A. KUIPER

Chasing a comet with the ESA Rosetta mission

…on behalf of all the Rosetta teams

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

Press Confer
Vienna | Austria | 12 – 17 April 20

The non-magnetic nucleus
of comet
Churyumov-Gerasimenko
IGEP

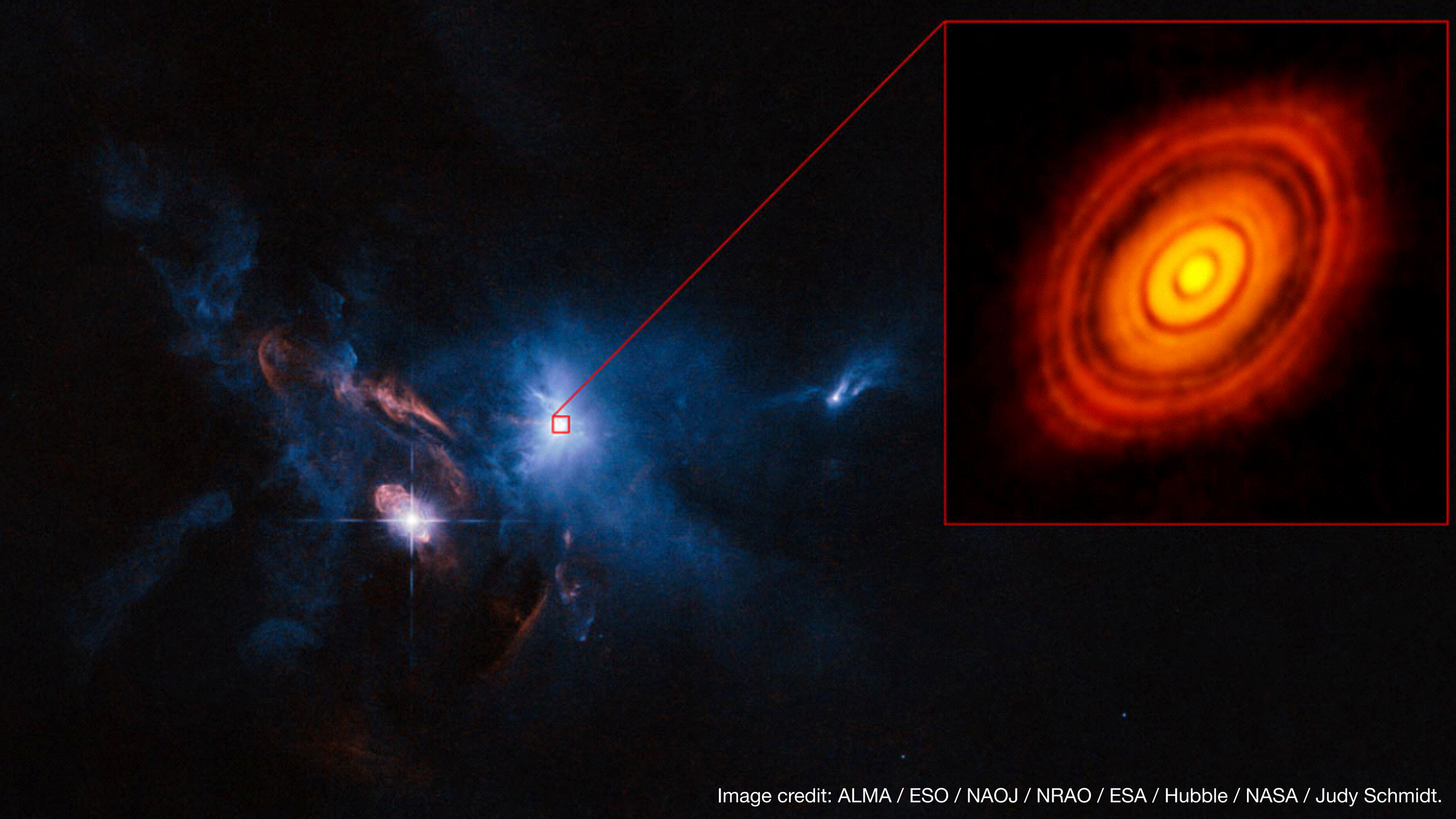
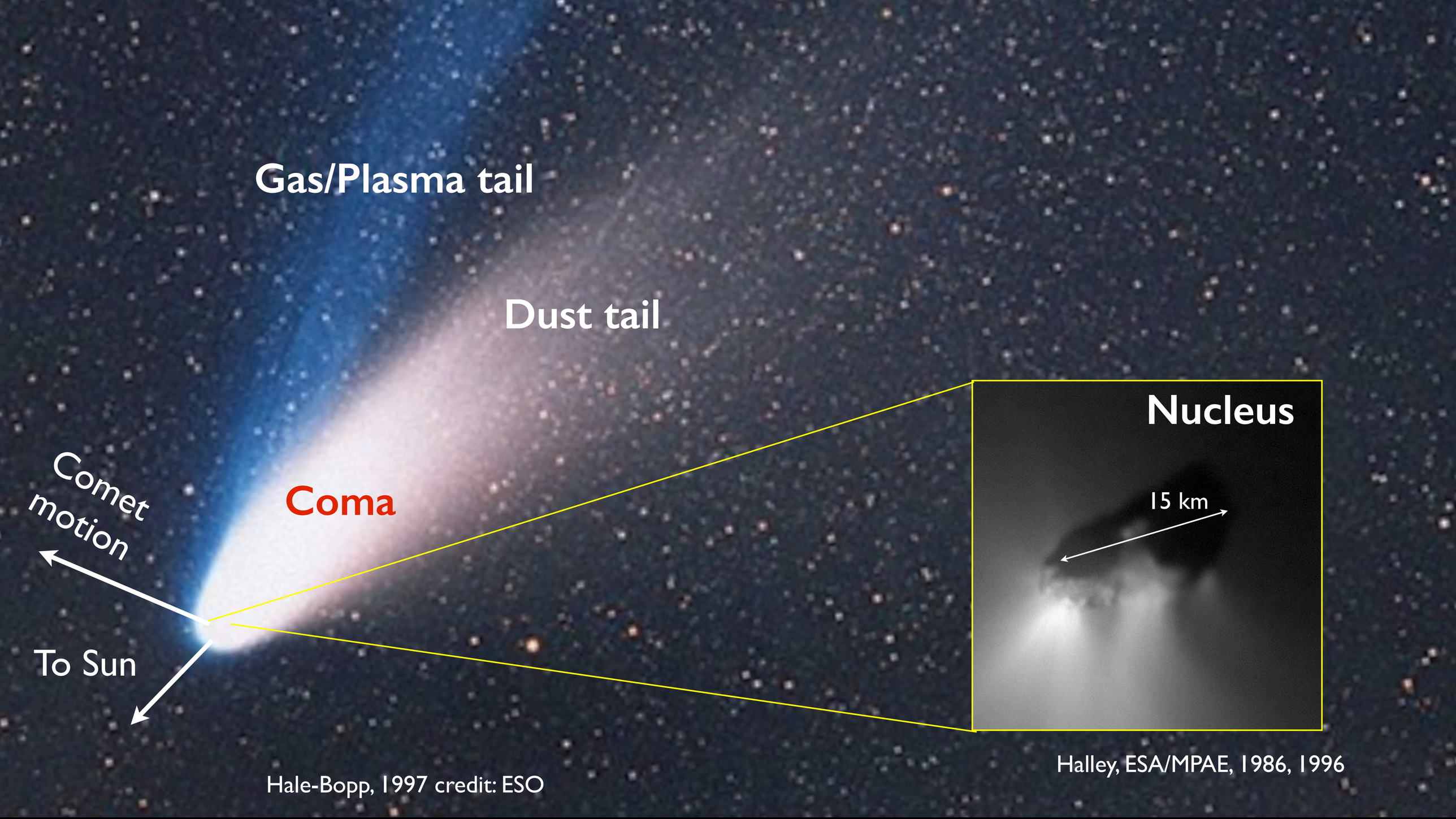
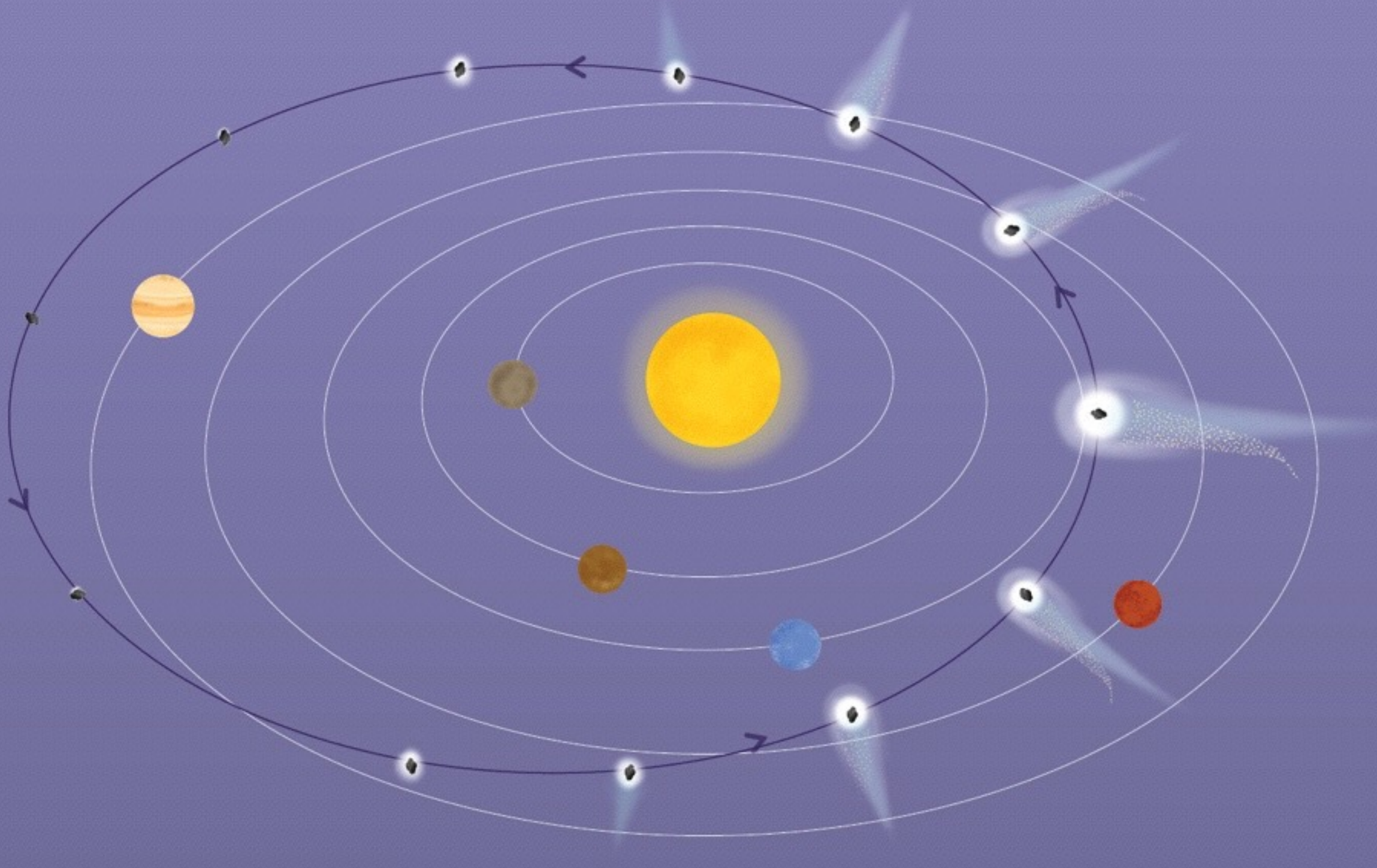
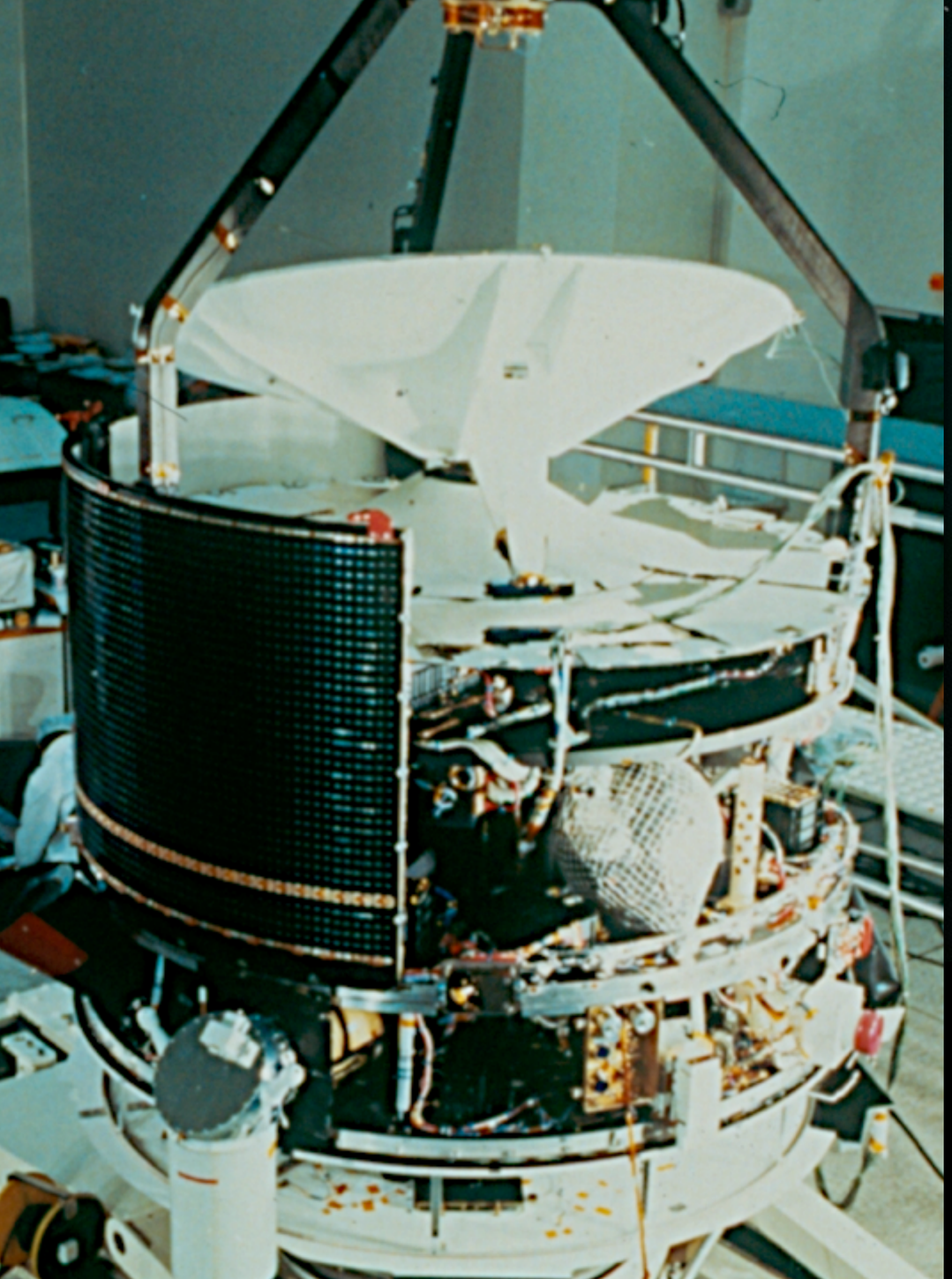


