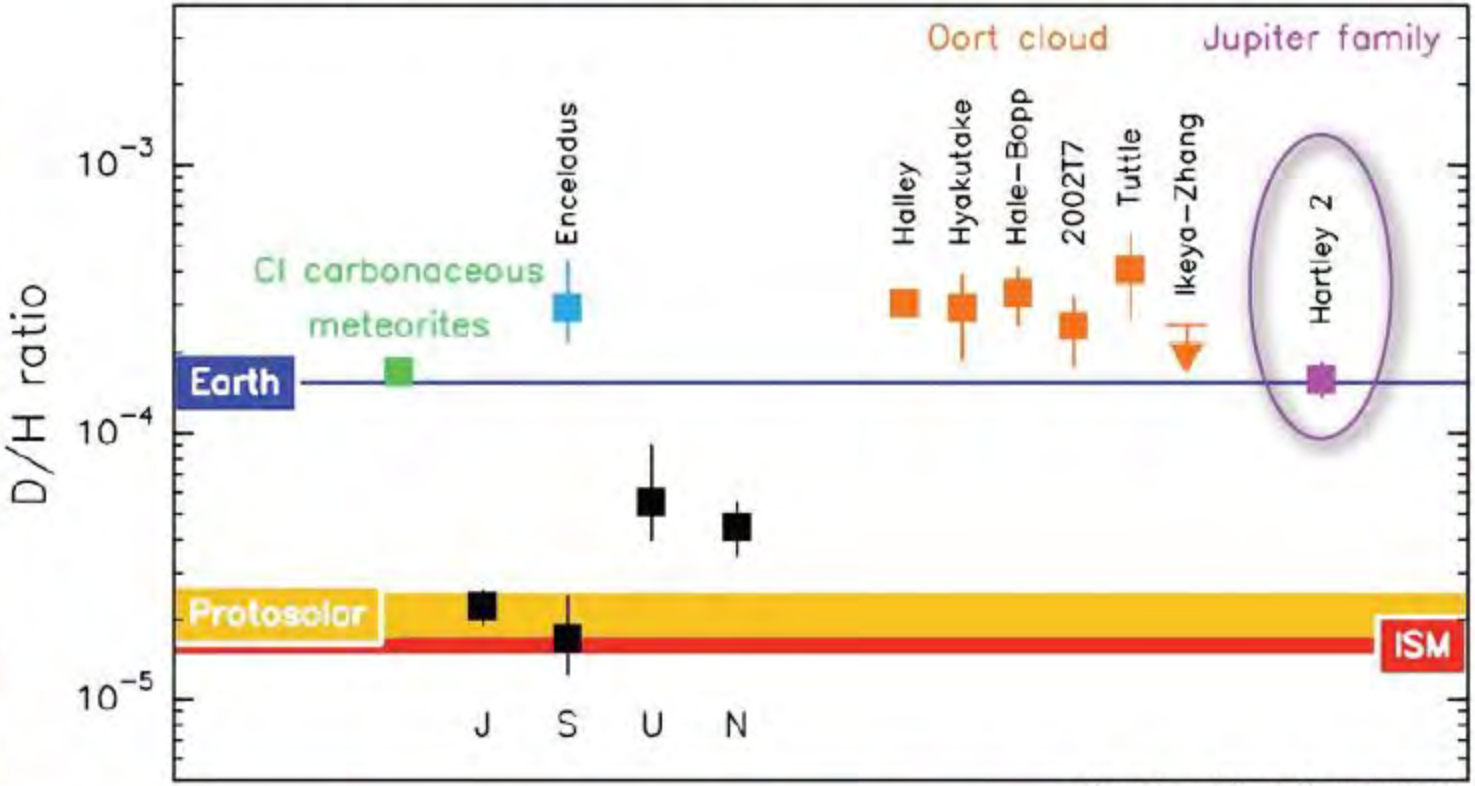
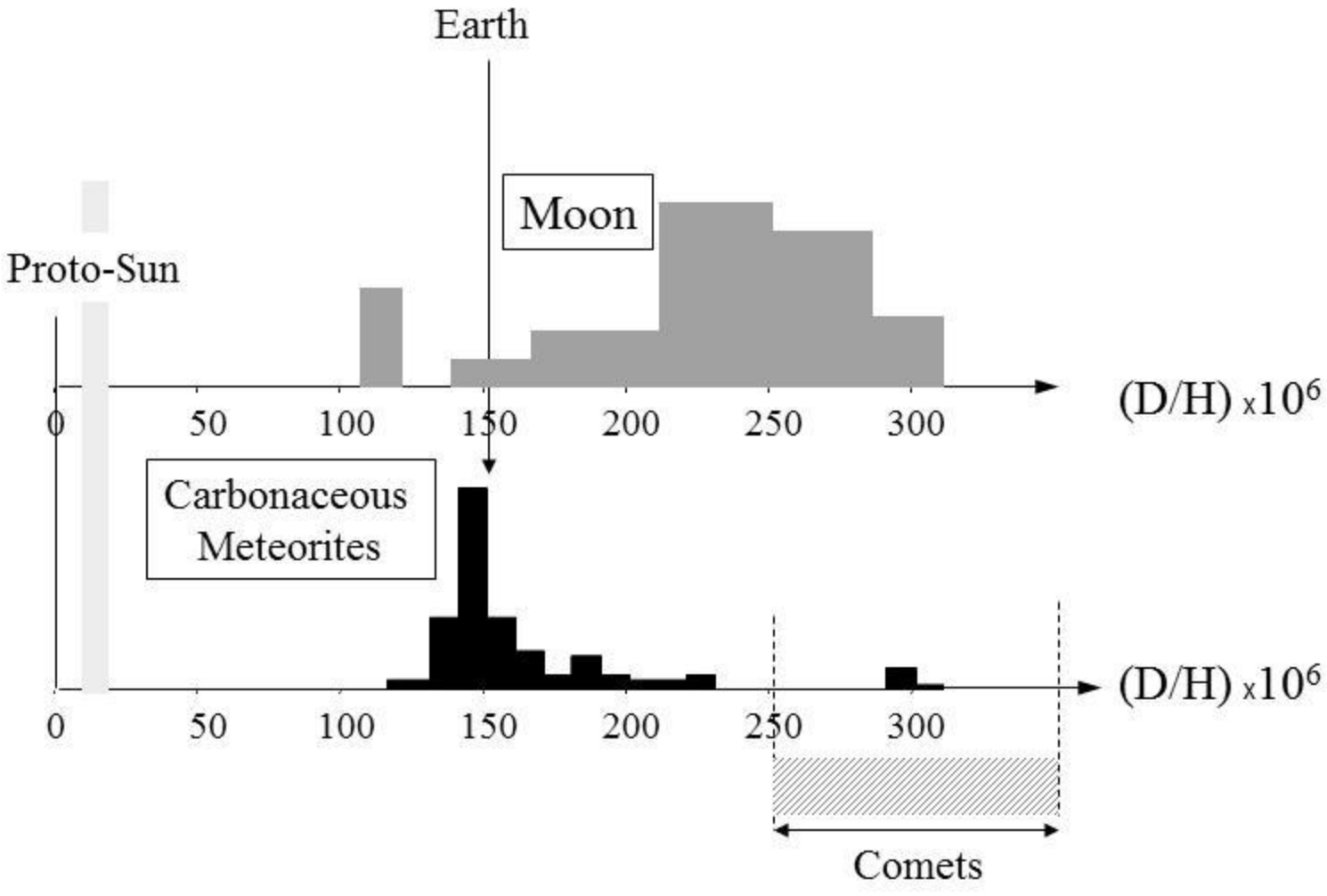

Queue de plasma
Queue de poussières
Noyau (masqué par la poussi

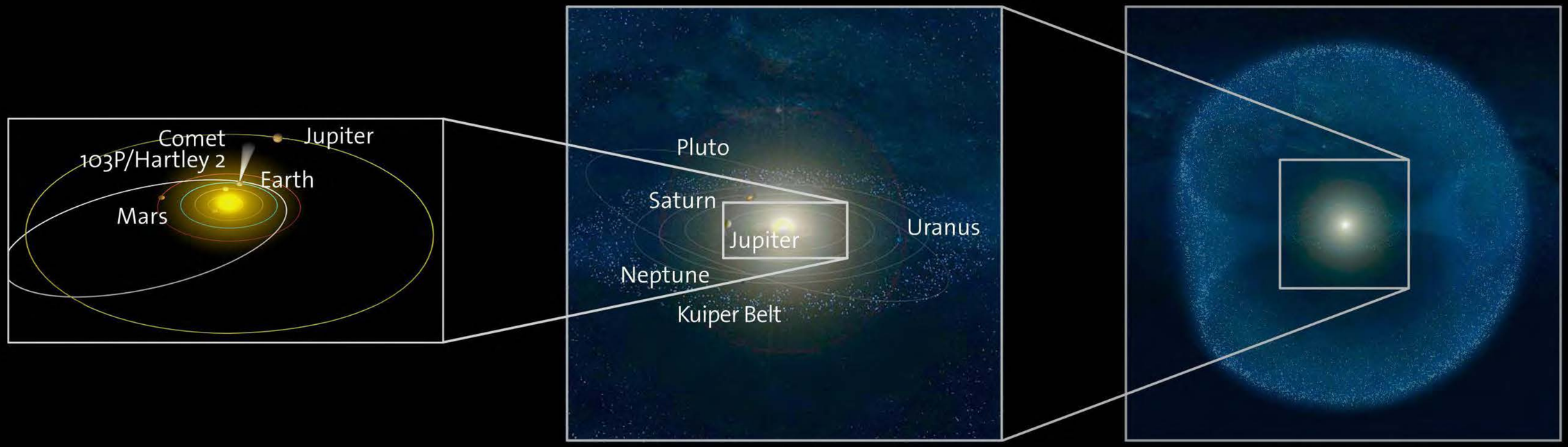
Comets as the origin of Earth's water?



Hartogh et al. (2011, Nature, 478, 4638)

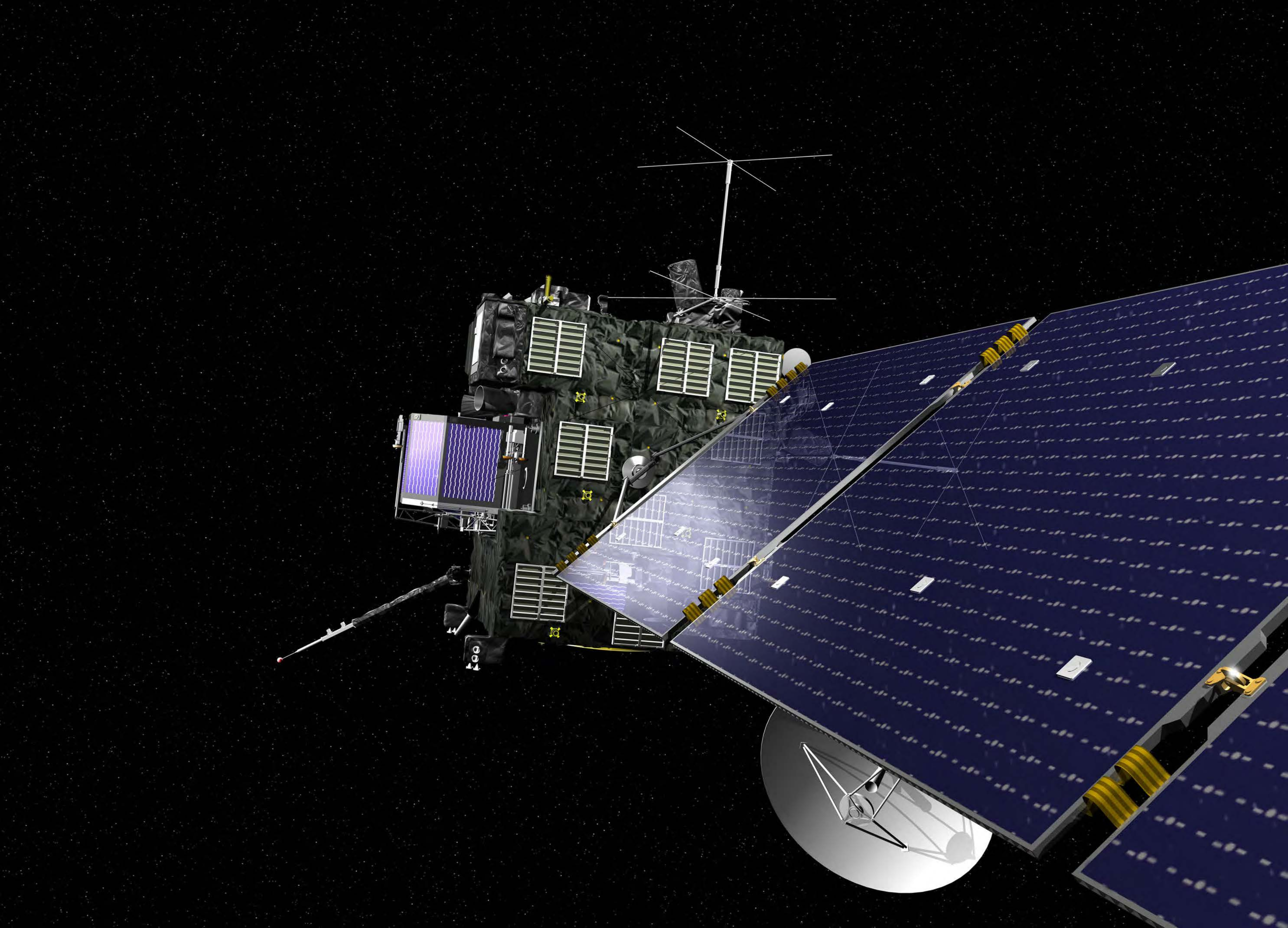
ESA Herschel far-infrared astrophysics observatory, launched 2009

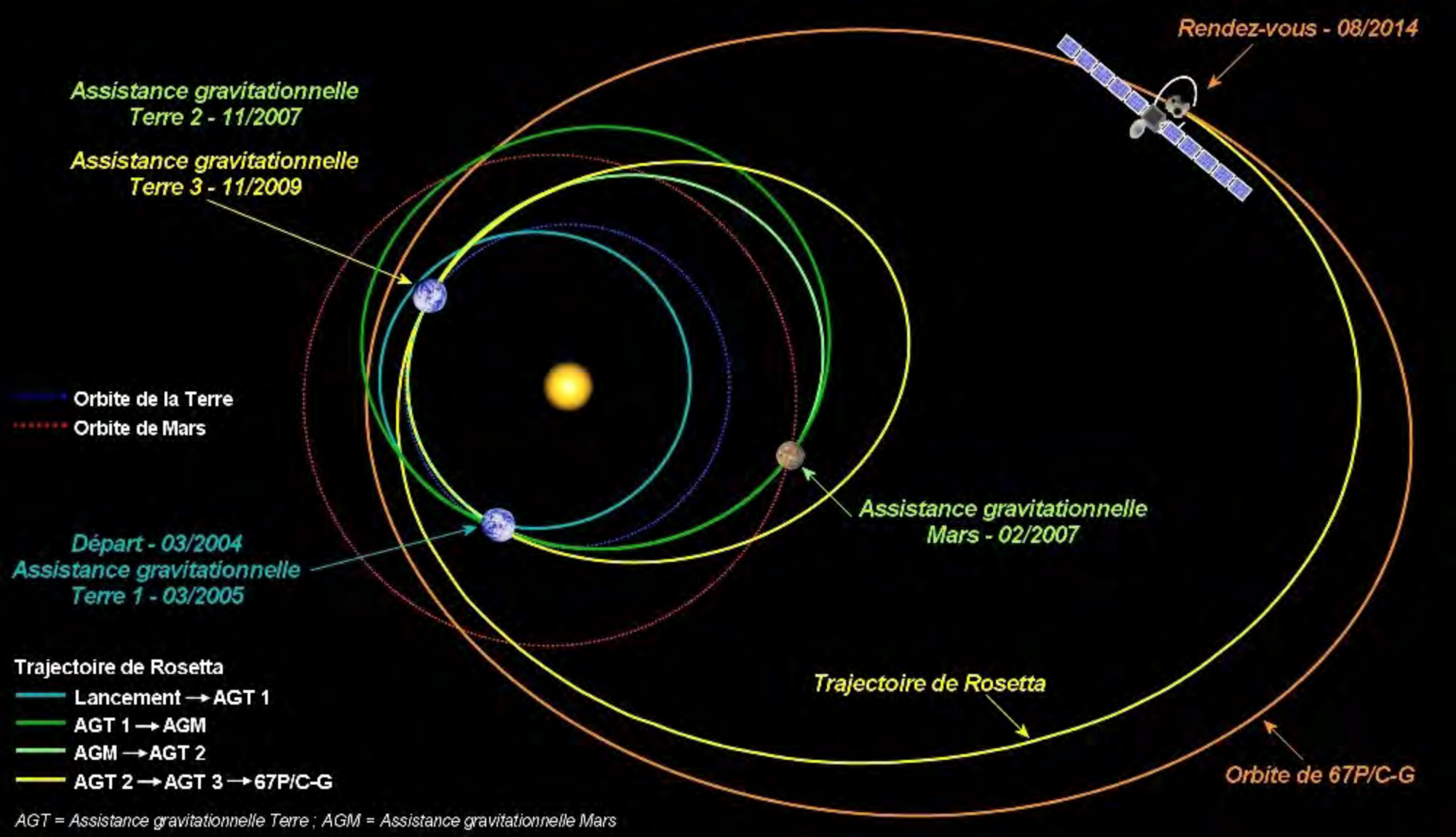

Earth
Moon
Proto-Sun
(D/H) x10^6
0
50
100
150
200
250
300
Carbonaceous Meteorites
(D/H) x10^6
0
50
100
150
200
250
300
Comets


Comet
103P/Hartley 2
Jupiter
Earth
Mars
Pluto
Saturn
Jupiter
Uranus
Neptune
Kuiper Belt
Inner Solar System
Outer Solar System
Oort Cloud

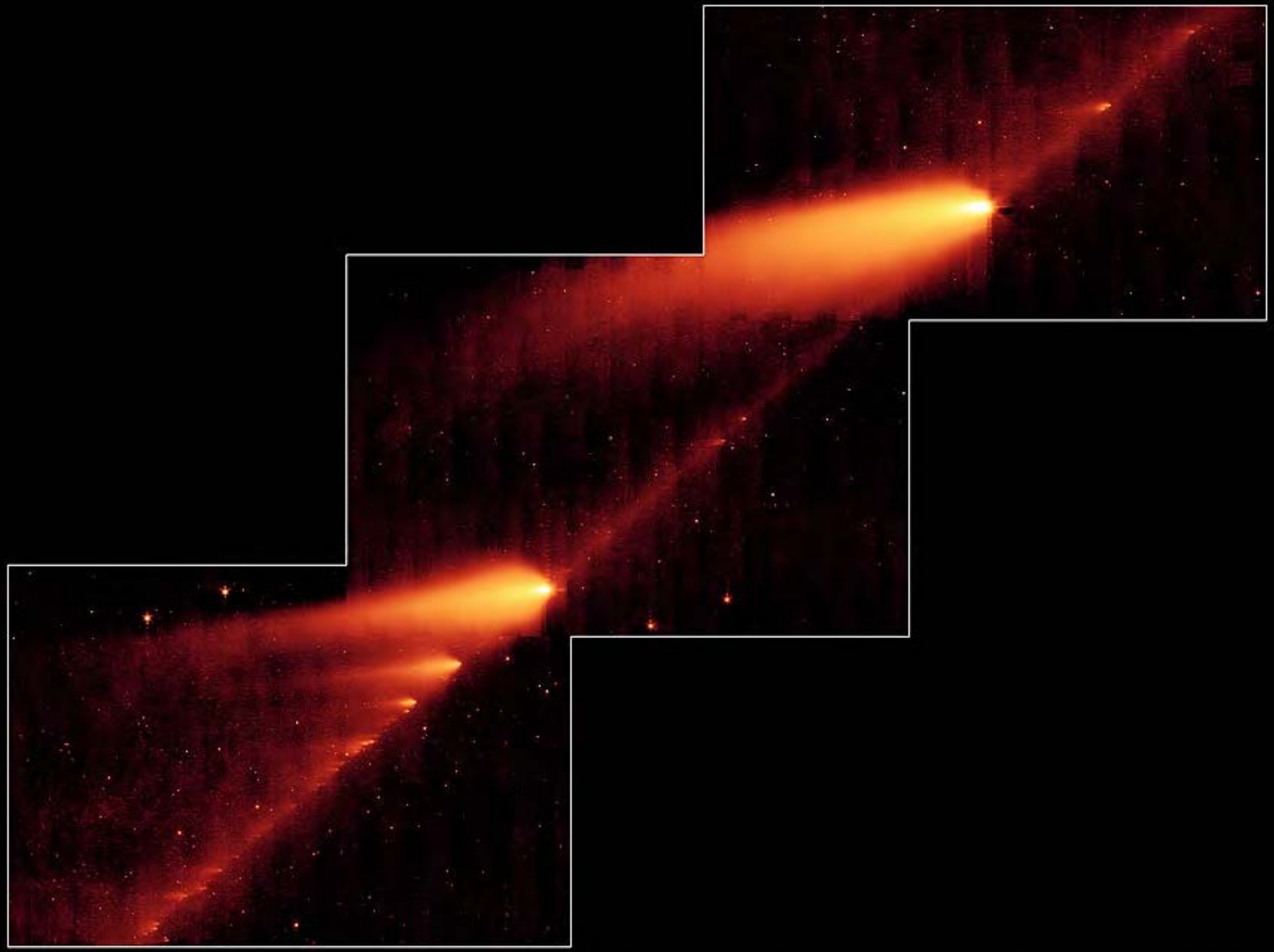
ROSETTA


©2003 ESA - CNES - ARIANESPACE / Photo Service Optique Vidéo CSG




Rendez-vous - 08/2014
Assistance gravitationnelle
Terre 2 - 11/2007
Assistance gravitationnelle
Terre 3 - 11/2009
Orbite de la Terre
Orbite de Mars
Assistance gravitationnelle
Mars - 02/2007
Départ - 03/2004
Assistance gravitationnelle
Terre 1 - 03/2005
Trajectoire de Rosetta
Trajectoire de Rosetta
Lancement → AGT 1
AGT 1 → AGM
AGM → AGT 2
AGT 2 → AGT 3 → 67P/C-G
Orbite de 67P/C-G
AGT = Assistance gravitationnelle Terre ; AGM = Assistance gravitationnelle Mars

67P/C-G



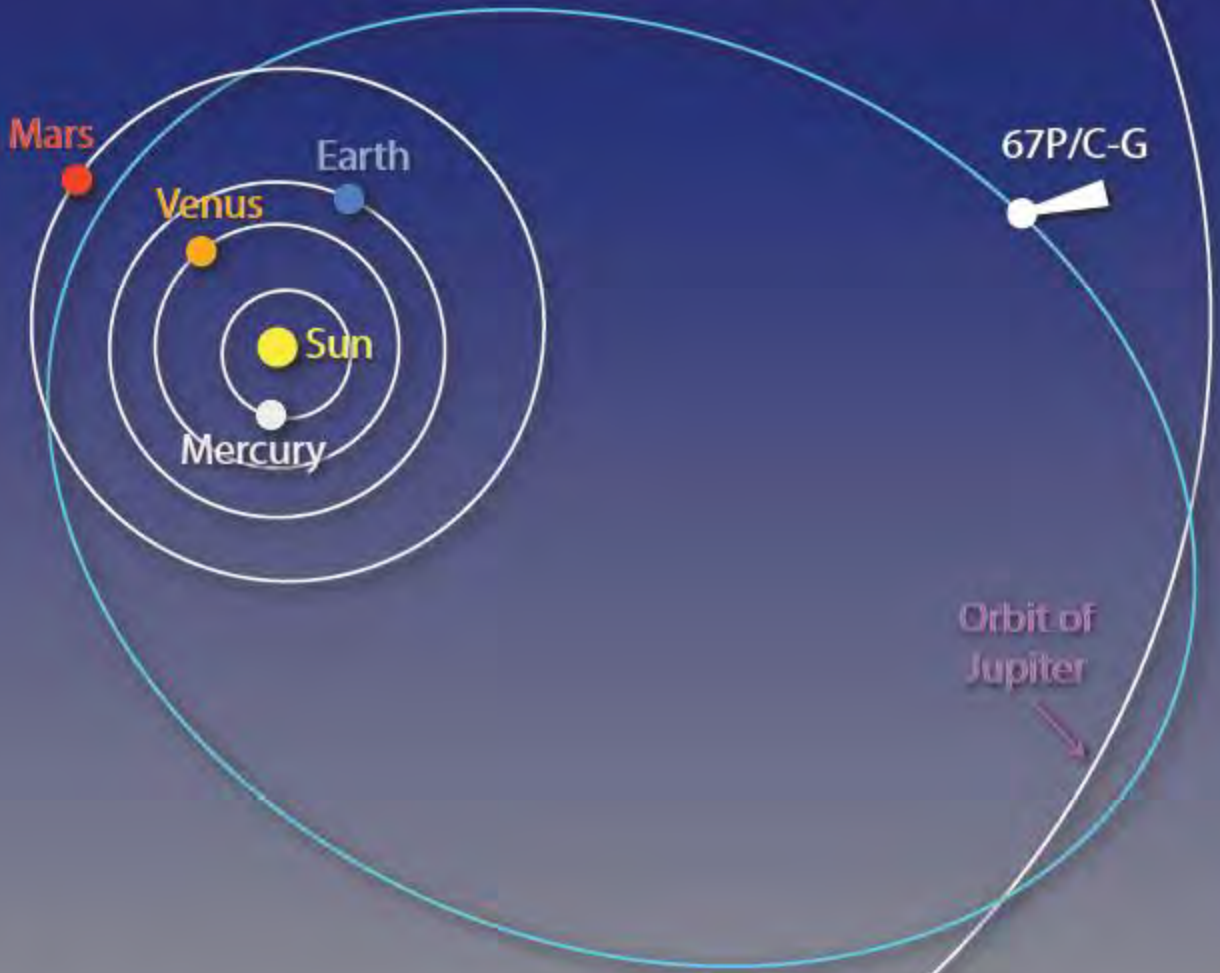
Comet 73P/Schwassmann-Wachmann 3

NASA / JPL-Caltech / W. Reach (SSC/Caltech)

