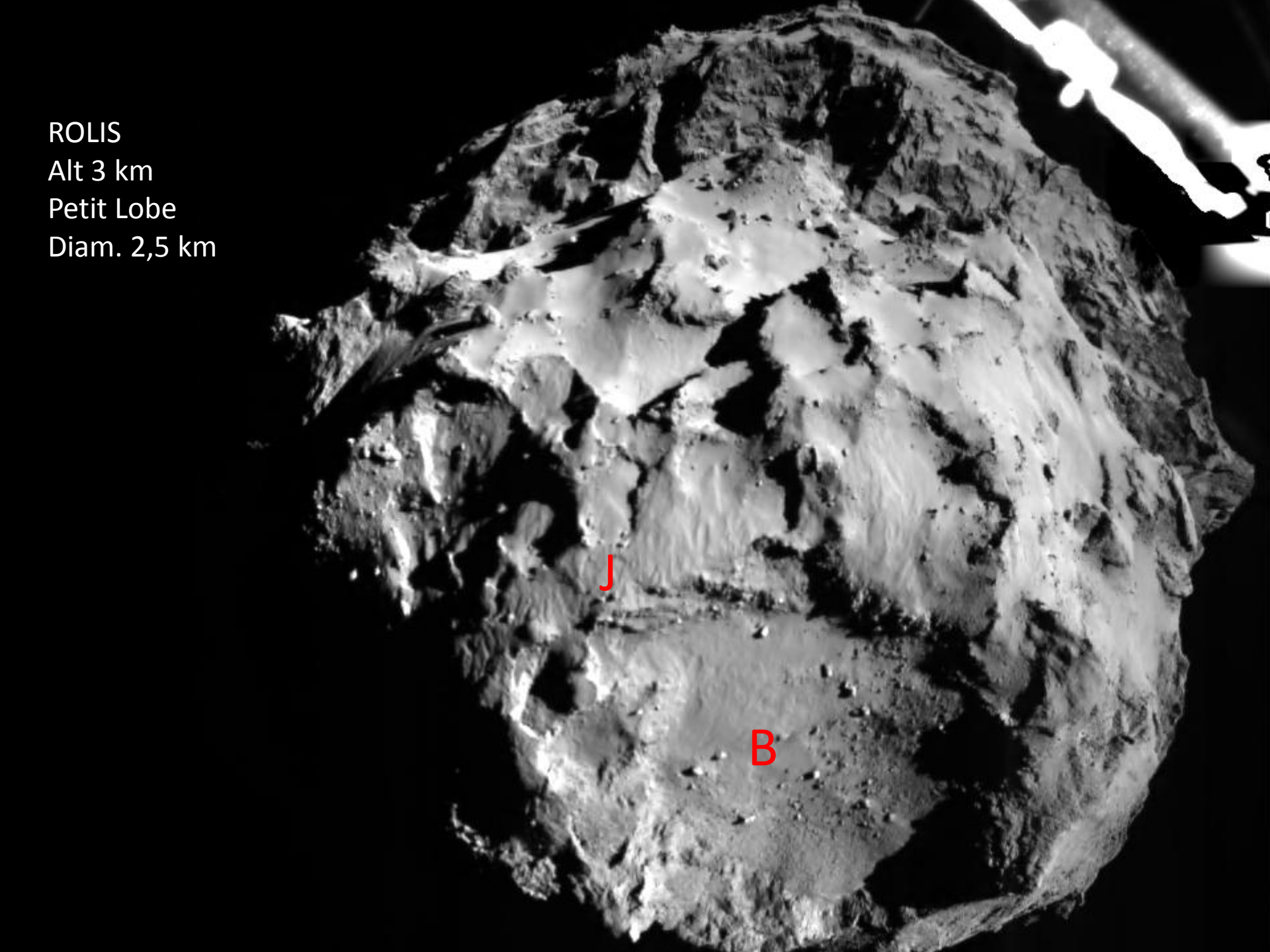
Touchdown

CIVA Panoramic image

COSAC & PTOLEMY Gas measurements

MUPUS Measurement of harpoon deceleration, surface & subsurface properties

ROLIS Close-up image of surface

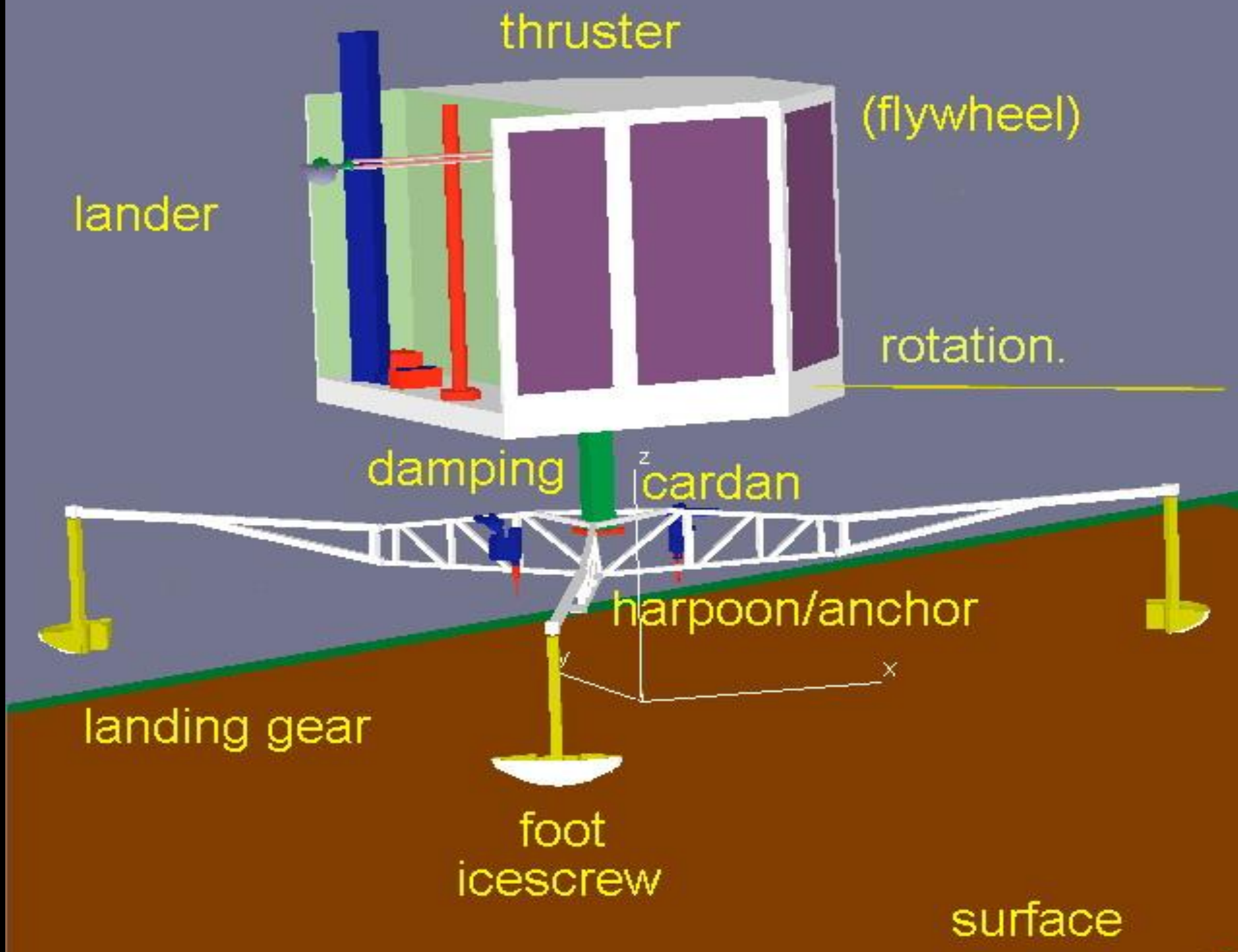

ROLIS
Alt 3 km
Petit Lobe
Diam. 2,5 km
J
B

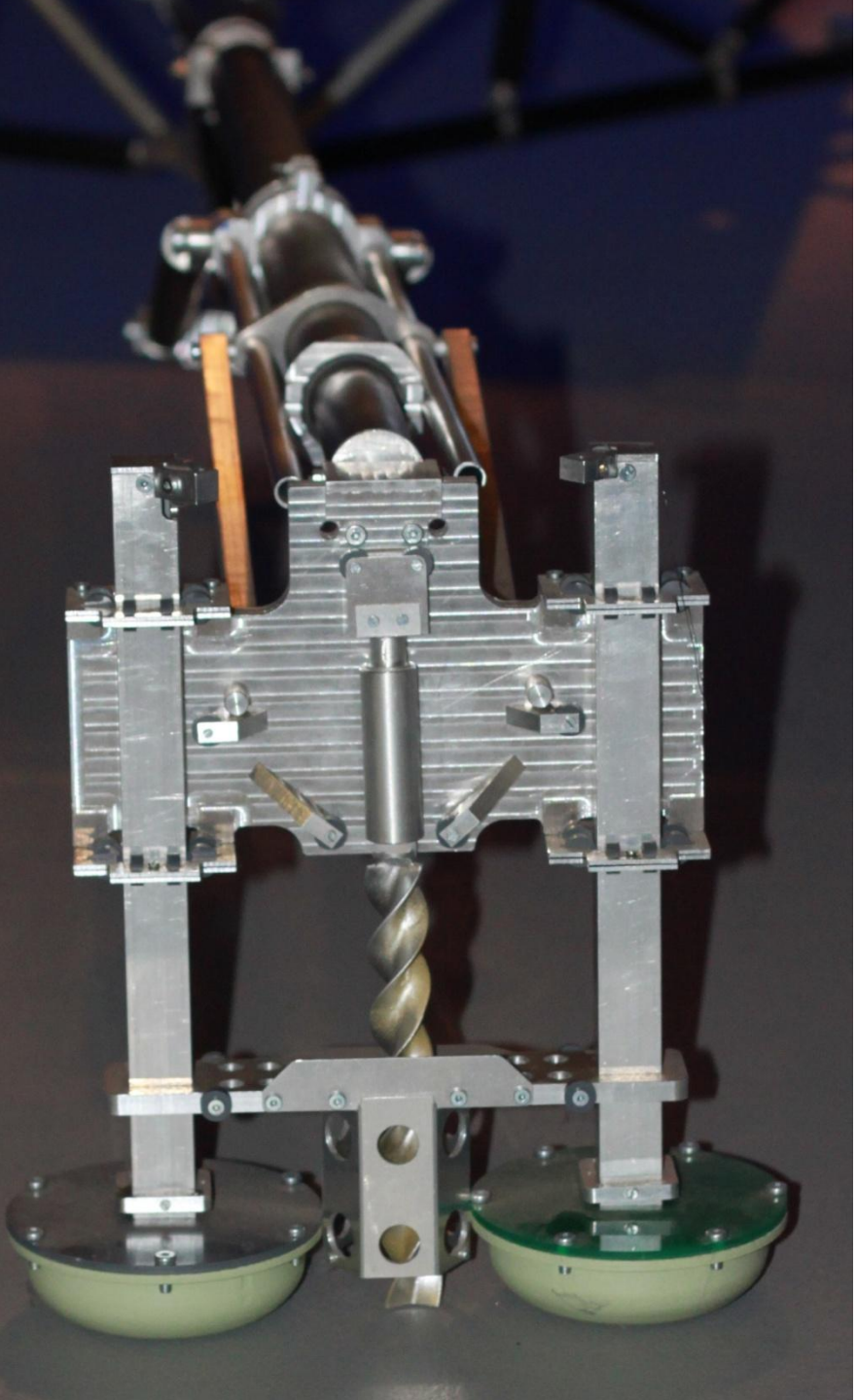
ROLIS
Dernière image
T – 40 sec
Alt 40 m
4 cm/pix