Image credit: ALMA / ESO / NAOJ / NRAO / ESA / Hubble / NASA / Judy Schmidt.

Courtesy of National Geographic


Gas/Plasma tail
Dust tail
Coma
Comet motion
To Sun
Nucleus
15 km
Hale-Bopp, 1997 credit: ESO
Halley, ESA/MPAE, 1986, 1996



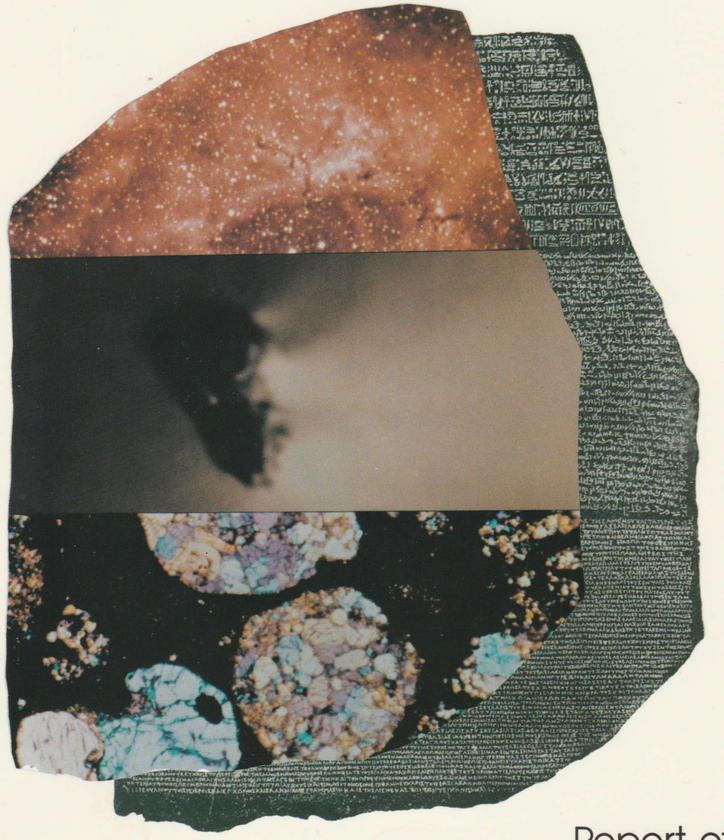


Me in 1986

SCI(87)3

ROSETTA

Comet Nucleus Sample Return



Report of the
Science Definition Team

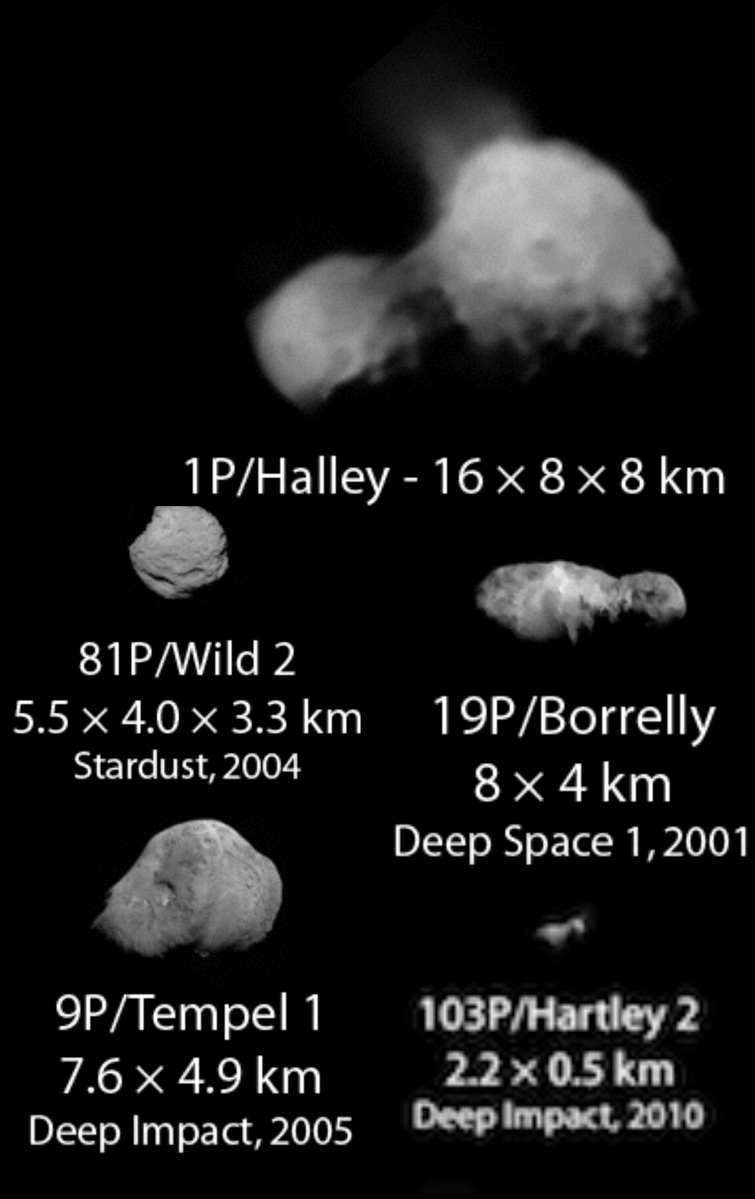
esa
european space agency

NASA
National Aeronautics and
Space Administration

Spacecraft Visits to Comets (imaged)

- The Halley Armada
  Giotto, Vega 1 and 2, Suisei, Sakigake
- Deep Space 1 (Borrelly)
- Stardust (Wild 2)
- Deep Impact (Tempel 1)
- EPOXI (Hartley 2)

Fly by's - 100's km
10's km/s

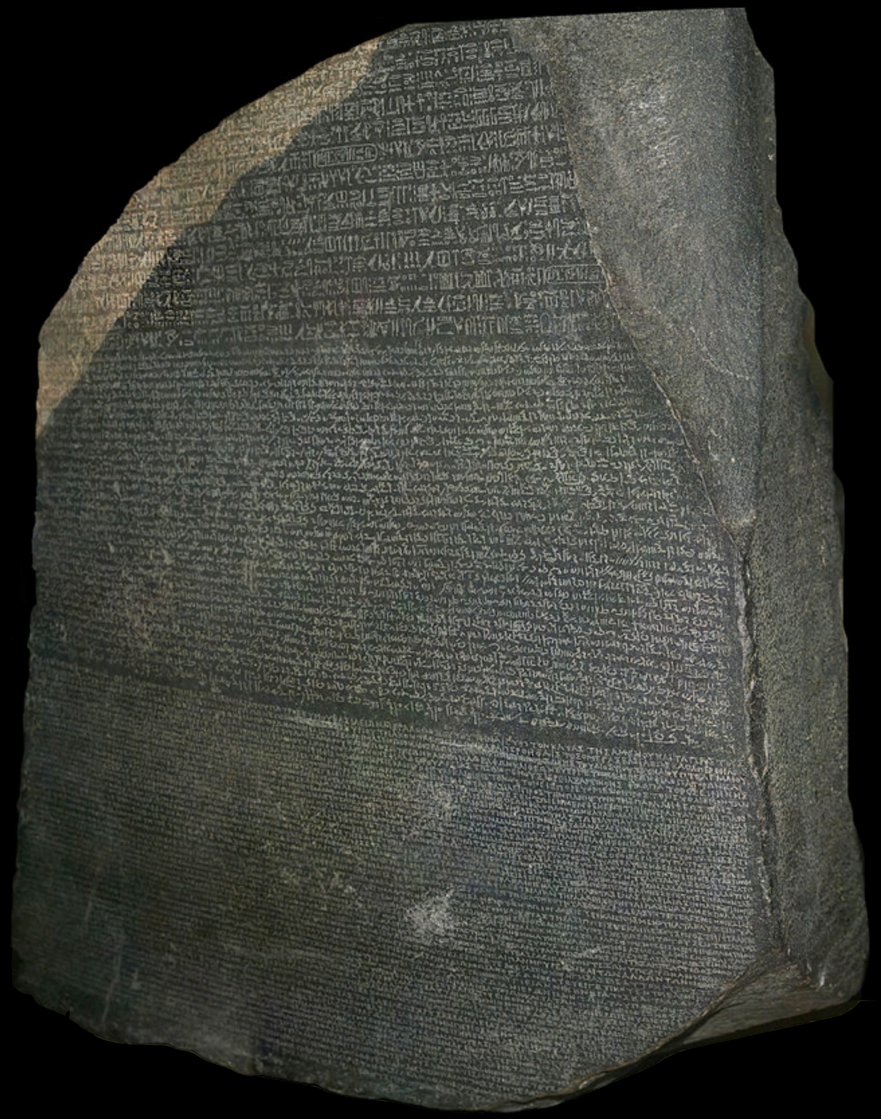


Spacecraft Visits to Comets (imaged)

- The Halley Armada
  Giotto, Vega 1 and 2, Suisei, Sakigake
- Deep Space 1 (Borrelly)
- Stardust (Wild 2)
- Deep Impact (Tempel 1)
- EPOXI (Hartley 2)
- **Rosetta (C-G)**