Spitzer Space Telescope • MIPS

ssc2006-13a

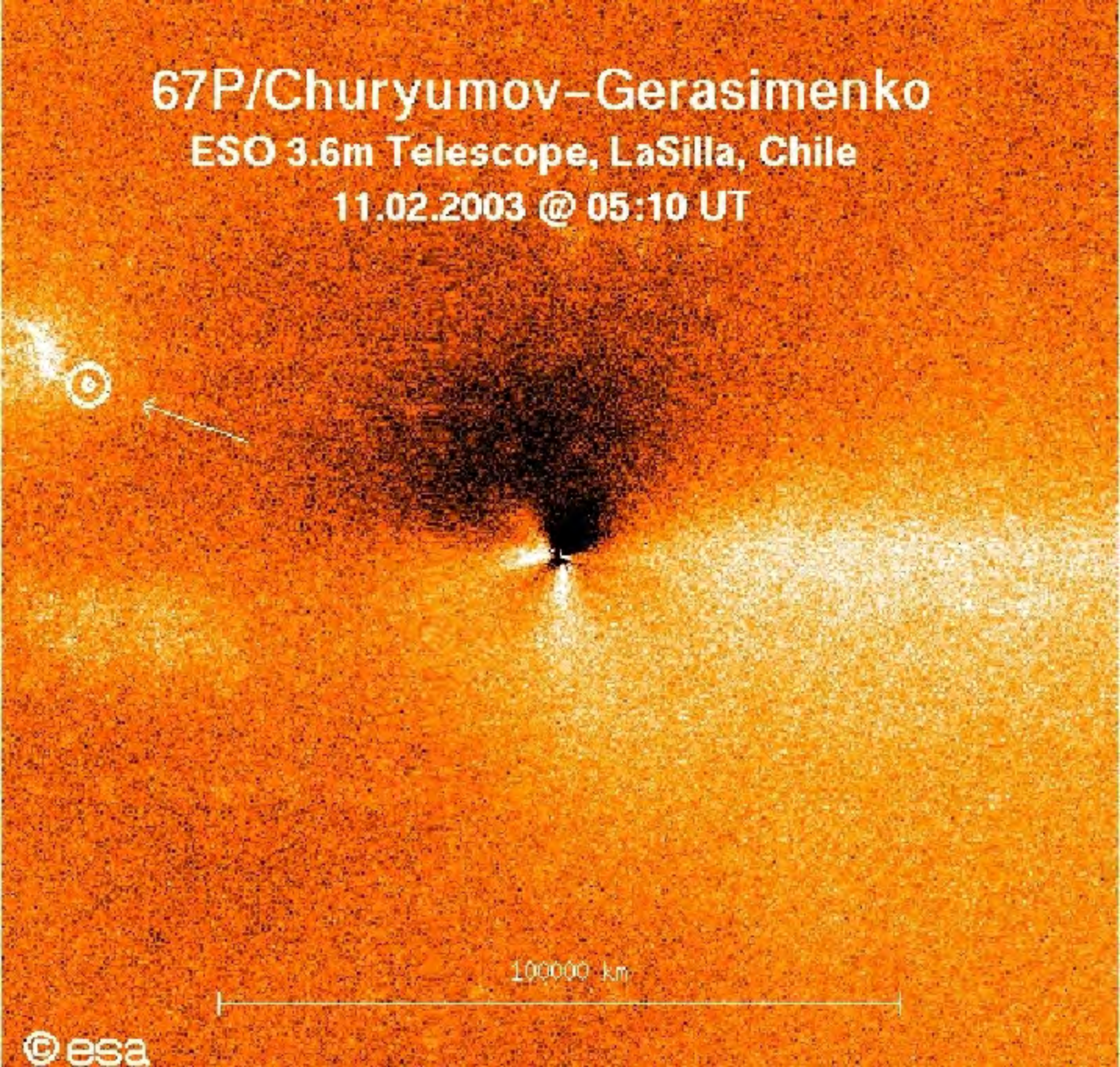
Target: 67P/Churyumov-Gerasimenko

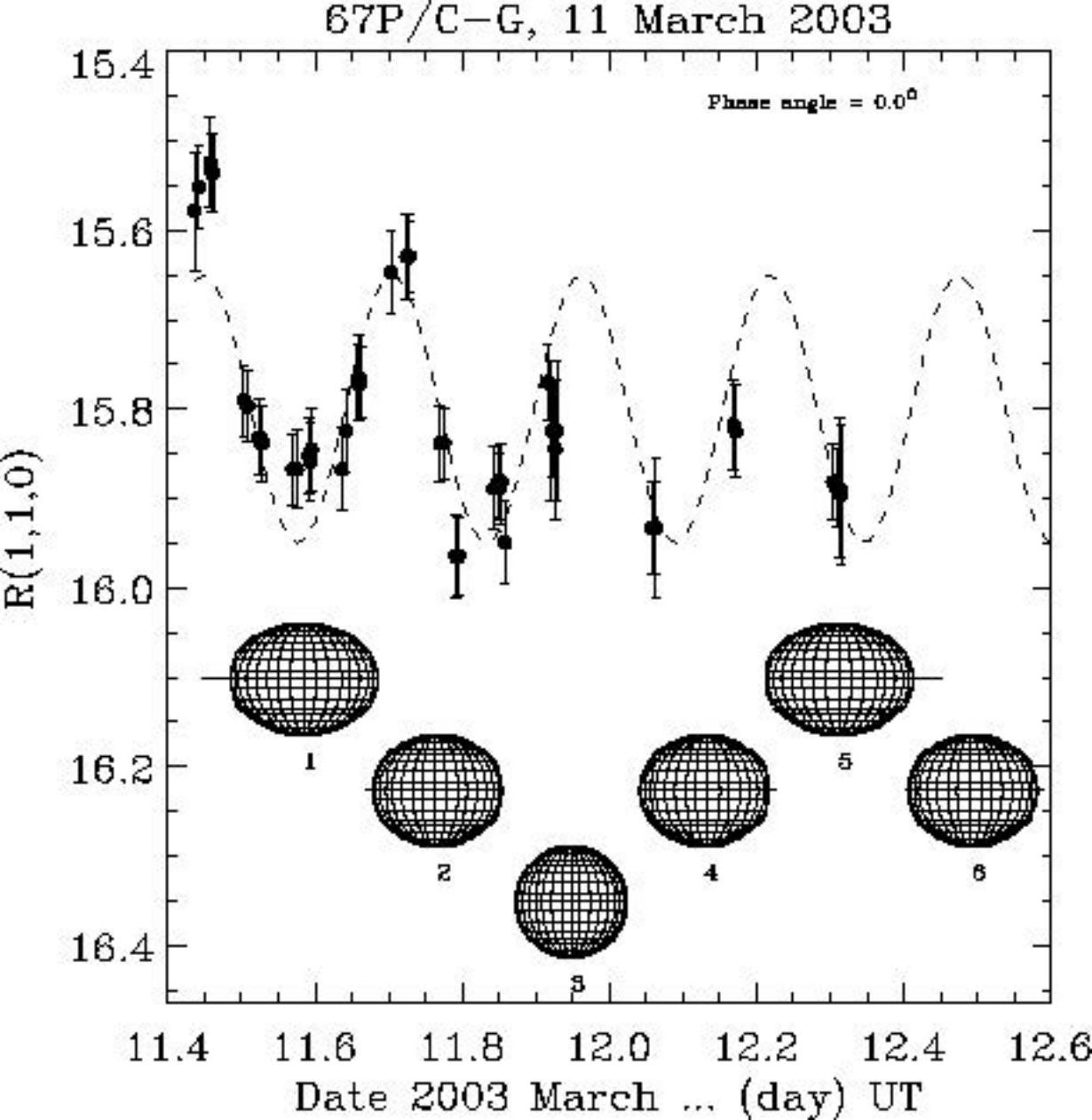


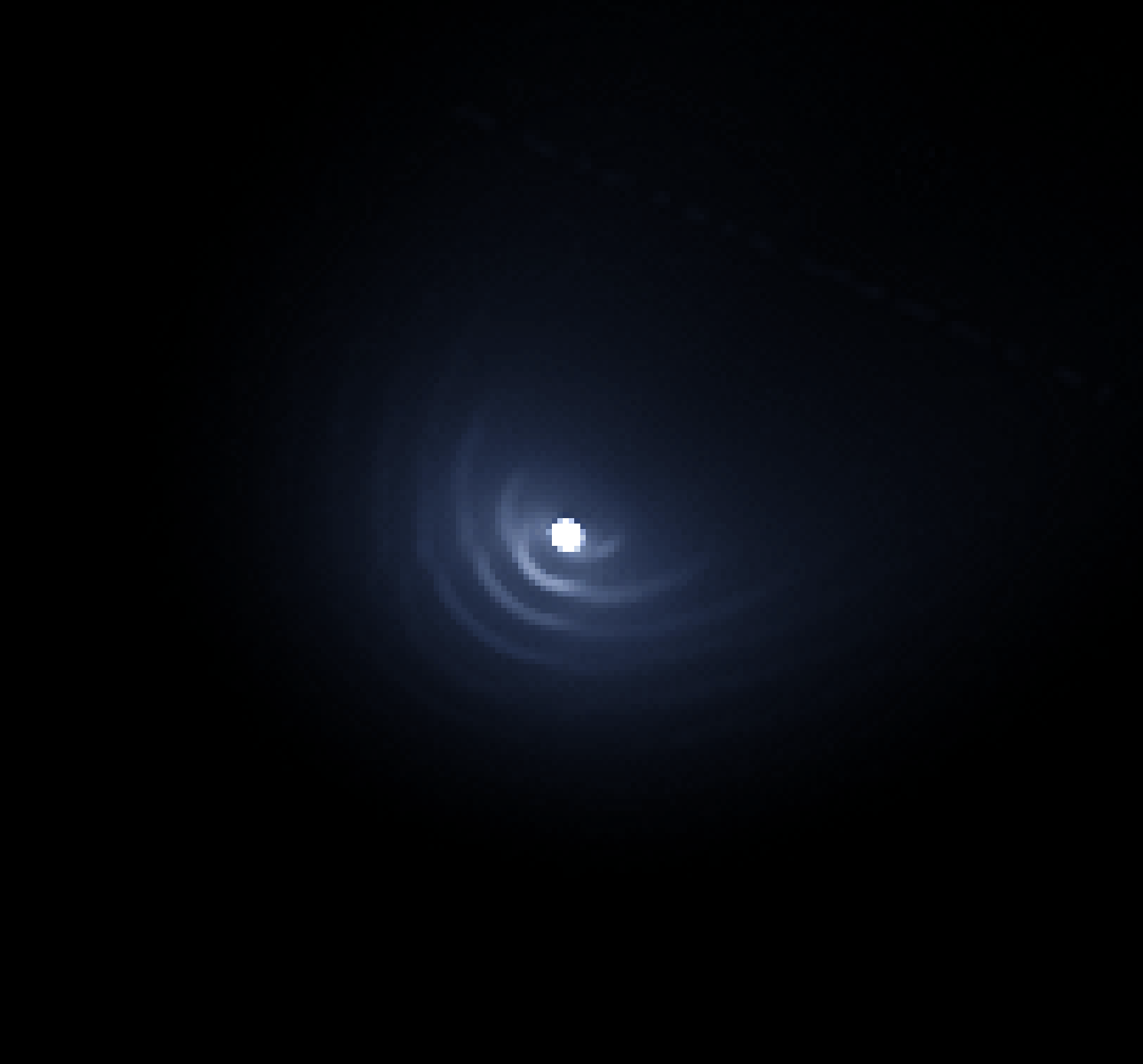
Klim Churyumov, Jean-Jacques Dordain (ESA), & Svetlana Gerasimenko at Rosetta launch

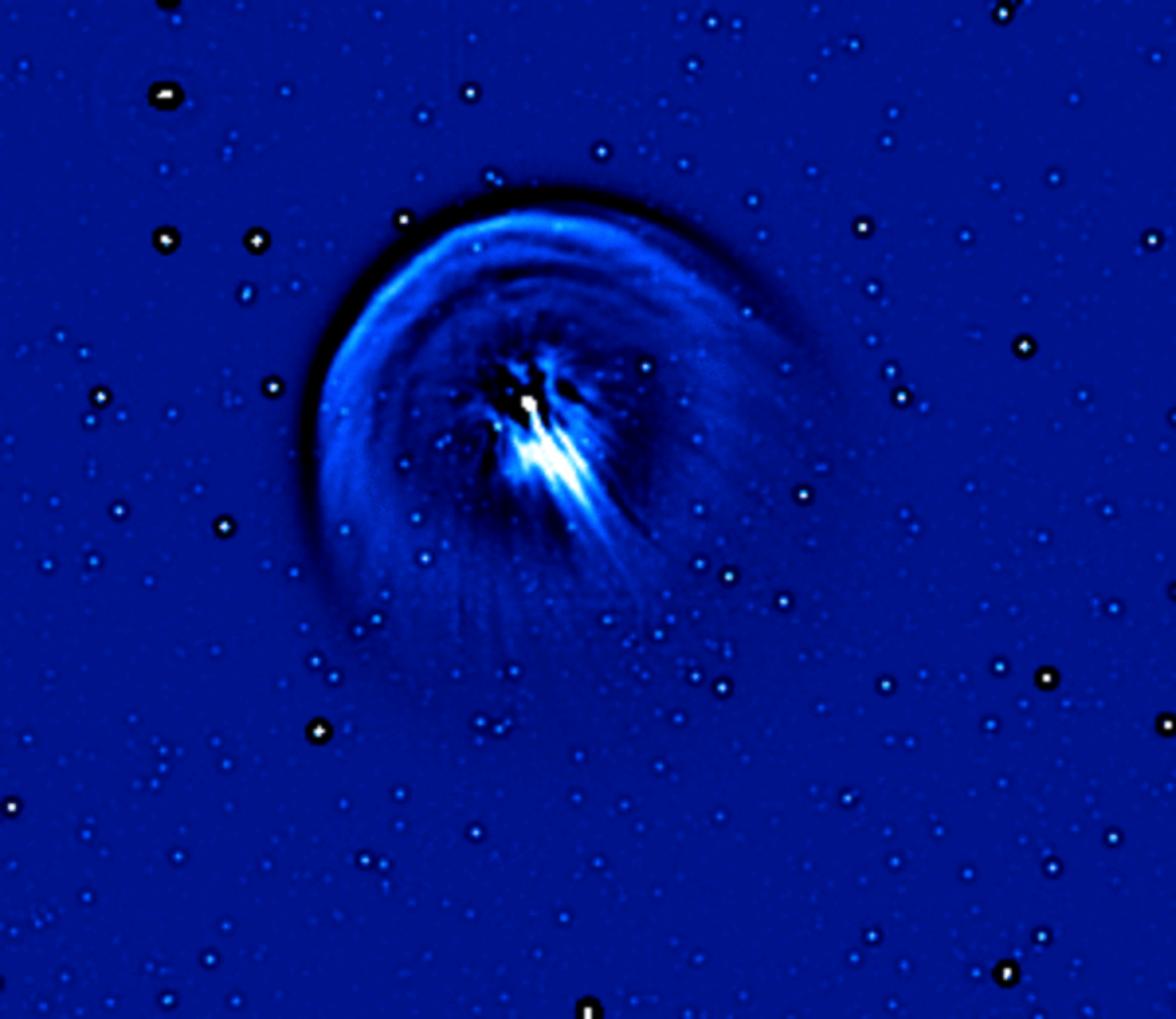
Discovery	1969
Perihelion	1.2458 AU
Aphelion	5.6839 AU
Semi-major axis	3.4648 AU
Eccentricity	0.64043
Inclination	7.0424°
Orbital period	6.45 yr

Plot showing orbits of inner planets, Jupiter, and Comet 67P/C-G on February 26, 2004

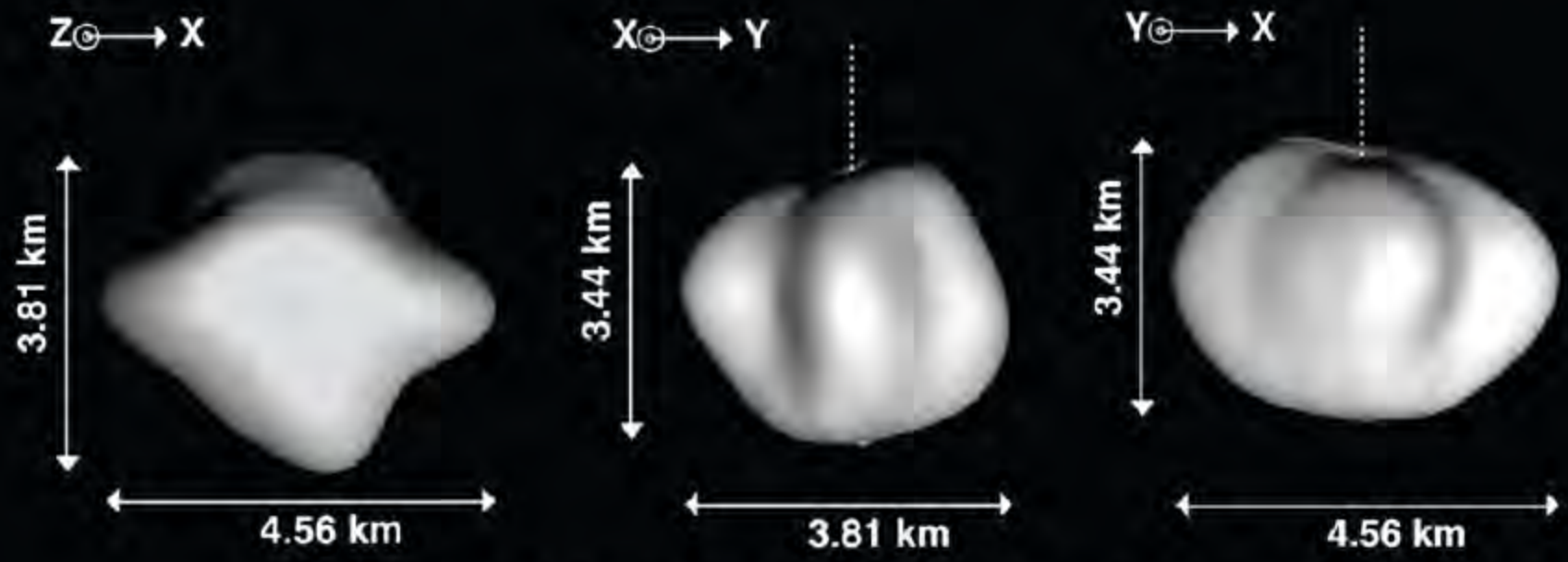

67P/Churyumov–Gerasimenko
ESO 3.6m Telescope, LaSilla, Chile
11.02.2003 @ 05:10 UT
100000 km
©esa


67P/C-G, 11 March 2003
Phase angle = 0.0°
R(1,1,0)
15.4
15.6
15.8
16.0
16.2
16.4
1
2
3
4
5
6
11.4
11.6
11.8
12.0
12.2
12.4
12.6
Date 2003 March ... (day) UT





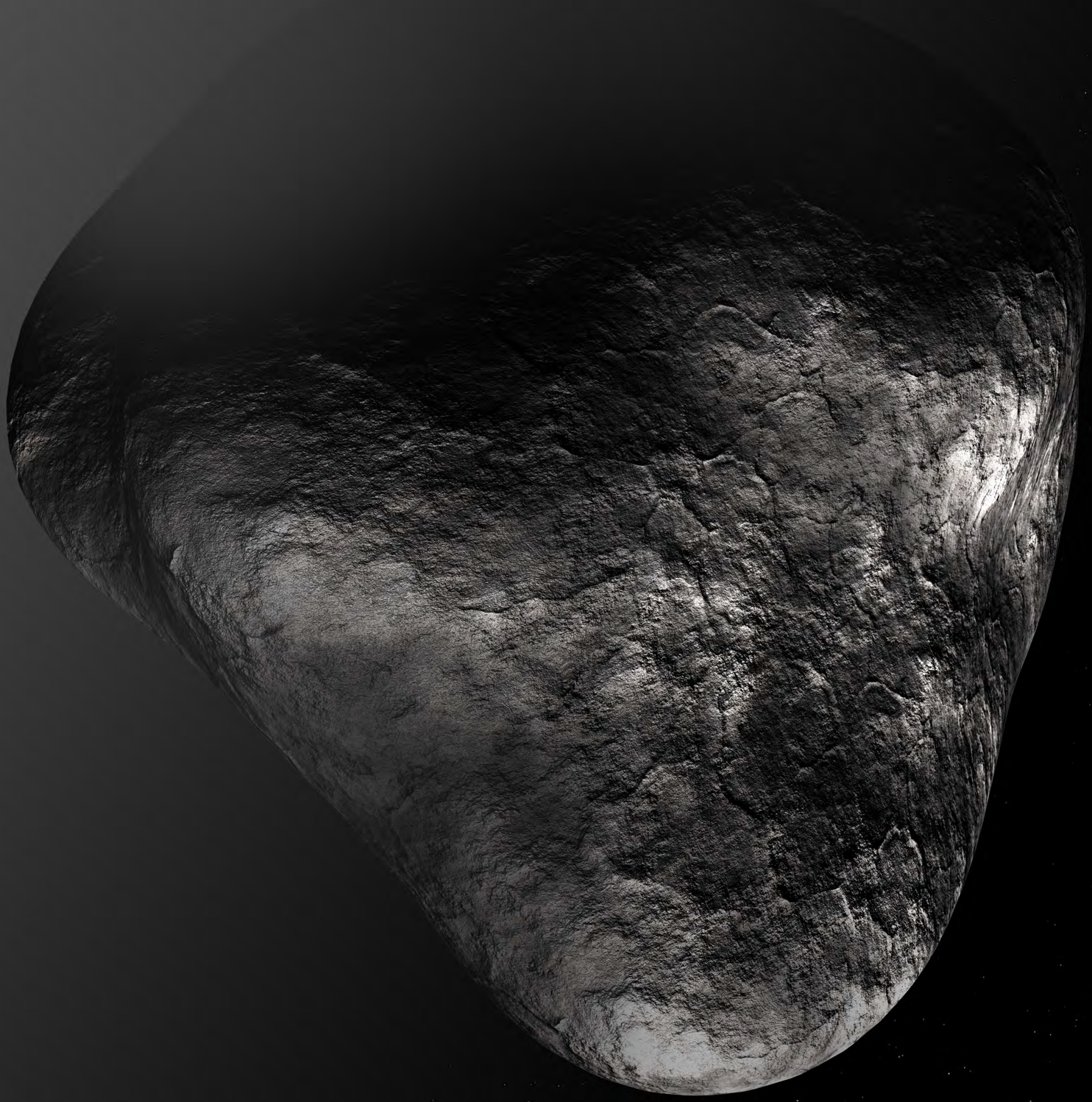
What does 67P/C-G look like?