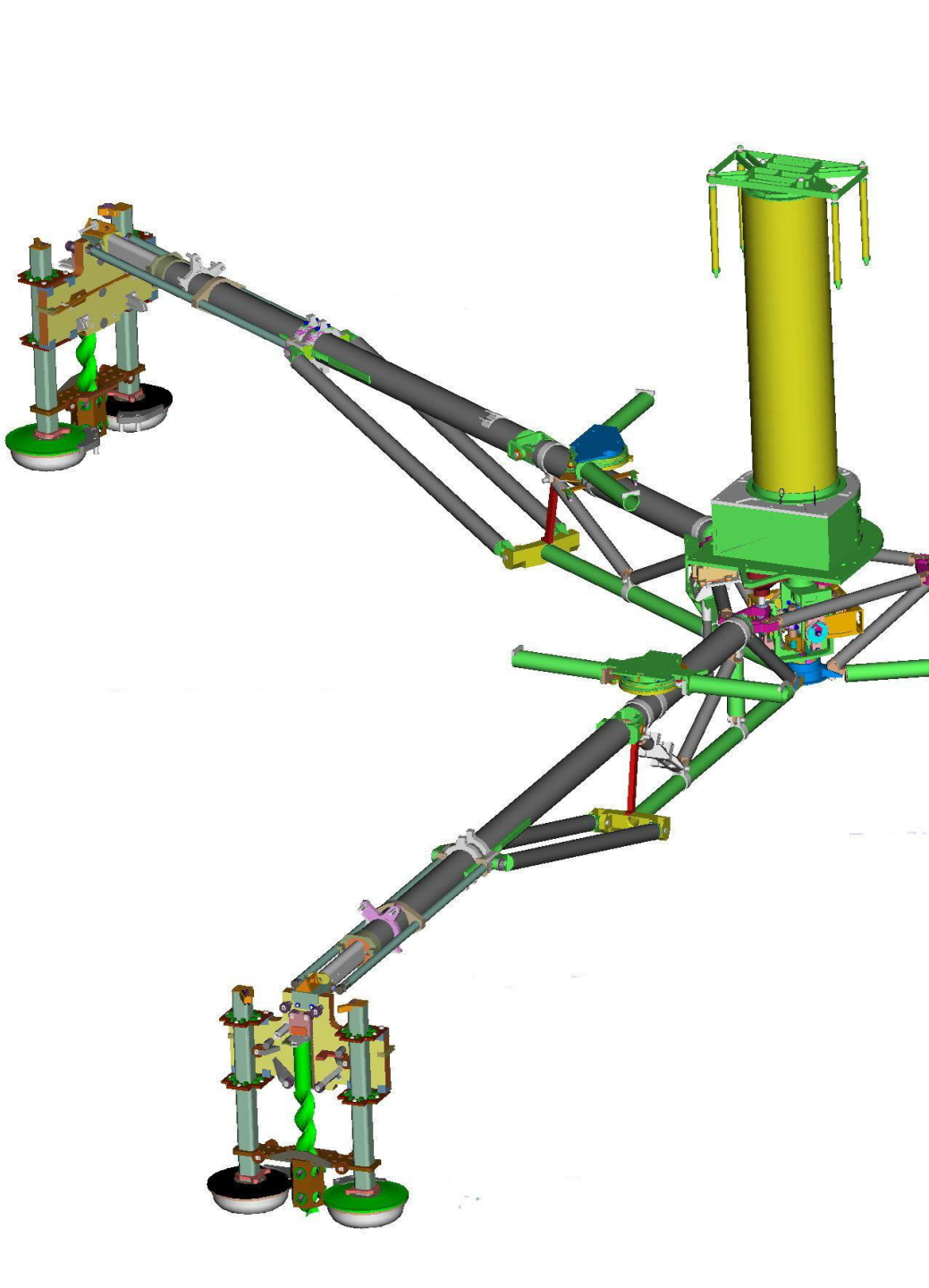
Bloc de 4 m

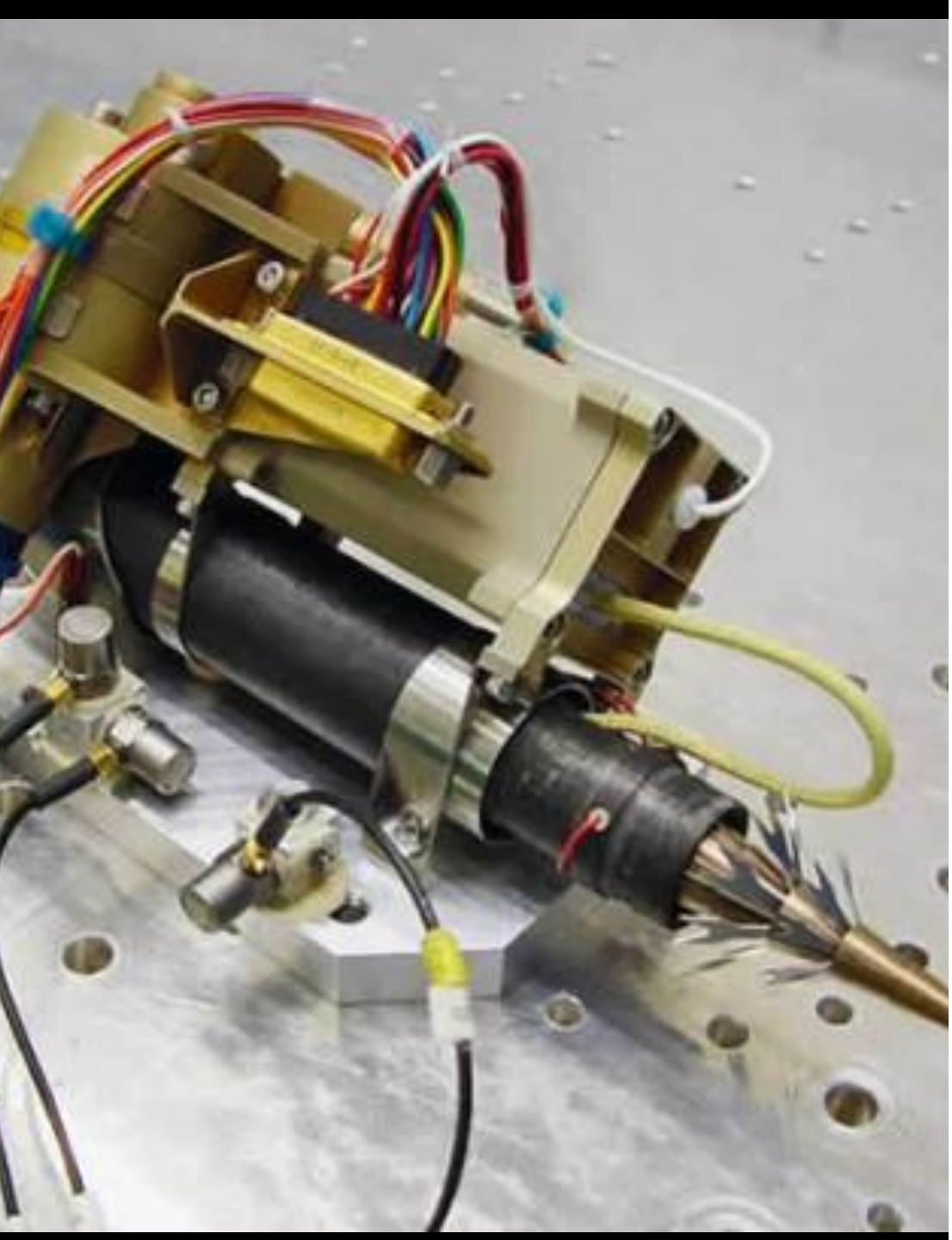
Grains du mm au dm

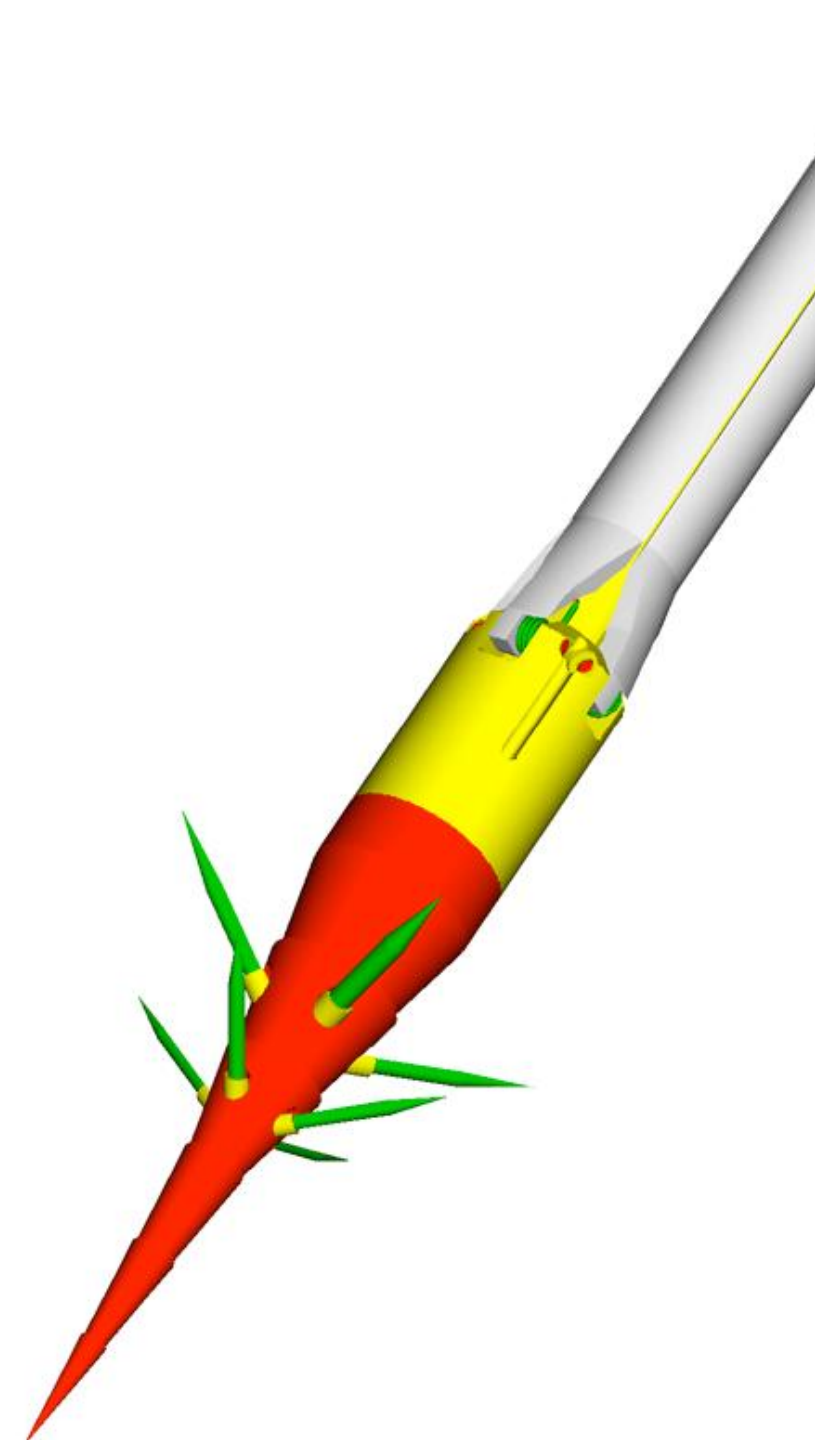

Credit: ESA/ATG medialab

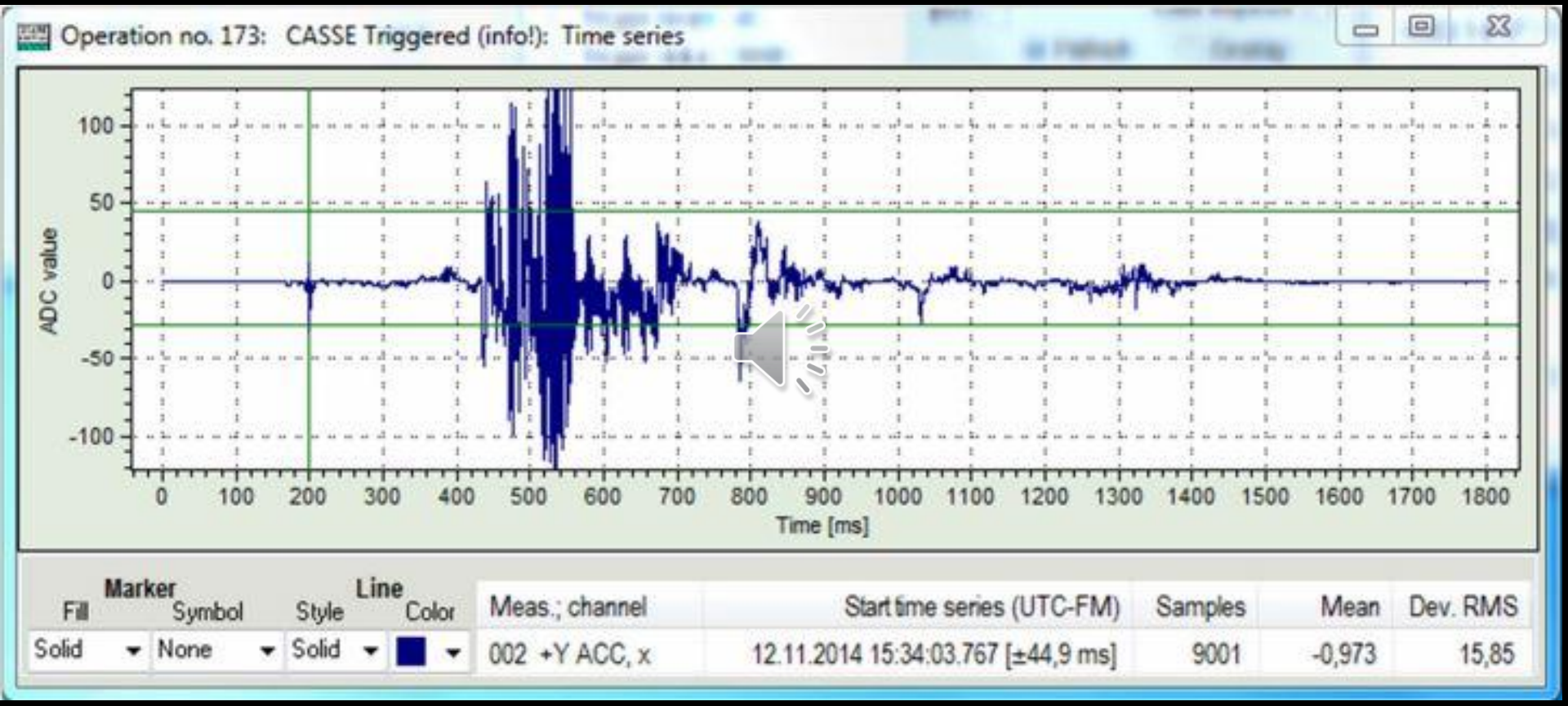

thruster
(flywheel)
lander
rotation.
damping
cardan
z
harpoon/anchor
y
x
landing gear
foot
icescrew
surface