<< 100 km at m/s

The Rosetta Stone

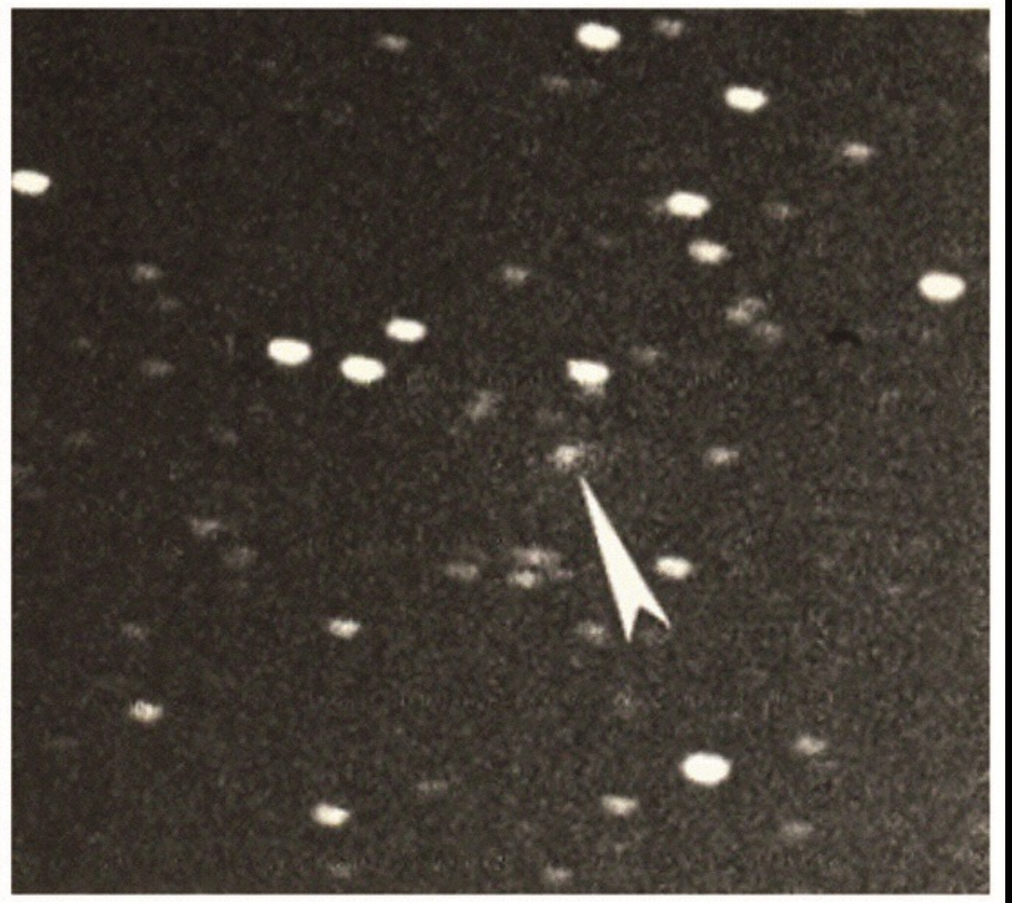


By © Hans Hillewaert, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=3153928

Philae temple of Isis

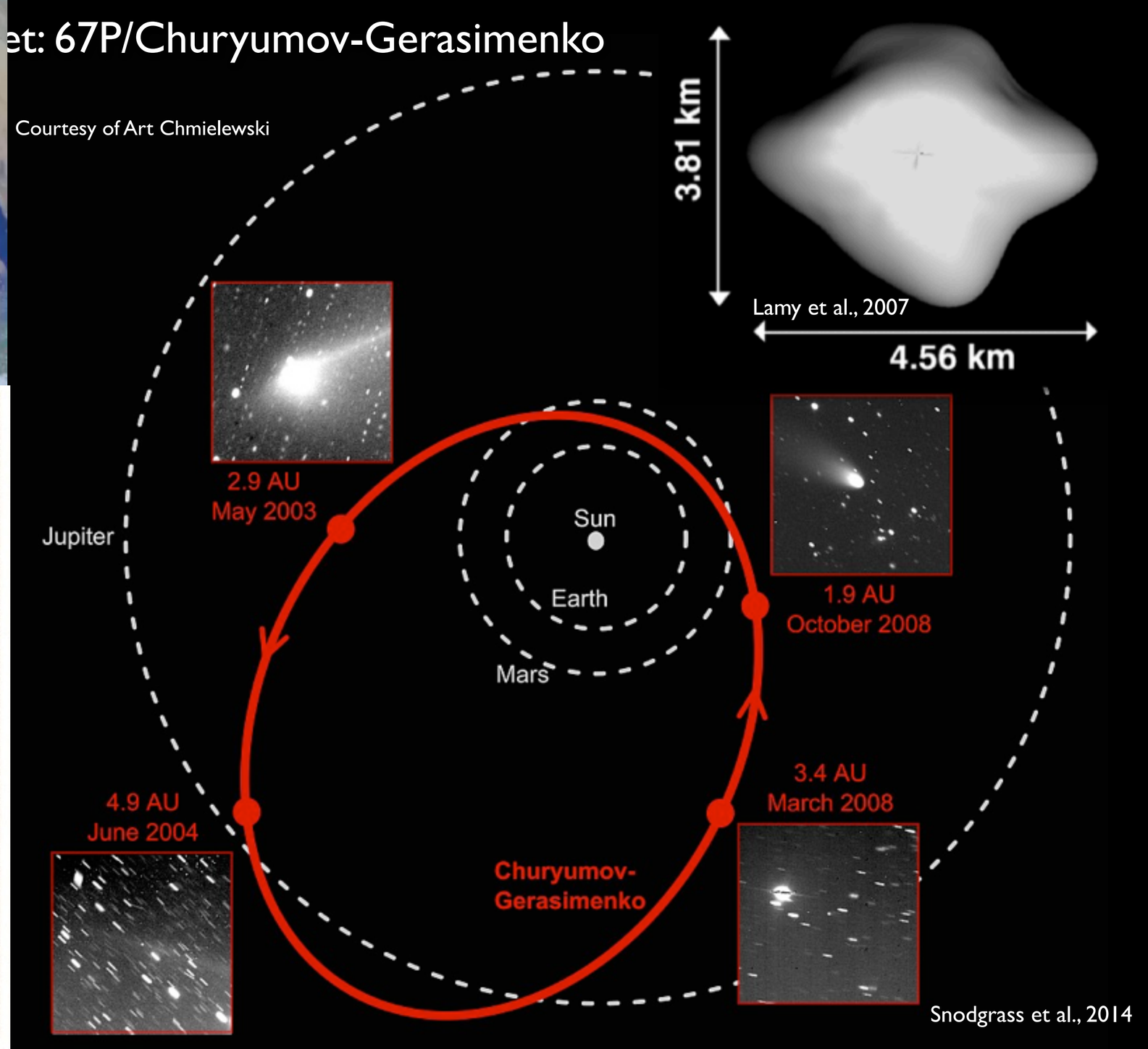
By Ivan Marcialis from Quartucciu, Italy - The Temple of Philae on Agilika Island, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=3818743

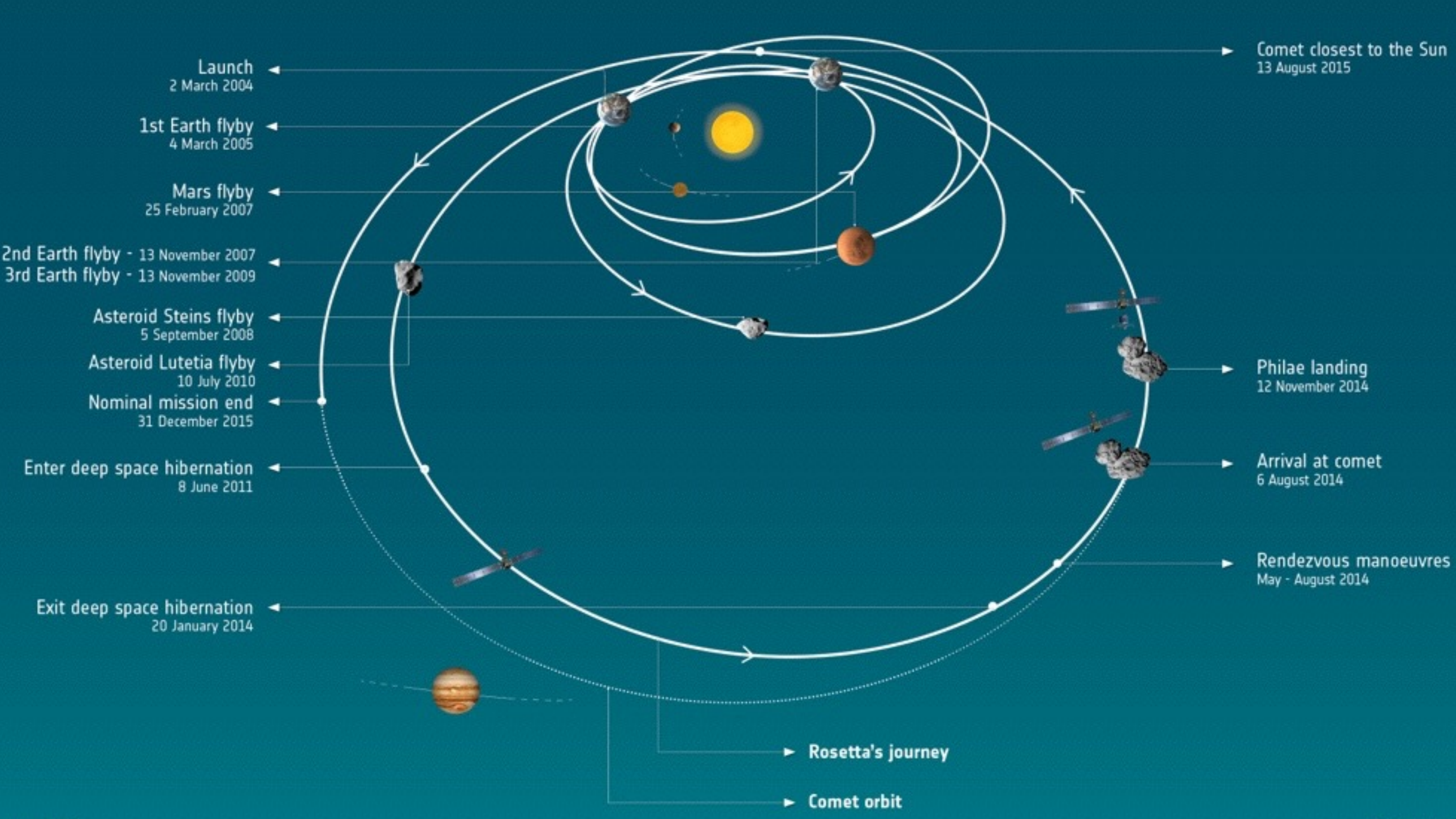
Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