Reconstruction of Hubble Space Telescope light-curve data taken in 2003
Distance from Sun: 2.5 AU Distance from Earth: 1.5 AU

In 2014, we will start to see 67P/C-G in much more detail

Lamy et al. 2006, A&A



ROSETTA

Wake Up

~Tsep -100d | ~Tsep -80d | ~Tsep -60d | ~Tsep -45d | ~Tsep -30d | ~Tsep -16d | Tsep

20 Jan | May | end Jul | mid/end Aug | mid Sep | end Sep | mid Oct | end Oct | mid Nov | Dec

NCD | FAT | CAT | GMP | COP | LDP | *Escort Phase*

Near Comet Drift
Far Approach Trajectory

Close Approach Trajectory

Global Mapping Phase

Close Observation Phase

Lander Delivery Preparation

Wake Up

Process Validation

LSSP Rehearsal

5 Candidate Landing Areas Selected

5 Candidate Landing Areas Ranked

Start Landing Site #1 Close Observation

5 Landing Areas Landing Feasibility Analisys ready

GO Landing Site #1

Landing Site #1 Feasibility Analisys ready

Separation

April

Post Hibernation Commissioning
~ 3 weeks

Philae Solar Array Test

Pre Delivery Calibration and Science

-10d | -2d | -22h

LDP FSS SDL upload

FSS

LTS

KP2 | **LOWG#17** | **LSSPRM** | **LOWG#18** | **LORR**

Execution

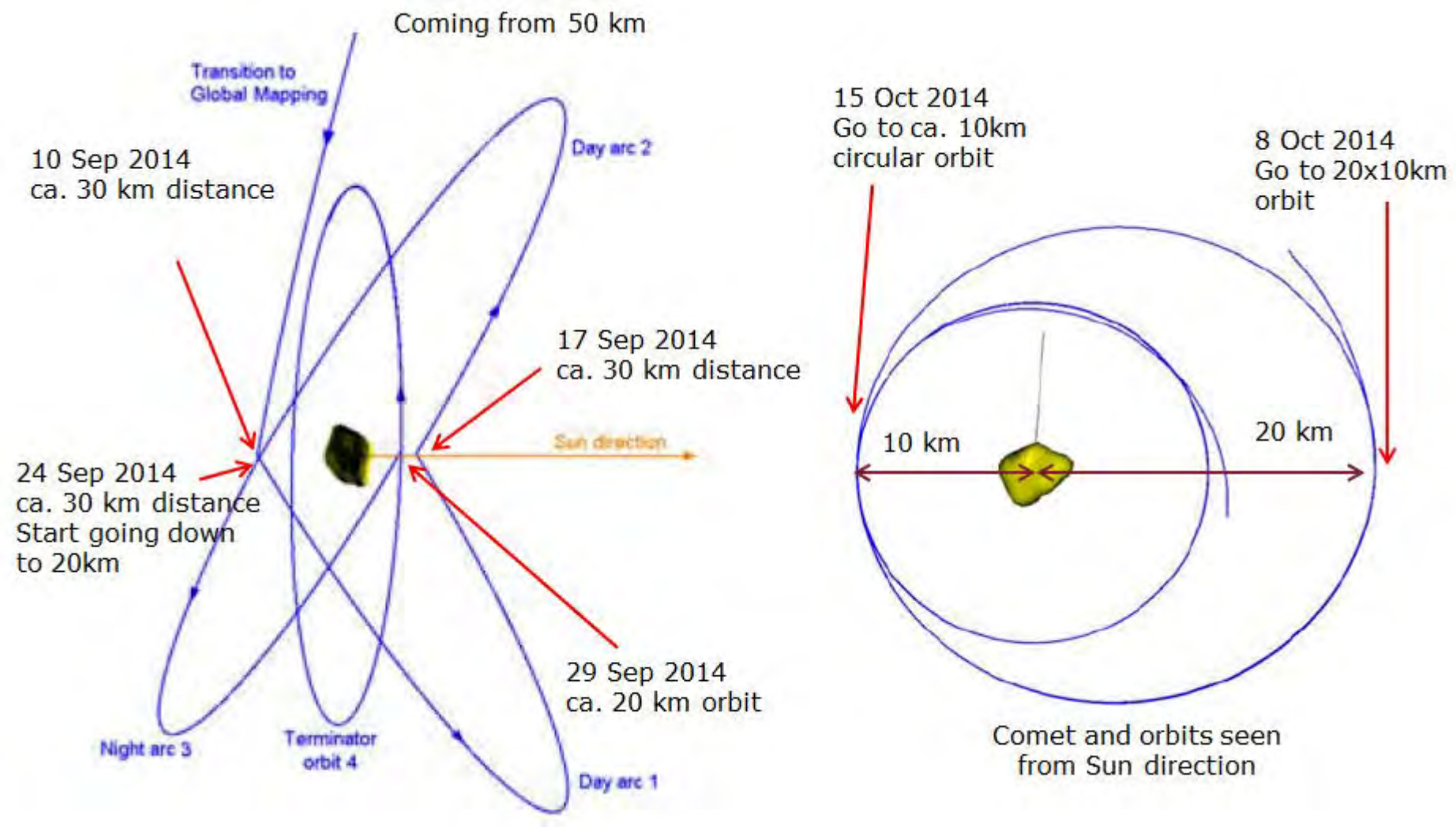
Escort Phase LTP Interaction for LTP 1
Most relevant for LDR: Nov - Feb

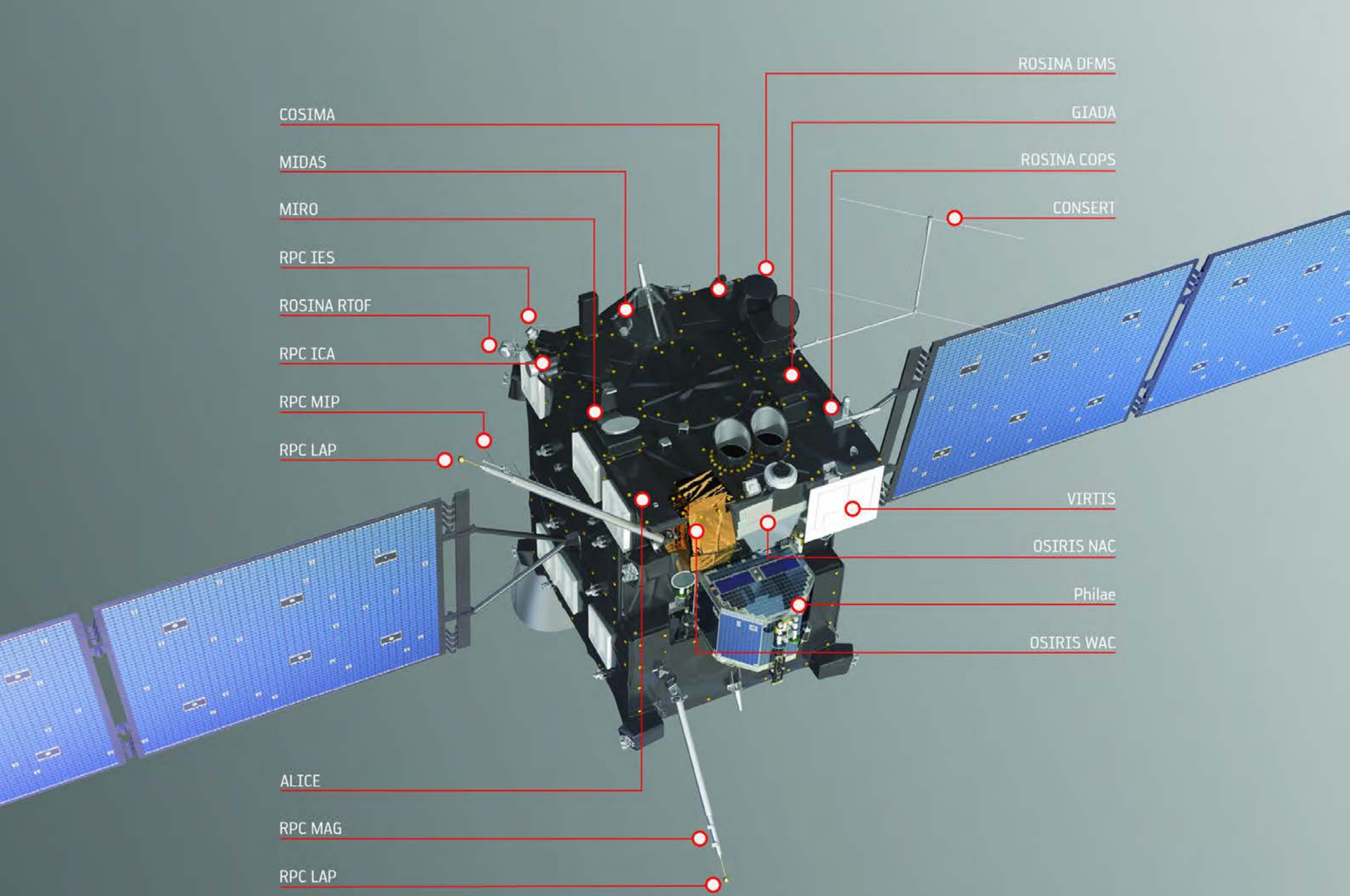
Escort Phase MTP Interaction Cycles

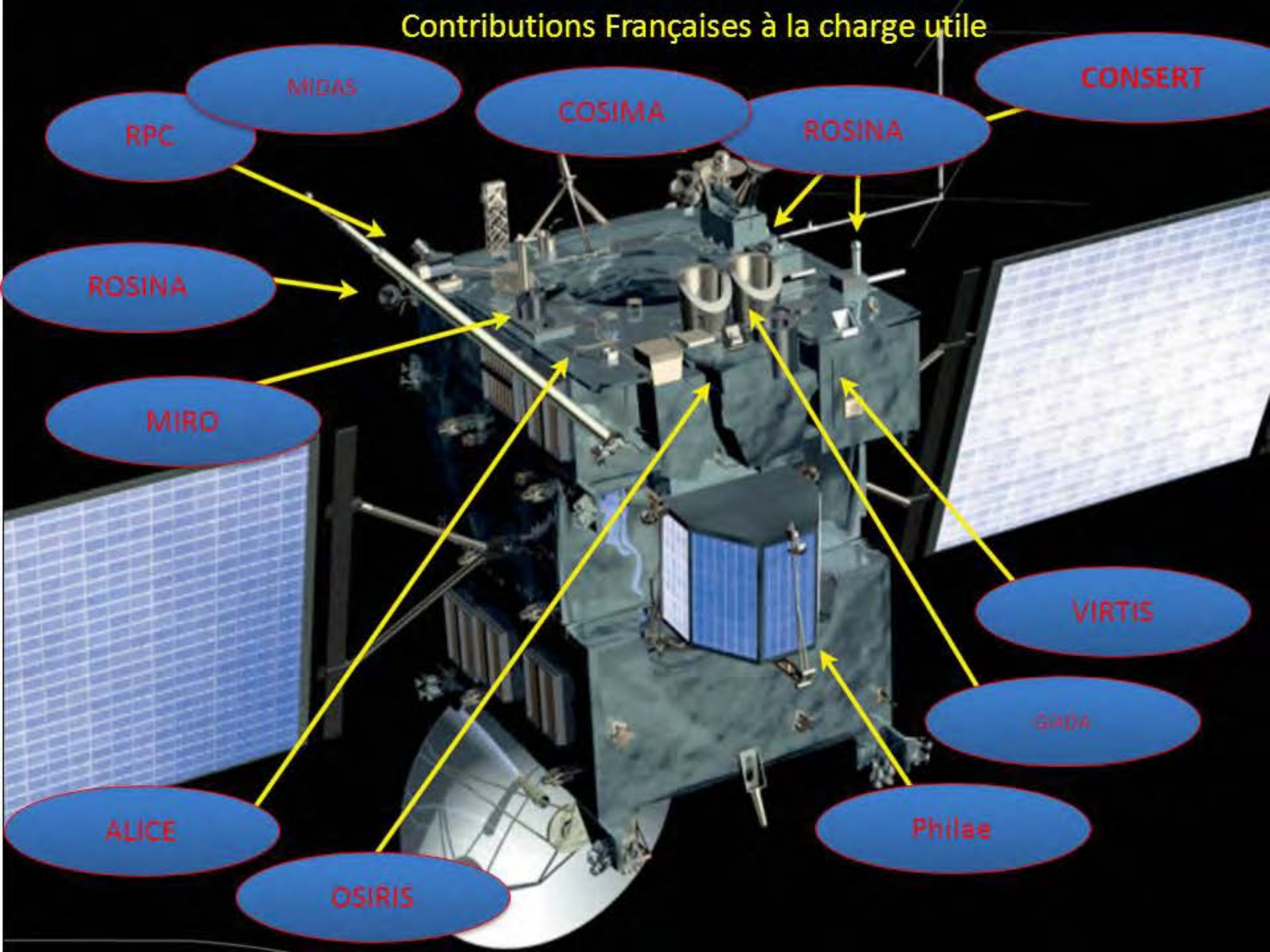
Distance to comet:

9.2e6 km | **2.1e6 km** | **1364 km** | **61 km** | **30 km circular** | **30x20 km** | **20x20 km**

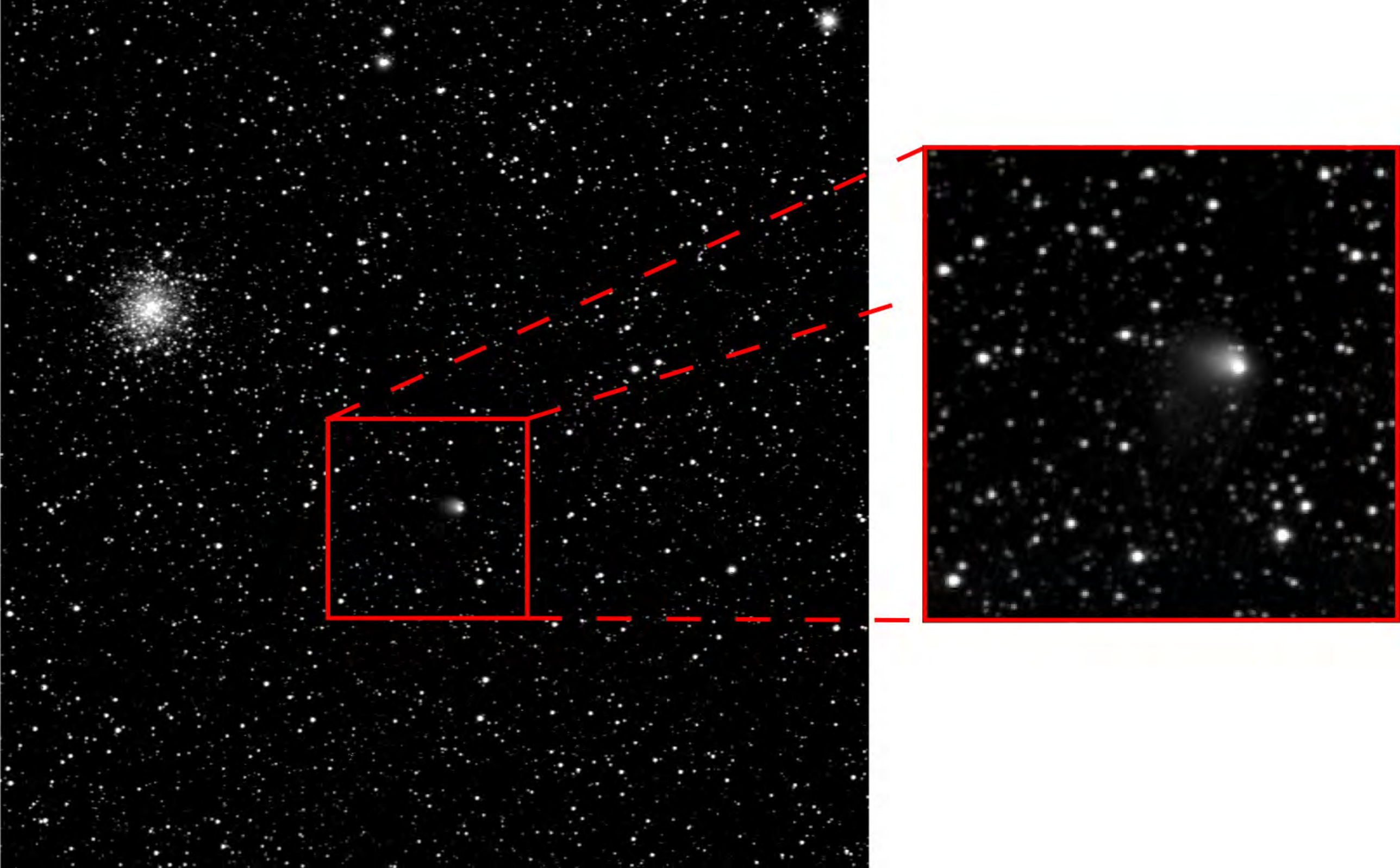
Rosetta
Phase d'Arrivée à la Comète


Coming from 50 km
Transition to Global Mapping
10 Sep 2014
ca. 30 km distance
Day arc 2
17 Sep 2014
ca. 30 km distance
Sun direction
24 Sep 2014
ca. 30 km distance
Start going down to 20km
29 Sep 2014
ca. 20 km orbit
Night arc 3
Terminator orbit 4
Day arc 1
15 Oct 2014
Go to ca. 10km circular orbit
8 Oct 2014
Go to 20x10km orbit
10 km
20 km
Comet and orbits seen from Sun direction

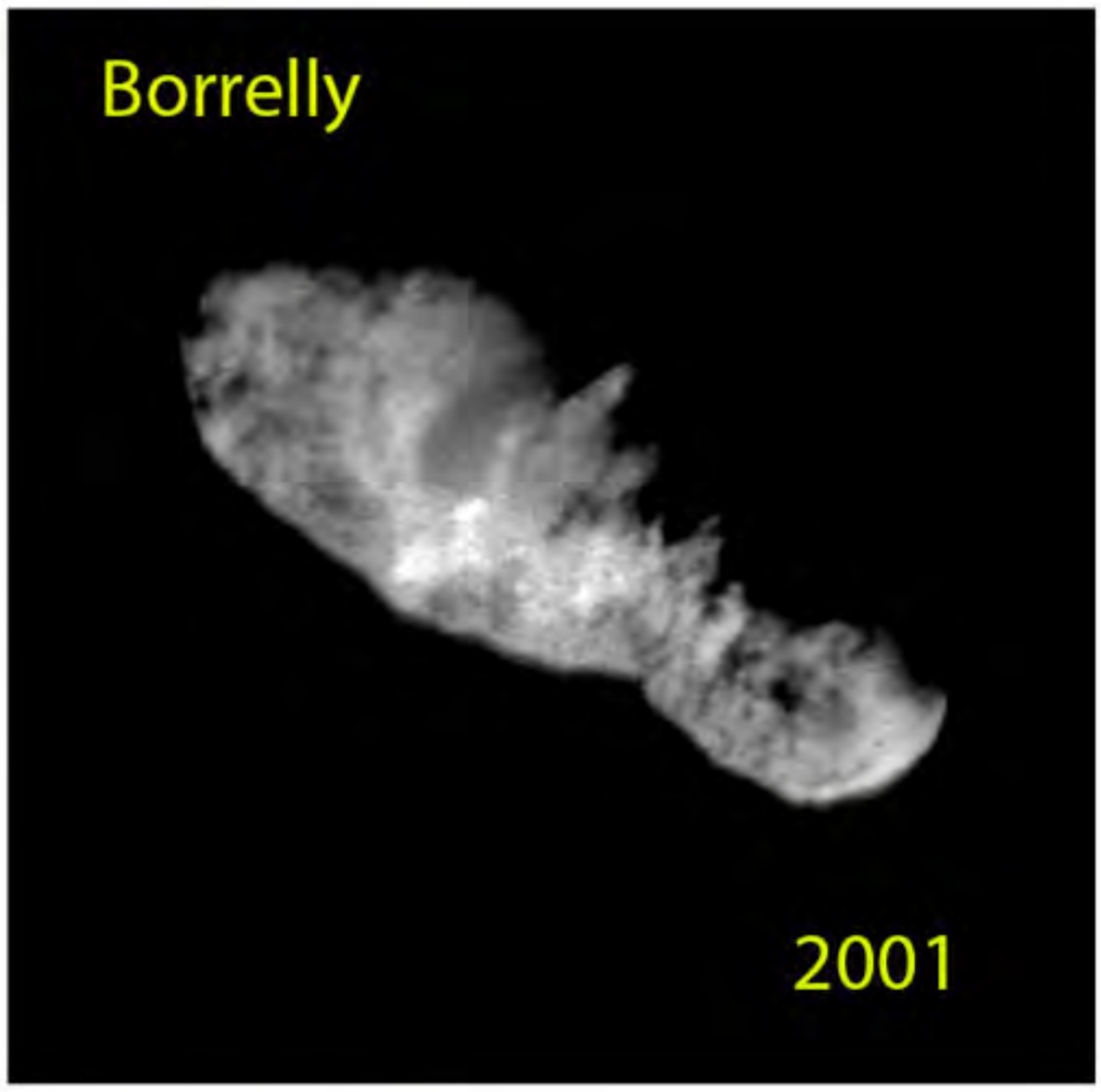

ROSINA DFMS
GIADA
ROSINA COPS
CONSERT
COSIMA
MIDAS
MIRO
RPC IES
ROSINA RTOF
RPC ICA
RPC MIP
RPC LAP
VIRTIS
OSIRIS NAC
Philae
OSIRIS WAC
ALICE
RPC MAG
RPC LAP

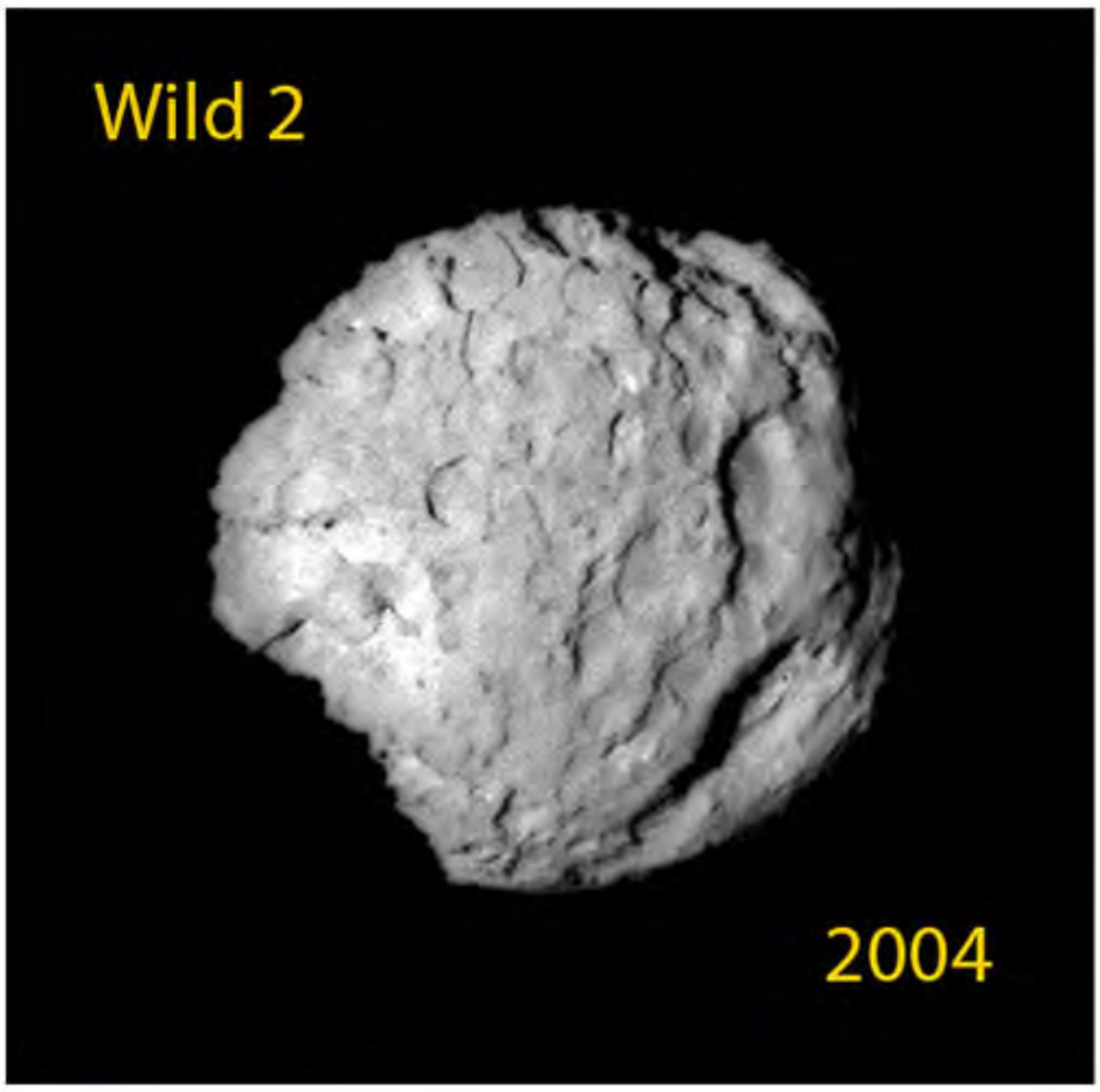

Contributions Françaises à la charge utile
MIDAS
RPC
COSIMA
ROSINA
CONSERT
ROSINA
MIRO
VIRTIS
GIADA
ALICE
Philae
OSIRIS