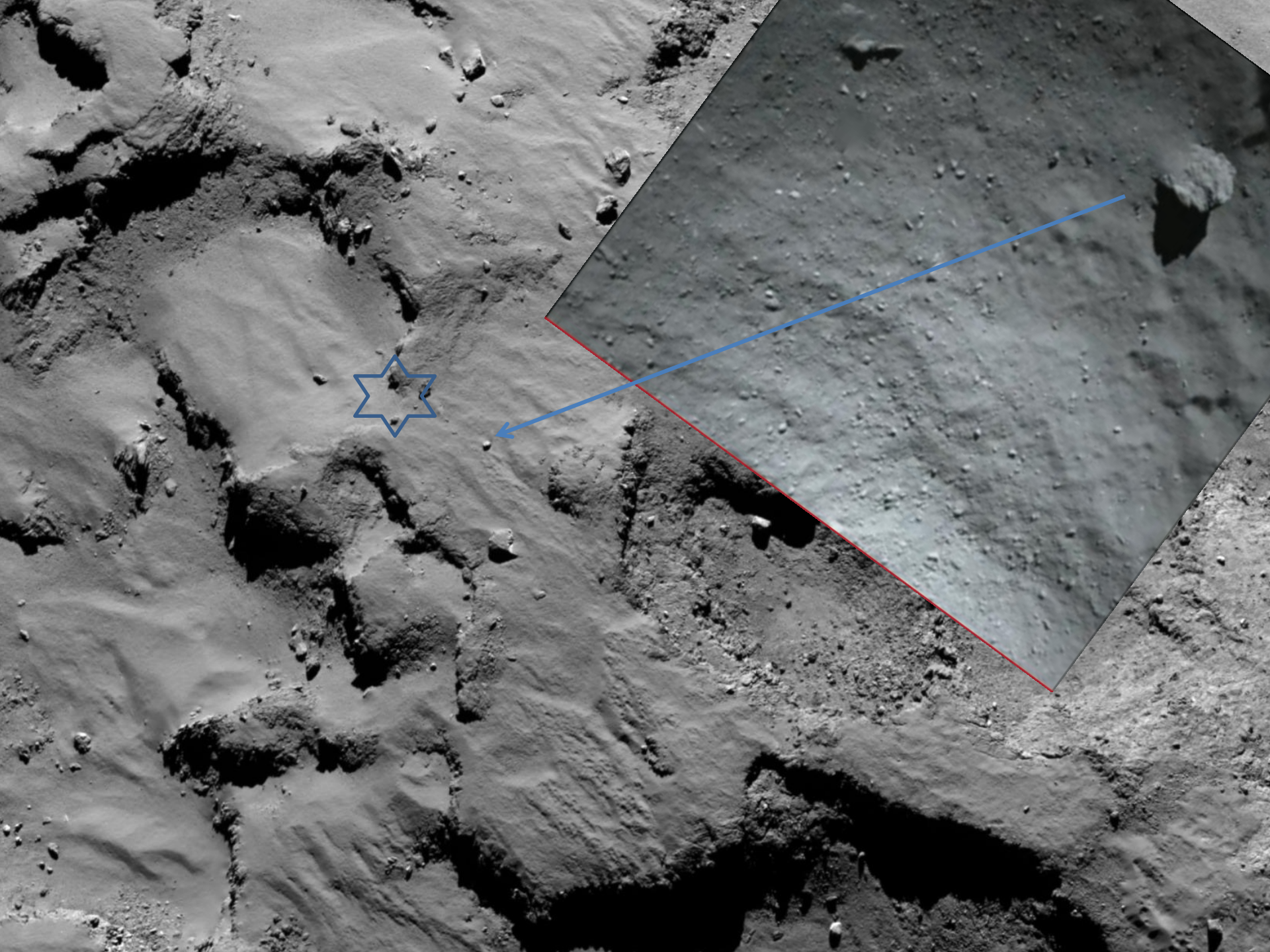


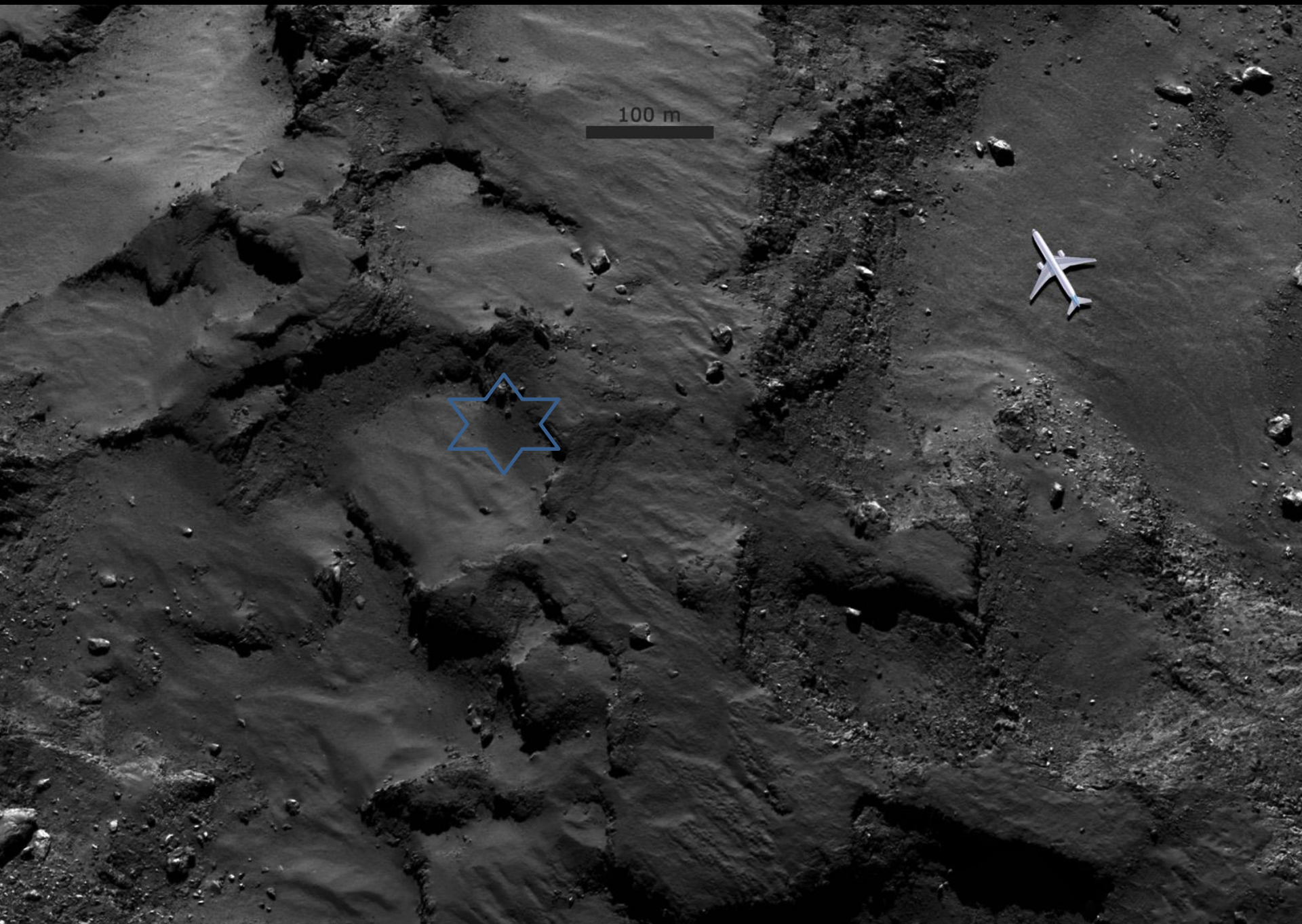


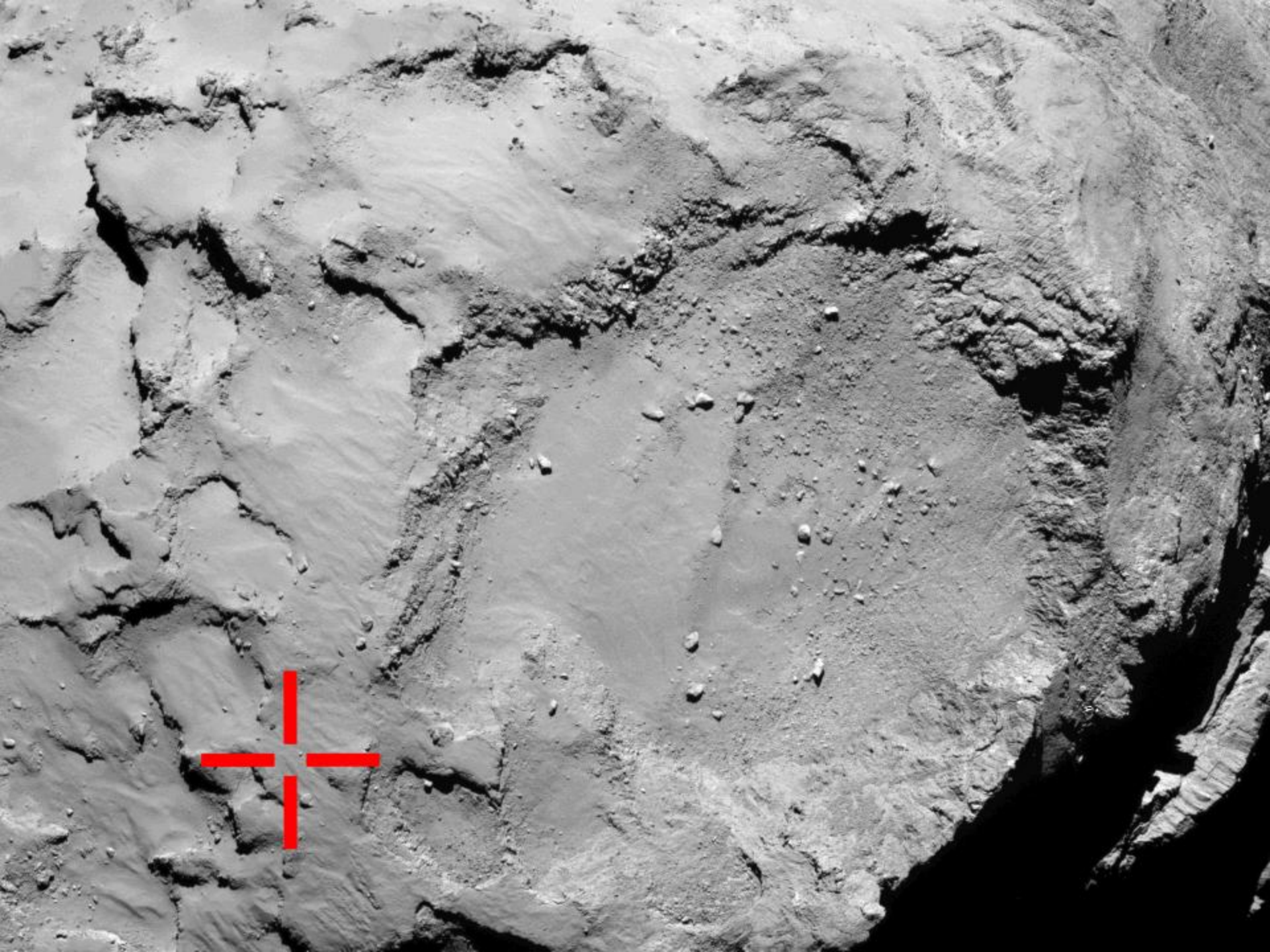




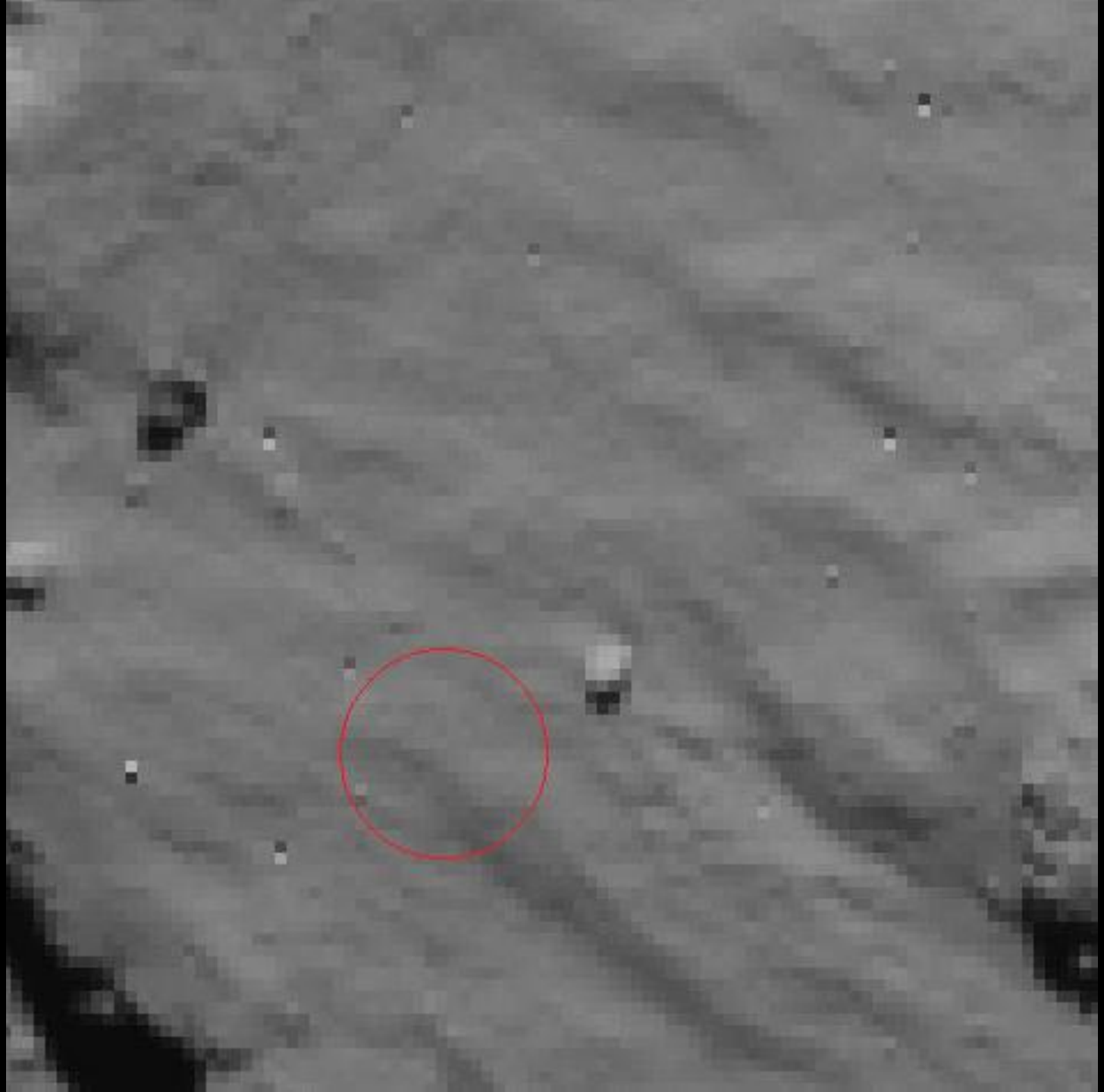
Marker Fill	Marker Symbol	Line Style	Line Color	Meas.; channel	Start time series (UTC-FM)	Samples	Mean	Dev. RMS
Solid	None	Solid		002 +Y ACC, x	12.11.2014 15:34:03.767 [±44,9 ms]	9001	-0,973	15,85