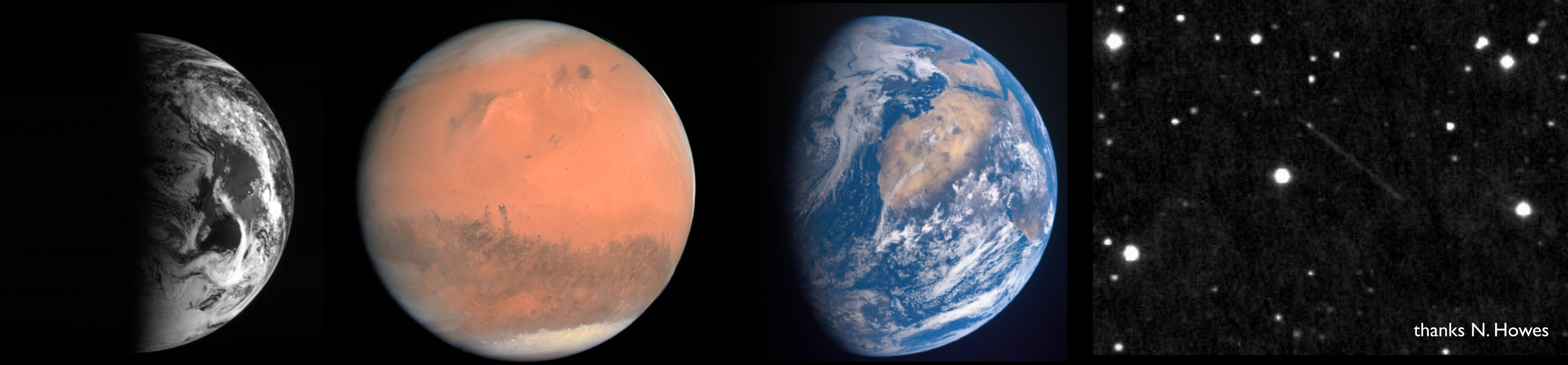


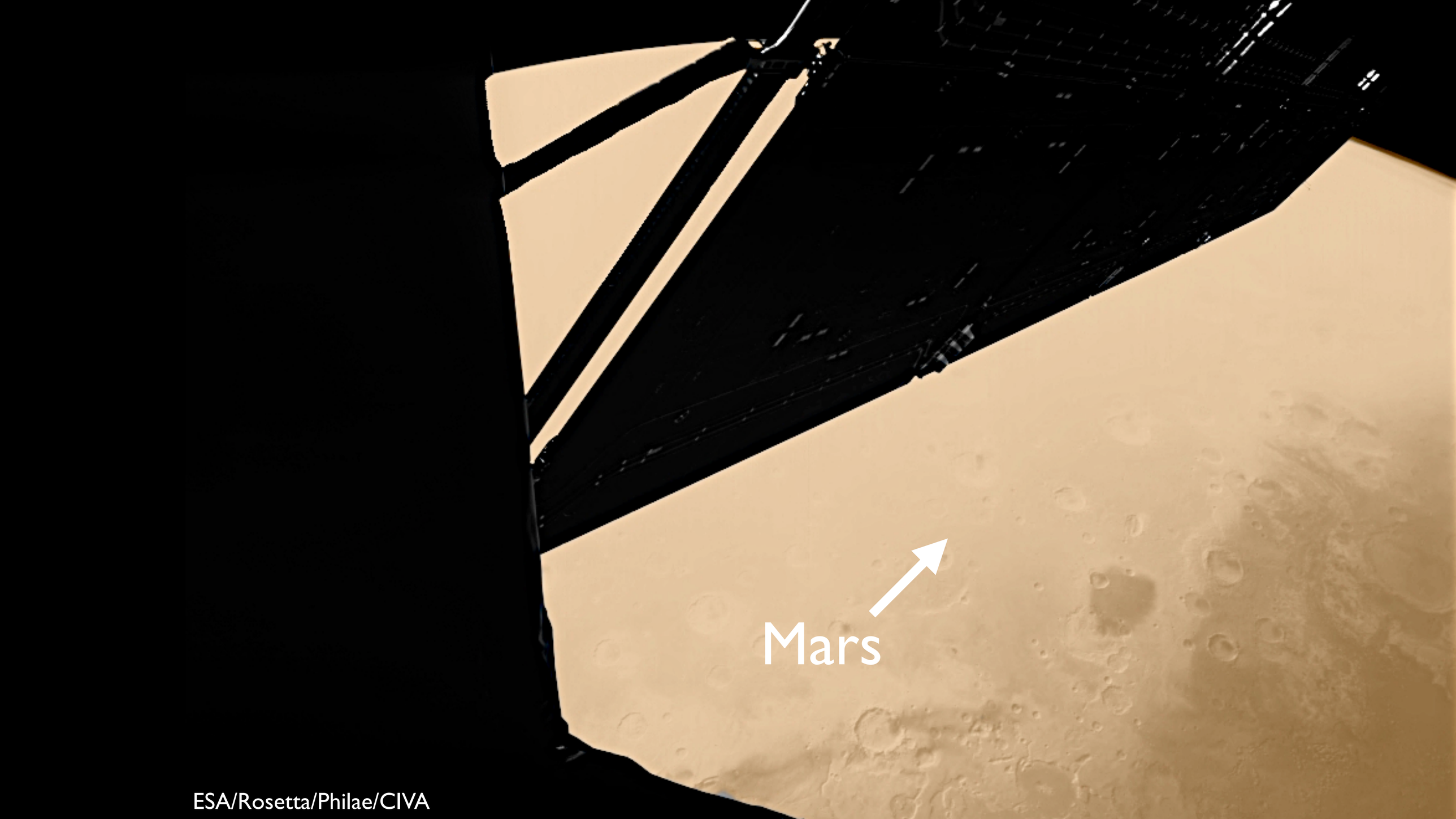
et: 67P/Churyumov-Gerasimenko

Courtesy of Art Chmielewski

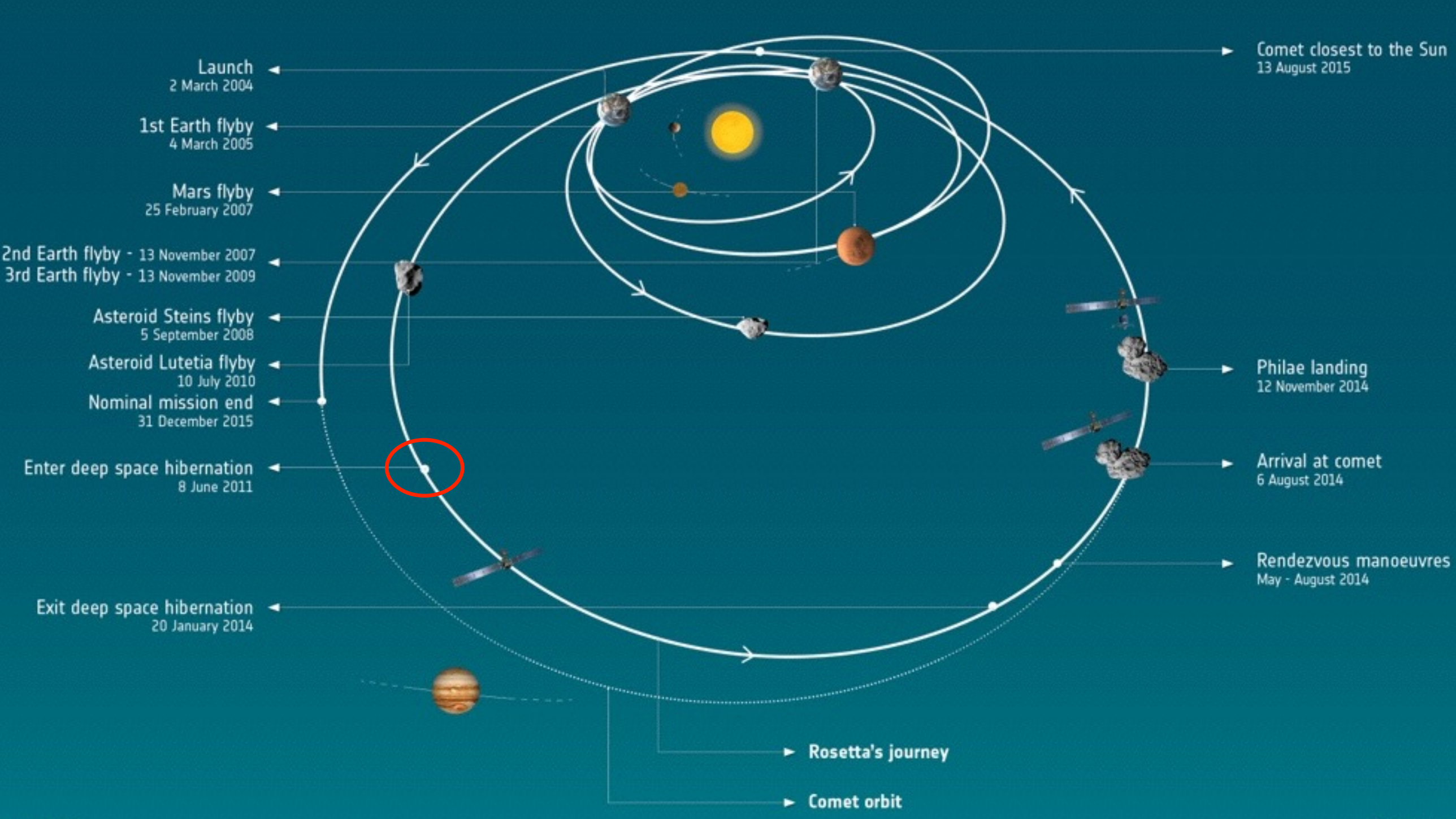


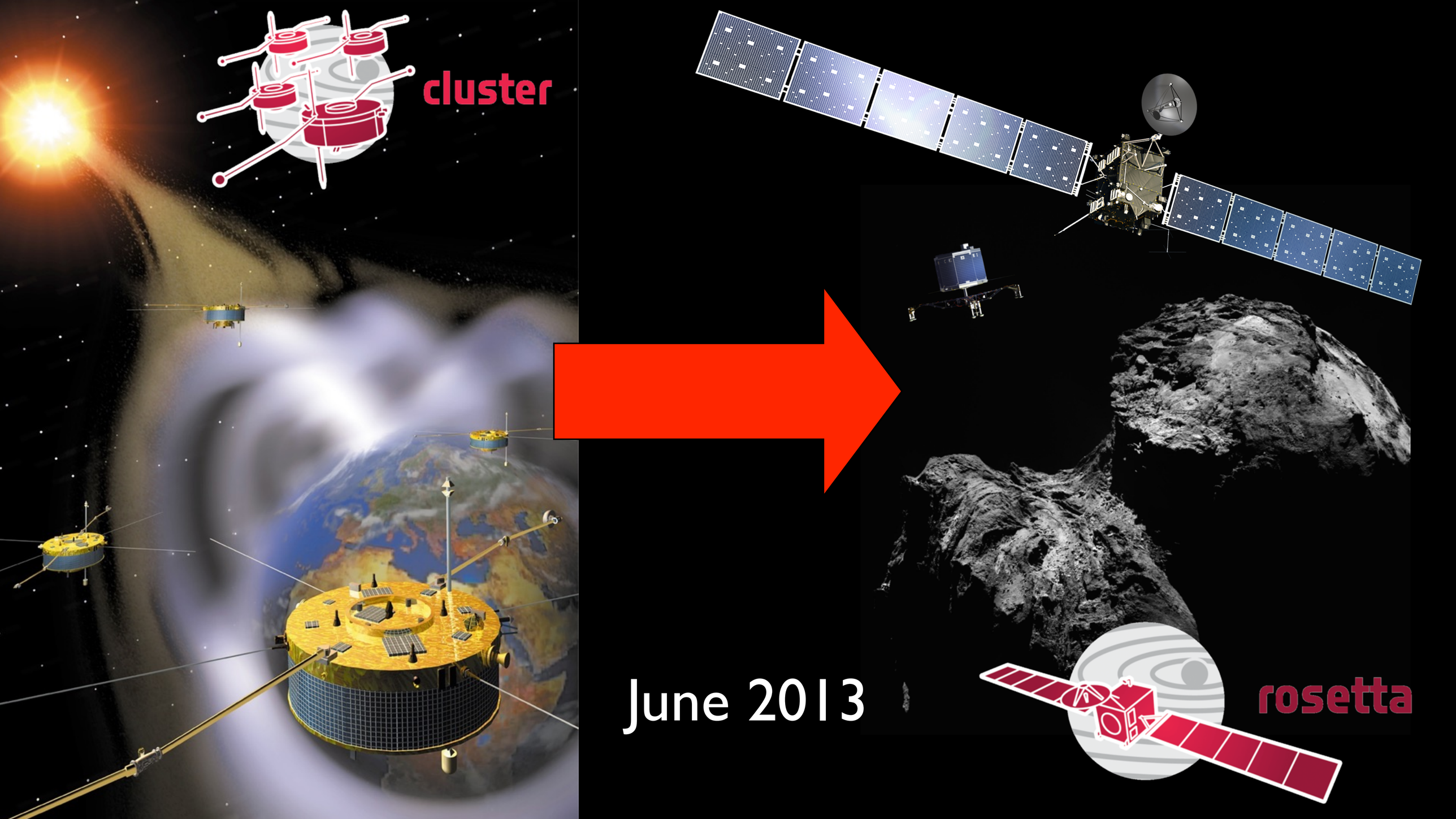

Launch
2 March 2004
1st Earth flyby
4 March 2005
Mars flyby
25 February 2007
2nd Earth flyby - 13 November 2007
3rd Earth flyby - 13 November 2009
Asteroid Steins flyby
5 September 2008
Asteroid Lutetia flyby
10 July 2010
Nominal mission end
31 December 2015
Enter deep space hibernation
8 June 2011
Exit deep space hibernation
20 January 2014
Comet closest to the Sun
13 August 2015
Philae landing
12 November 2014
Arrival at comet
6 August 2014
Rendezvous manoeuvres
May - August 2014
Rosetta's journey
Comet orbit