67P/Churyumov-Gerasimenko

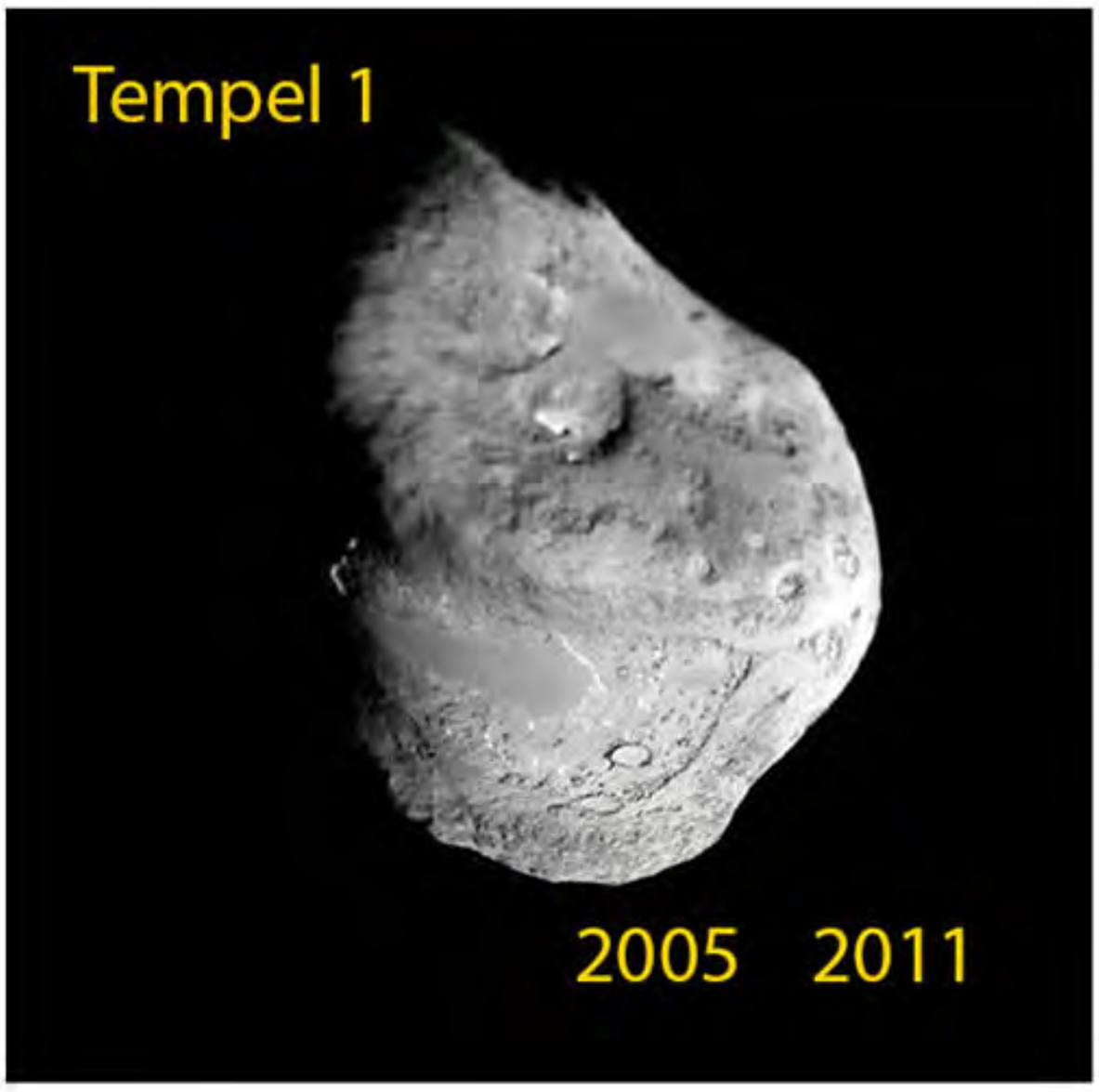



Halley
1986

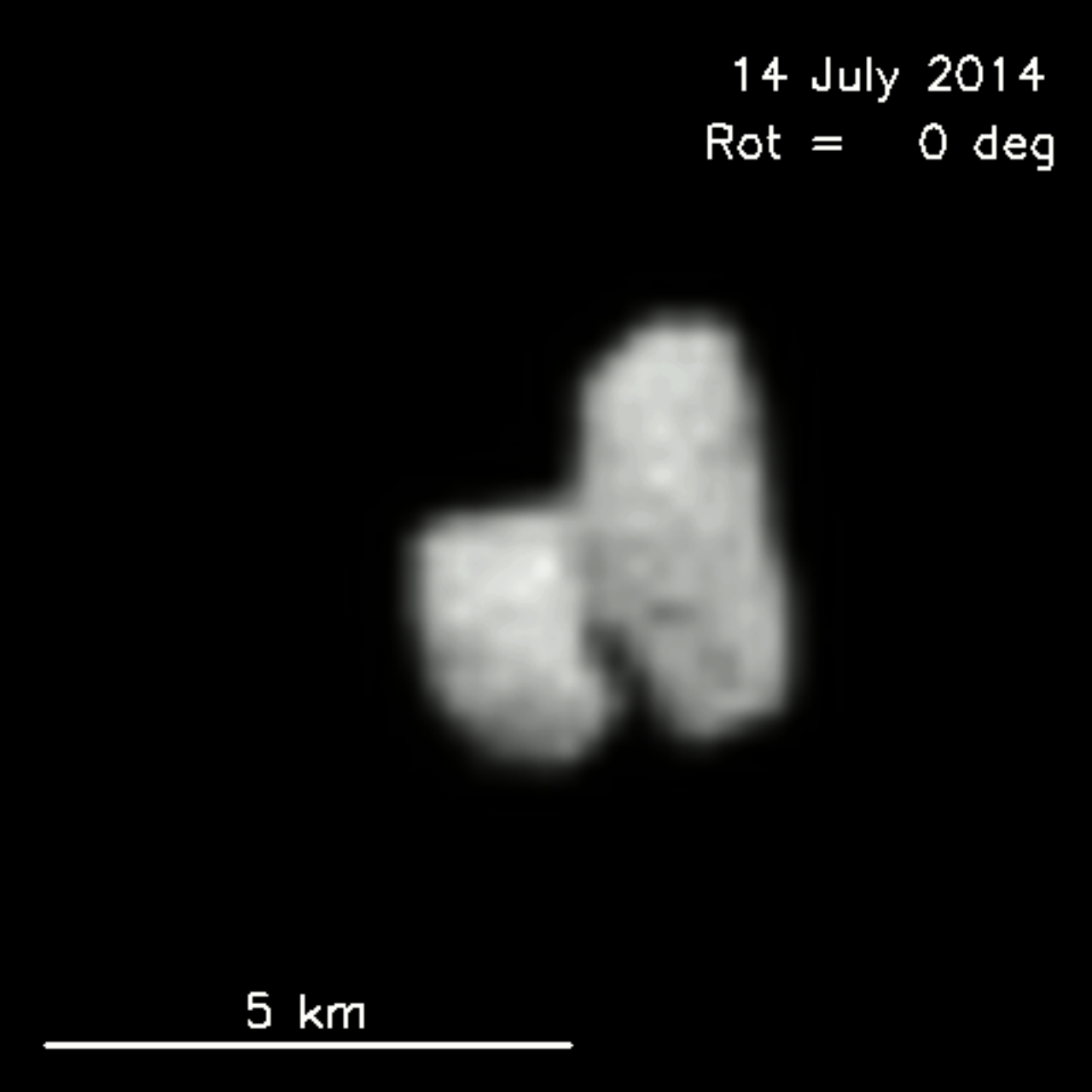

Borrelly
2001

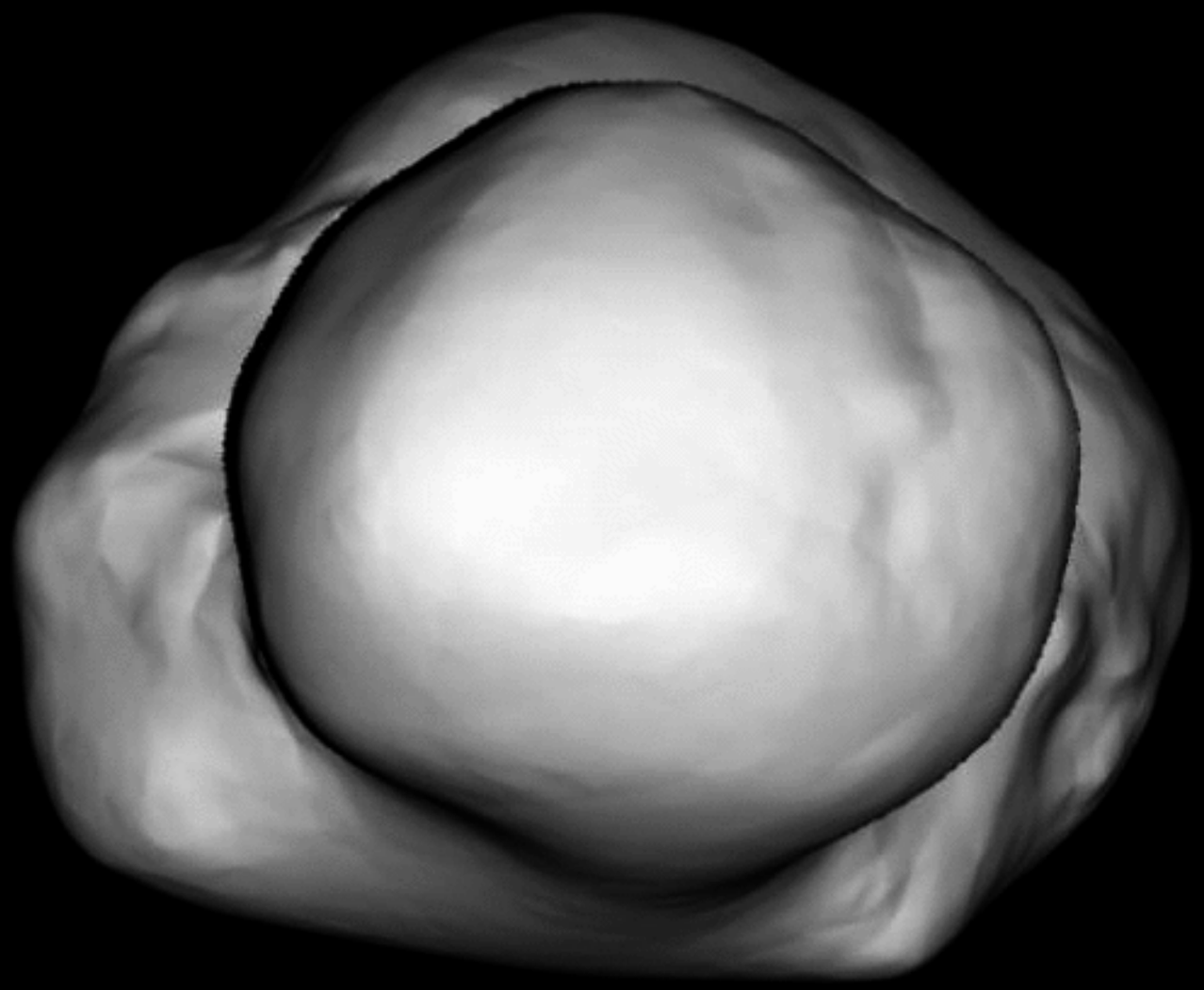

Wild 2
2004


Hartley 2
2010


Tempel 1
2005 2011


Churyumov-Gerasimenko
2014


14 July 2014
Rot = 0 deg
5 km



MakeAGIF.com

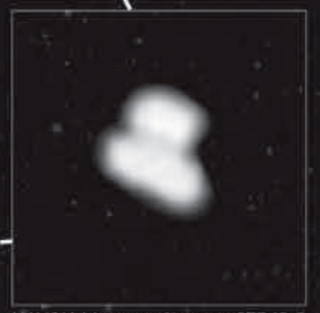
First VIRTIS measurements reveal a temperature of -70°C suggesting that the surface of comet 67P/Churyumov-Gerasimenko is predominantly covered by dust

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

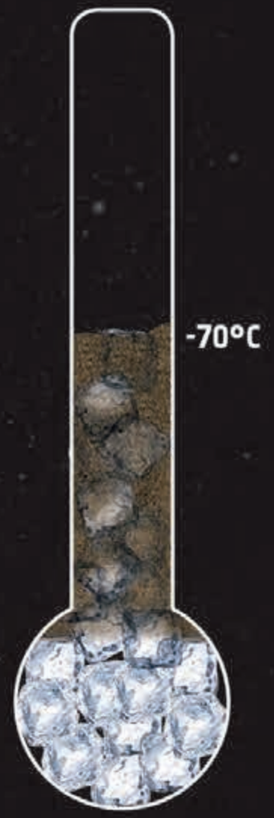
Sun

553.5 million km

≈ 14 000 - 5 000 km

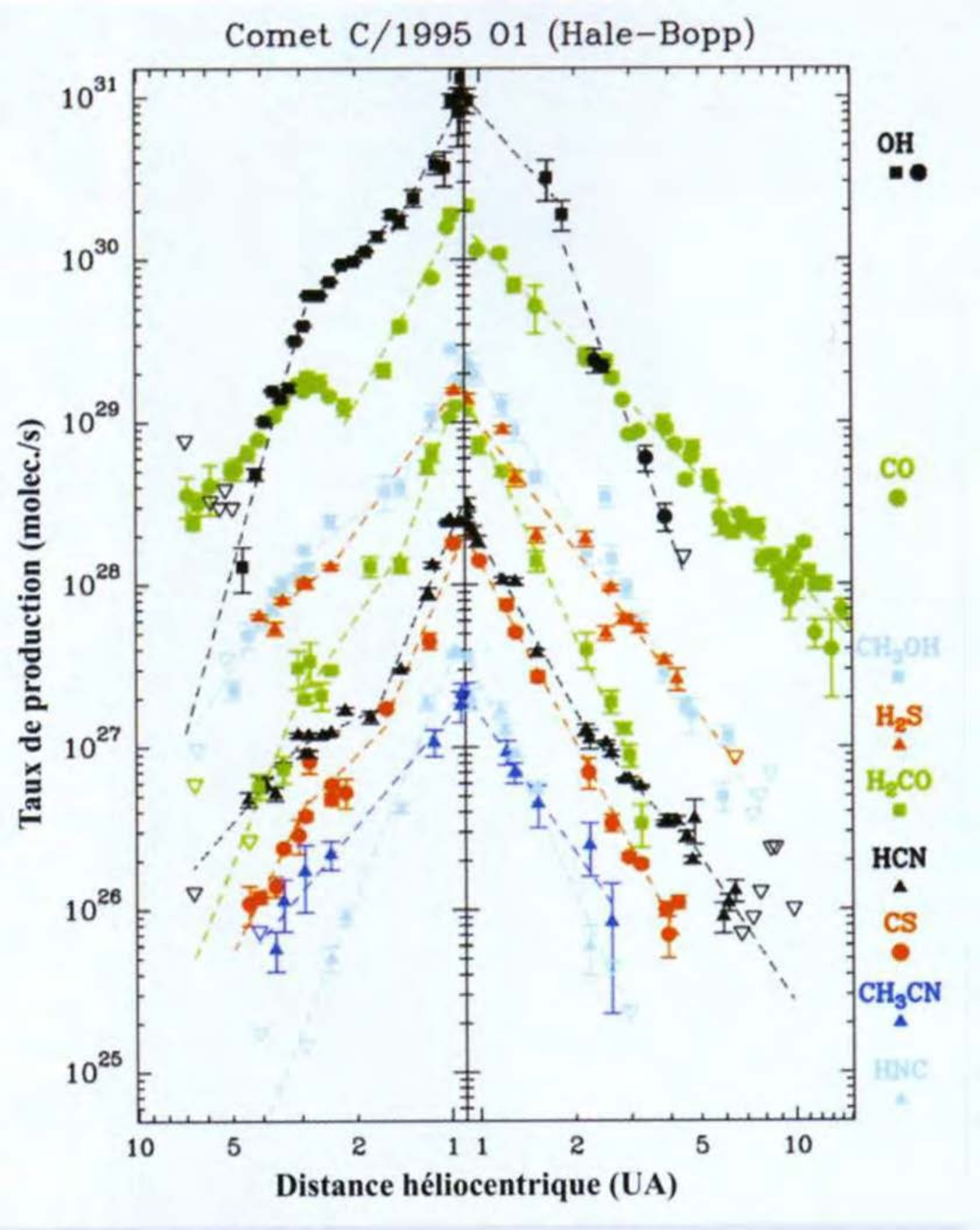


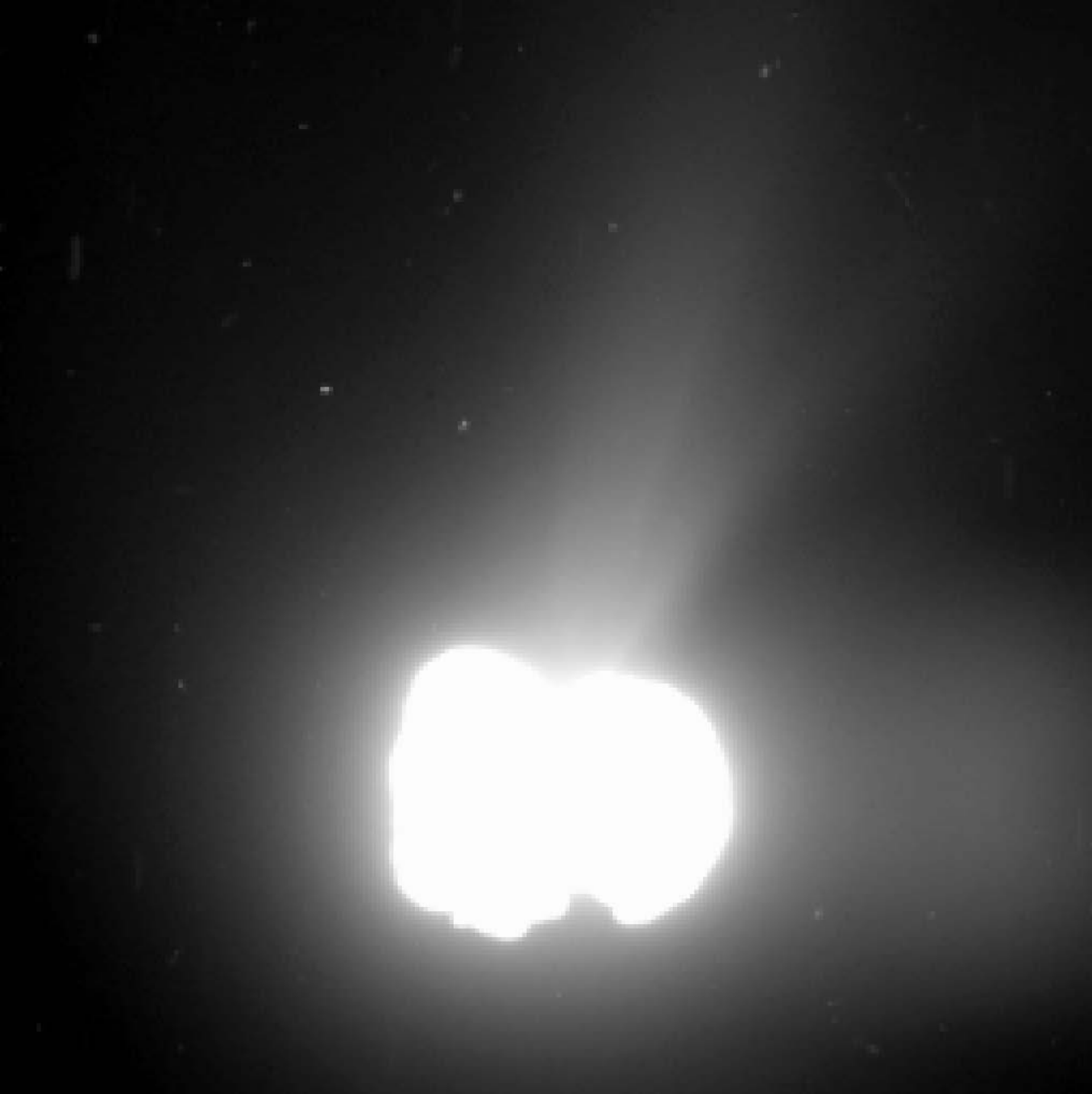
NAVCAM image of comet 67P/C-G on 23 July 2014