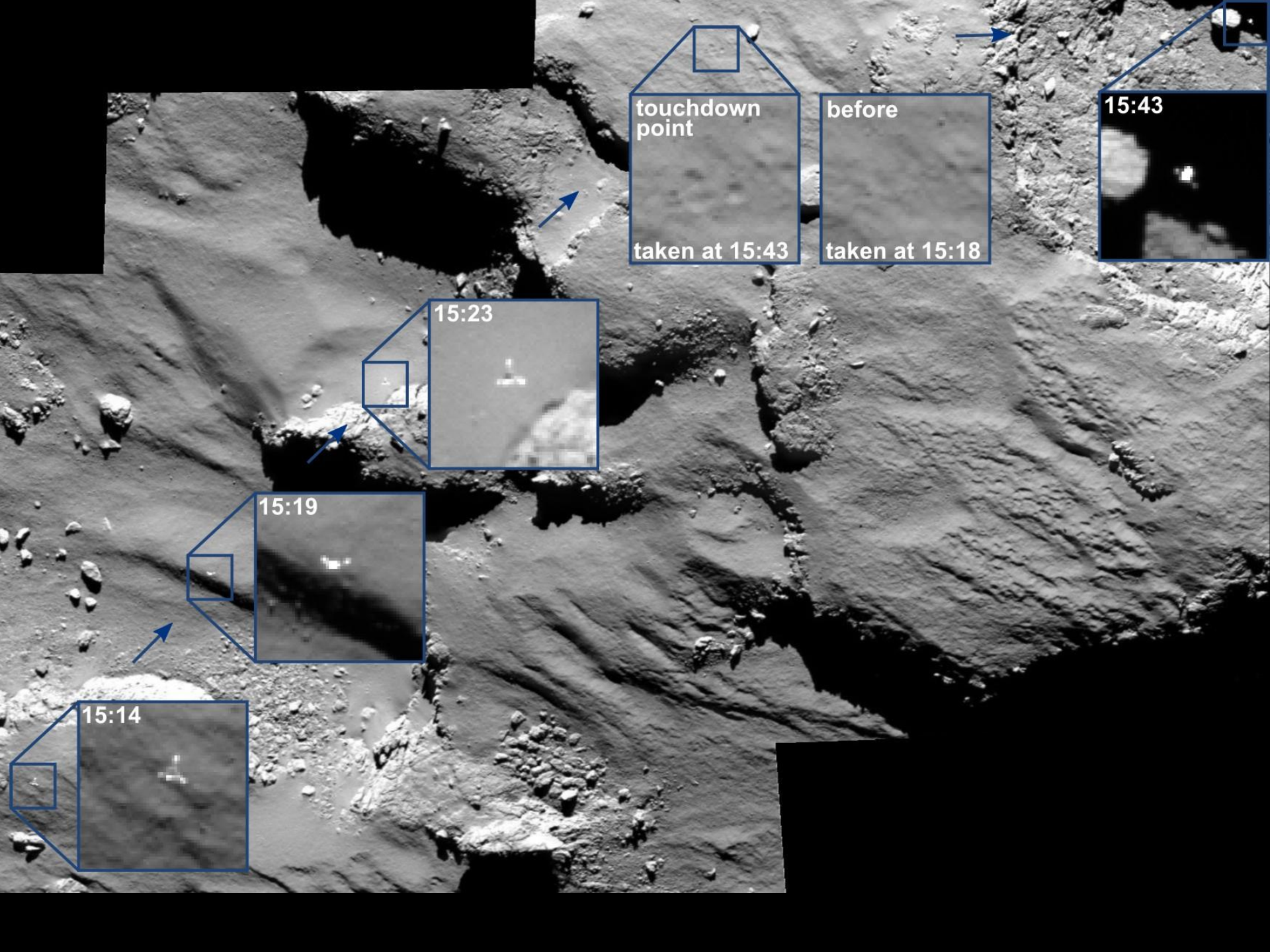


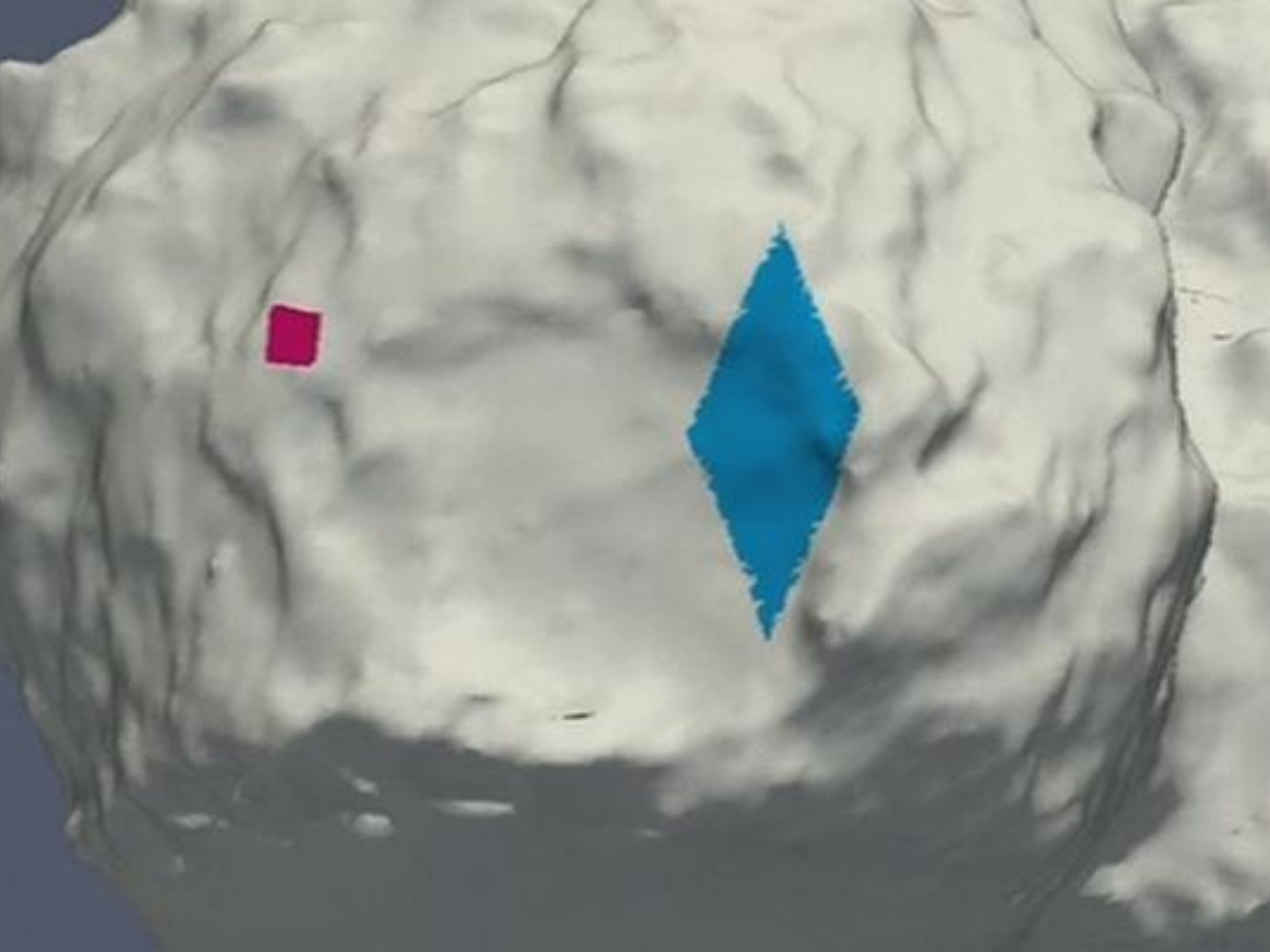

100 m

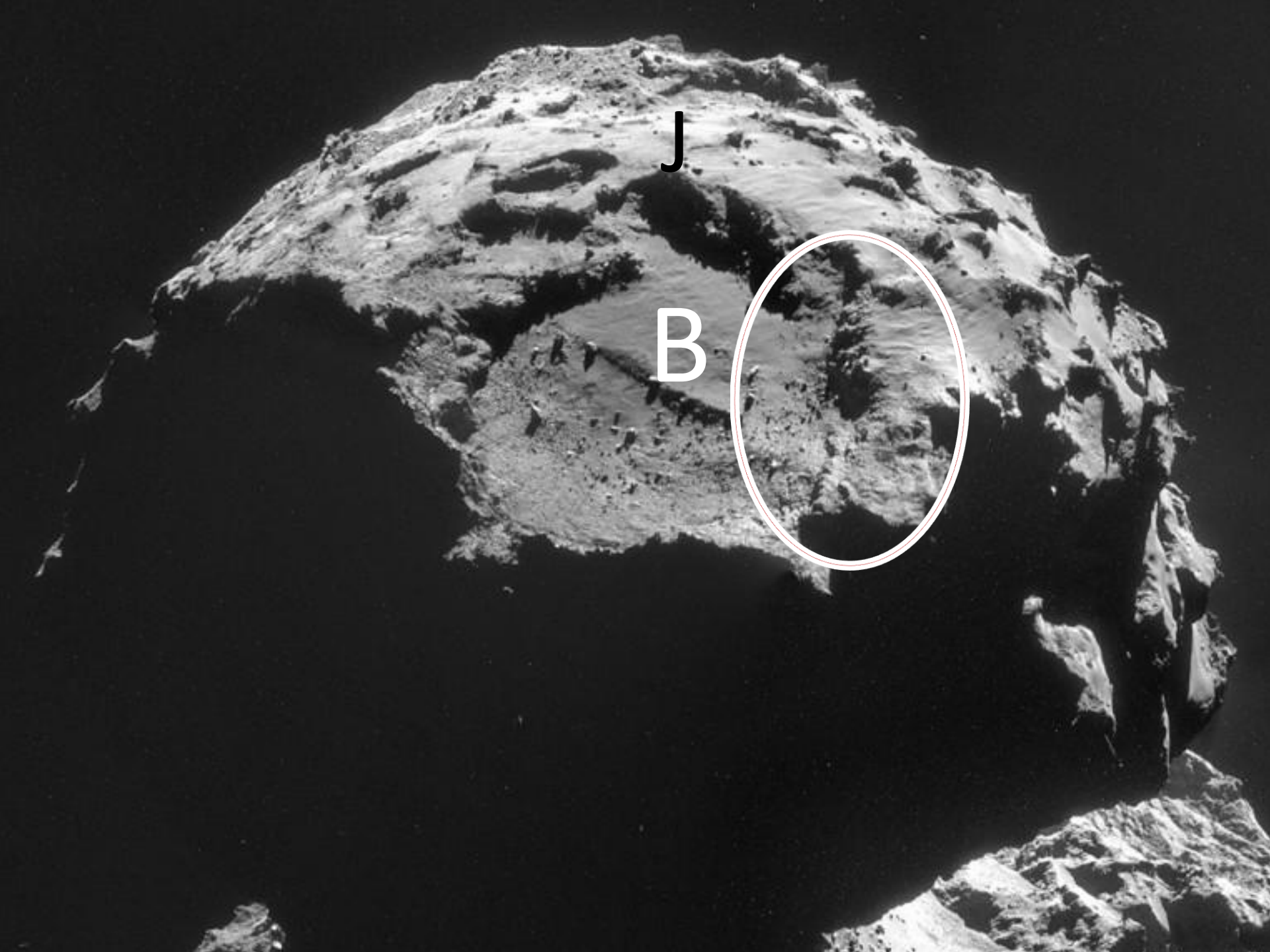


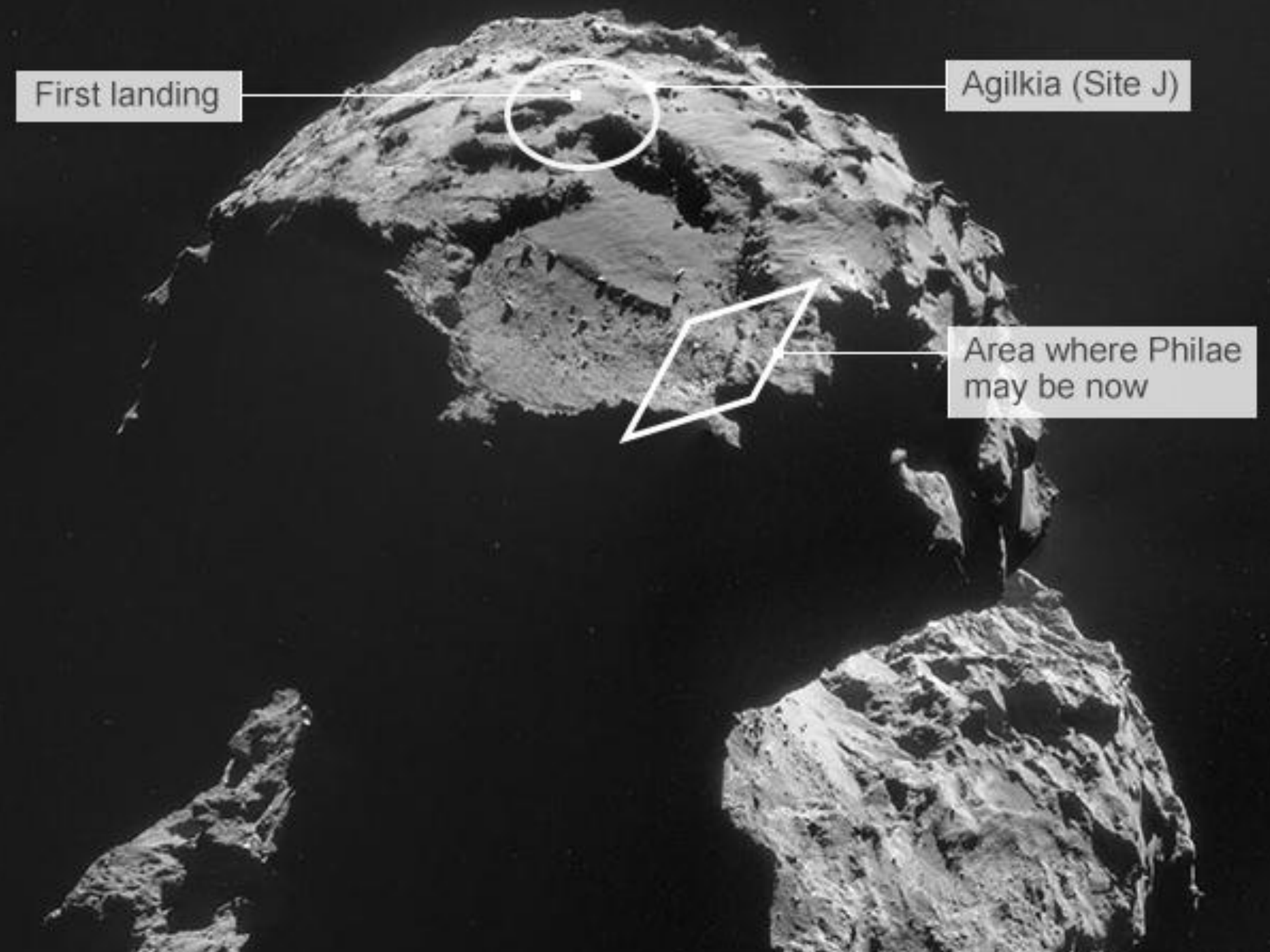

15:30:32




touchdown point
taken at 15:43
before
taken at 15:18
15:43
15:23
15:19
15:14

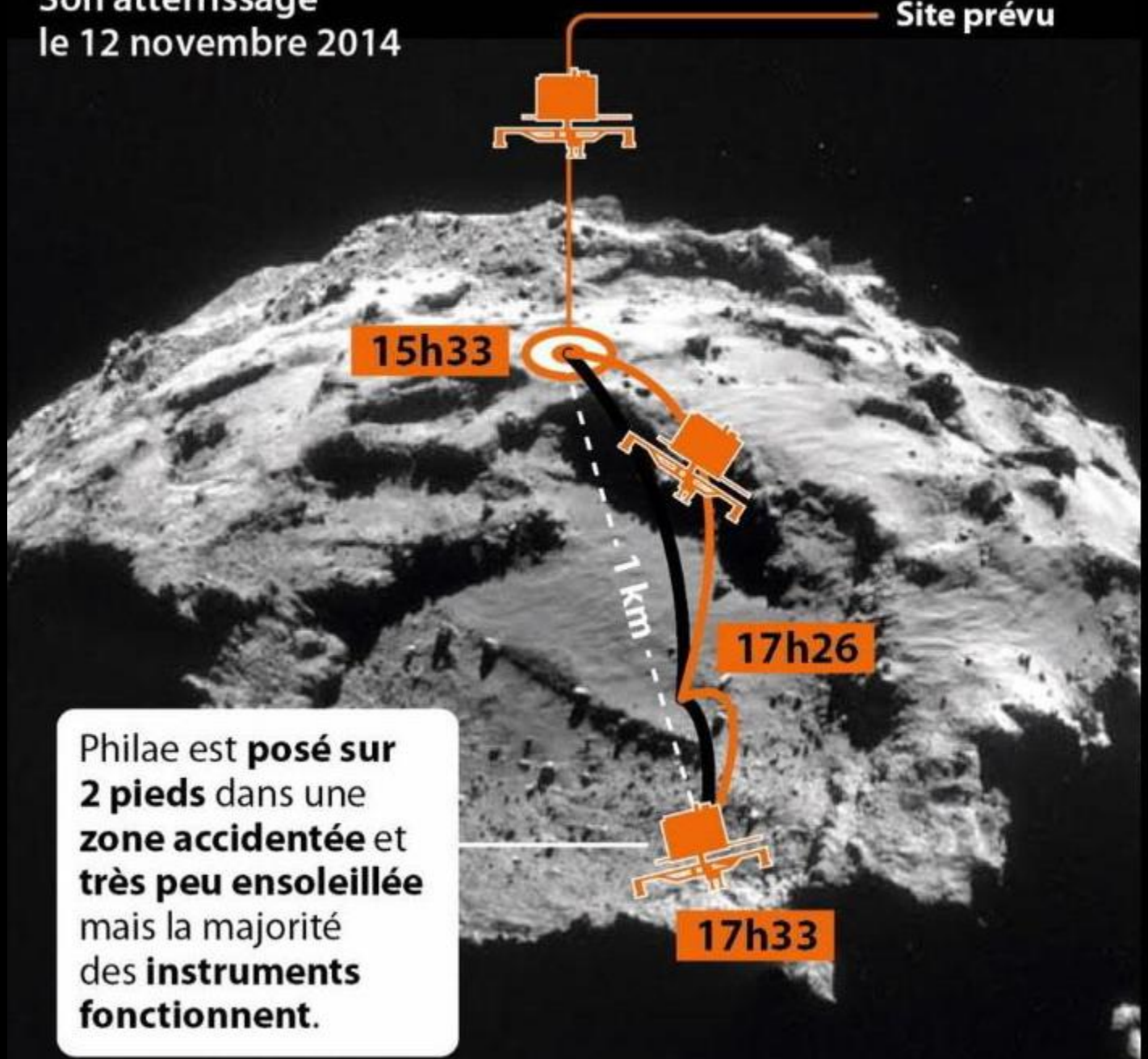



J
B


First landing
Agilkia (Site J)
Area where Philae may be now

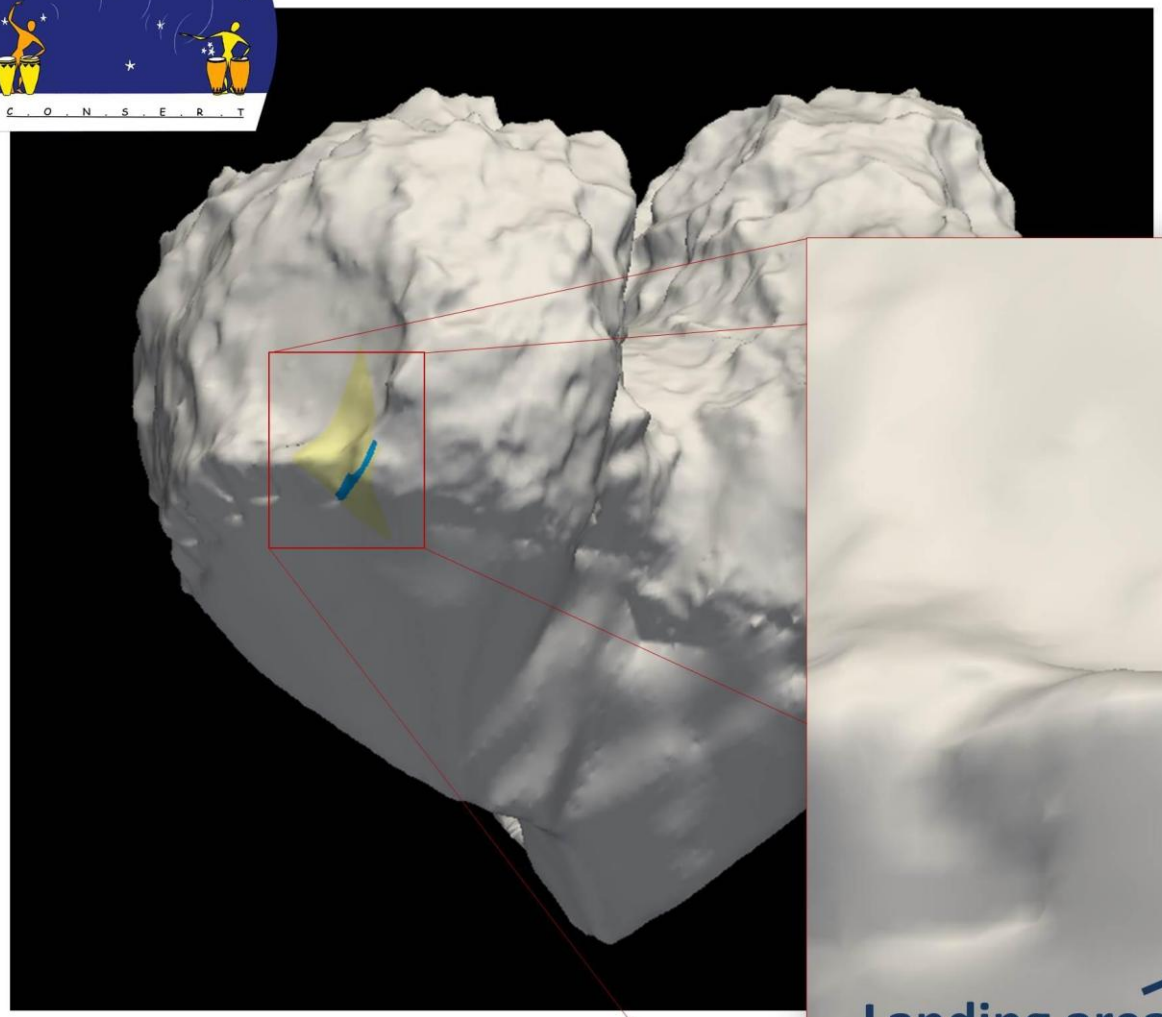
Philae sur la comète « Tchouri »

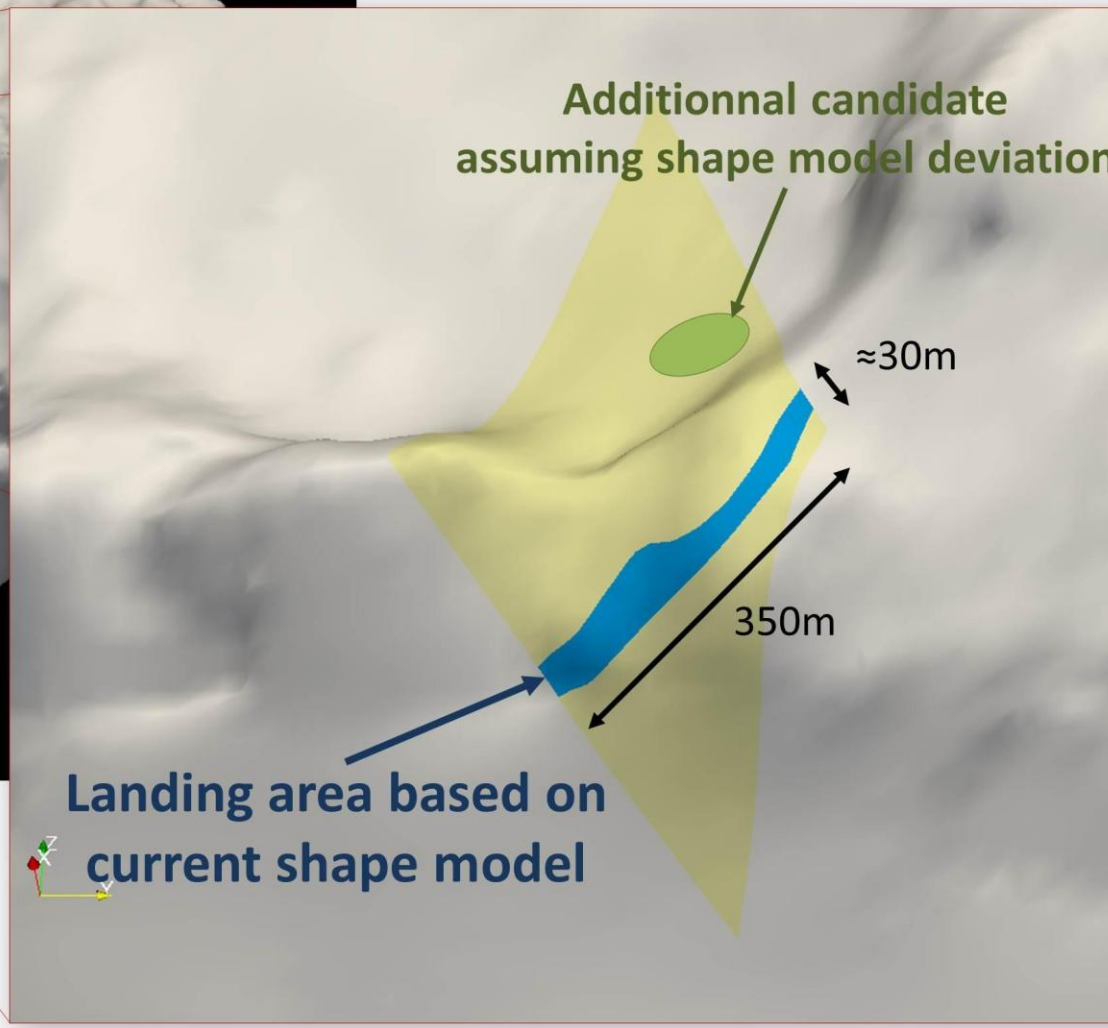
Son atterrissage
le 12 novembre 2014



Philae est **posé sur 2 pieds** dans une **zone accidentée** et **très peu ensoleillée** mais la majorité des **instruments fonctionnent**.