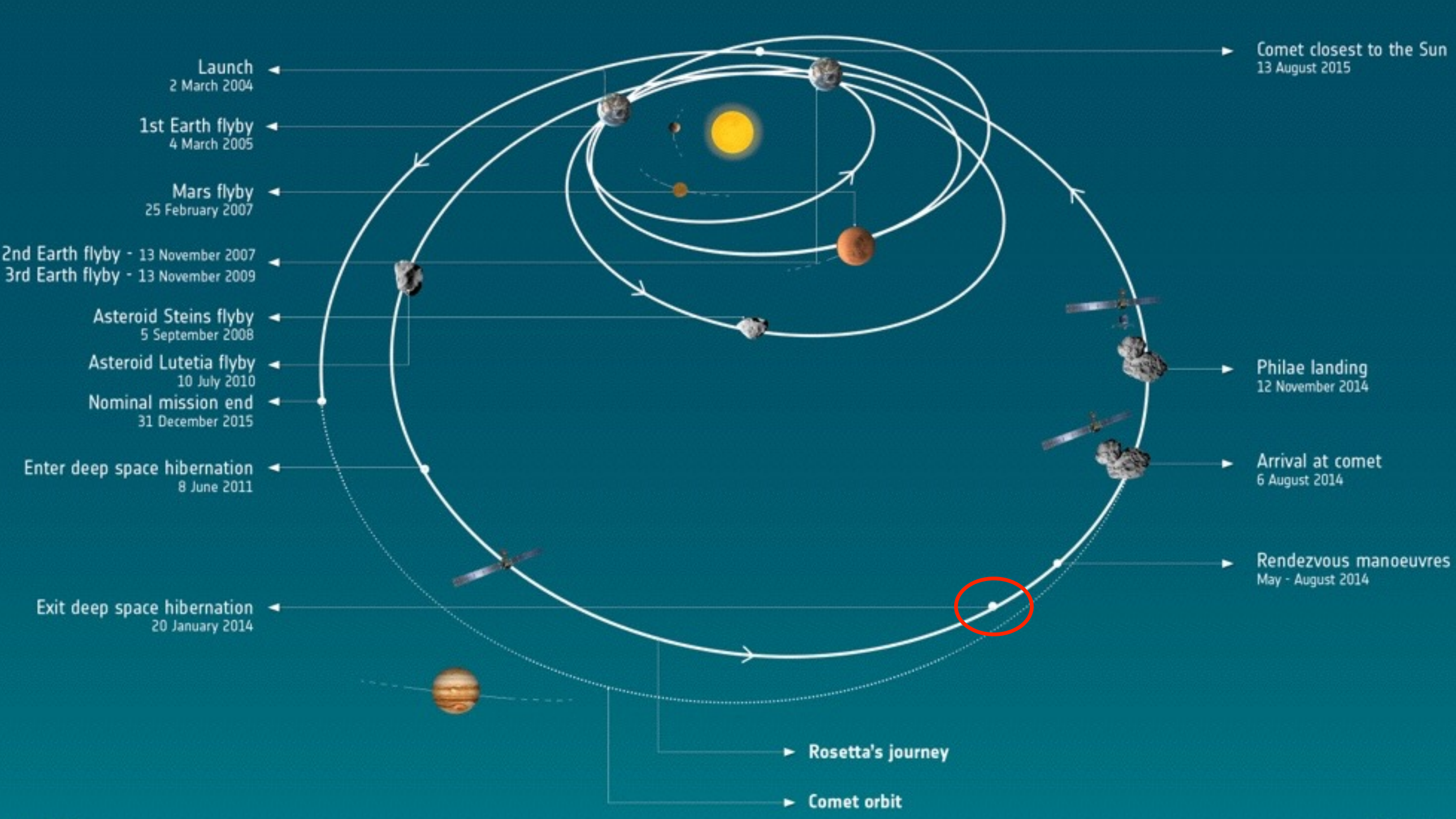

thanks N. Howes



ESA/Rosetta/Philae/CIVA


Launch
2 March 2004
1st Earth flyby
4 March 2005
Mars flyby
25 February 2007
2nd Earth flyby - 13 November 2007
3rd Earth flyby - 13 November 2009
Asteroid Steins flyby
5 September 2008
Asteroid Lutetia flyby
10 July 2010
Nominal mission end
31 December 2015
Enter deep space hibernation
8 June 2011
Exit deep space hibernation
20 January 2014
Comet closest to the Sun
13 August 2015
Philae landing
12 November 2014
Arrival at comet
6 August 2014
Rendezvous manoeuvres
May - August 2014
Rosetta's journey
Comet orbit

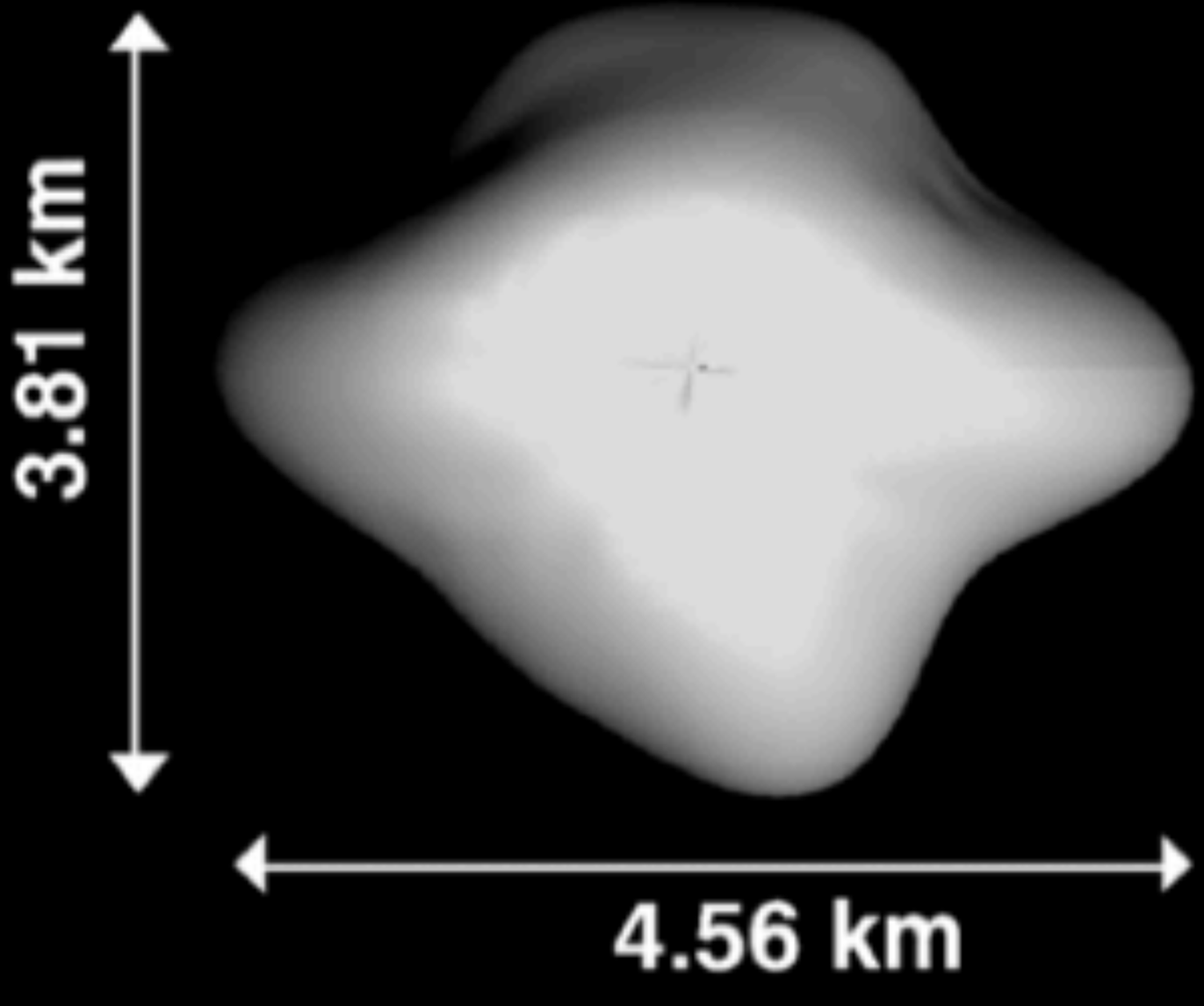

cluster
June 2013
rosetta

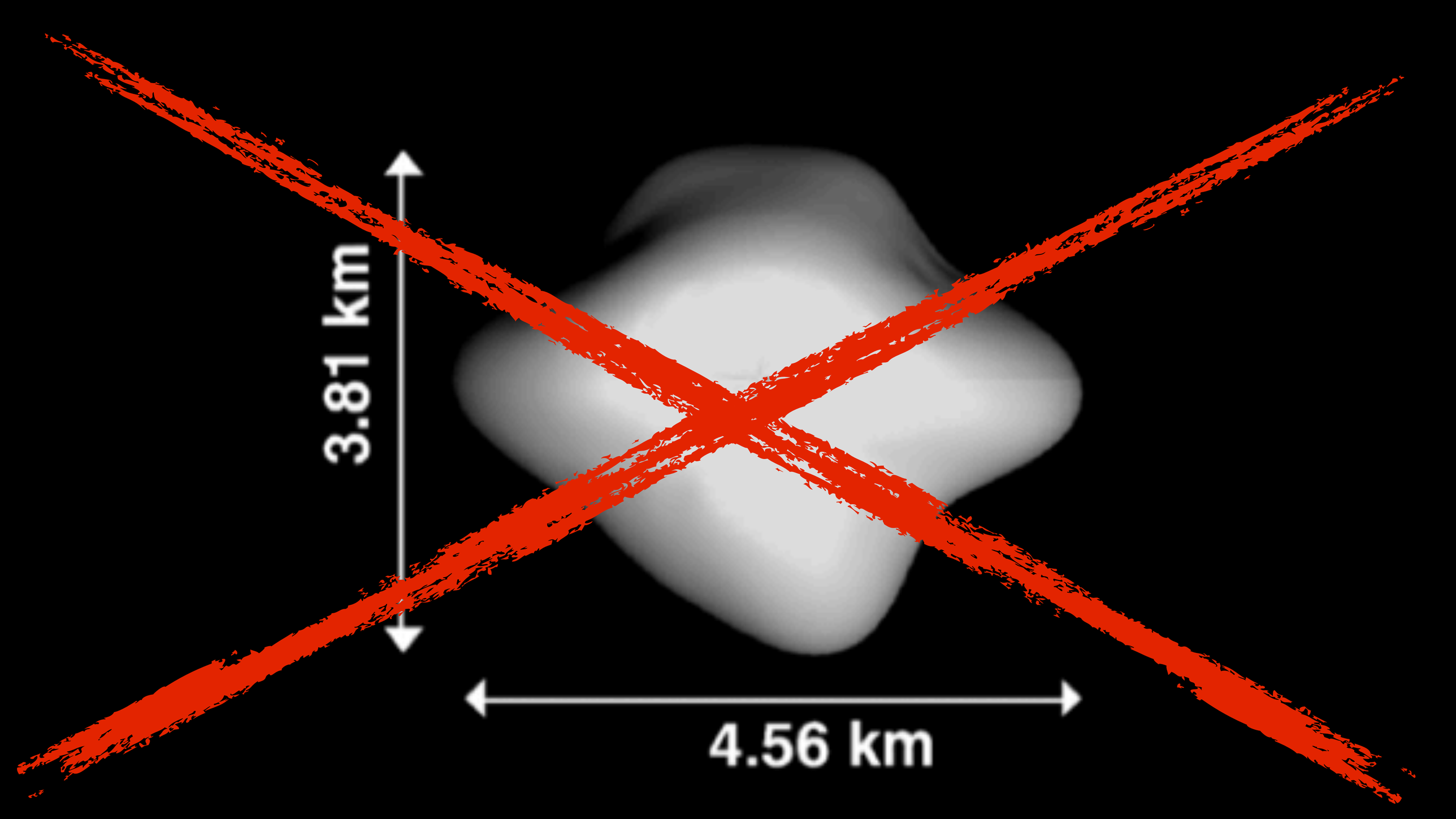

Launch
2 March 2004
1st Earth flyby
4 March 2005
Mars flyby
25 February 2007
2nd Earth flyby - 13 November 2007
3rd Earth flyby - 13 November 2009
Asteroid Steins flyby
5 September 2008
Asteroid Lutetia flyby
10 July 2010
Nominal mission end
31 December 2015
Enter deep space hibernation
8 June 2011
Exit deep space hibernation
20 January 2014
Comet closest to the Sun
13 August 2015
Philae landing
12 November 2014
Arrival at comet
6 August 2014
Rendezvous manoeuvres
May - August 2014
Rosetta's journey
Comet orbit