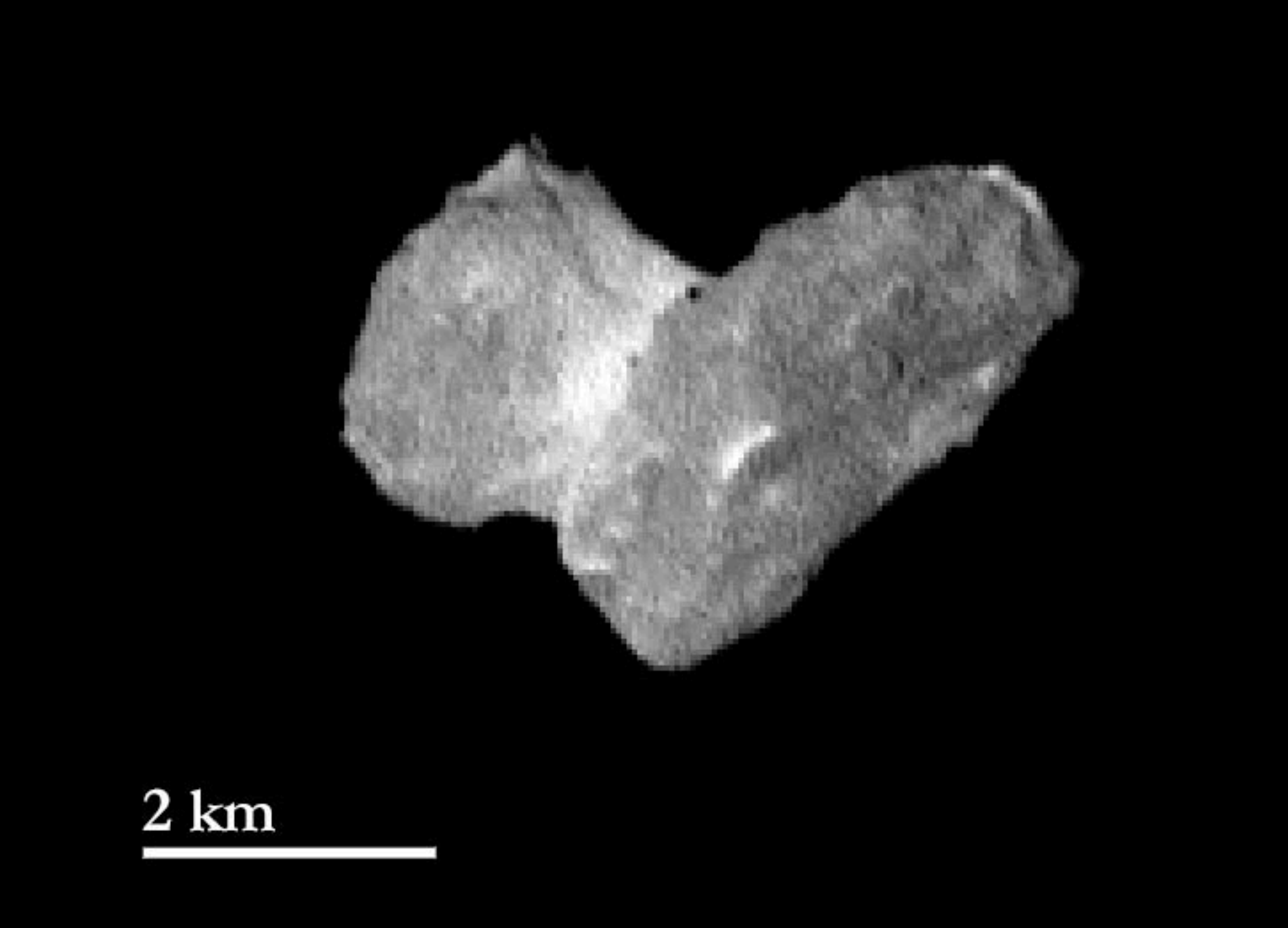


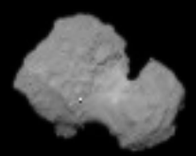
www.esa.int

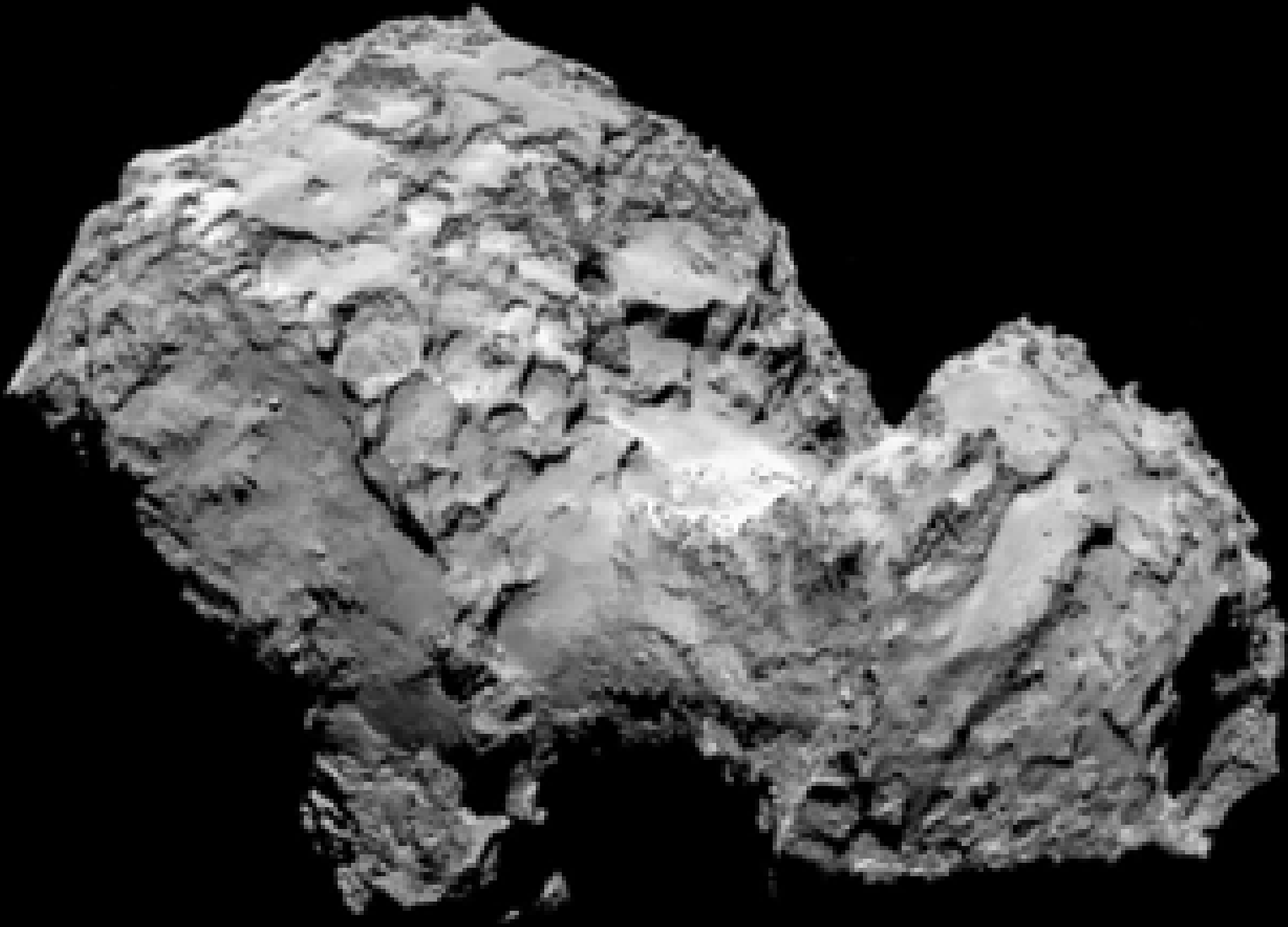
European Space Agency

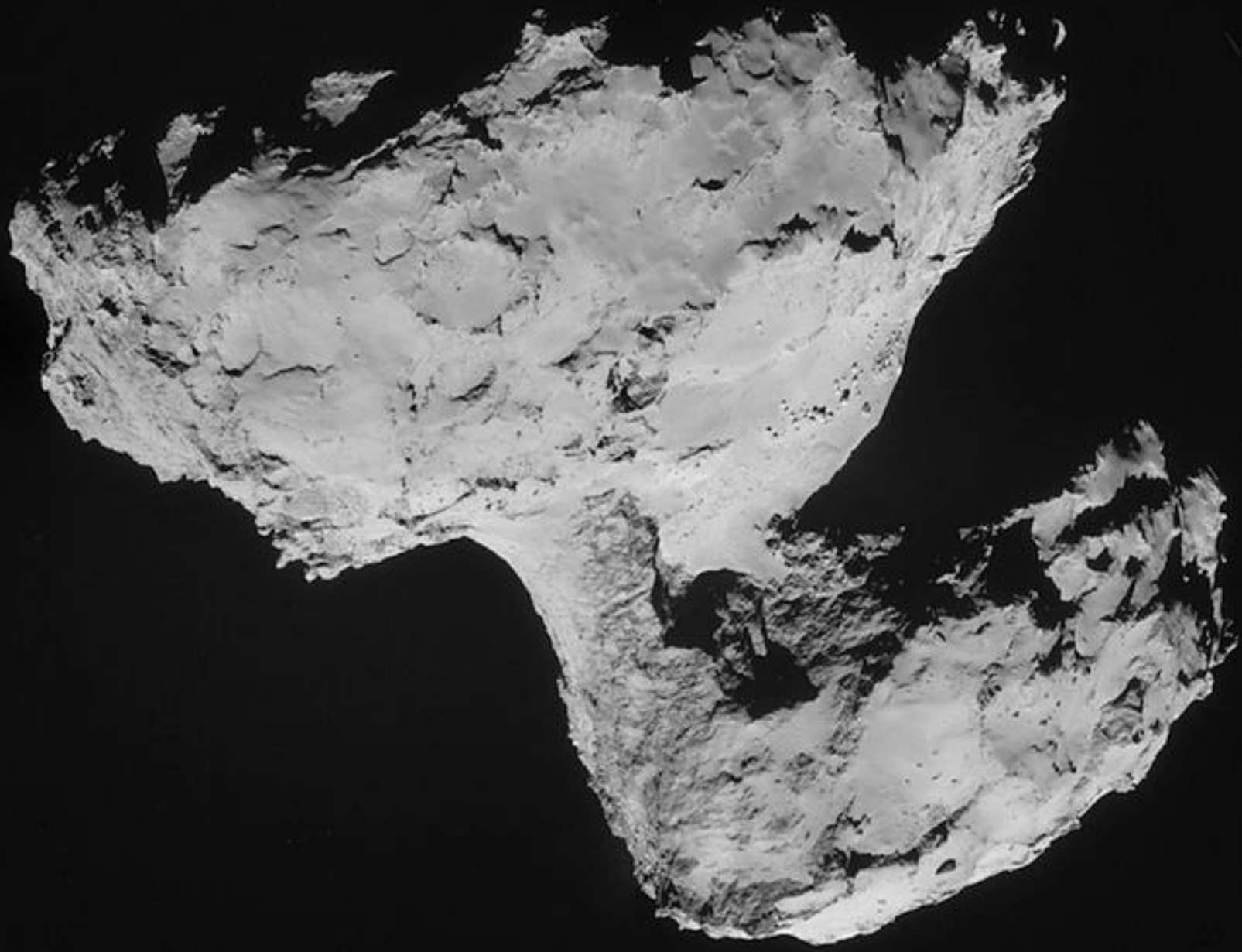

Comet C/1995 O1 (Hale-Bopp)
Taux de production (molec./s)
10^{31}
10^{30}
10^{29}
10^{28}
10^{27}
10^{26}
10^{25}
10
5
2
1
1
2
5
10
Distance héliocentrique (UA)
OH
CO
CH_3OH
H_2S
H_2CO
HCN
CS
CH_3CN
HNC