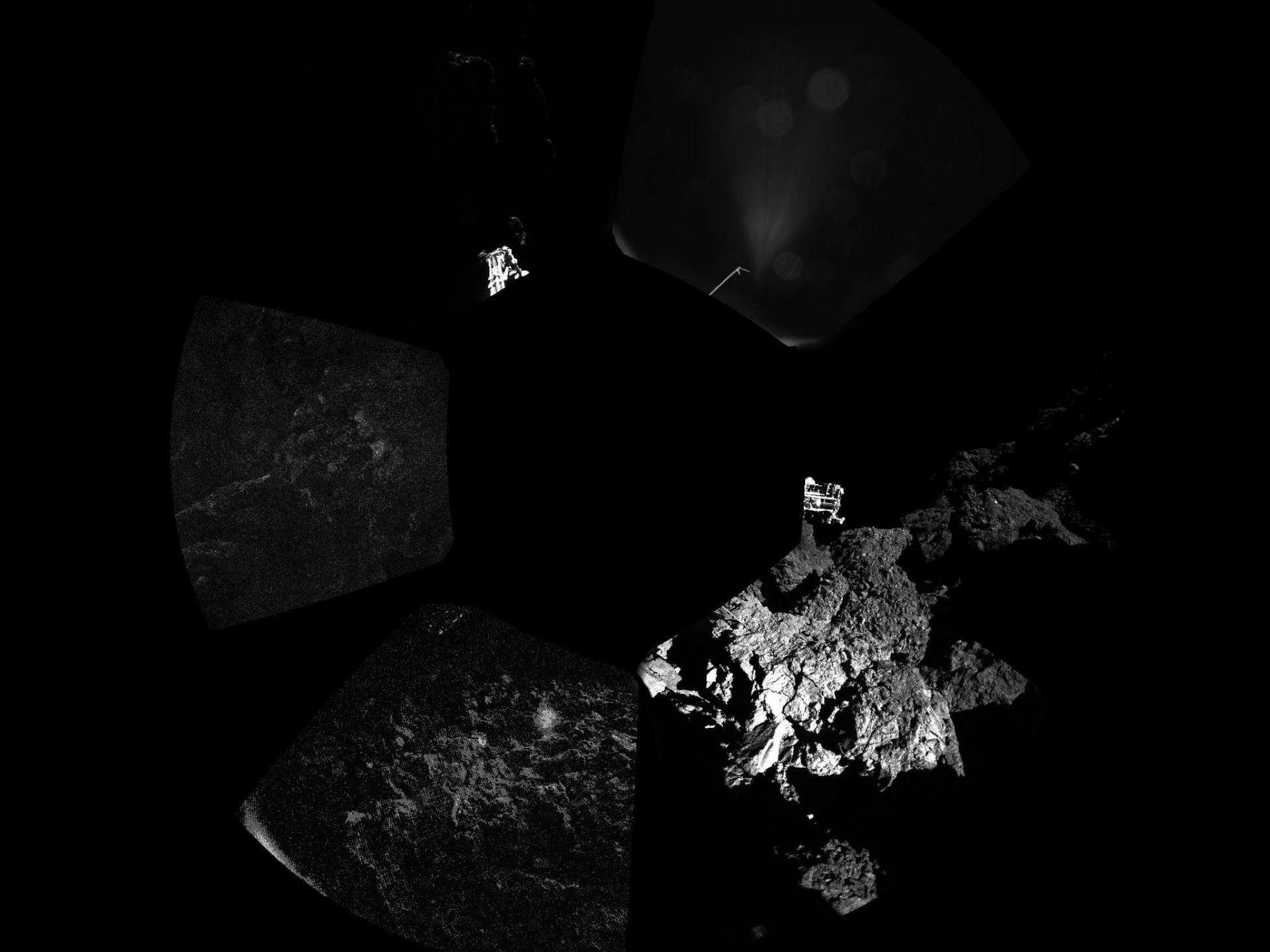
CONSERT estimation of landing area

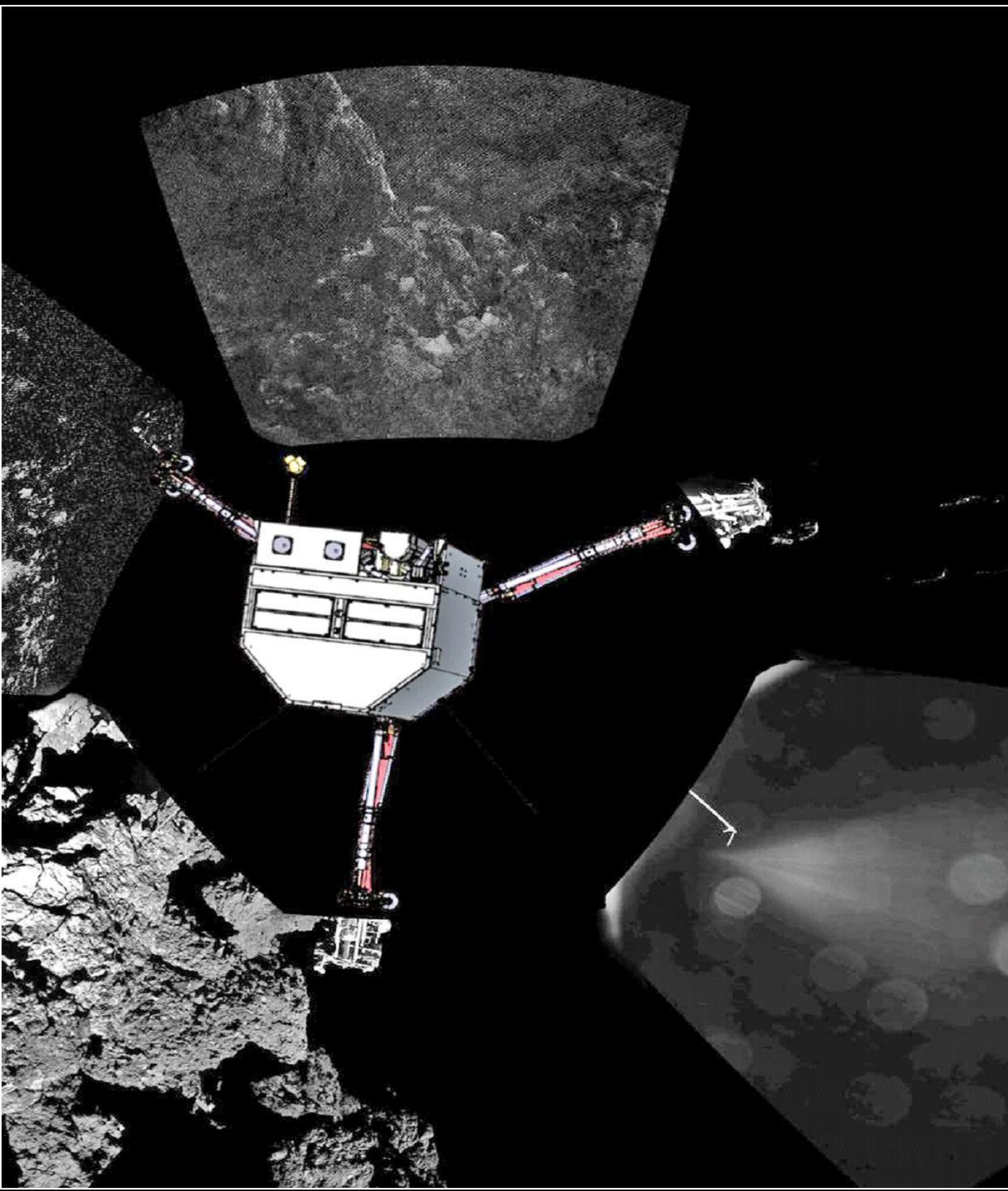




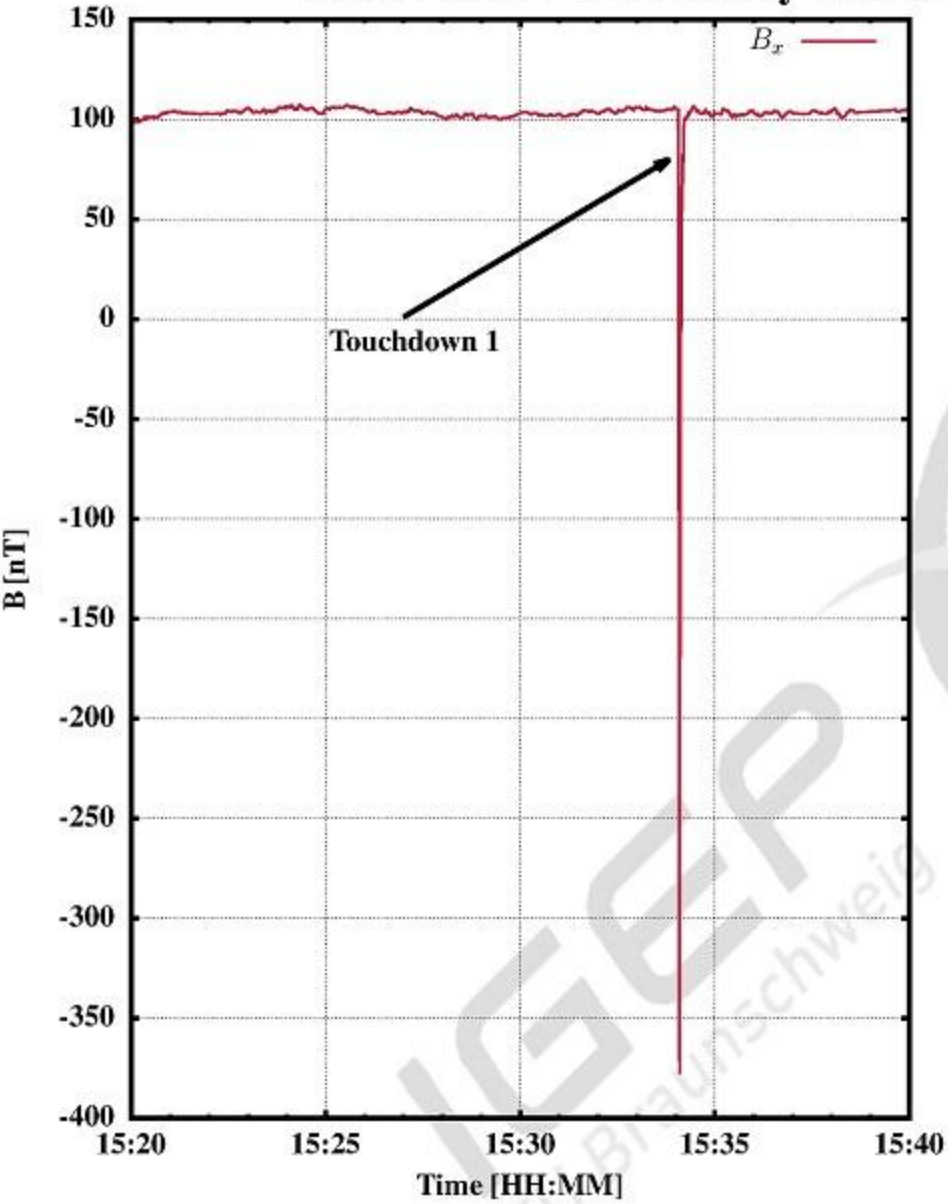
CIVA
1ère image
au sol

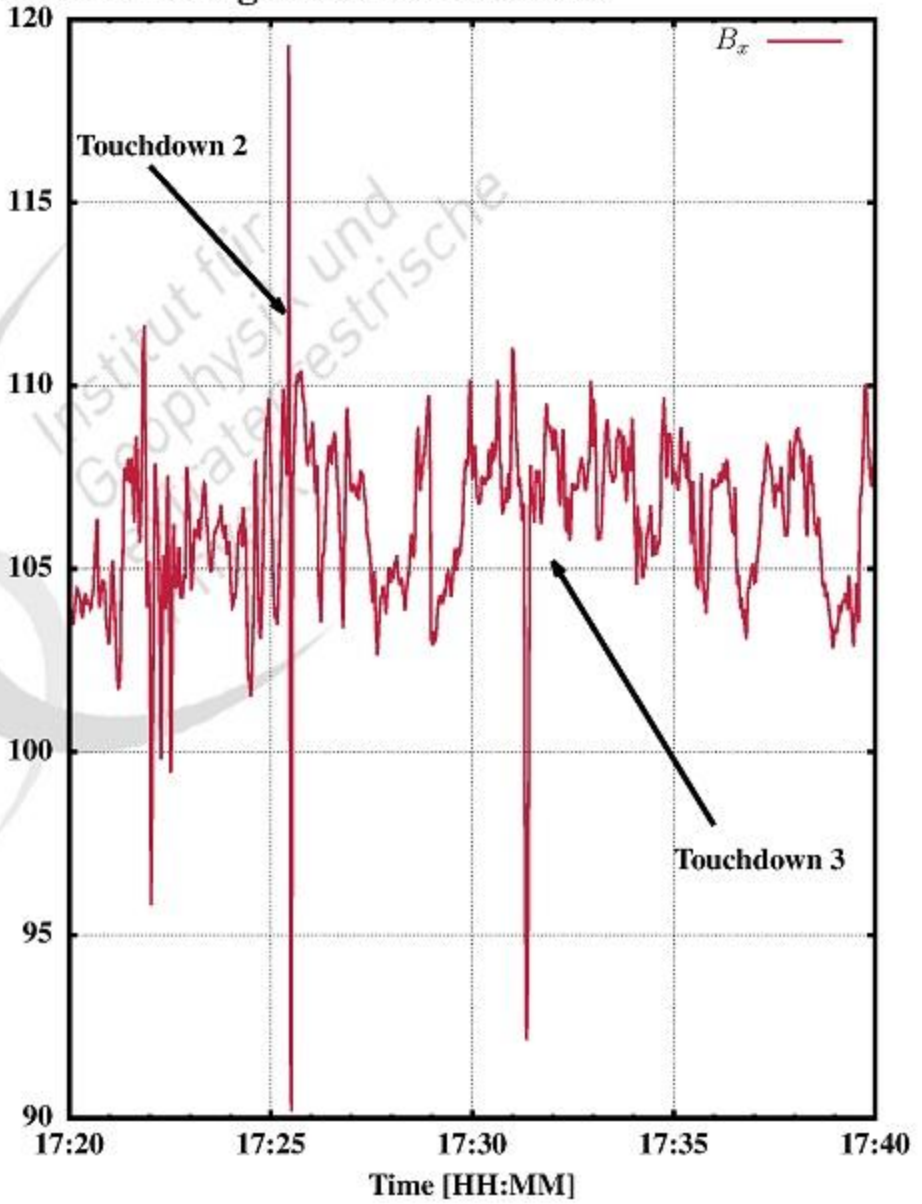
PHILAE serait sur
le flanc !