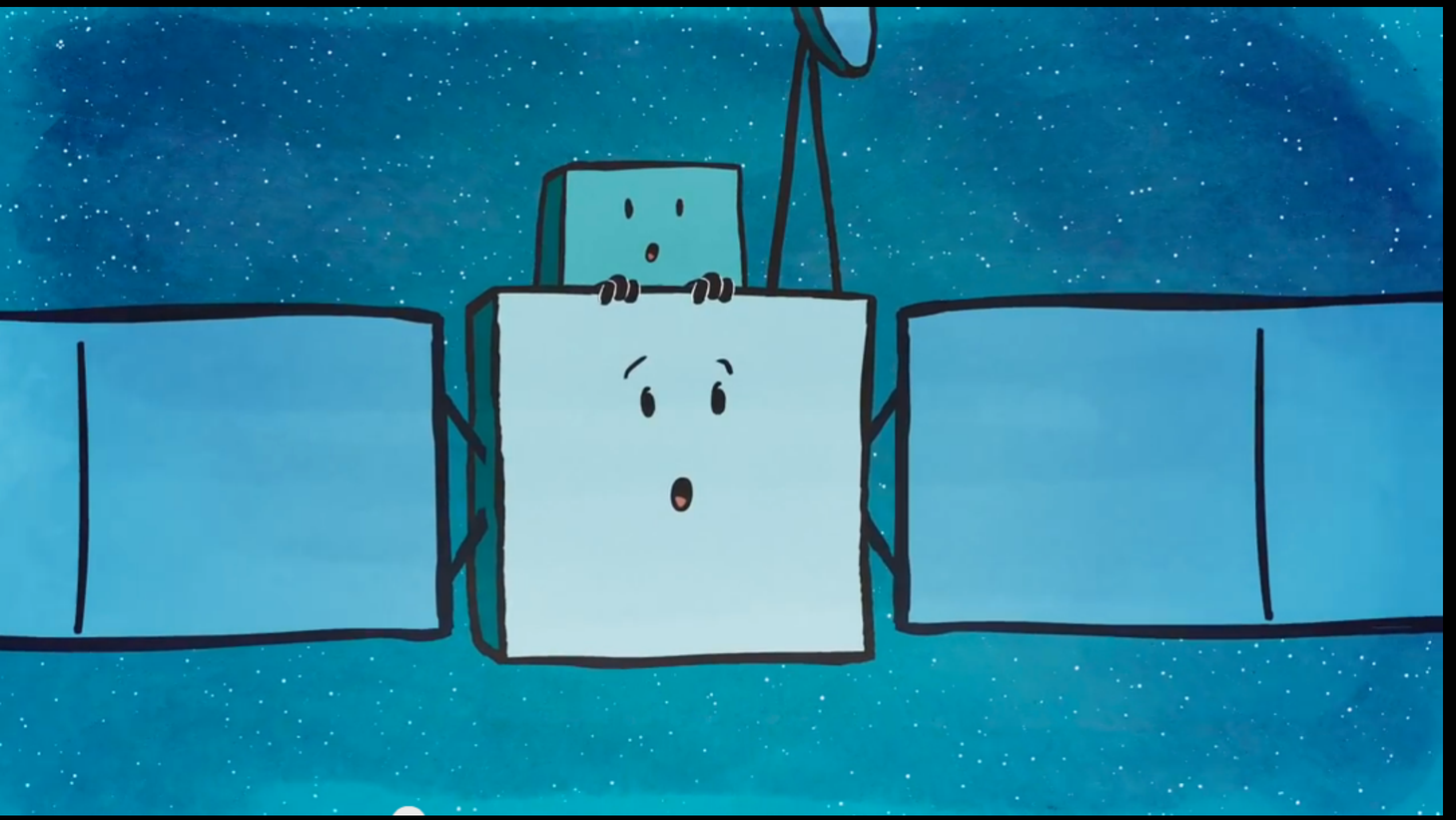
#WakeUpRosetta
Help us shout out to Europe's
comet chaser!

1971
Top of the Pops
Alan Price and Georgie Fame - Rosetta
"Rosetta,
are you better?
are you well?"

ESA Rosetta Mission
@ESA_Rosetta
“Hello, world!"
RETWEETS
4,939
LIKES
1,824
10:18 a.m. - 20 Jan 2014