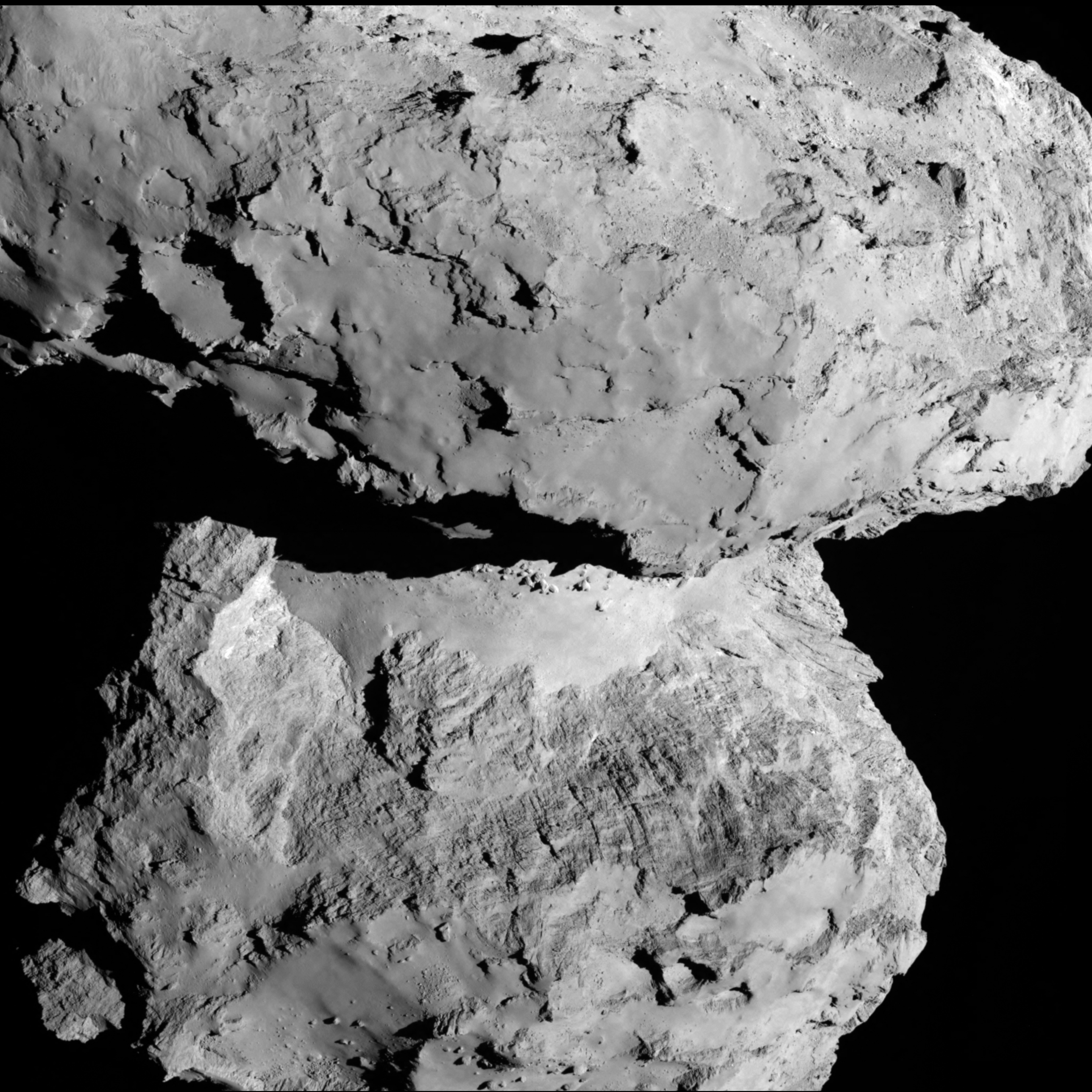

2 km



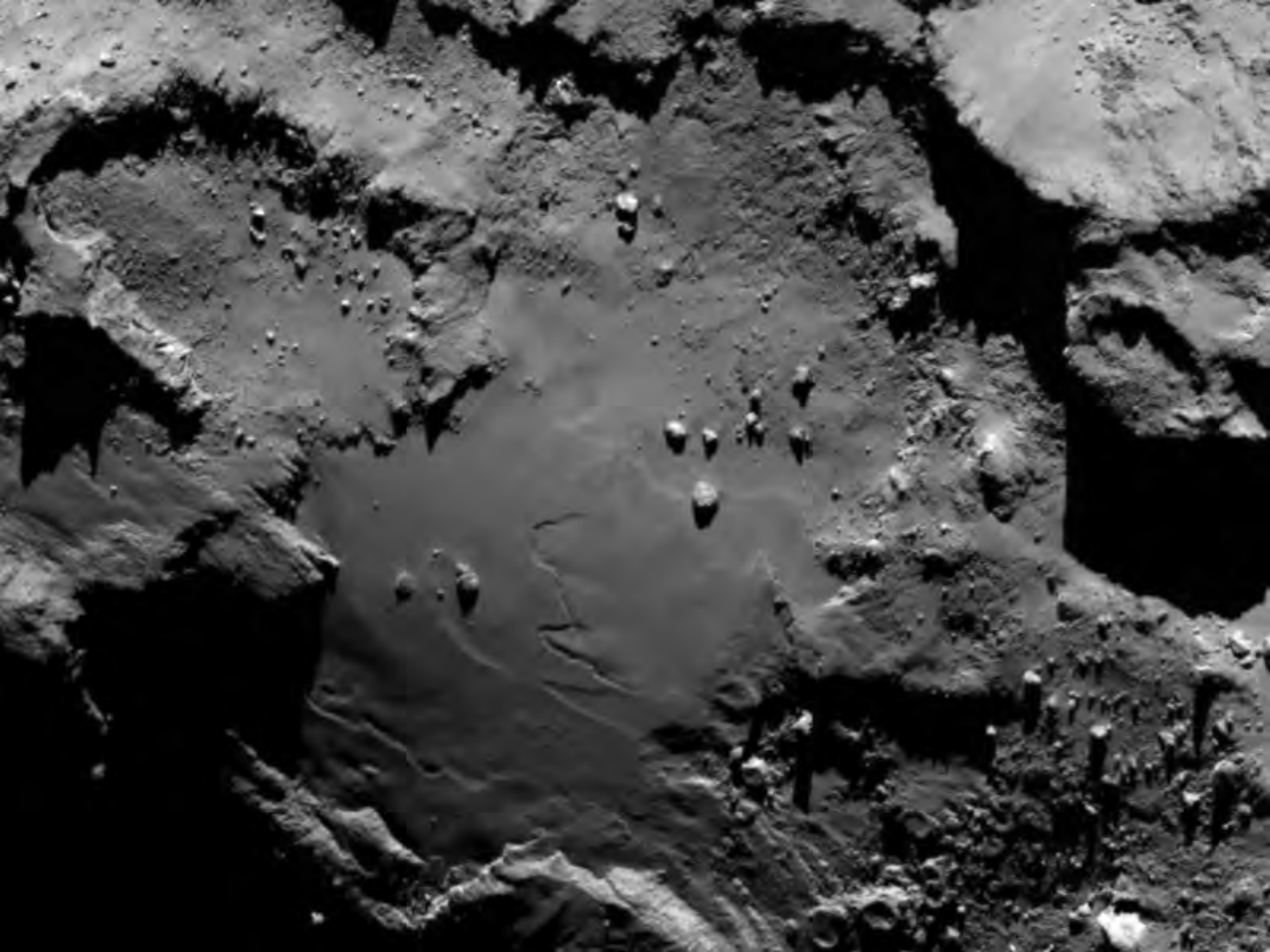


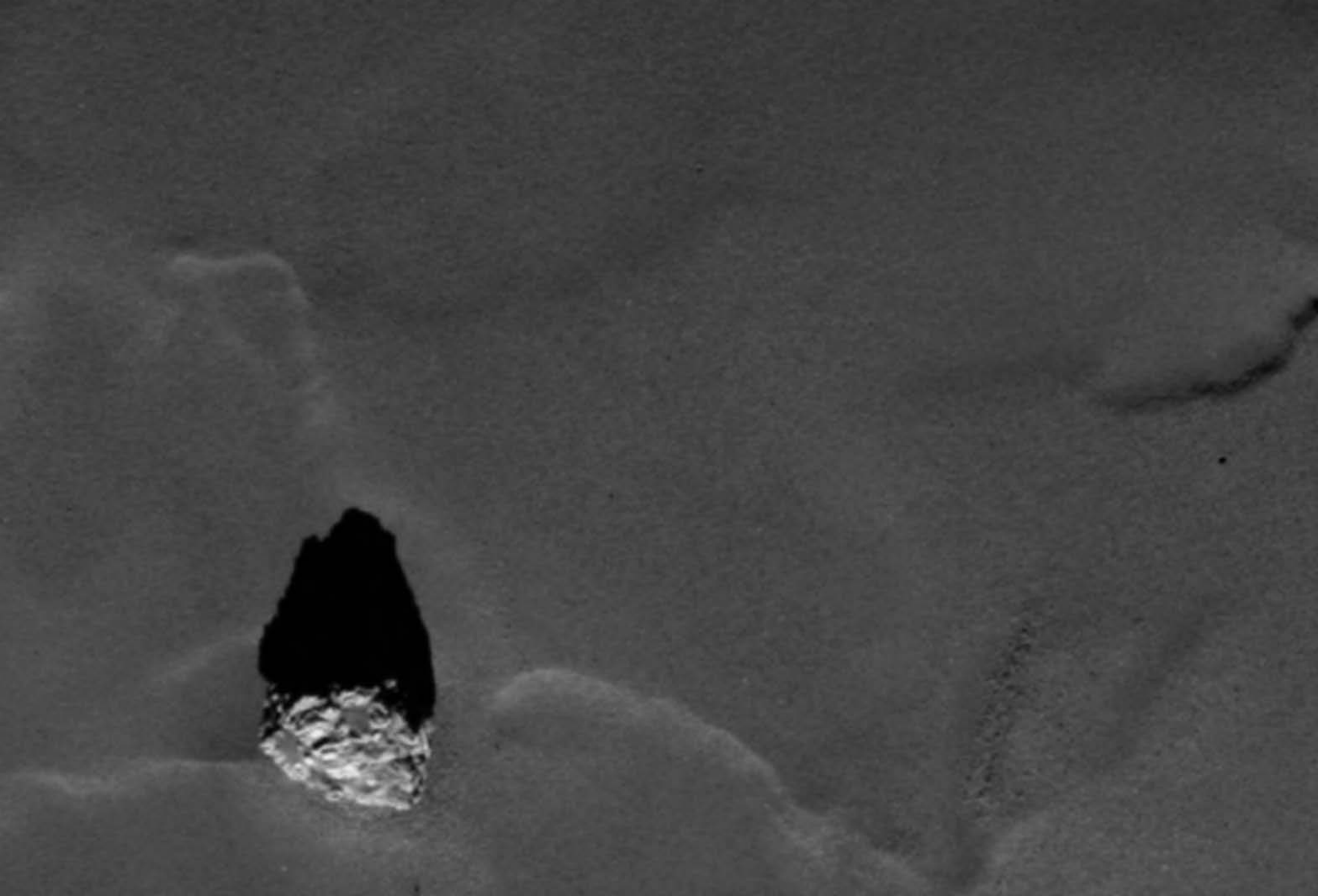


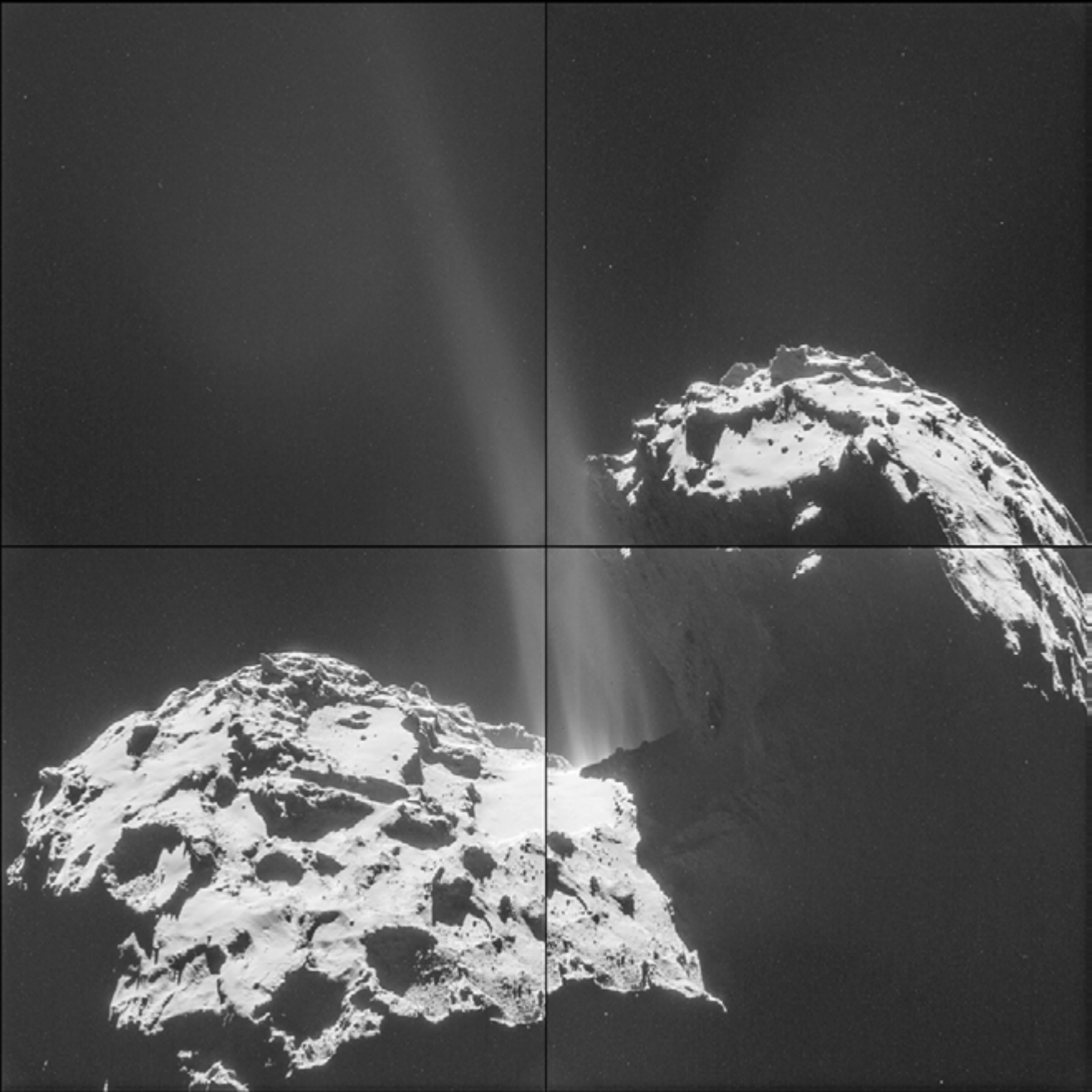
ESA/Rosetta/NAVCAM/Damia Bouic

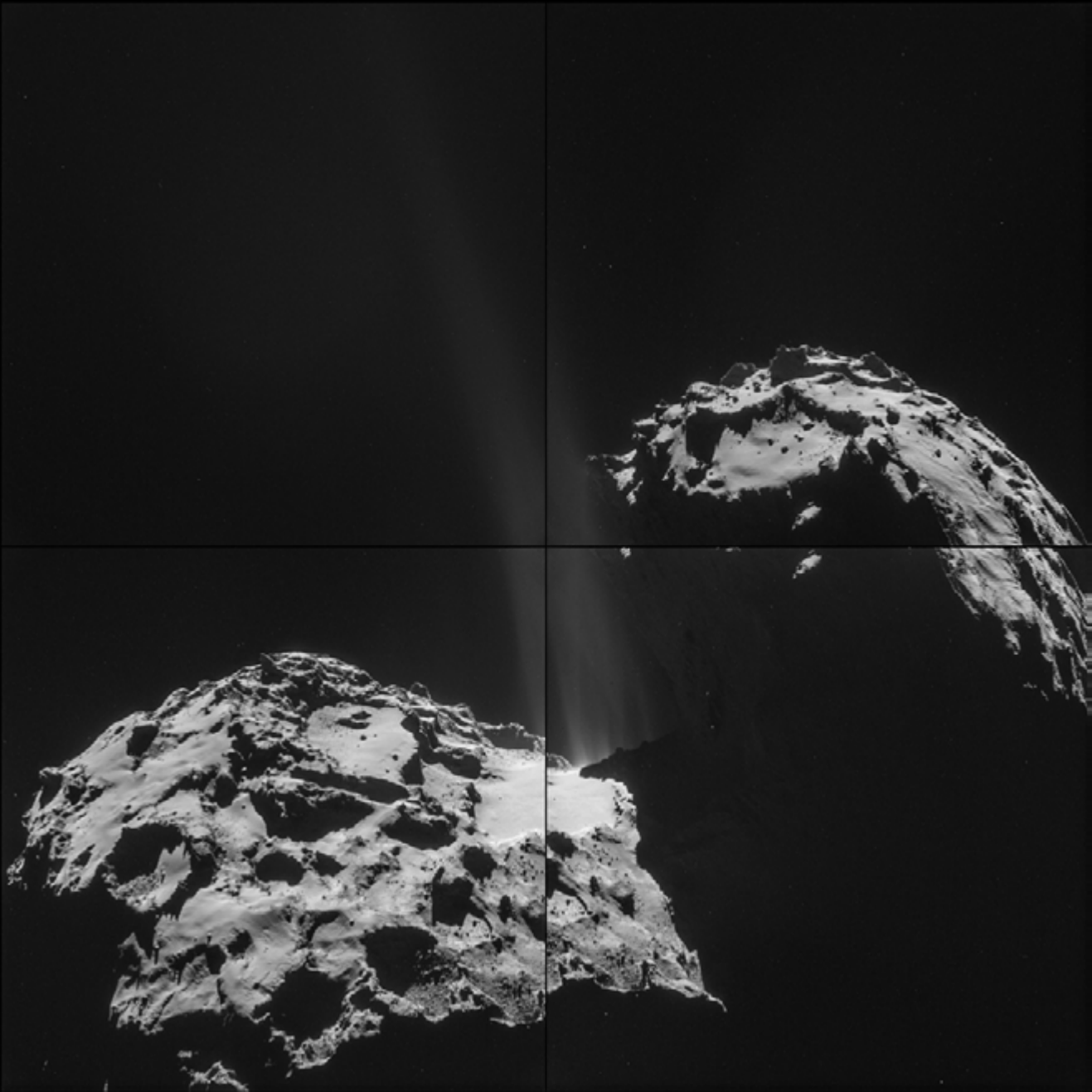


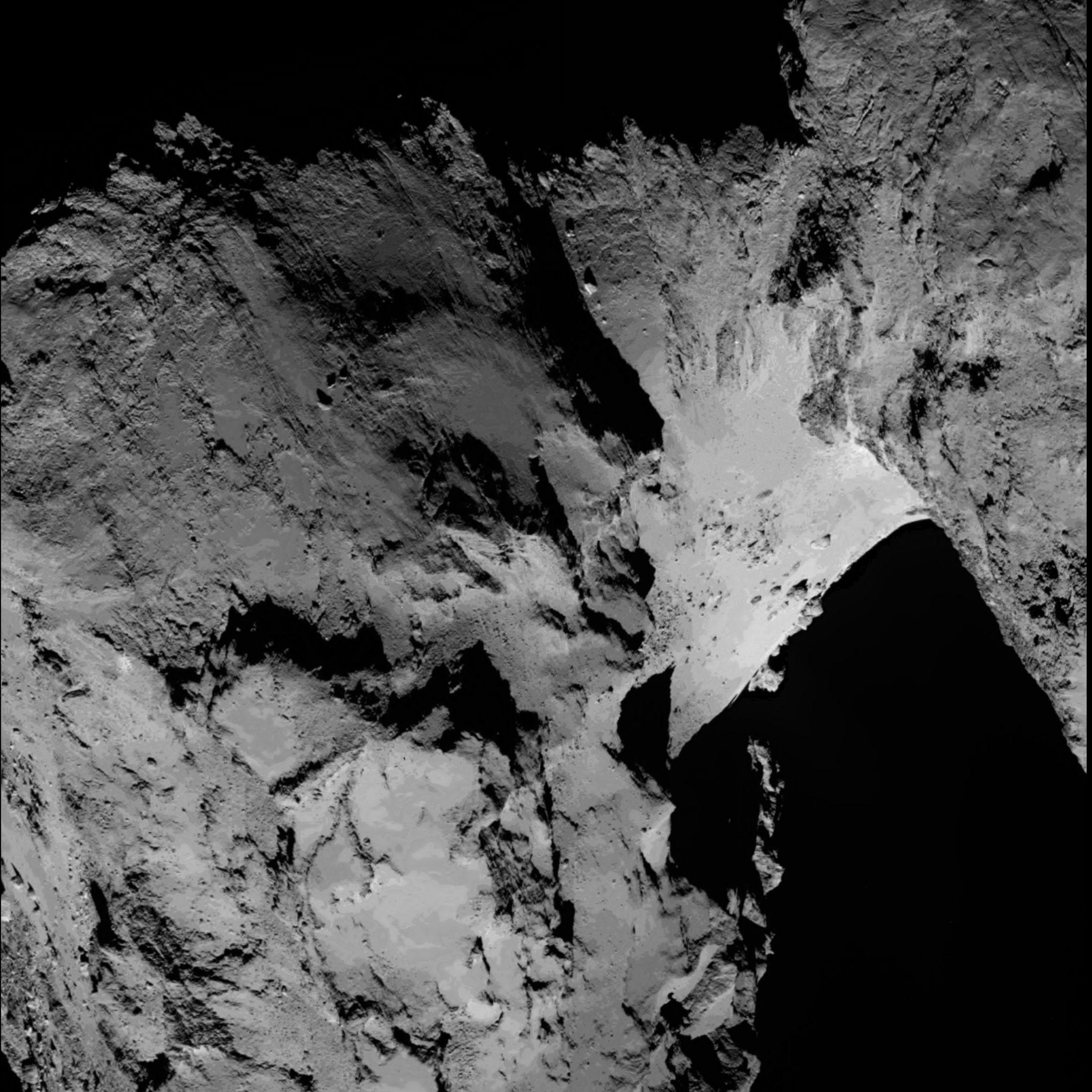

Ma’at
Hathor
Aten
Aker
Ash
Khepry
Imhotep
Atum



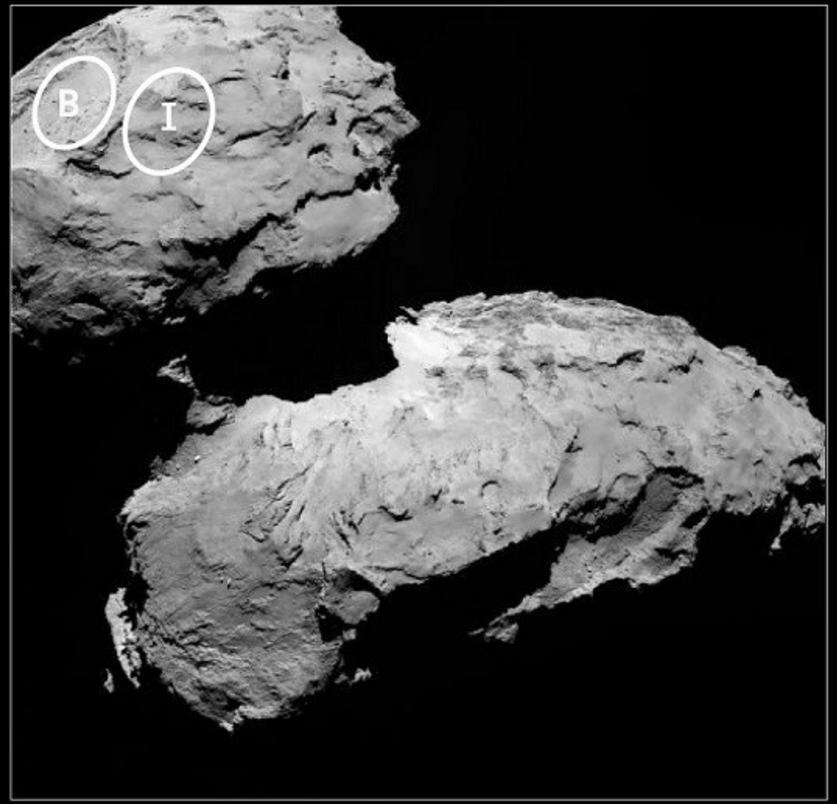


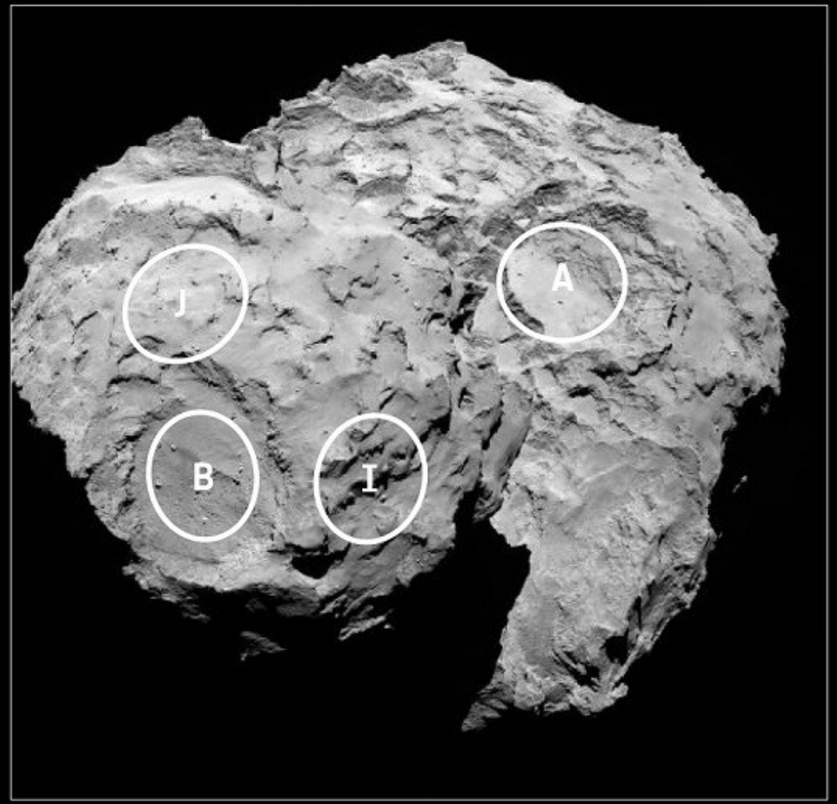


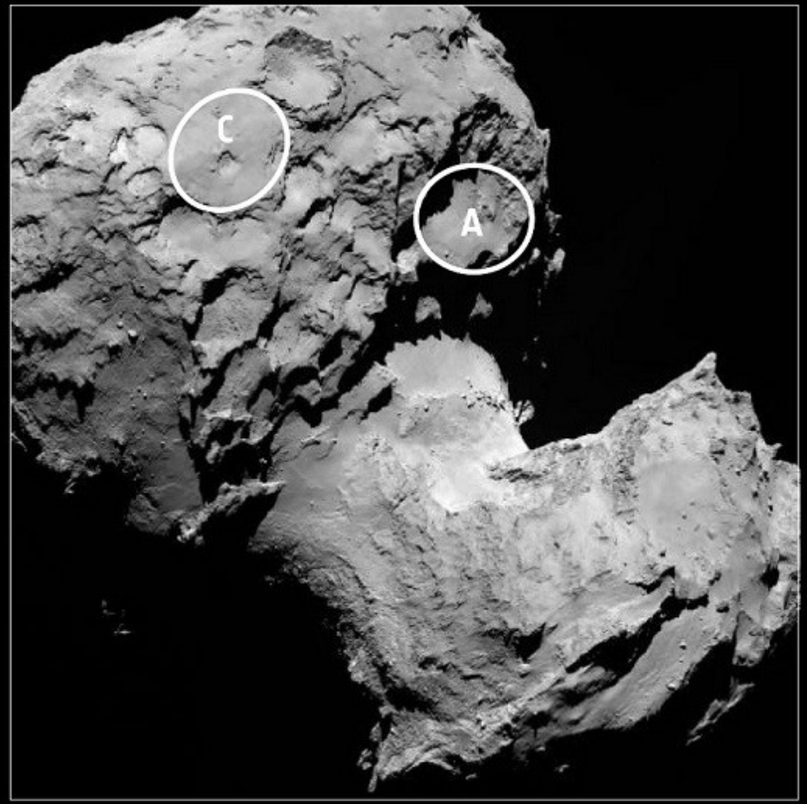




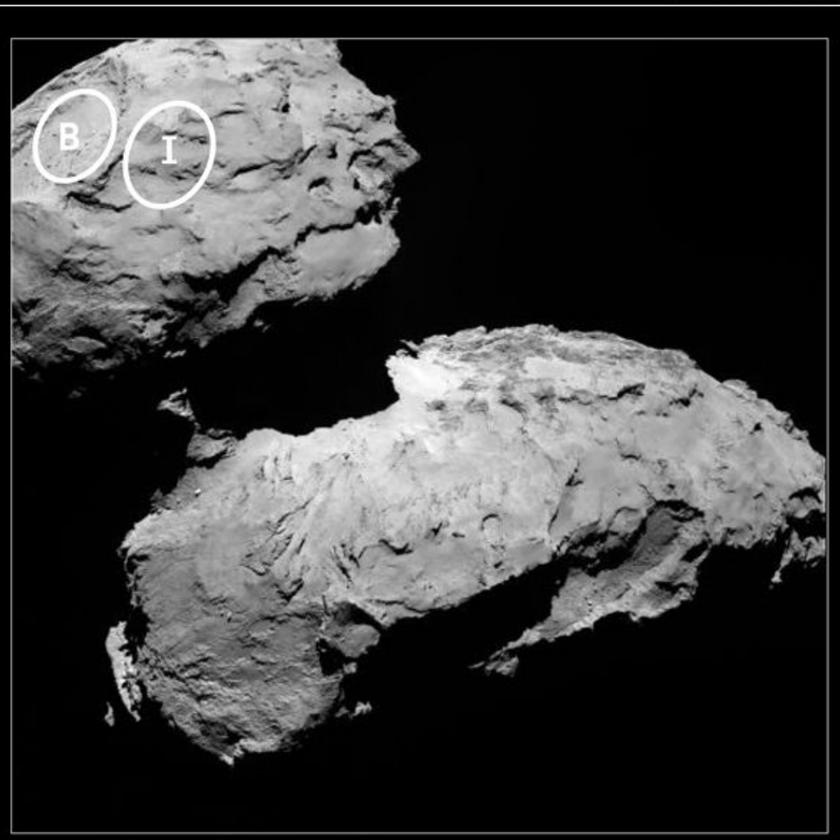
Landing Sites

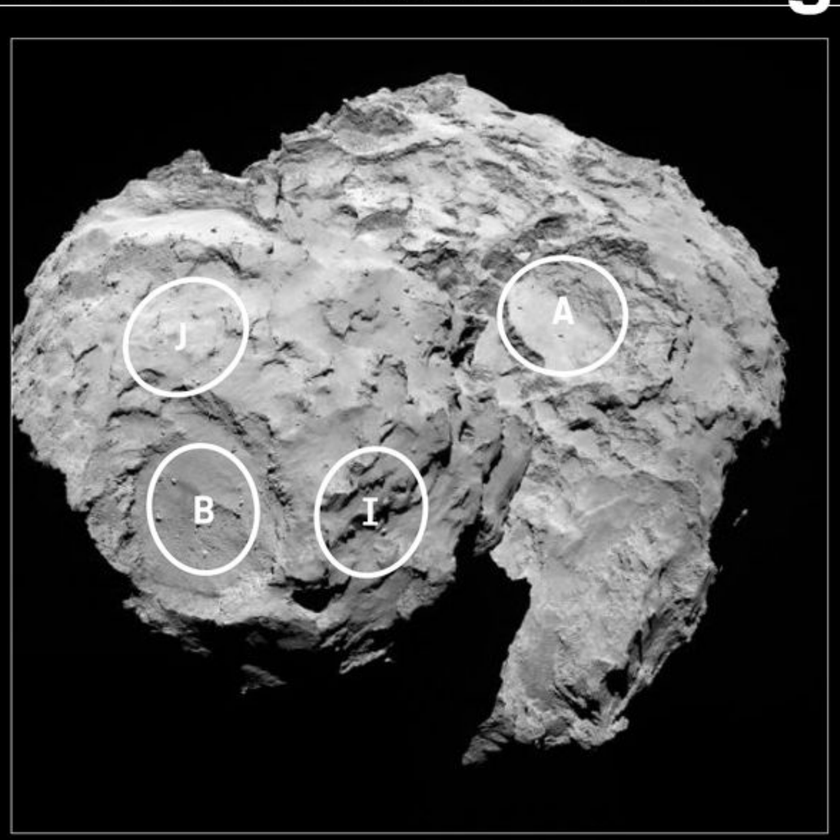

B
I


J
A
B
I

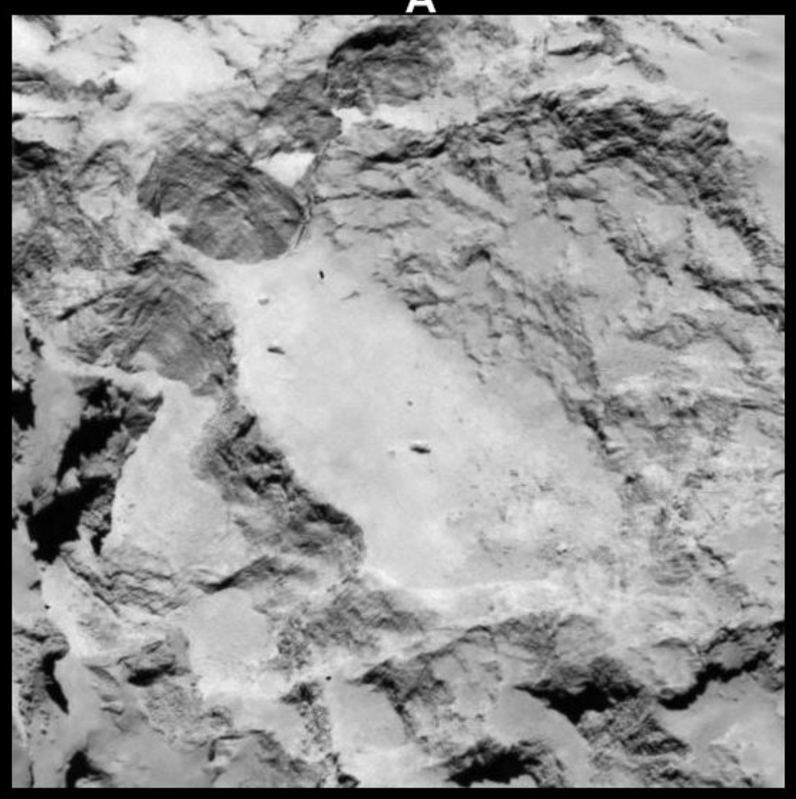

C
A

Philae candidate landing sites

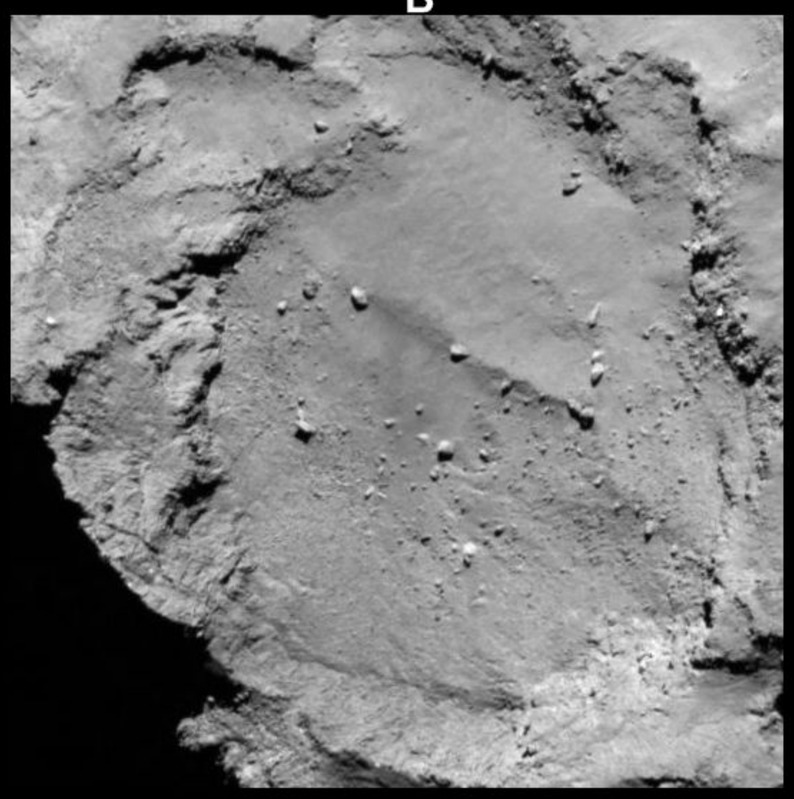