Measurements obtained by ROSETTA Lander Magnetometer ROMAP

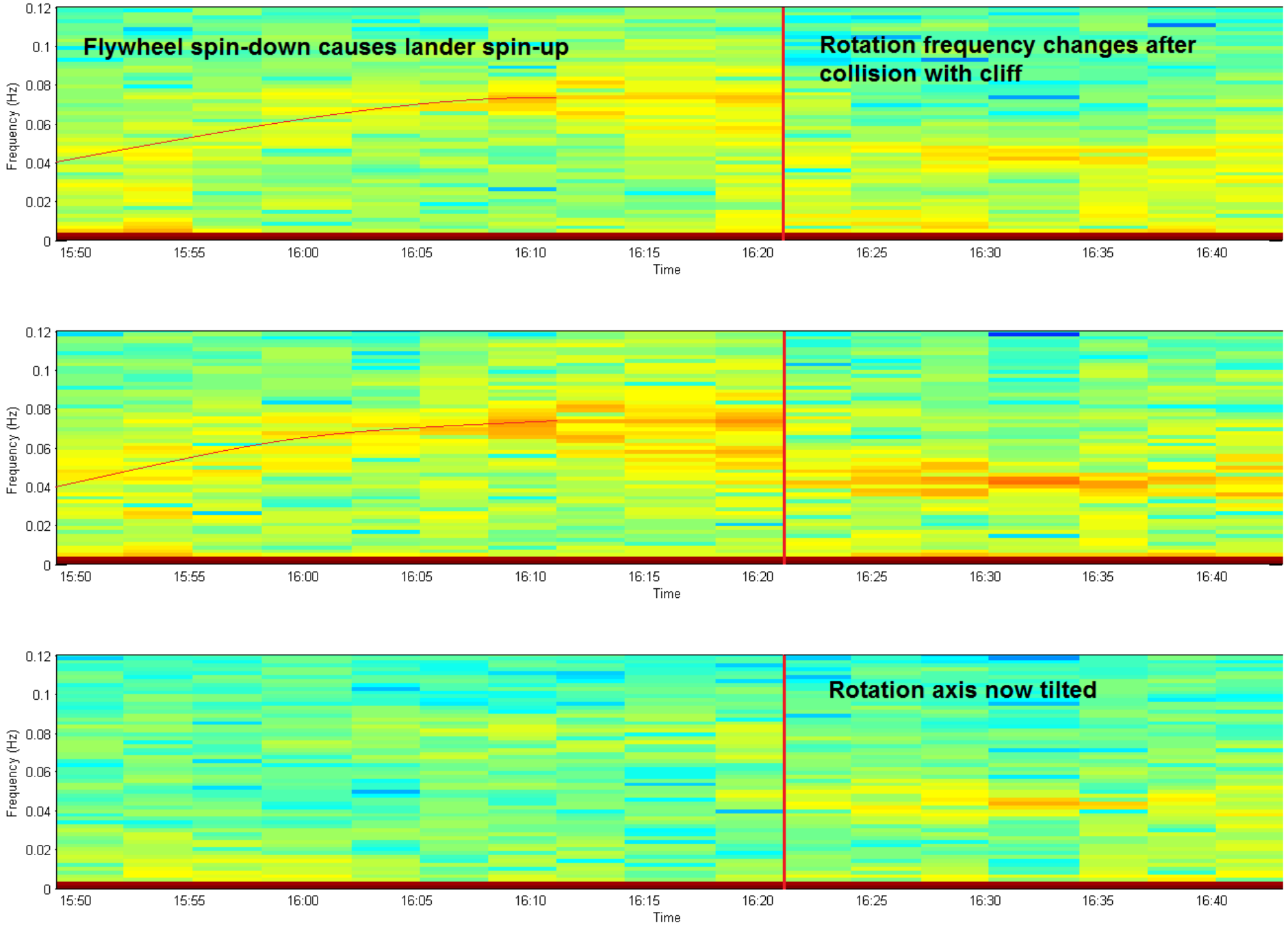


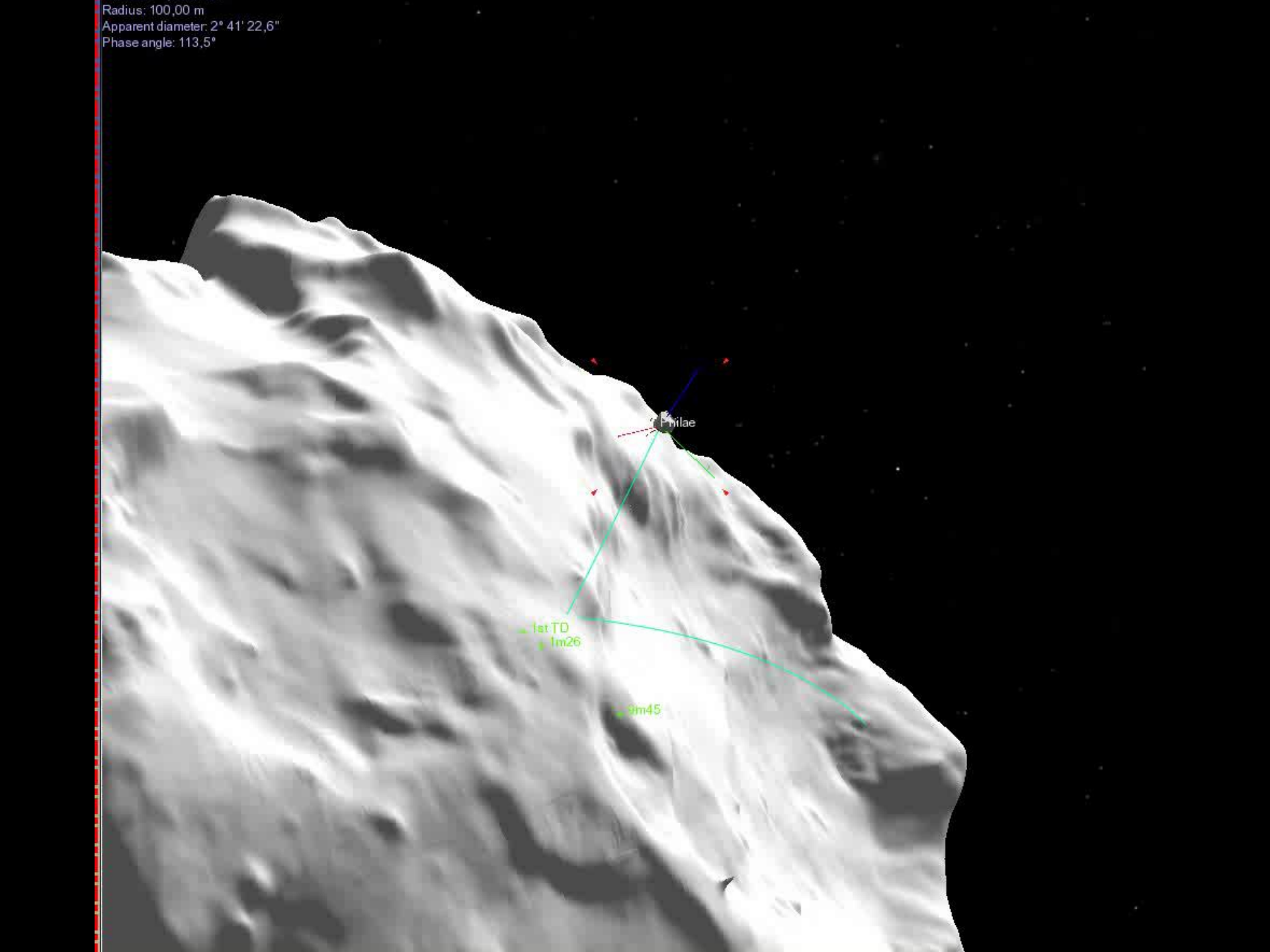


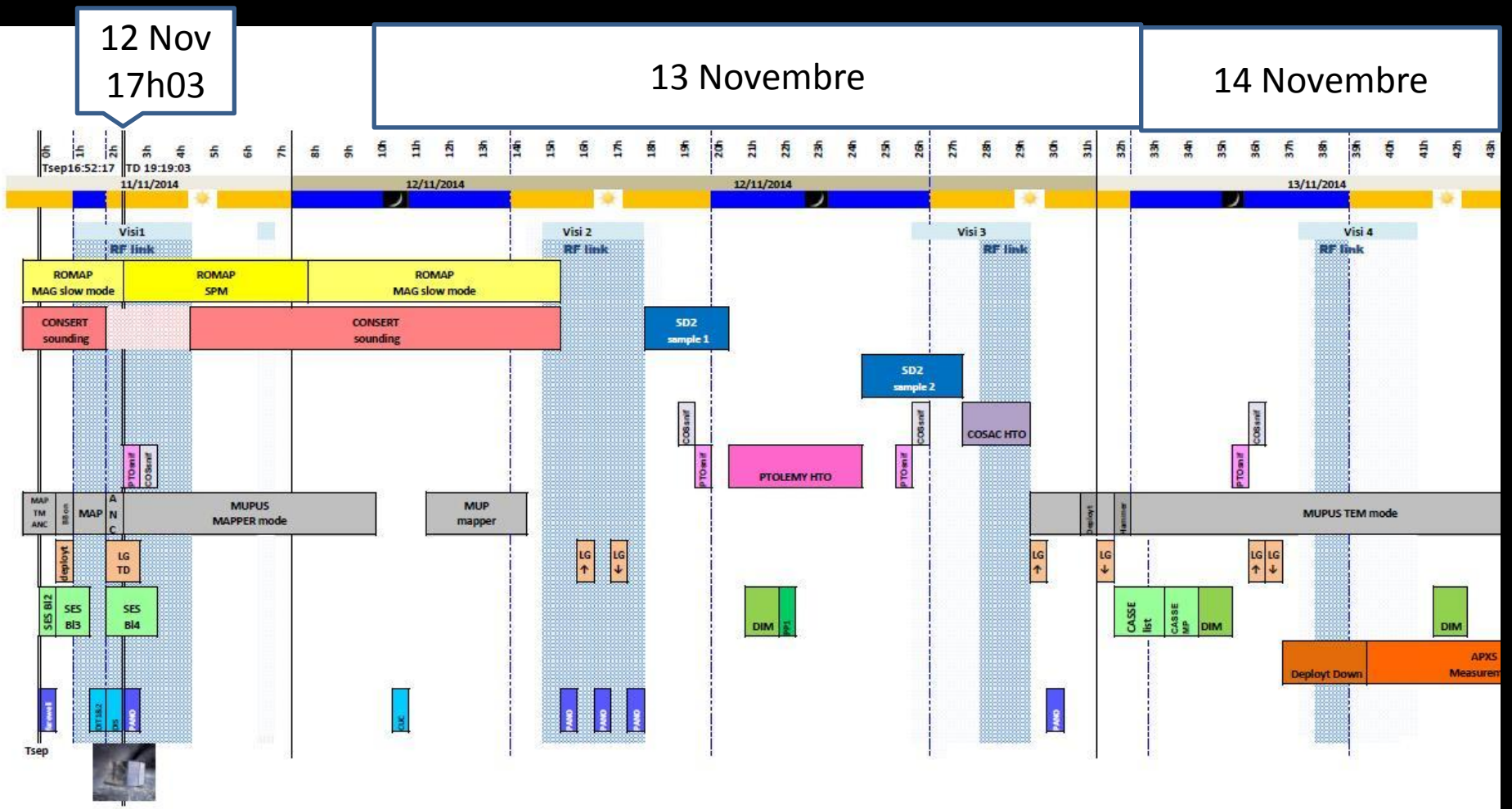
Rosetta/ROMAP/IGeP_TU Braunschweig/Hungarian Academy of Sciences for Energy Research/Space Research Institute Graz