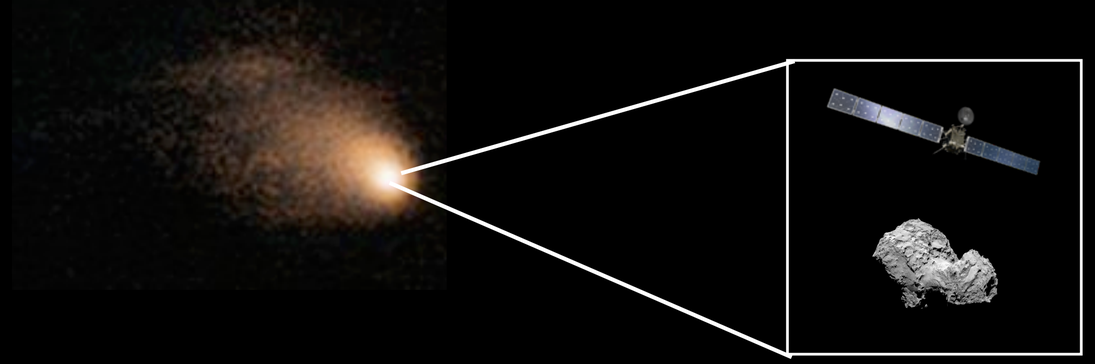

3.81 km
4.56 km


3.81 km
4.56 km



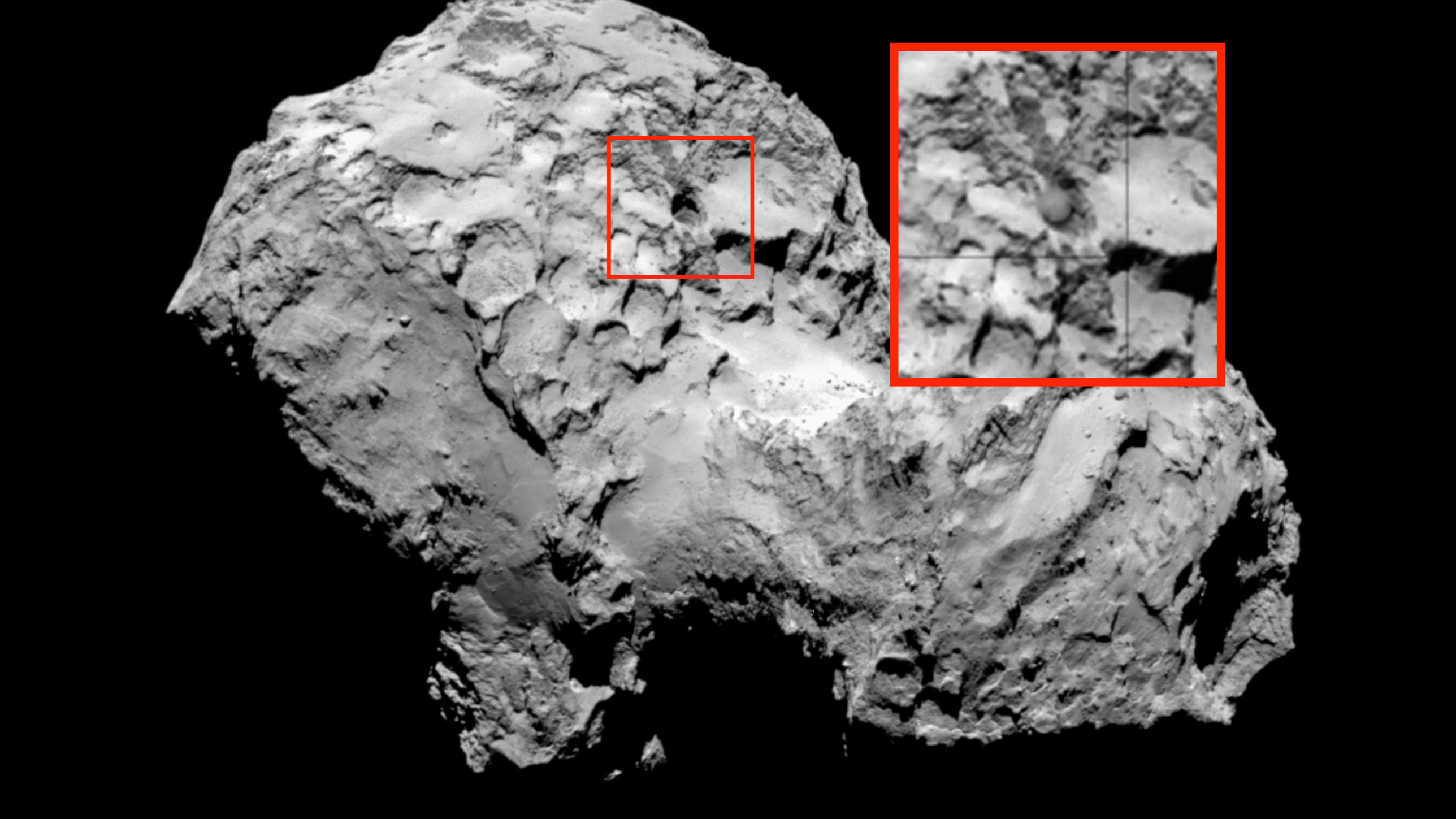
14 July 2014
Rot = 0 deg

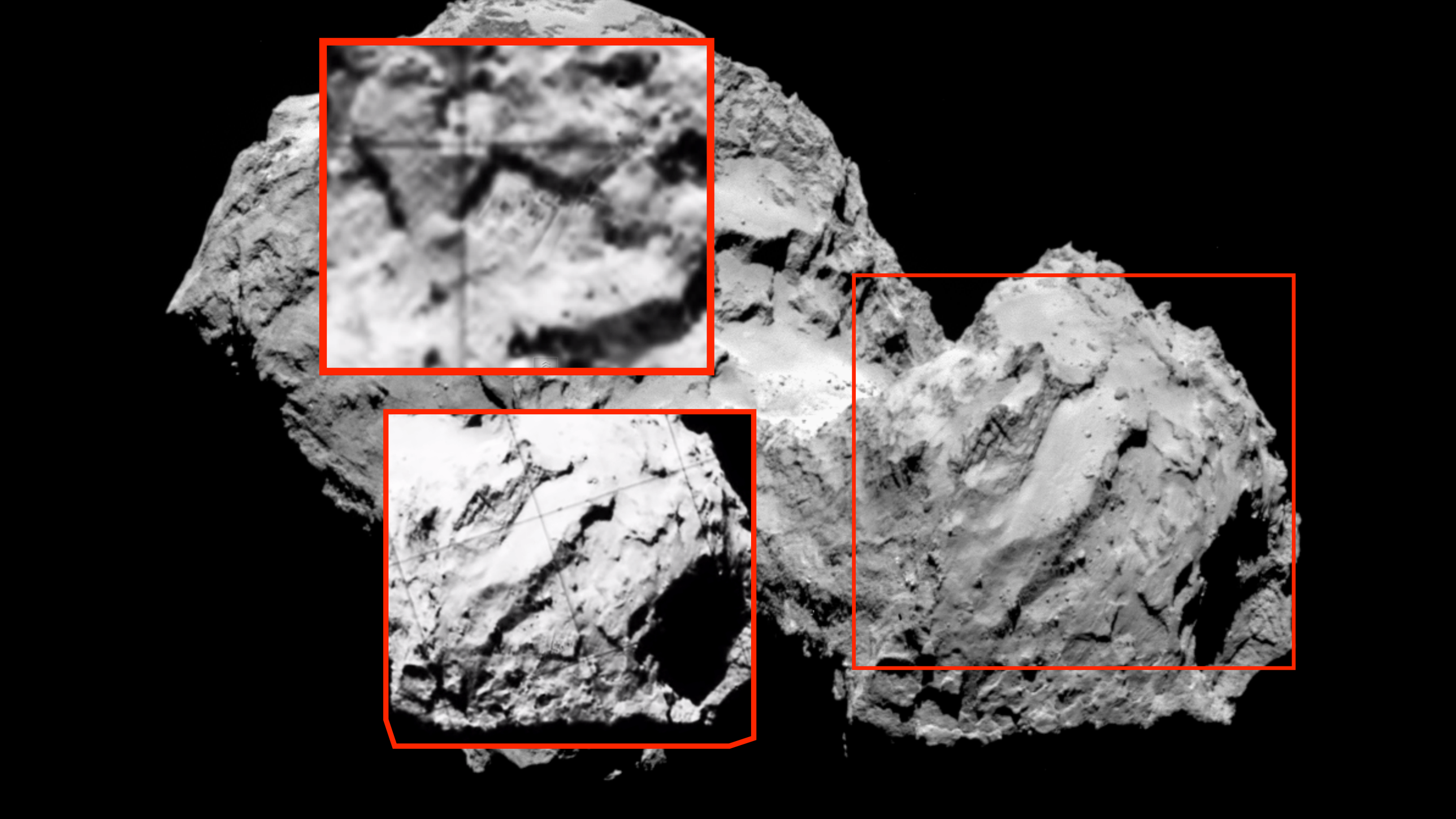
5 km

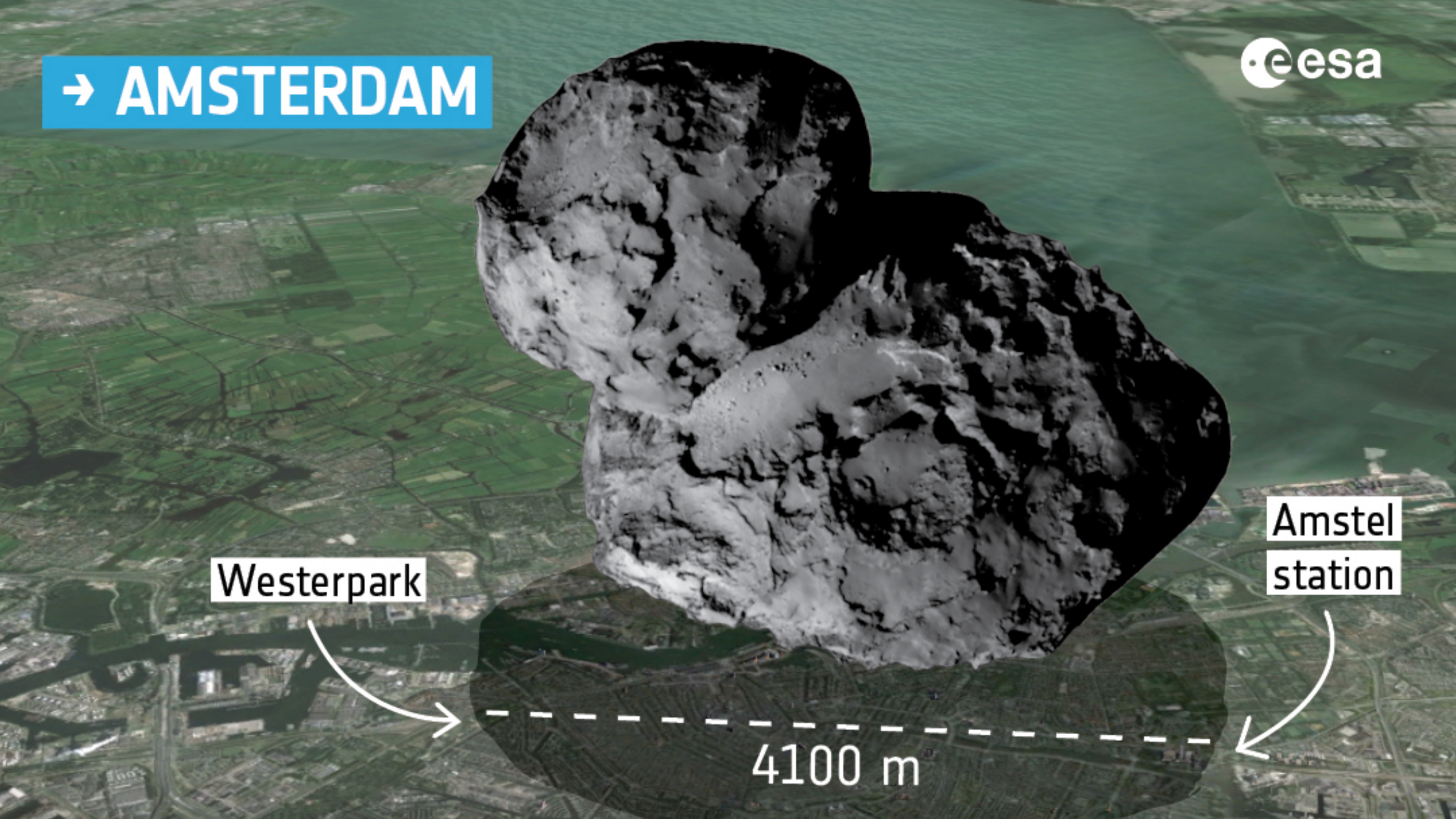


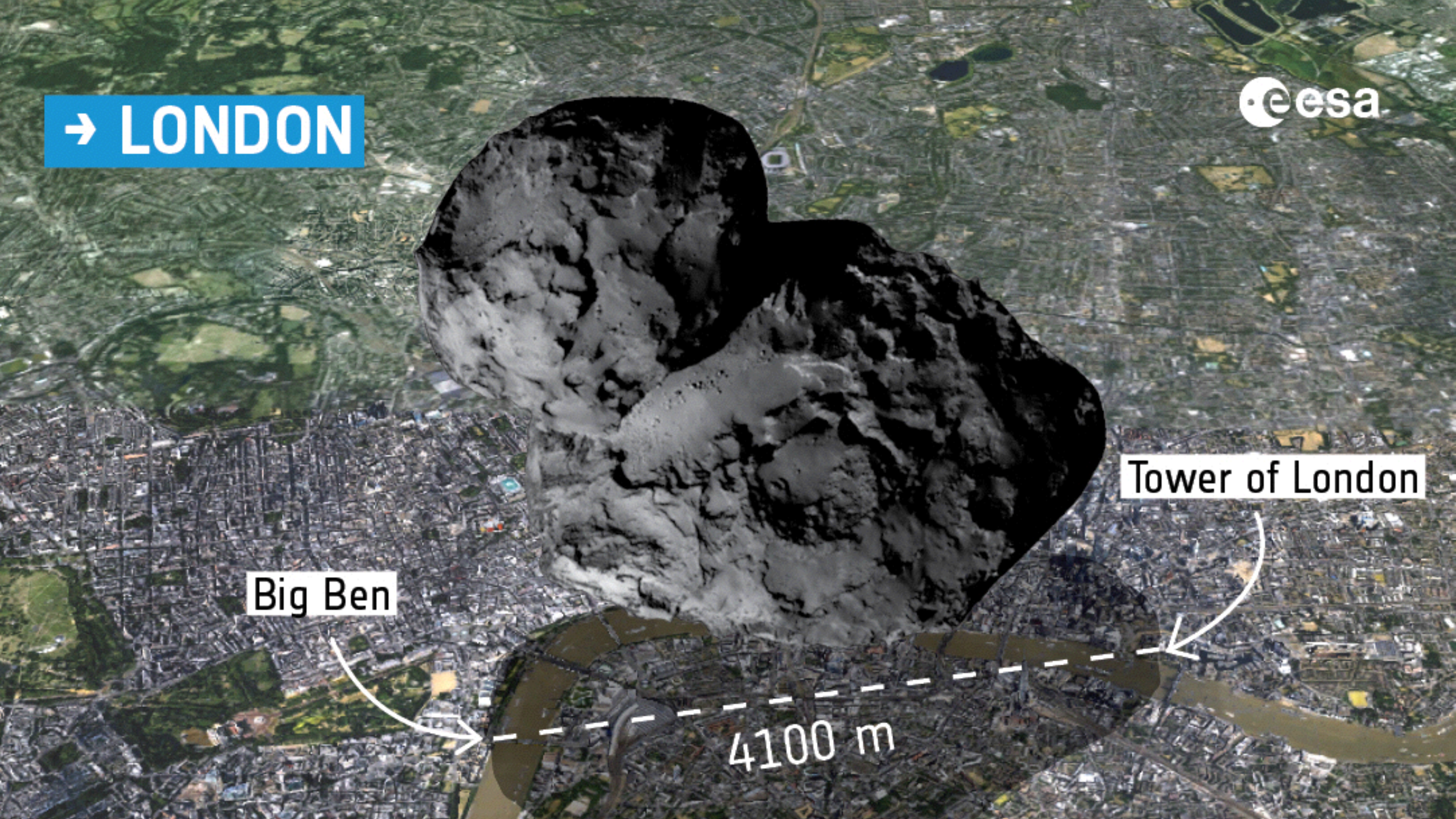
ESO/ESA Snodgrass et al., 2014

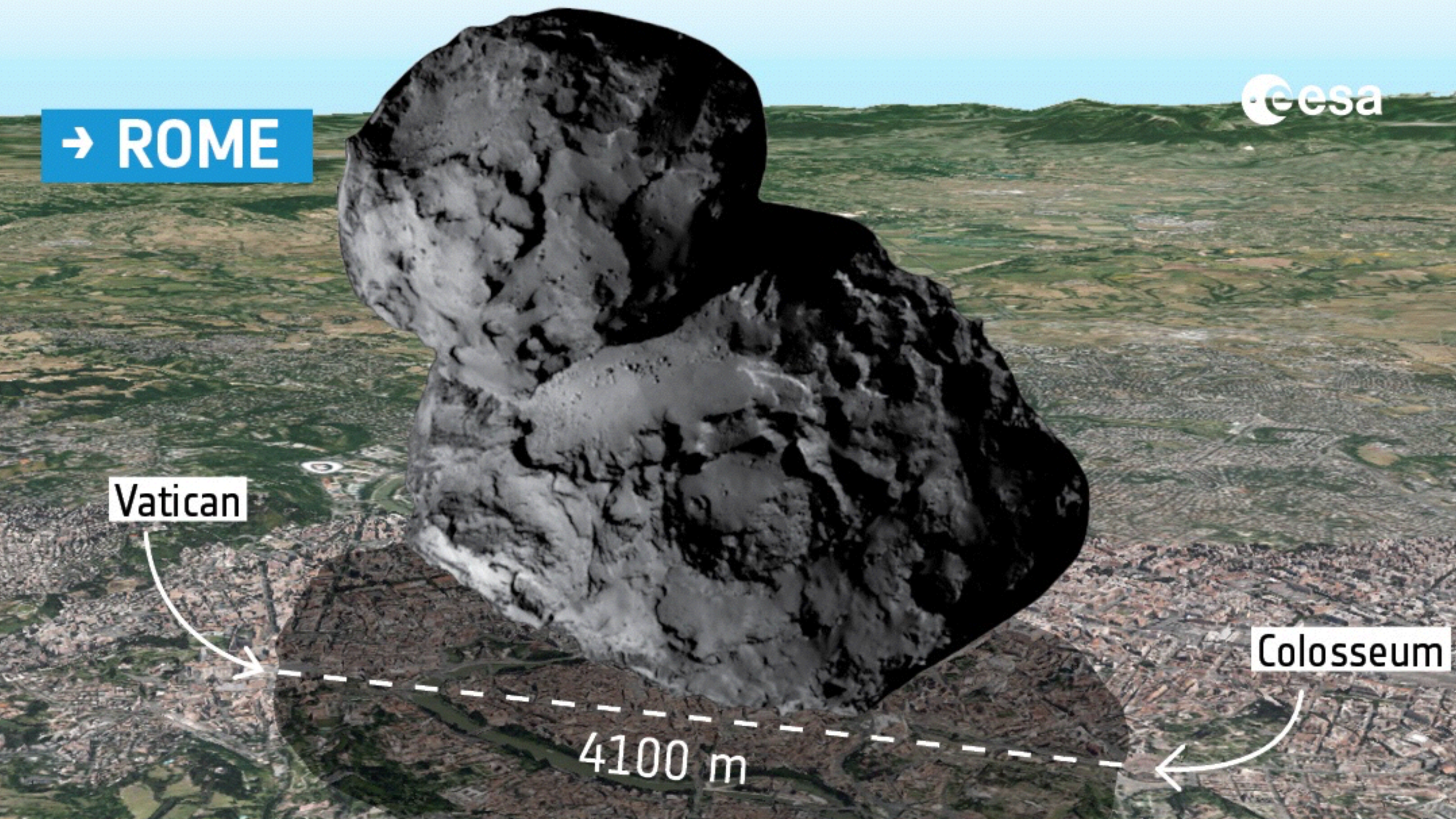
ESA/Rosetta/OSIRIS