A



B



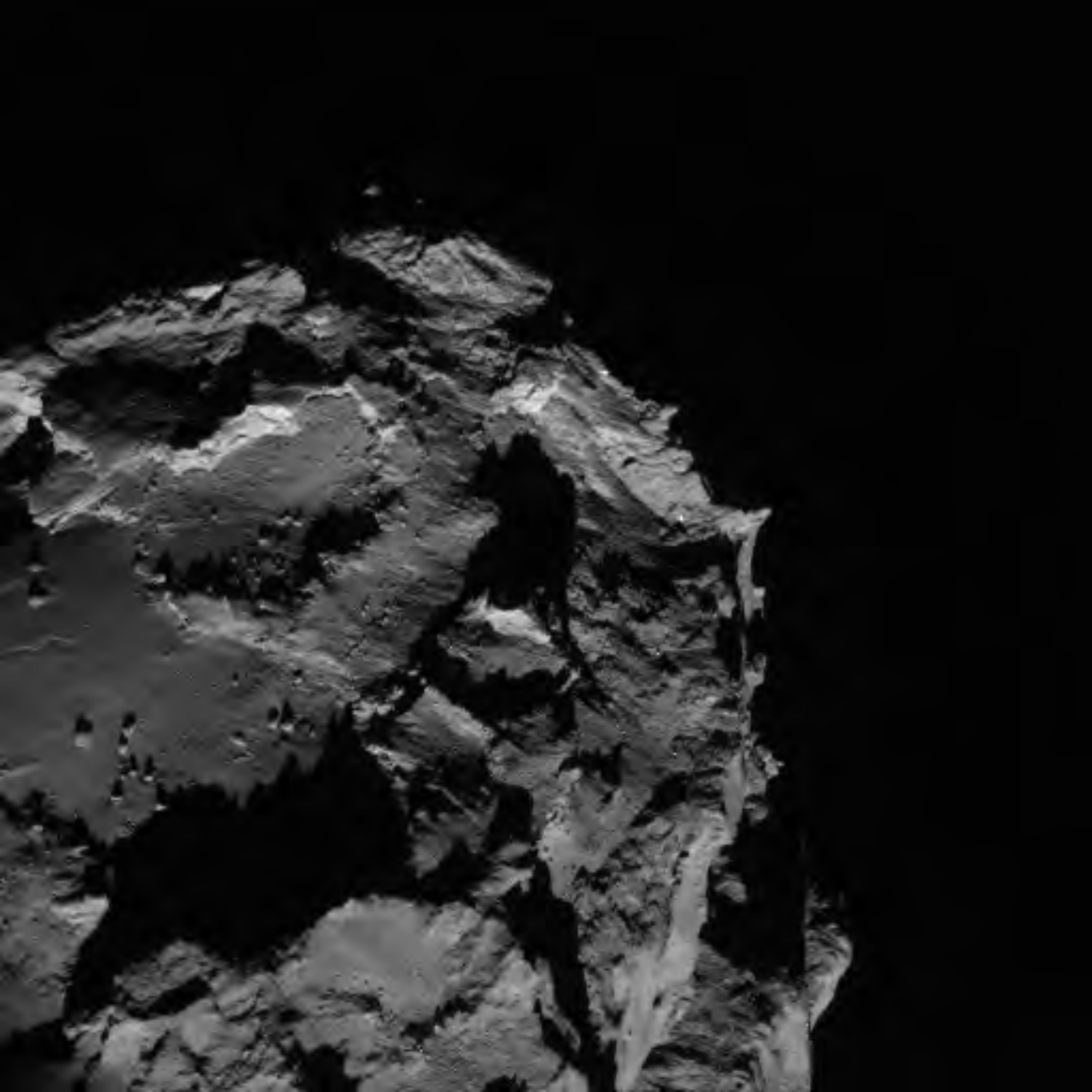
C

I

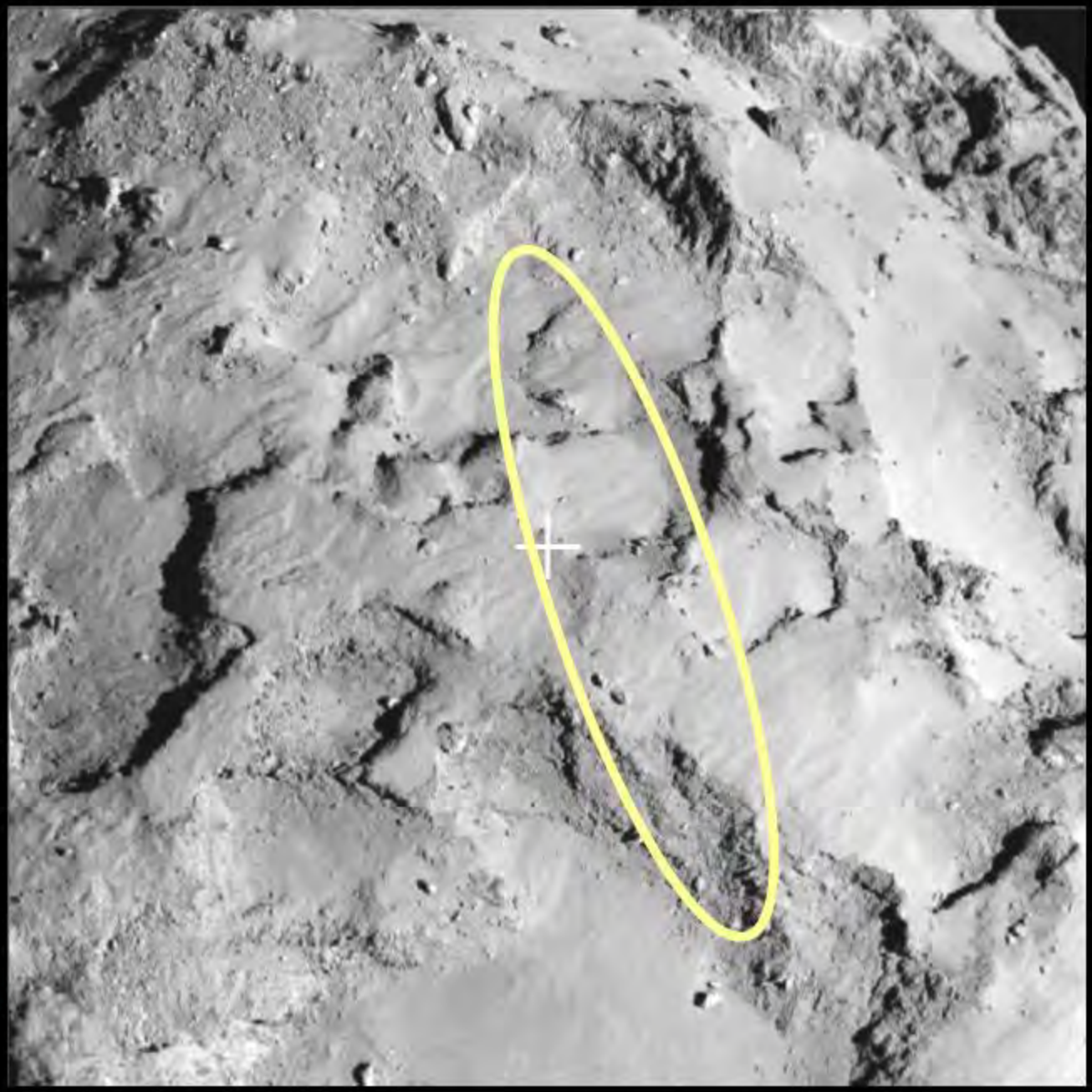
J

1 km

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



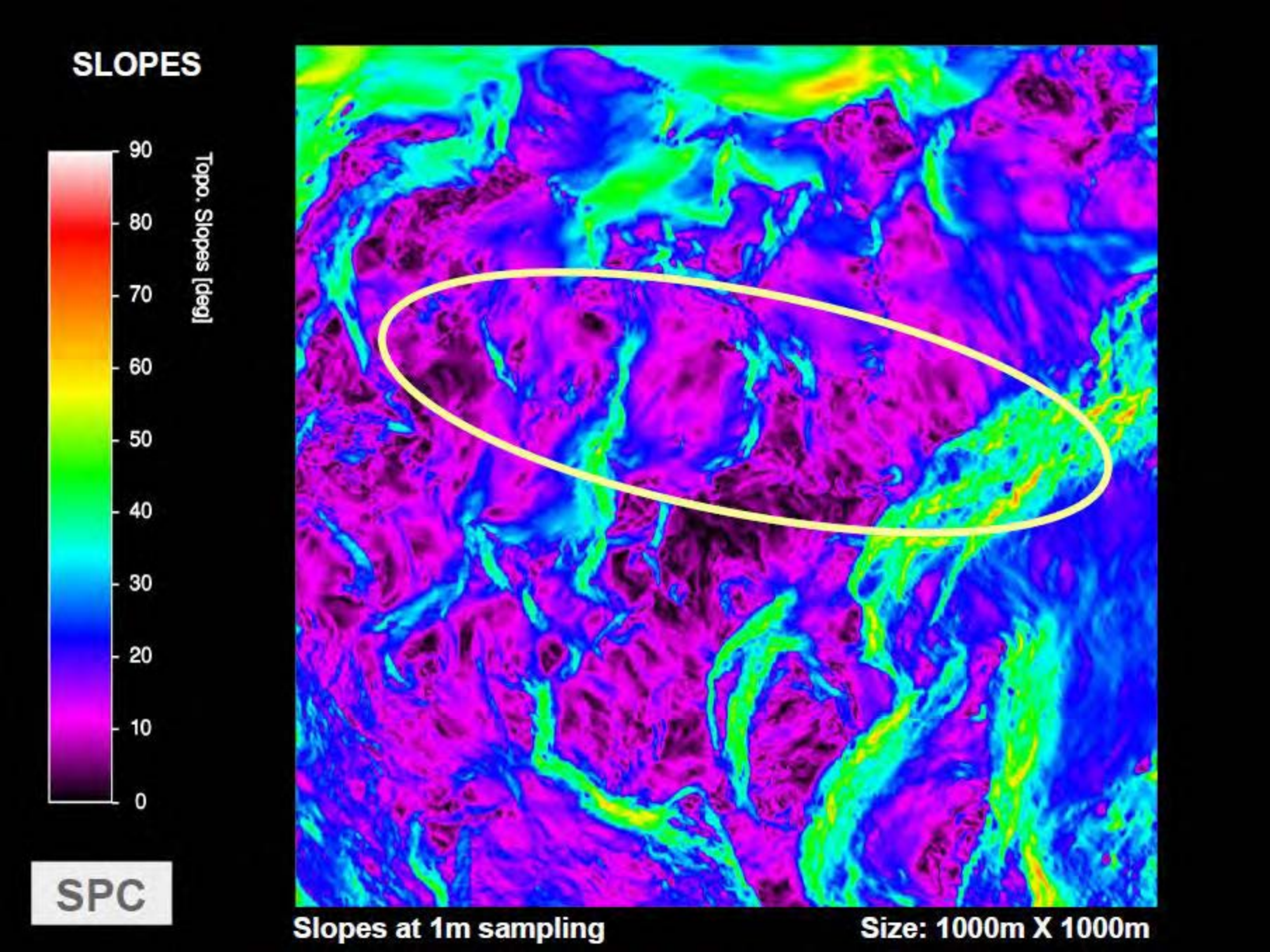
IMAGE

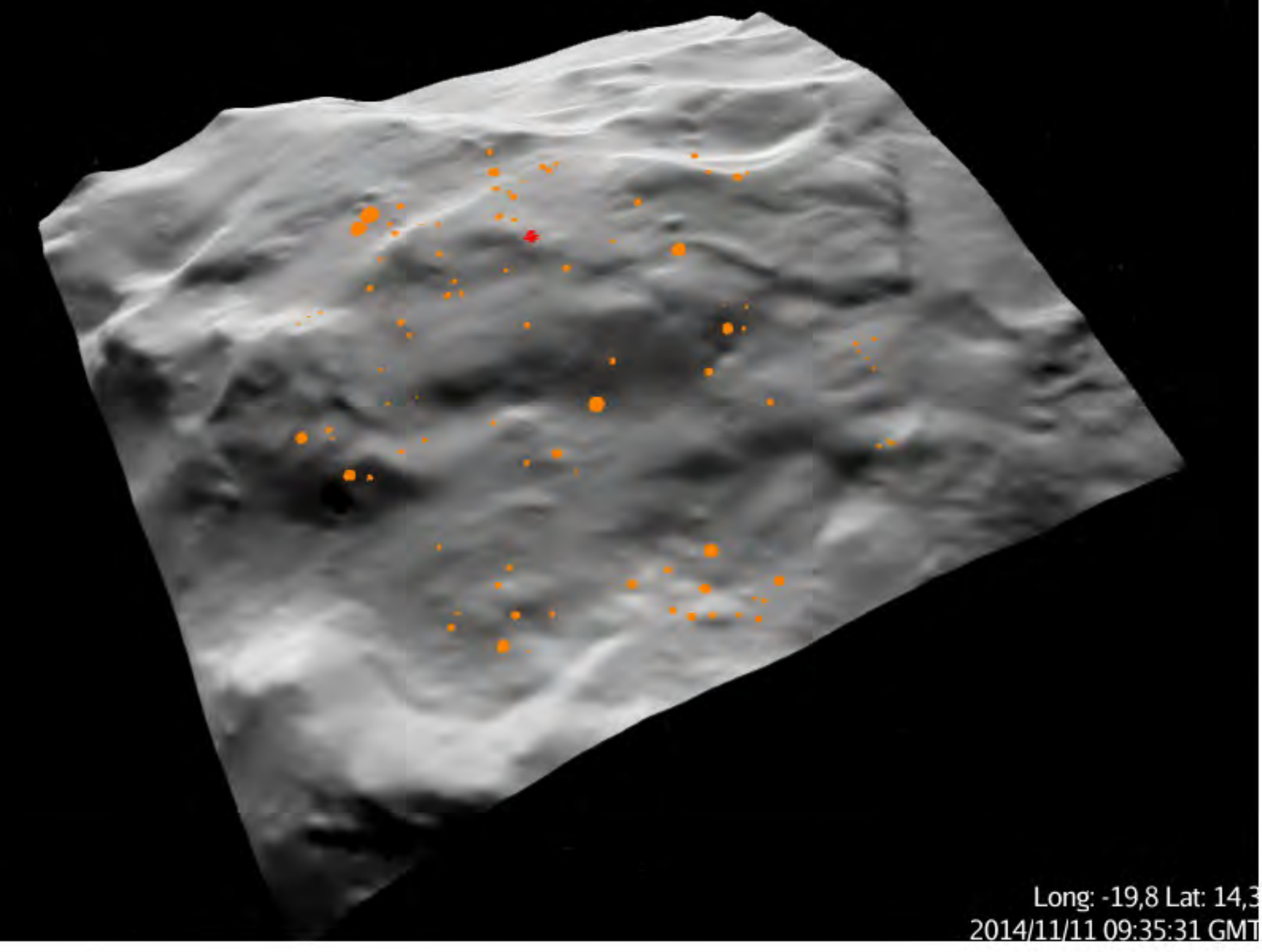


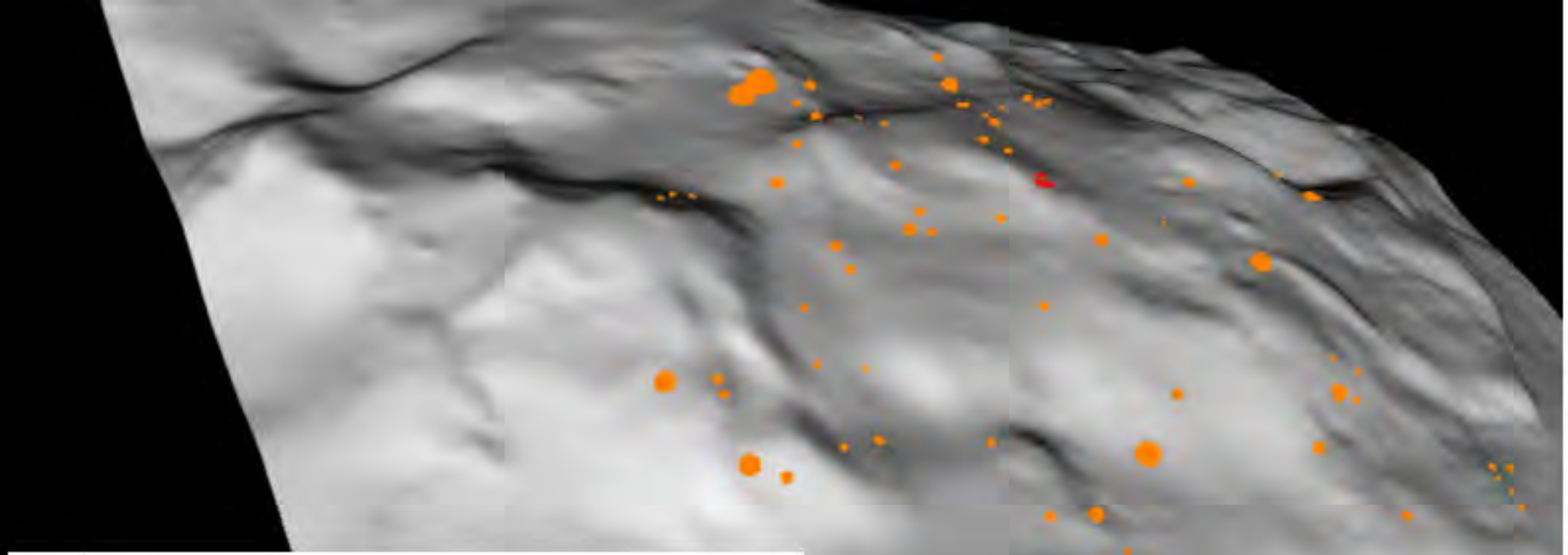
Phase = 42°

Scale = 1.28m/px

Side = 1280 m


SLOPES
90
80
70
60
50
40
30
20
10
0
Topo. Slopes [deg]
SPC
Slopes at 1m sampling
Size: 1000m X 1000m


Long: -19,8 Lat: 14,3
2014/11/11 09:35:31 GMT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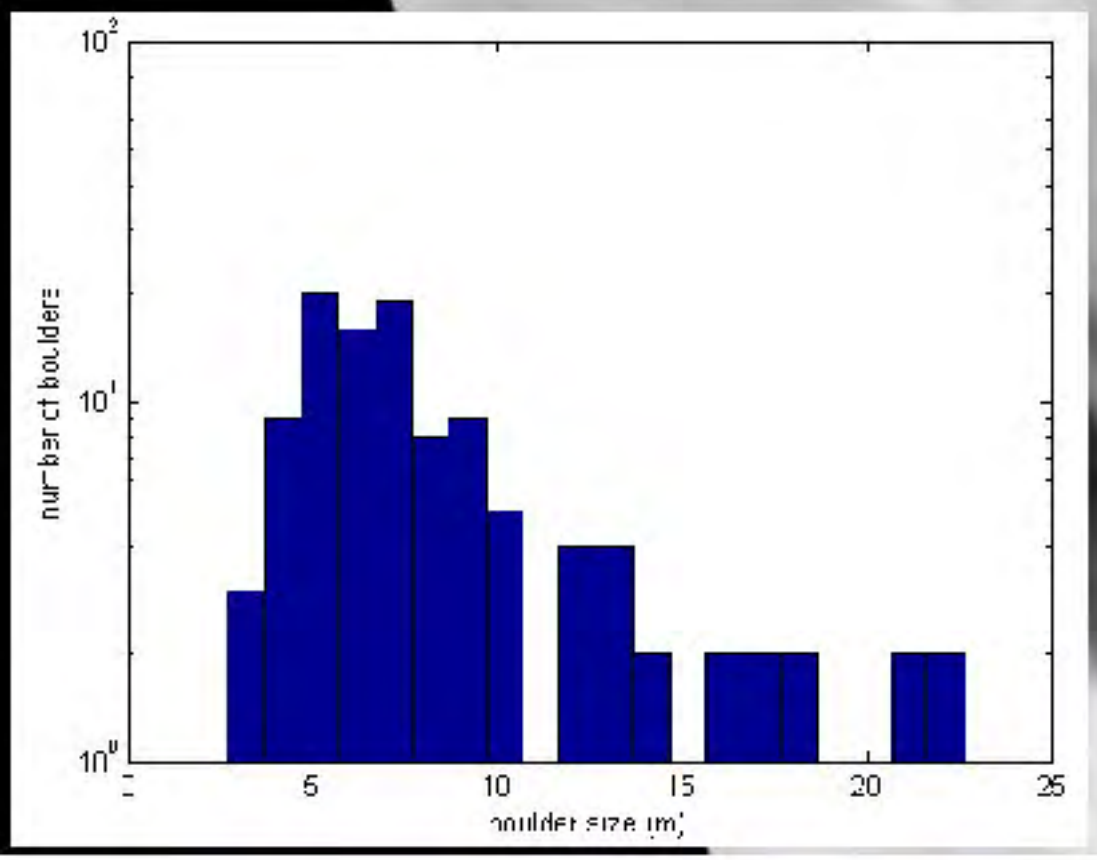
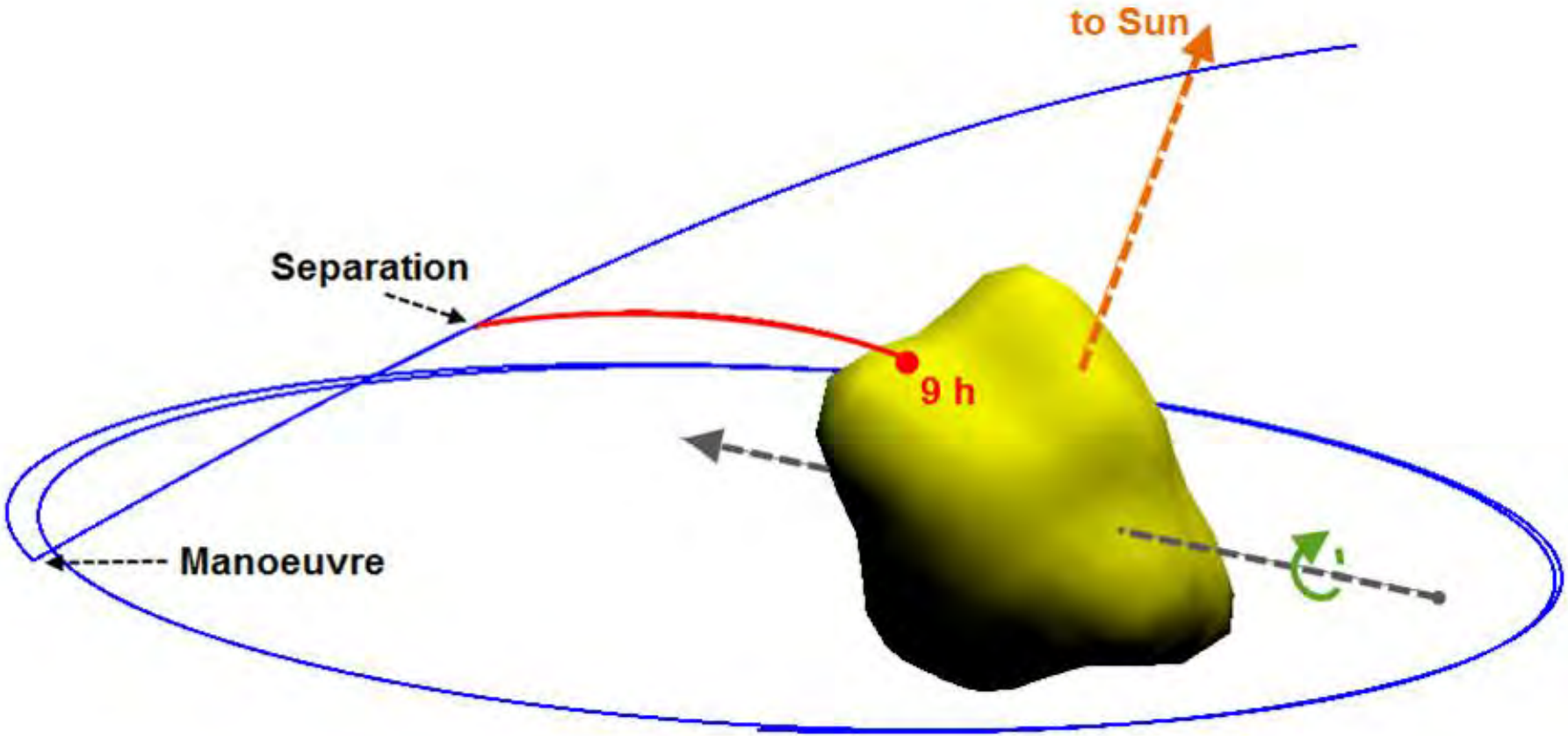
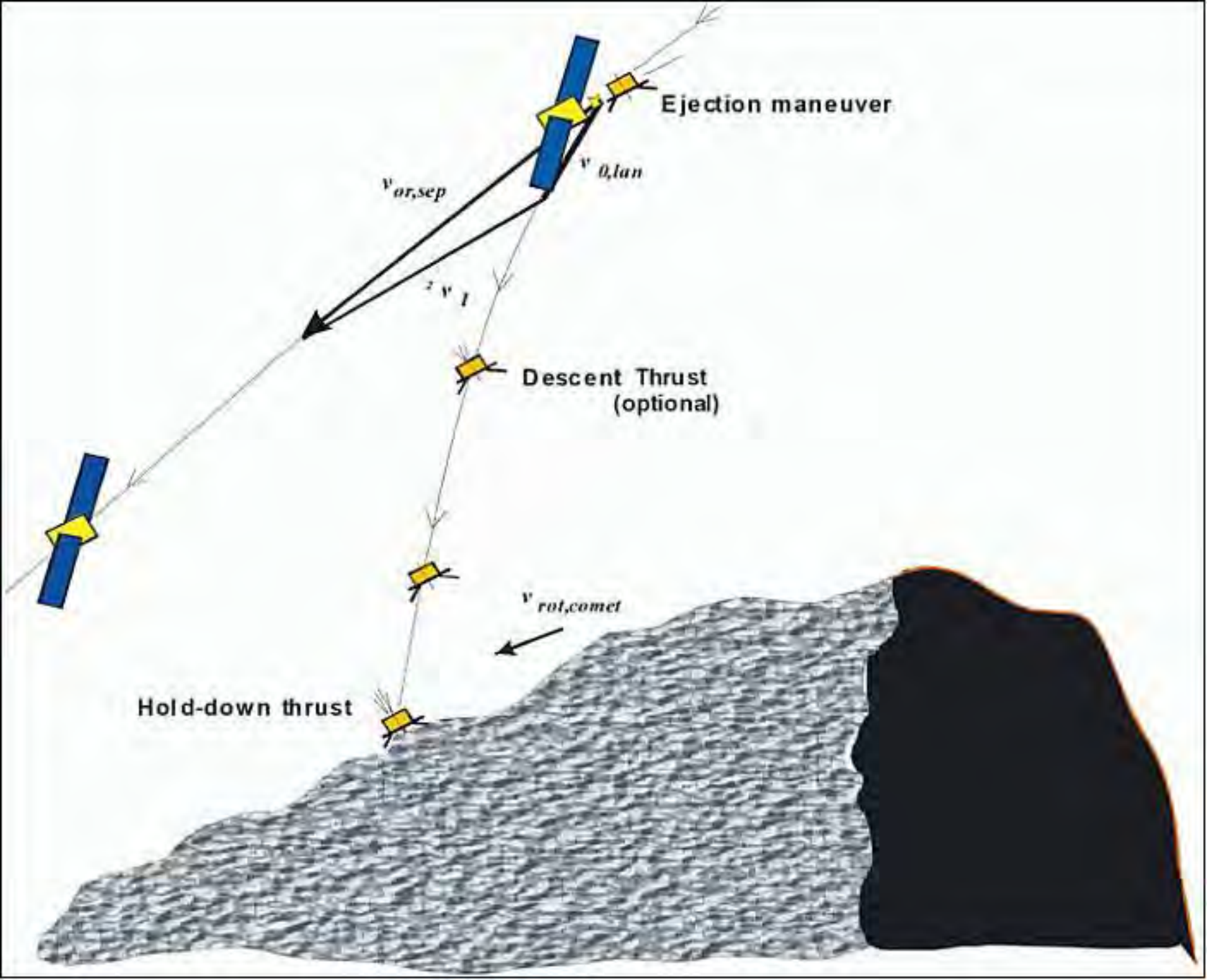
2014/11/11 05:24:00 GMT