Technische Universität Braunschweig

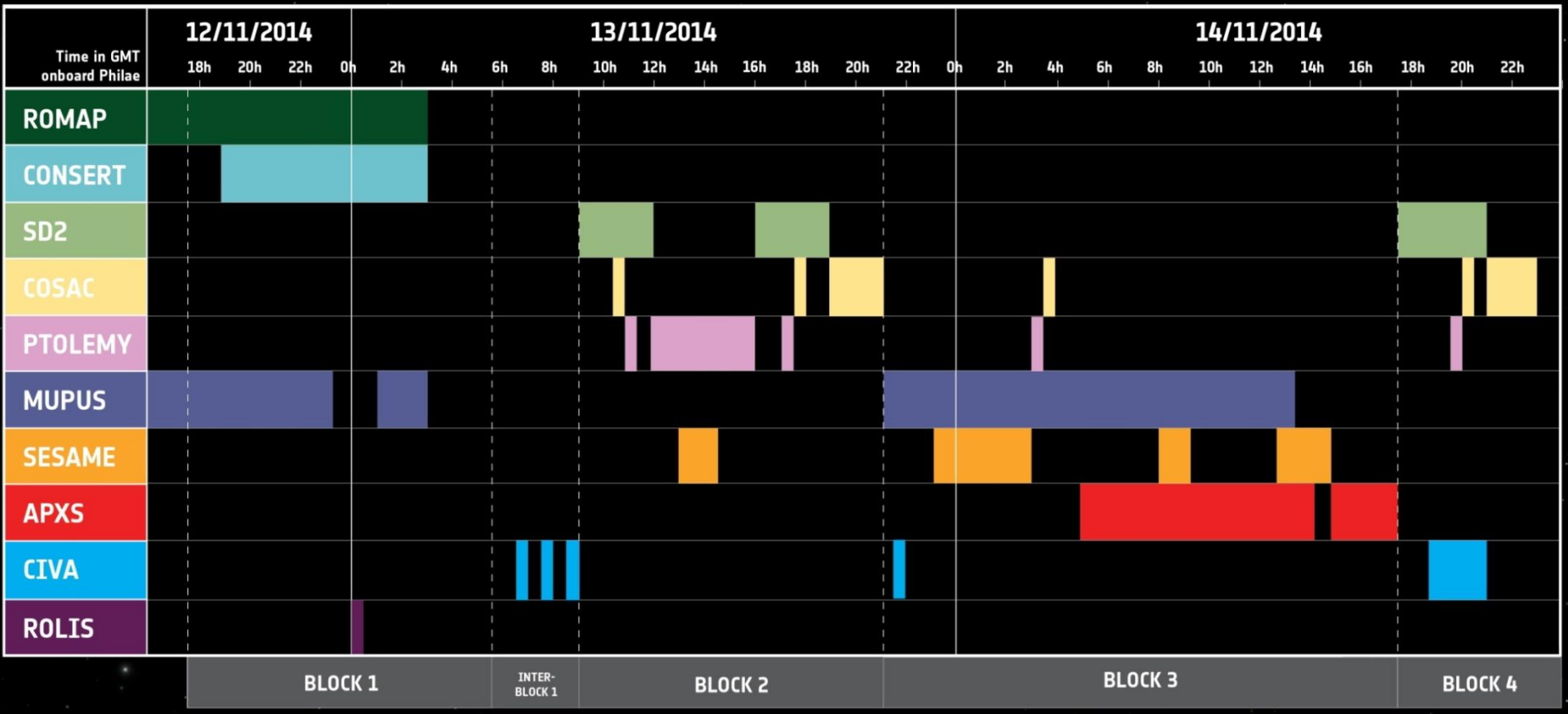
IGEP TU Braunschweig

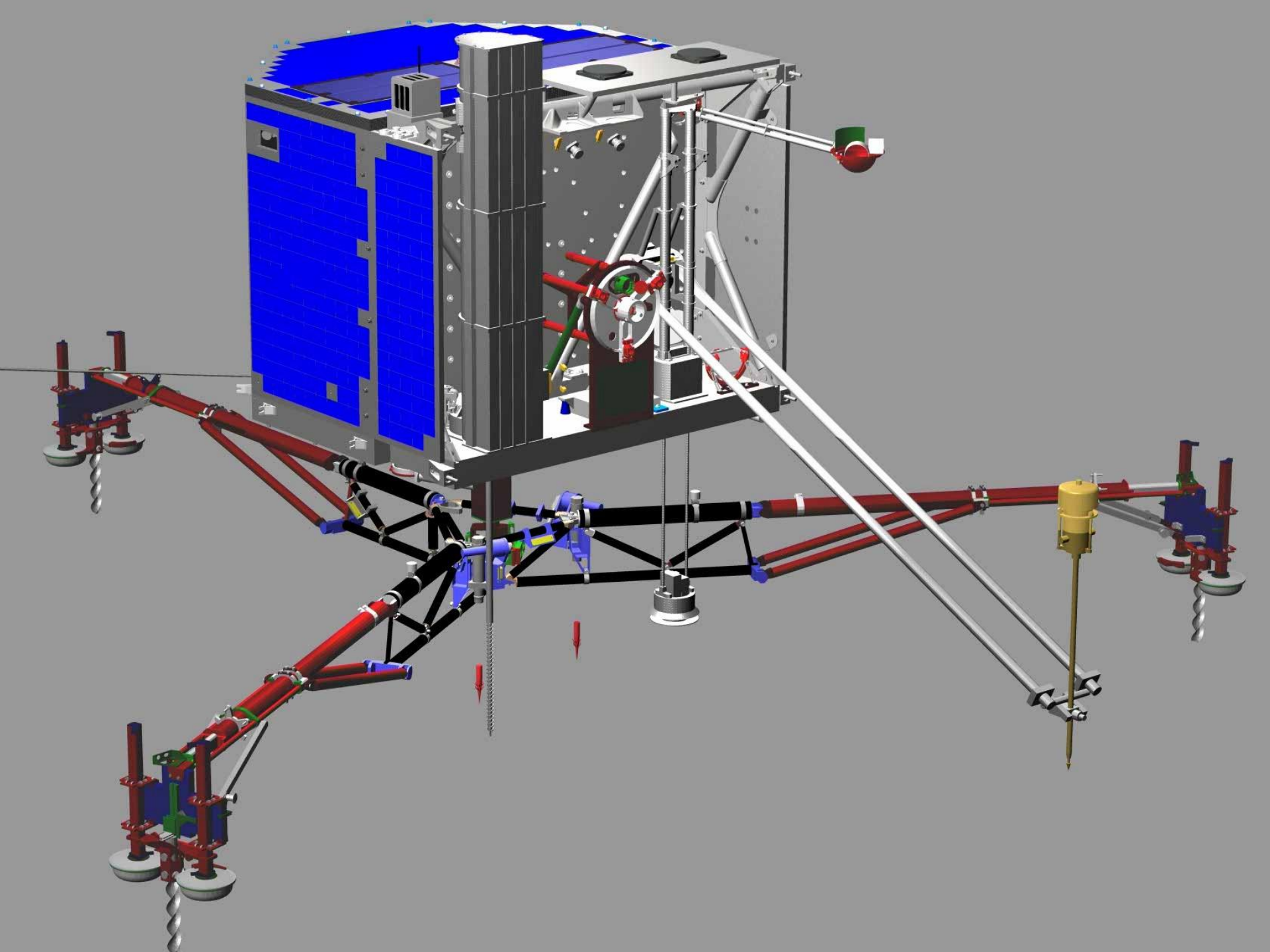

Flywheel spin-down causes lander spin-up
Rotation frequency changes after collision with cliff
Rotation axis now tilted
Frequency (Hz)
0.12
0.1
0.08
0.06
0.04
0.02
0
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time

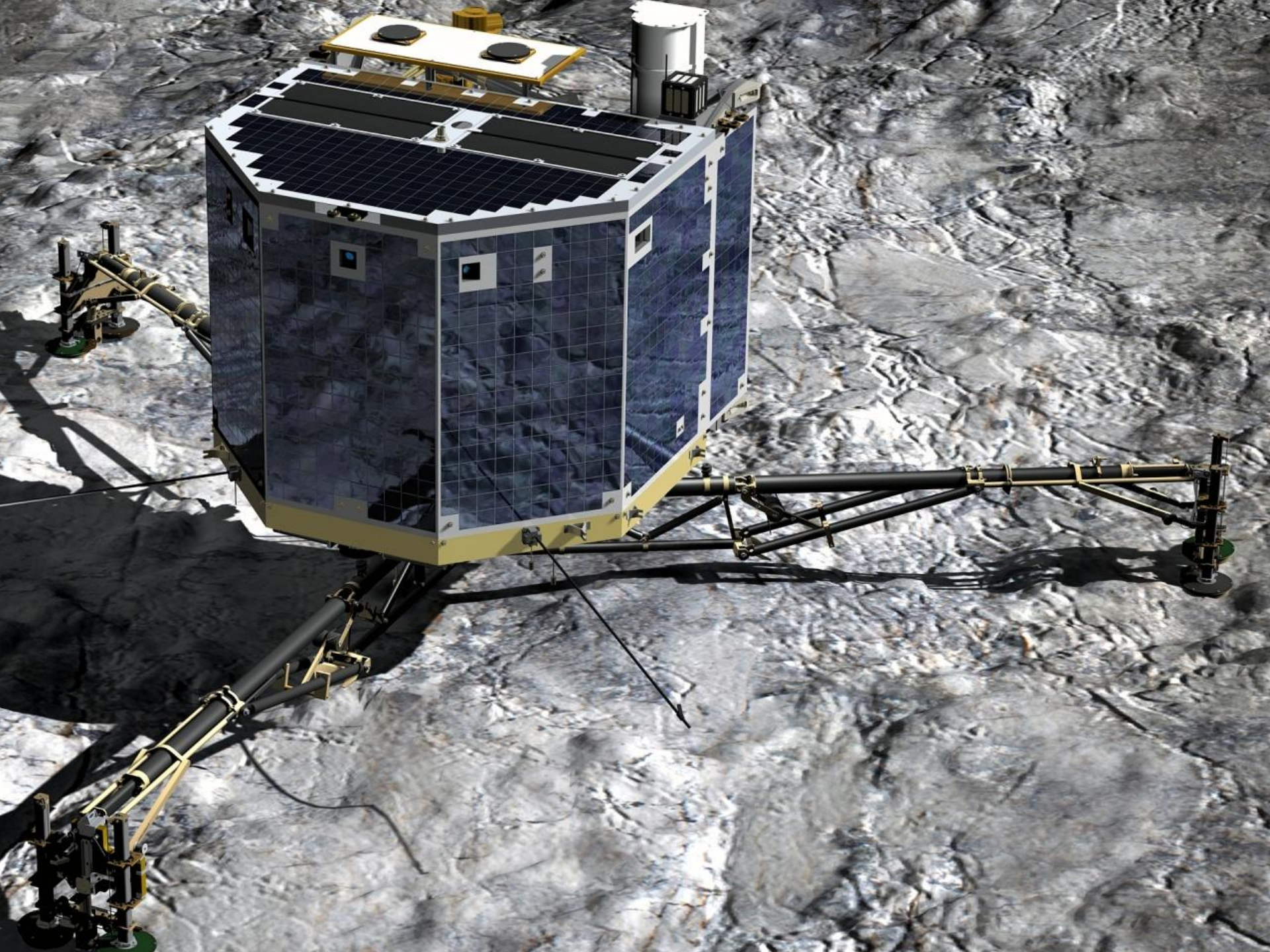

Radius: 100,00 m
Apparent diameter: 2° 41' 22,6"
Phase angle: 113,5°
Philae
1st TD
1m26
9m45

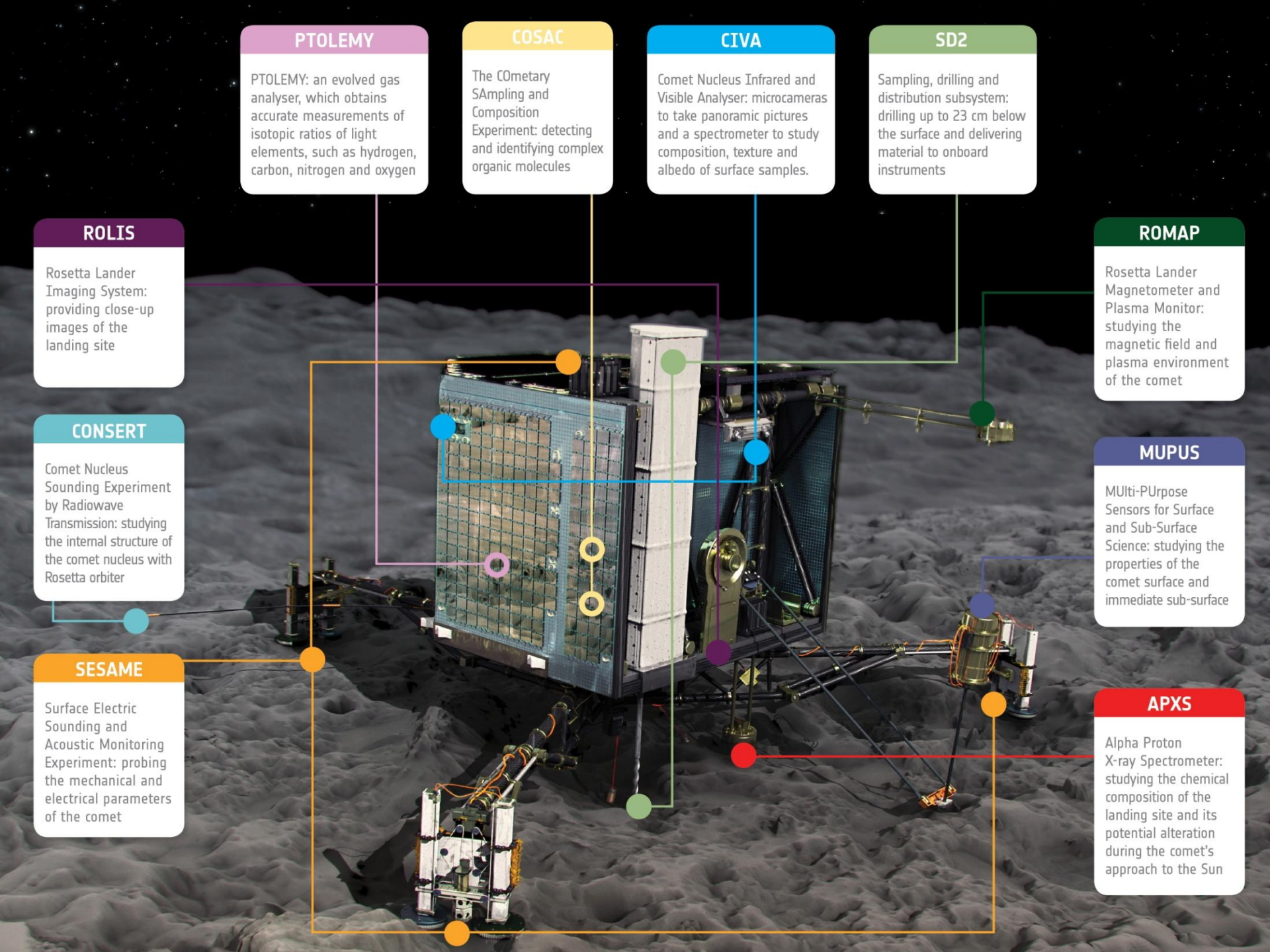

12 Nov
17h03
13 Novembre
14 Novembre
Tsep16:52:17
TD 19:19:03
11/11/2014
12/11/2014
12/11/2014
13/11/2014
Visi1
Visi 2
Visi 3
Visi 4
RF link
ROMAP
MAG slow mode
ROMAP
SPM
ROMAP
MAG slow mode
CONSERT
sounding
CONSERT
sounding
SD2
sample 1
SD2
sample 2
COSAC HTO
PTOLEMY HTO
MAP
MUPUS
MAPPER mode
MUP
mapper
MUPUS TEM mode
LG
TD
SES
Bl3
SES
Bl4
DIM
CASSE
list
DIM
DIM
Deploy Down
APXS
Measuren
Tsep