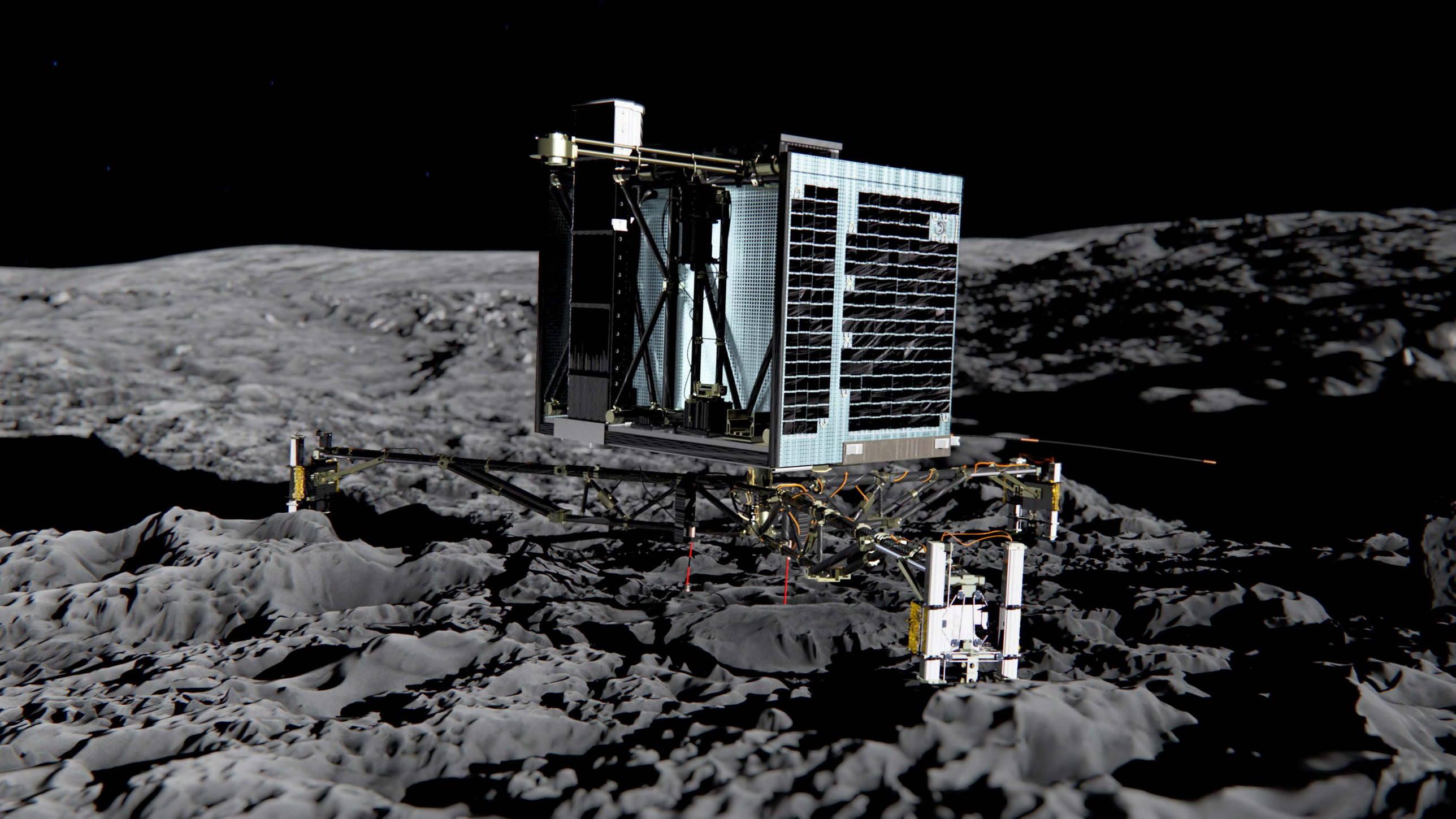

10^2
10^1
10^0
number of boulders
5
10
15
20
25

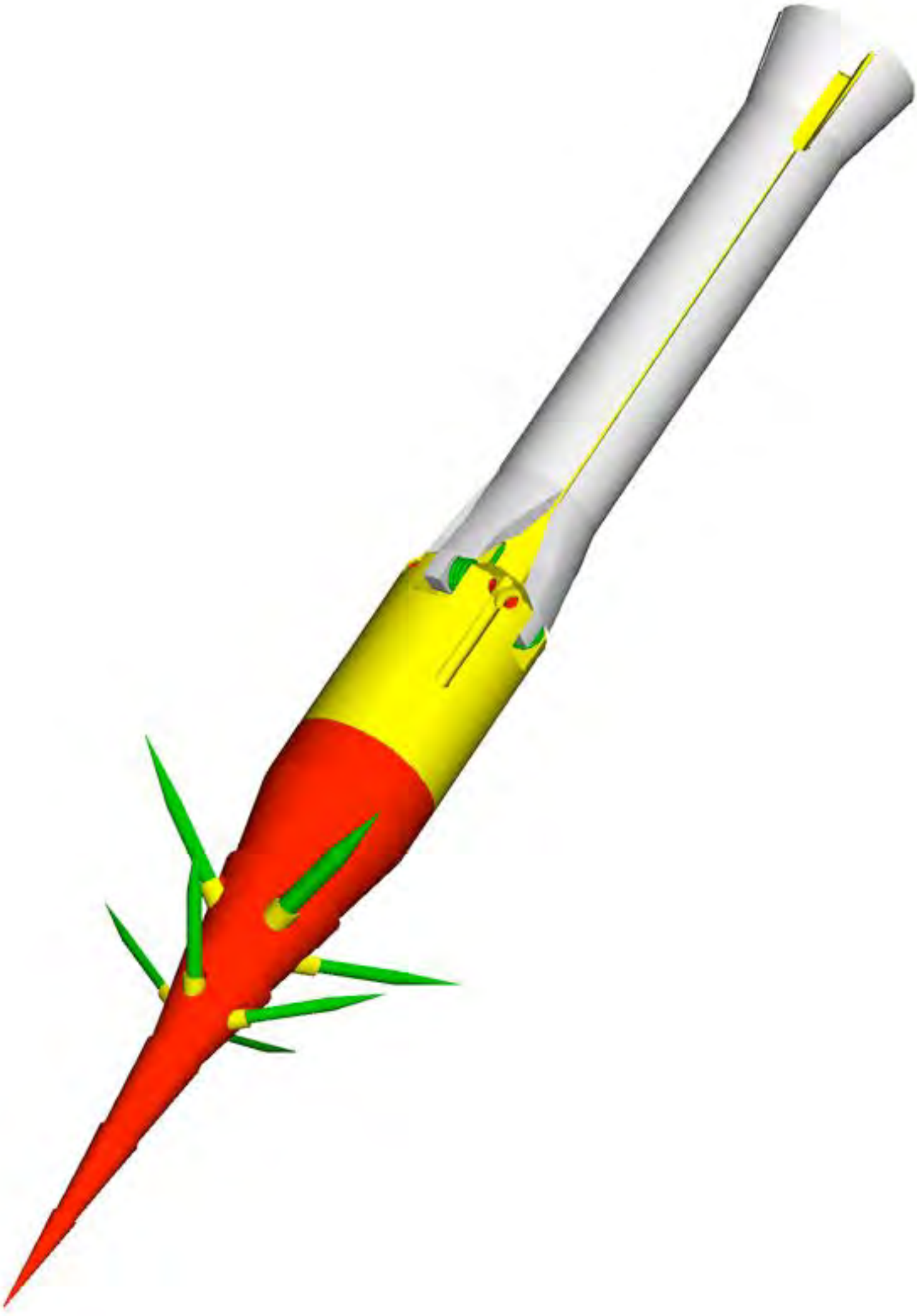
Go for Landing


to Sun
Separation
9 h
Manoeuvre

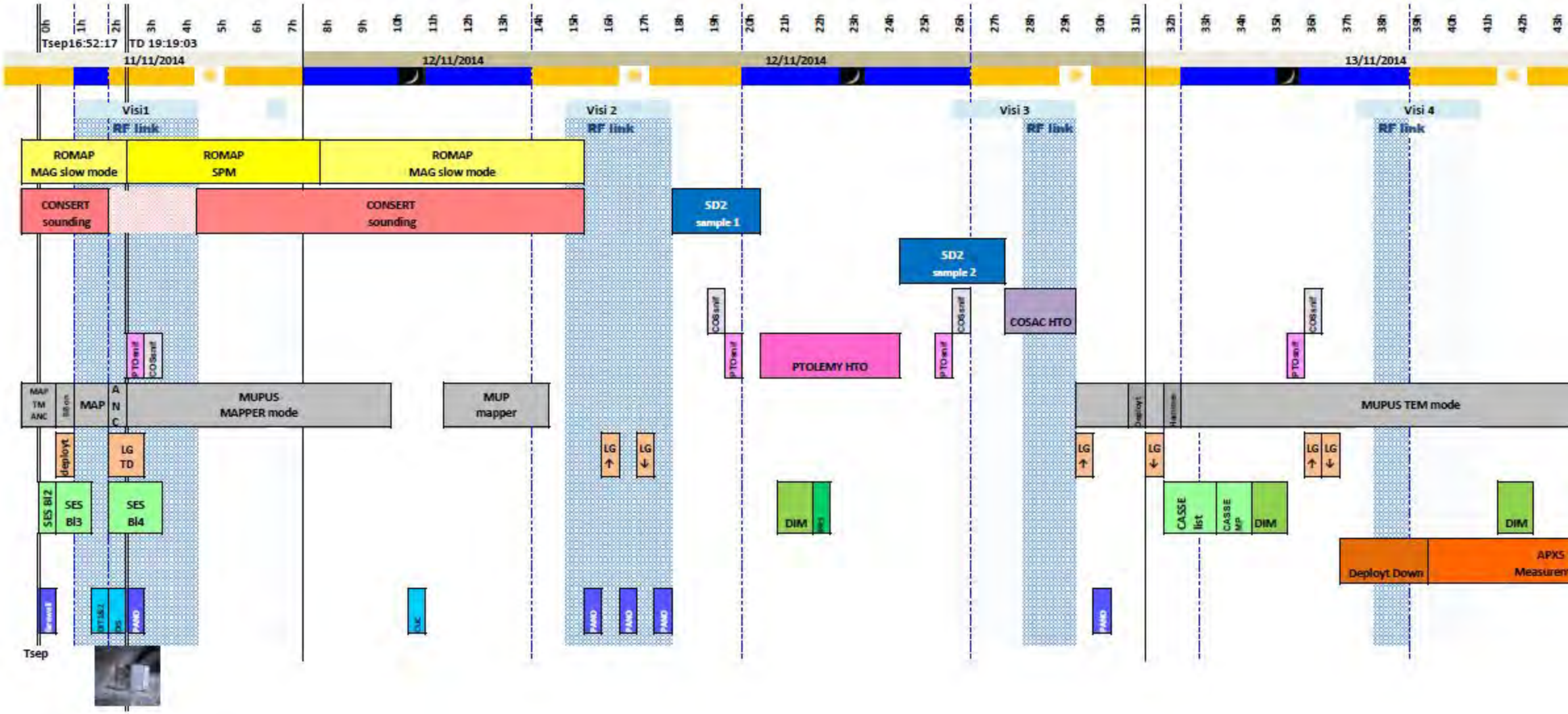

Ejection maneuver
$v_{0,lan}$
$v_{or,sep}$
$^{2}v_{1}$
Descent Thrust
(optional)
$v_{rot,comet}$
Hold-down thrust

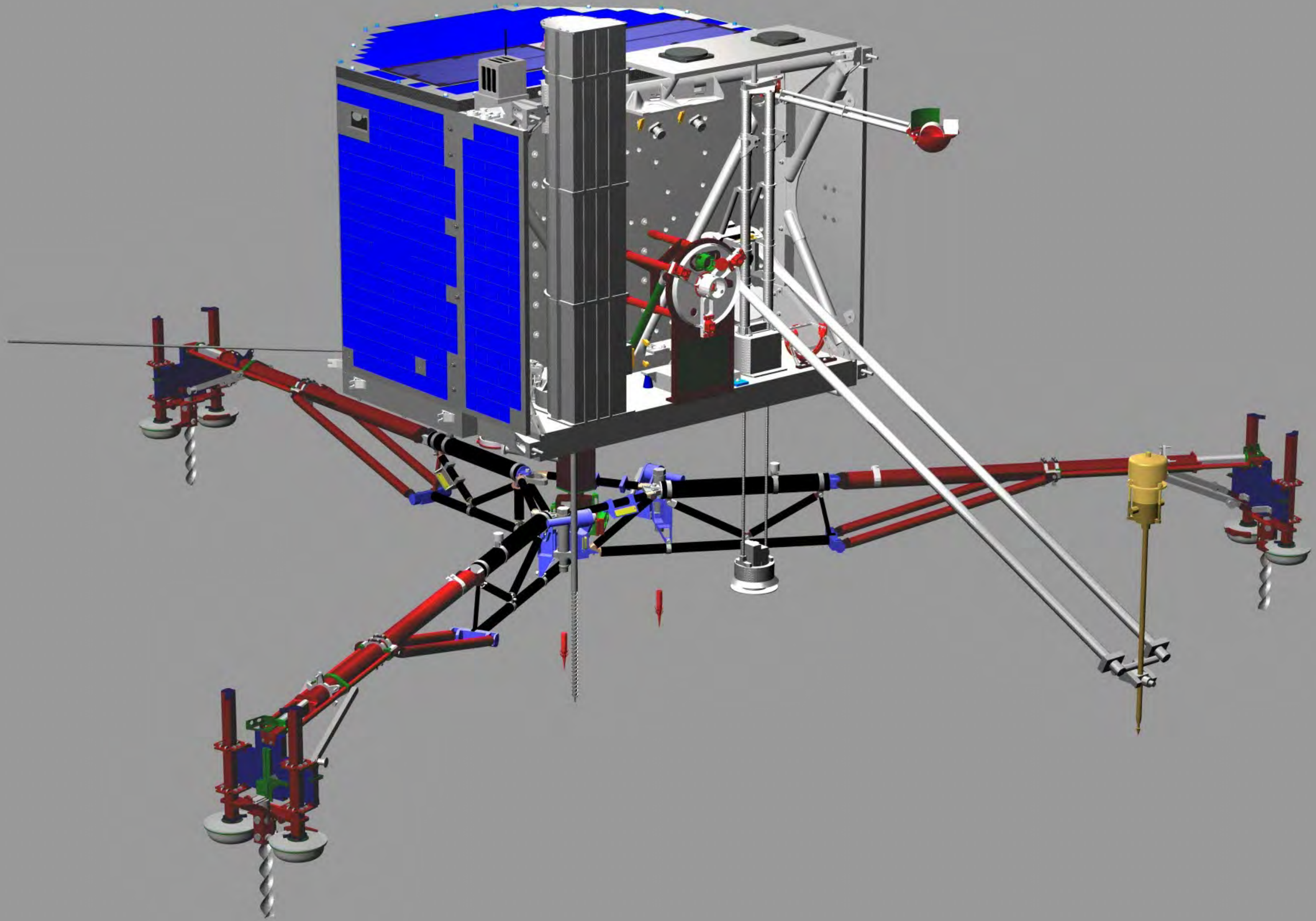
Credit: ESA/ATG medialab

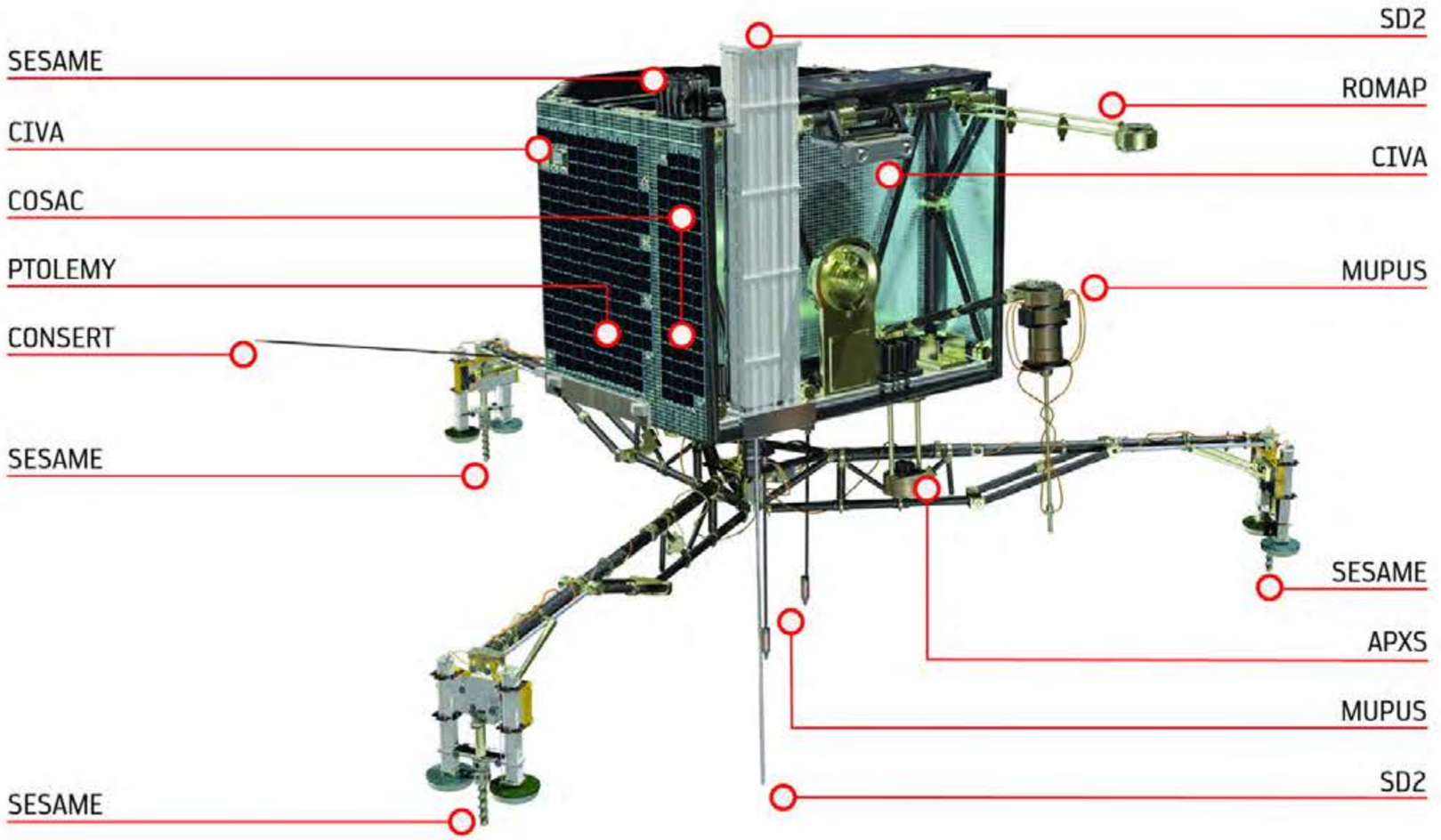




First Science Sequence


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
PTOself
COSself
PTOLEMY HTO
MAP TM ANC
MAP
MUPUS MAPPER mode
MUP mapper
MUPUS TEM mode
deployt
LG TD
LG
SES BI2
SES BI3
SES BI4
DIM
CASSE list
CASSE MP
Deployt Down
APXS
Tsep




SESAME
CIVA
COSAC
PTOLEMY
CONSERT
SESAME
SESAME
SD2
ROMAP
CIVA
MUPUS
SESAME
APXS
MUPUS
SD2


Drill (SD²)
SESAME sensor
CIVA camera
CIVA camera
CIVA camera
CIVA camera
ADS
COSAC
Batteries
Flywheel
TxRx
PTOLEMY
COSAC
CONSERT antenna
CONSERT antenna

CIVAP6

CIVAP7

CIVAP1

CIVAP2

CIVAP3

CIVAP4

CIVAP5

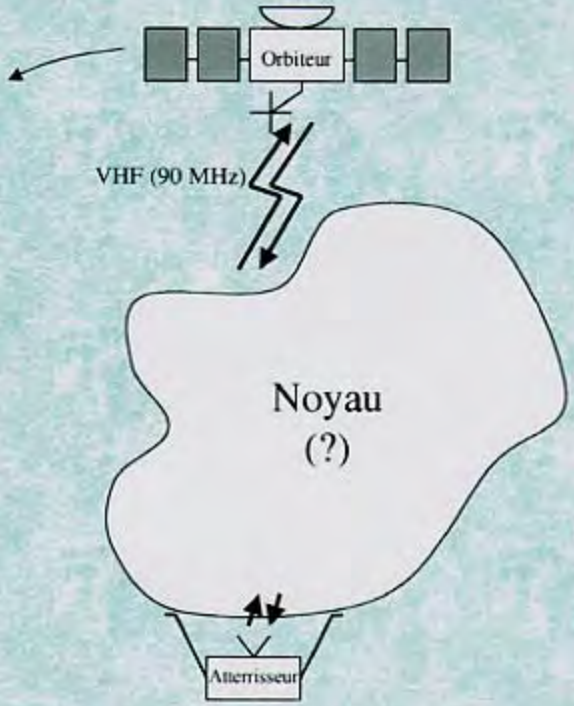
Long: -4,6 Lat: 5,2
2014/10/20 05:32:38 GMT

Molécule	1P/Halley	C/1995 O1 Hale-Bopp	C/1996 B2 Hyakutake	153P/2002 C1 Ikeya-Zhang	Domaine de détection
H_2O	100	100	100	100	IR
CO	3.5-11	12-23	14-30	2,4-5	Radio, IR, UV
CO_2	3-4	6			IR
CH_4	0.8	1.5	0.8	0.5	IR
C_2H_2	0.3	0.1 – 0.3	0.2-0.5	0.18	IR
C_2H_6	0.4	0.6	0.6	0.62	IR
CH_3OH	1.8	2.4	2	2.5	Radio, IR
H_2CO	4	1.1	1	0.4	Radio, IR
HCOOH		0.09		0.1	Radio
$HCOOCH_3$		0.08			Radio
CH_3CHO		0.02			Radio
NH_2CHO		0.015			Radio
$HOCH_2CH_2OH$		0.25			Radio
NH_3	1.5	0.7	0.5	<0.2	Radio, IR
HCN	0.1	0.25	0.1-0.2	0.1-0.2	Radio, IR
HNCO		0.1	0.07	0.04	Radio
HNC		0.04	0.01	0.005	Radio
CH_3CN		0.02	0.01	0.01	Radio
HC_3N		0.02		<0.01	Radio
H_2S	0.4	1.5	0.8	0.8	Radio
OCS		0.4	0.1	<0.2	Radio, IR
SO_2		0.2			Radio
H_2CS		0.05			Radio
S_2			0.005	0.004	UV

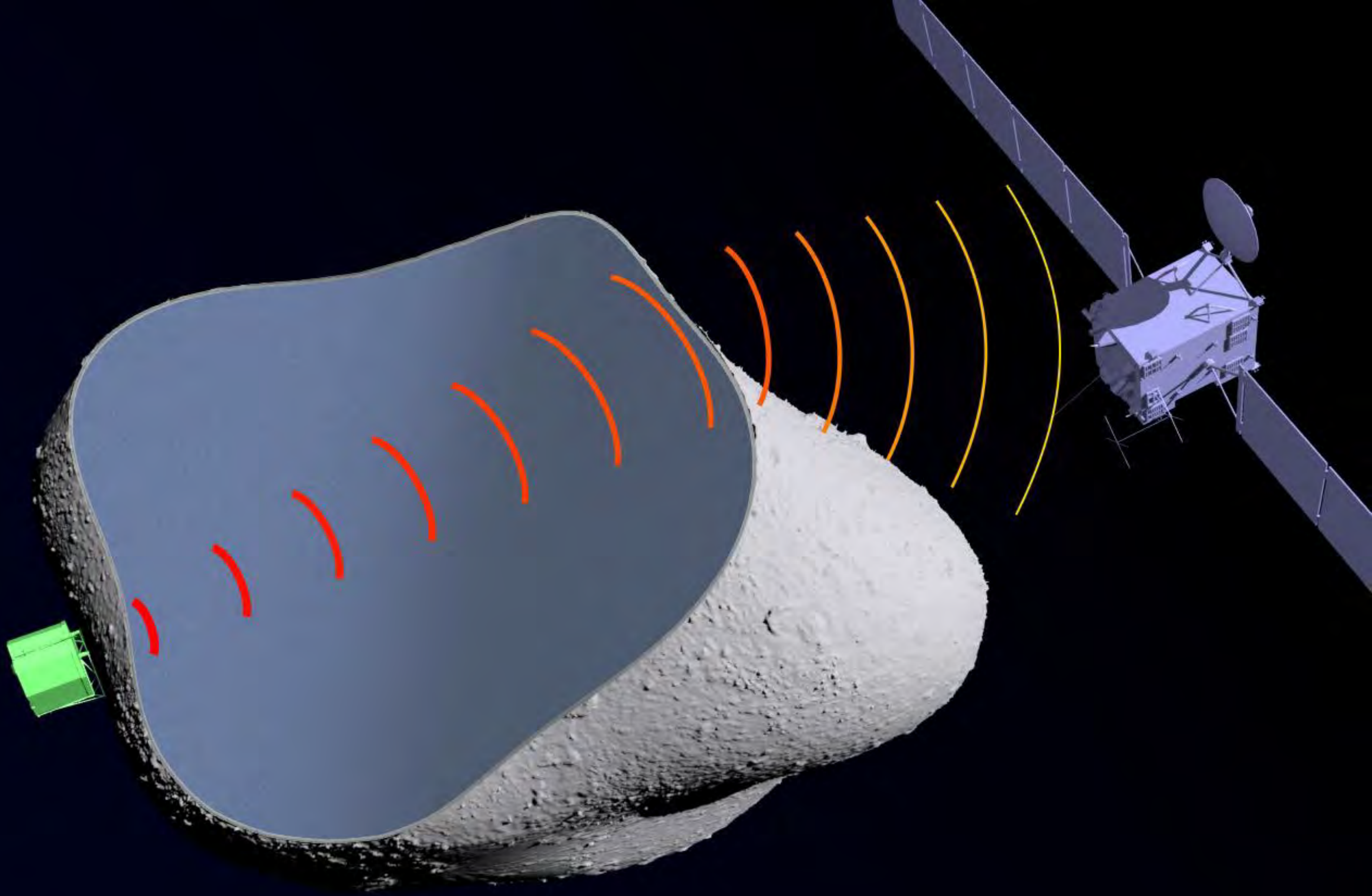
Abondances par rapport à H_2O

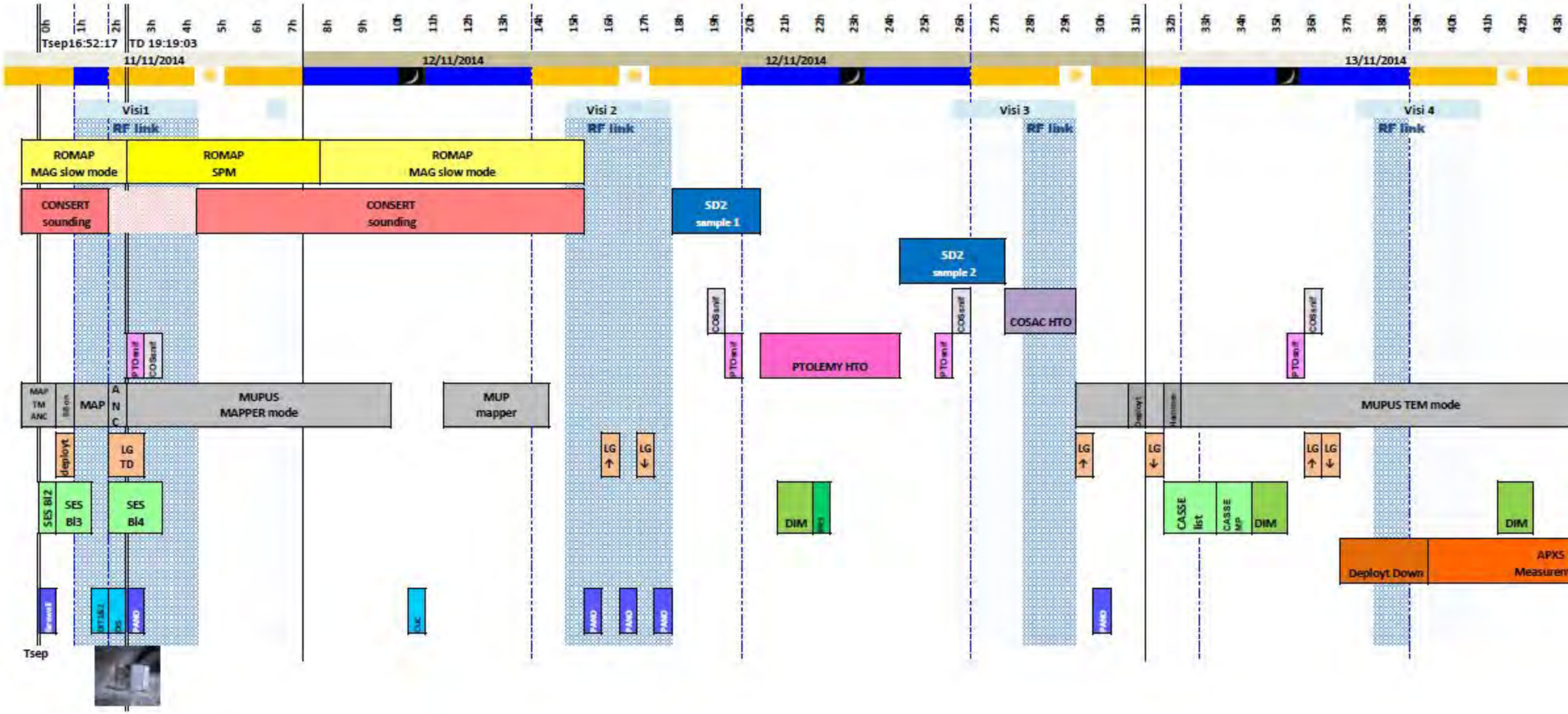
CONSERT

(Comet Nucleus Sounding Experiment by Radiowave Transmission)



Mesures de déphasage et d'atténuation → Permittivité interne du noyau → Structure et composition du noyau




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
PTOself
COSself
PTOLEMY HTO
MAP TM ANC
MAP
MUPUS MAPPER mode
MUP mapper
MUPUS TEM mode
deployt
LG TD
LG
SES BI2
SES BI3
SES BI4
DIM
CASSE list
CASSE MP
Deployt Down
APXS
Tsep