→ PHILAE'S FIRST SCIENCE SEQUENCE

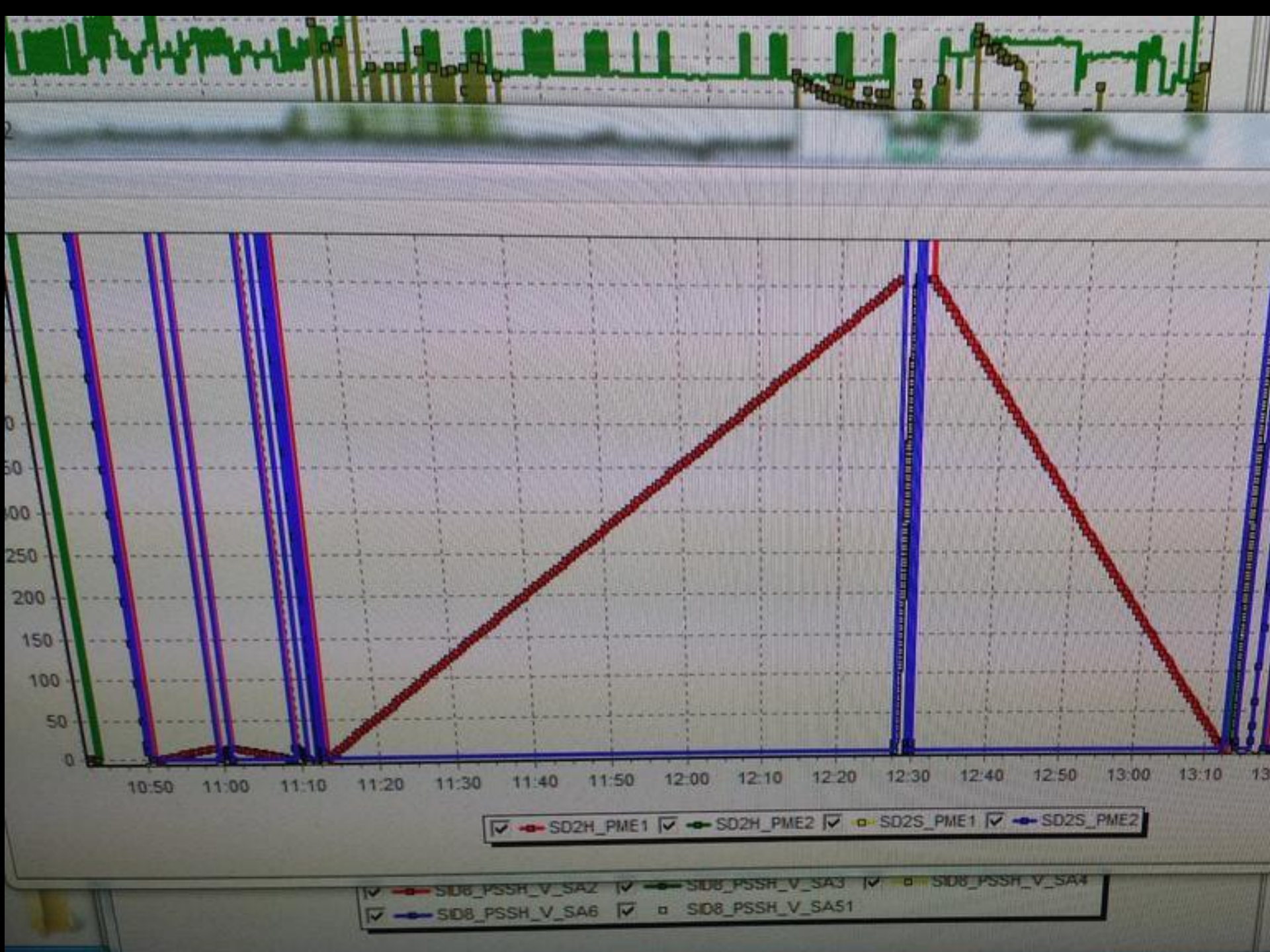


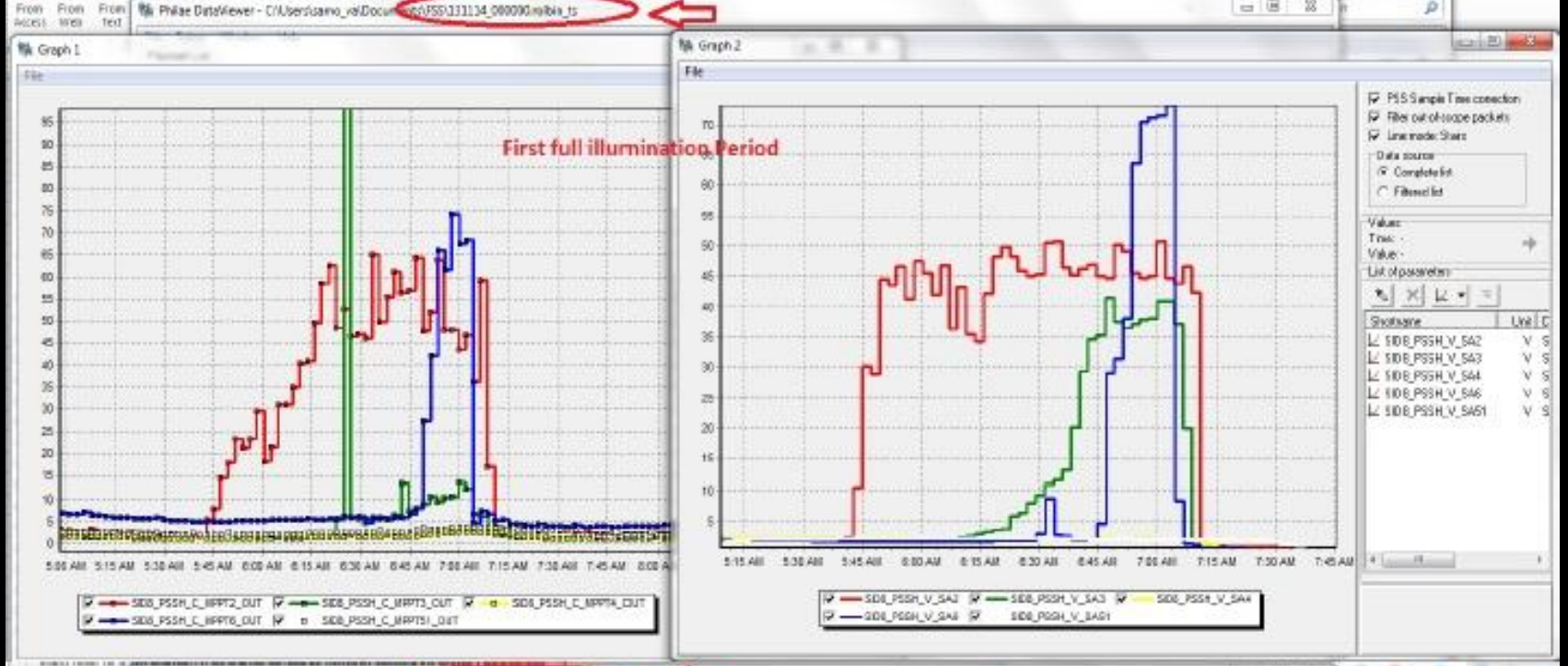


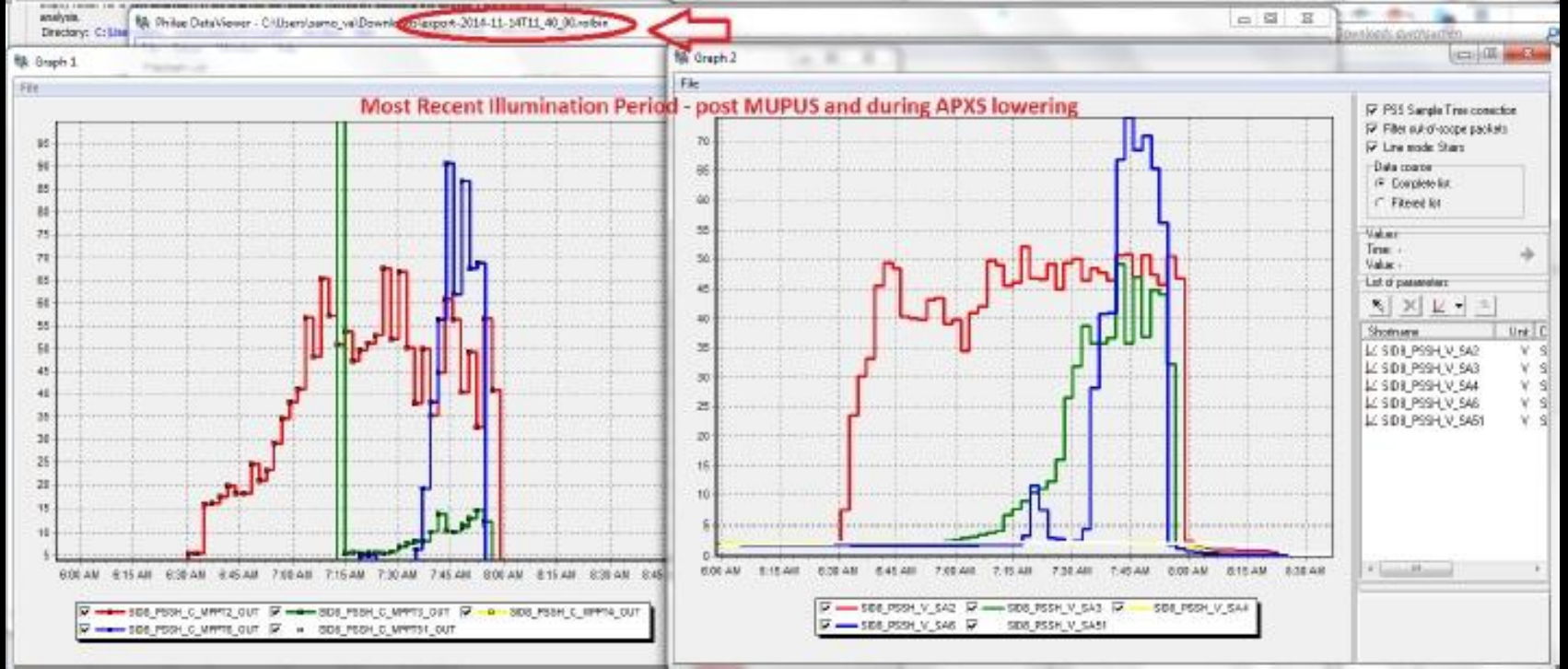


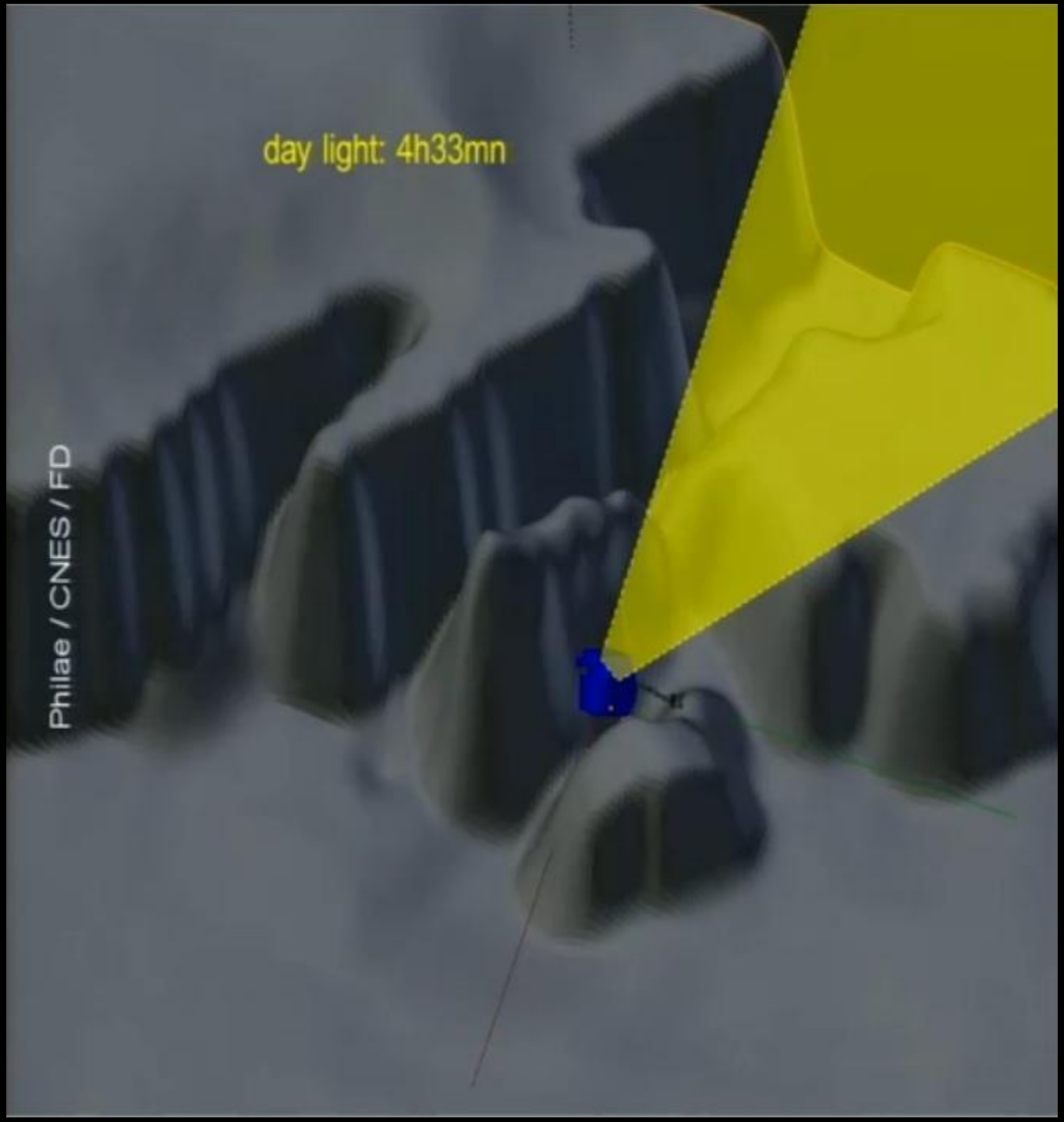

PTOLEMY
PTOLEMY: an evolved gas analyser, which obtains accurate measurements of isotopic ratios of light elements, such as hydrogen, carbon, nitrogen and oxygen
COSAC
The COmetary SAmpling and Composition Experiment: detecting and identifying complex organic molecules
CIVA
Comet Nucleus Infrared and Visible Analyser: microcameras to take panoramic pictures and a spectrometer to study composition, texture and albedo of surface samples.
SD2
Sampling, drilling and distribution subsystem: drilling up to 23 cm below the surface and delivering material to onboard instruments
ROLIS
Rosetta Lander Imaging System: providing close-up images of the landing site
ROMAP
Rosetta Lander Magnetometer and Plasma Monitor: studying the magnetic field and plasma environment of the comet
CONSERT
Comet Nucleus Sounding Experiment by Radiowave Transmission: studying the internal structure of the comet nucleus with Rosetta orbiter
MUPUS
MUlti-PUrpose Sensors for Surface and Sub-Surface Science: studying the properties of the comet surface and immediate sub-surface
SESAME
Surface Electric Sounding and Acoustic Monitoring Experiment: probing the mechanical and electrical parameters of the comet
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


Primary Bus Voltage
DOIT AVOIR ETE TESTEE SUR LA SCI


250
200
150
100
50
0
10:50
11:00
11:10
11:20
11:30
11:40
11:50
12:00
12:10
12:20
12:30
12:40
12:50
13:00
13:10
SD2H_PME1
SD2H_PME2
SD2S_PME1
SD2S_PME2
SID8_PSSH_V_SA6
SID8_PSSH_V_SA51


First full illumination Period


Most Recent Illumination Period - post MUPUS and during APXS lowering


day light: 4h33mn
Philae / CNES / FD

Recherche Google

J'ai de la chance

Rosetta & Philae, héros interplanétaires (AFP)

- La semaine dernière, au plus fort de l'intrigue, quand la sonde a largué son robot pour qu'il aille se poser sur la comète, Rosetta et Philae ont généré environ **600.000 tweets**, selon les statistiques du site Topsy.

- Les deux héros ont d'ailleurs à eux deux plus d'abonnés sur Twitter - respectivement 383.000 et 277.000 – que @Madonna.

- Philae (@Philae2014) a même tweeté en **14 langues** pour confirmer la nouvelle: "Atterrissage ! Voici ma nouvelle adresse: 67P".

- **380 médias** à l'ESOC

- Vidéo du 12 novembre sur Youtub vue **1.146.000** fois

#cometlanding

comets are cooler

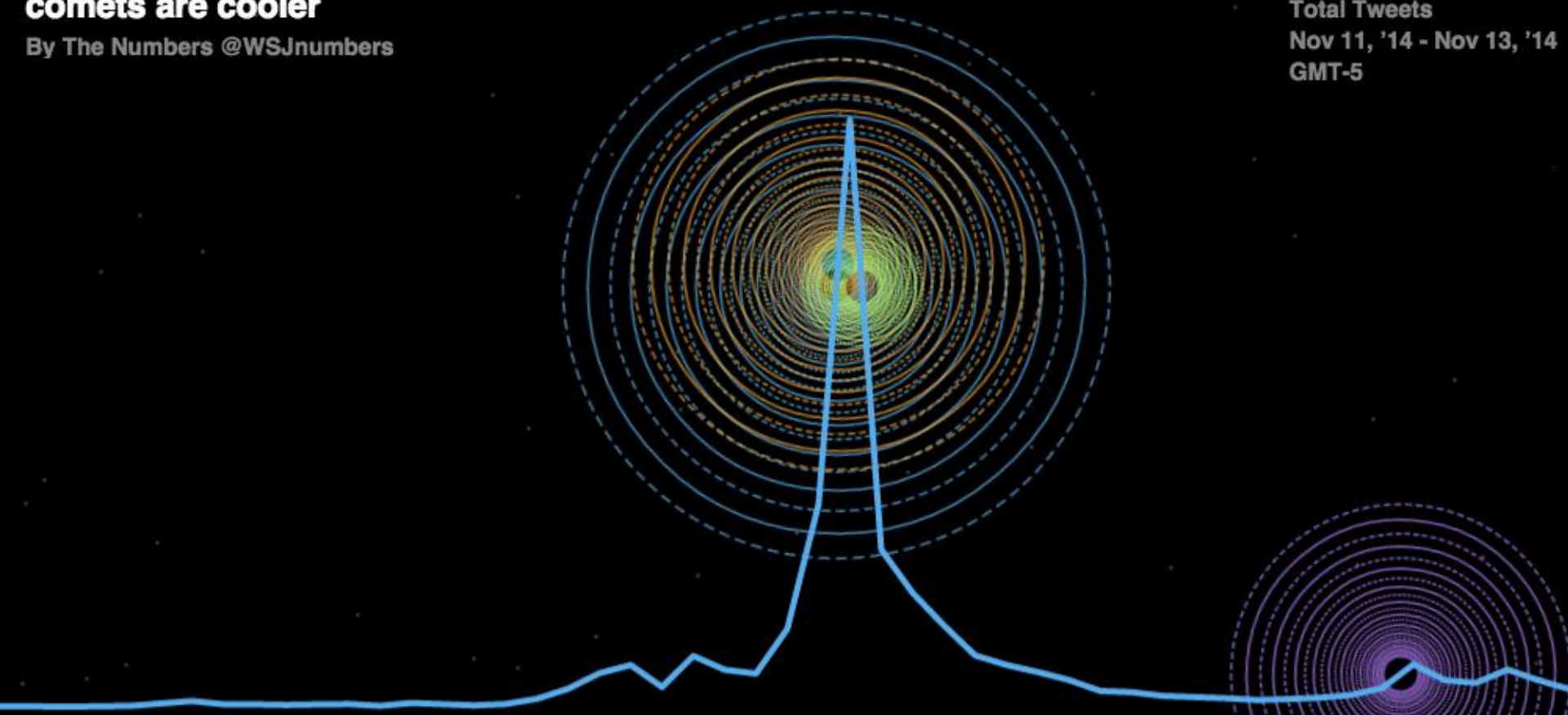
By The Numbers @WSJnumbers

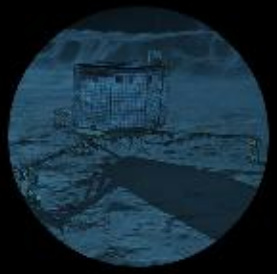
667,574

Total Tweets

Nov 11, '14 - Nov 13, '14

GMT-5





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THE WALL STREET JOURNAL

The Rosetta's Comet

We interrupt regular coverage of human folly for a tale of breathtaking ingenuity. On Wednesday, 317 million miles deep in space, a machine built on this planet landed on a rocky comet a little over two miles in diameter, constantly spinning and moving at 85,000 miles an hour.

The horizon of the great unknown that is the universe receded when the Philae lander touched down on the surface of the 67P/Churyumov-Gerasimenko comet. The landing brought cheers from scientists at the European Space Agency in Darmstadt, Germany, who sent the Rosetta orbiter on this cosmic chase. Launched in 2004, the Rosetta travelled some 500 million miles to track and orbit the comet that passes around the sun in long loops.

There's a little Trekkie in most of us. As millions of viewers were glued to black-and-white television sets in 1969 for the Apollo moon landing, people today take to the Internet to see this history happen. The old human penchant for cynicism is on display as well. #WeCanLandOnACometButWeCant was trending on Twitter on Wednesday.

Philae's planned experiments may provide insight into the origin of life on earth. Comets date to the birth of the universe, and Philae will tell us about its composition of rocks and ice. Some scientists think comets brought water to earth.

Rosetta marks the second success this year for the European Space Agency, which in March confirmed a standard theory in modern cosmology known as inflation. Europe isn't renowned for its innovative spirits these days, but these engineers and scientists are the residual intellectual capital from the Continent's glory years. Congratulations to them—and to the human race.

Who says the spirit of innovation is dead in Europe?