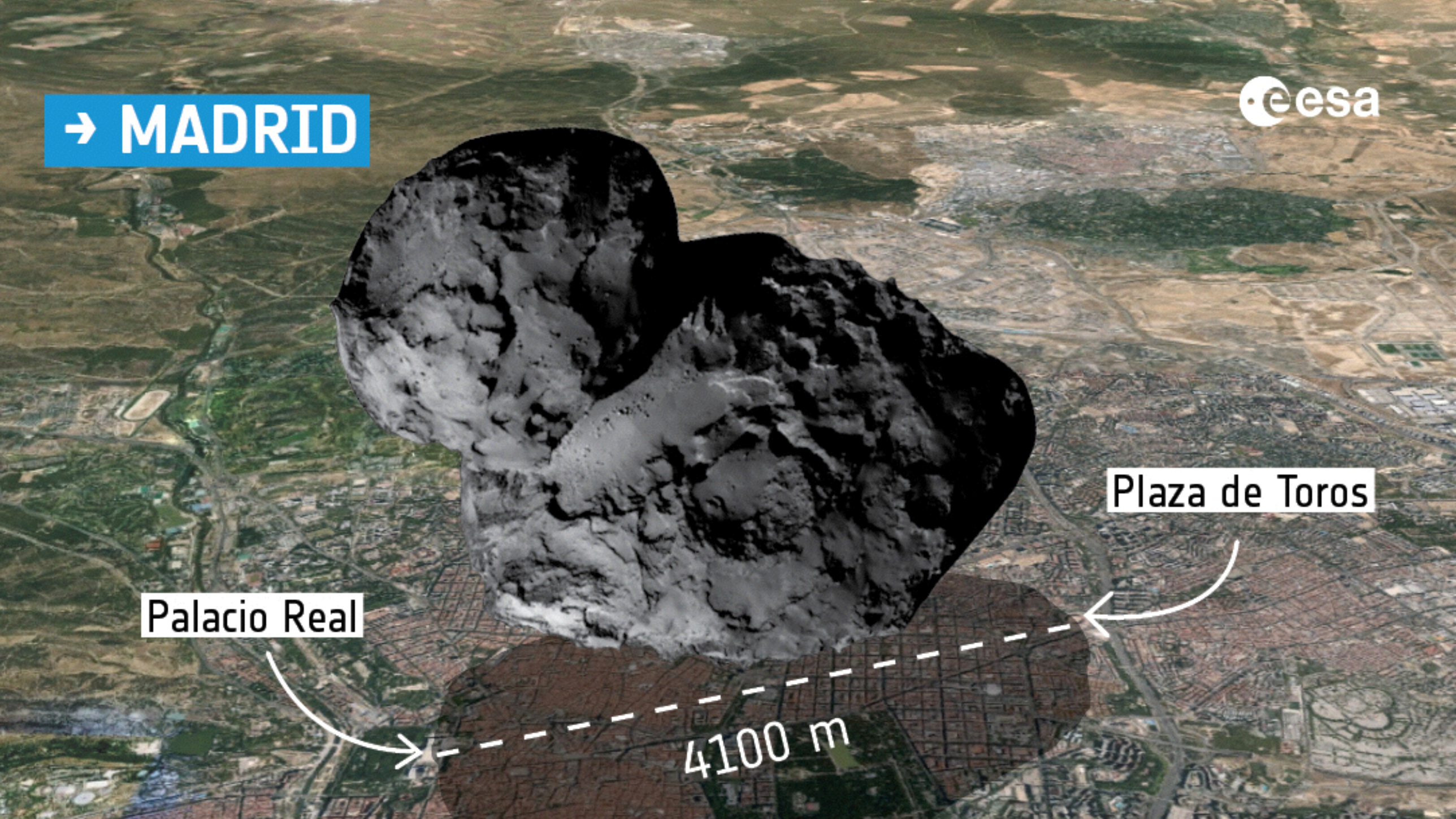





→ AMSTERDAM
esa
Westerpark
Amstel
station
4100 m


→ LONDON
esa
Tower of London
Big Ben
4100 m


→ ROME
esa
Vatican
Colosseum
4100 m


→ MADRID
esa
Plaza de Toros
Palacio Real
4100 m

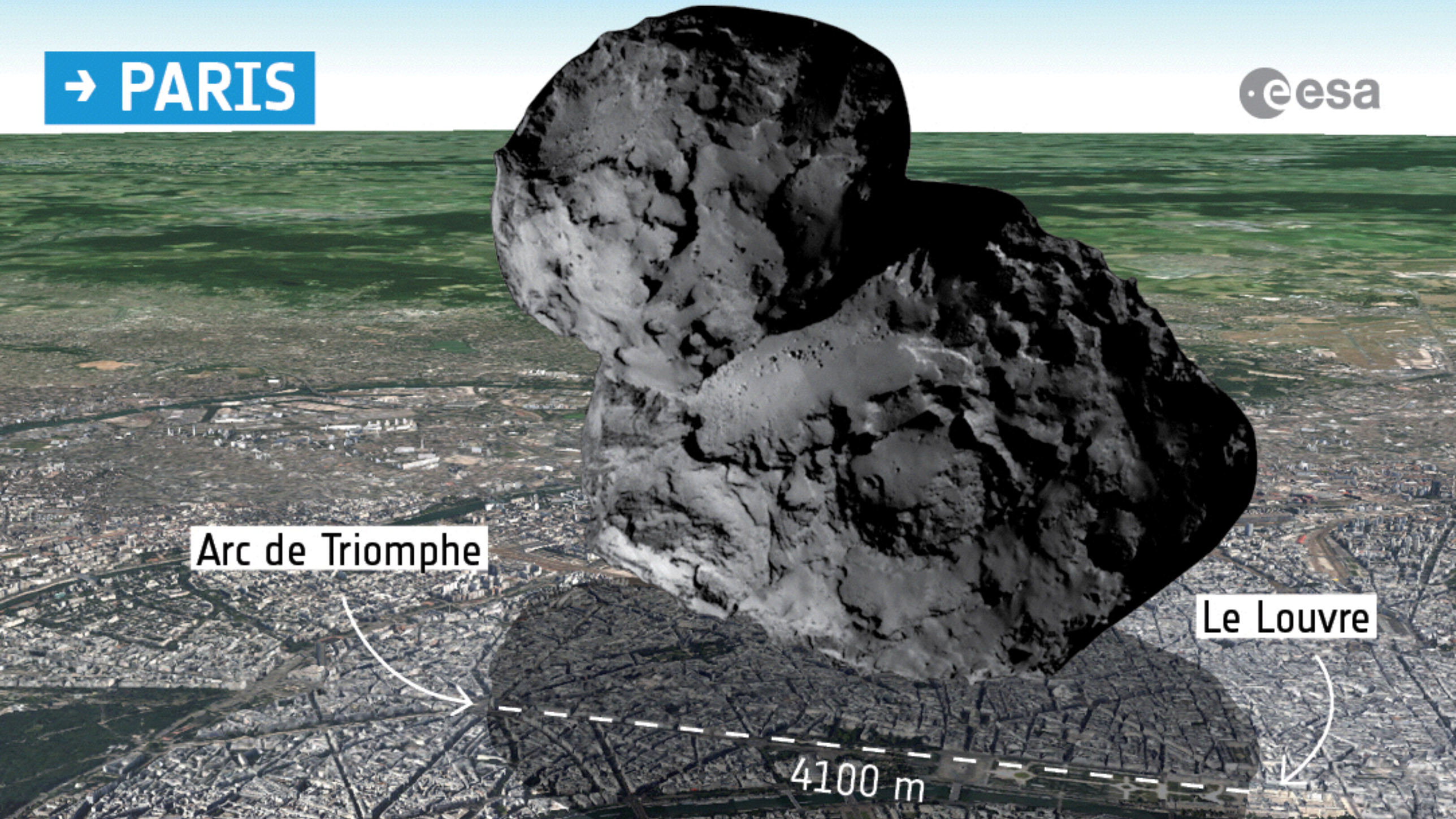
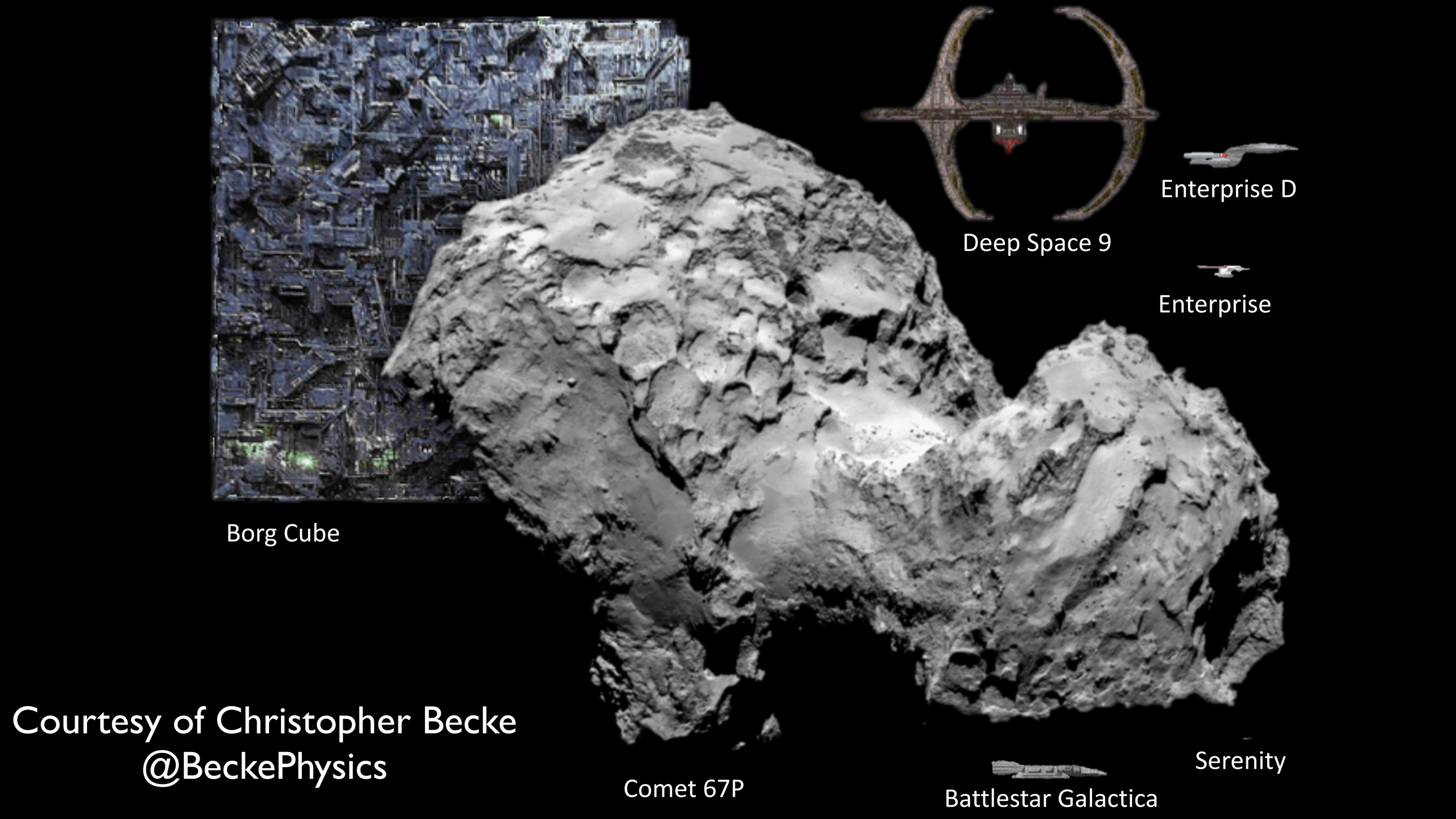

→ PARIS
esa
Arc de Triomphe
Le Louvre
4100 m

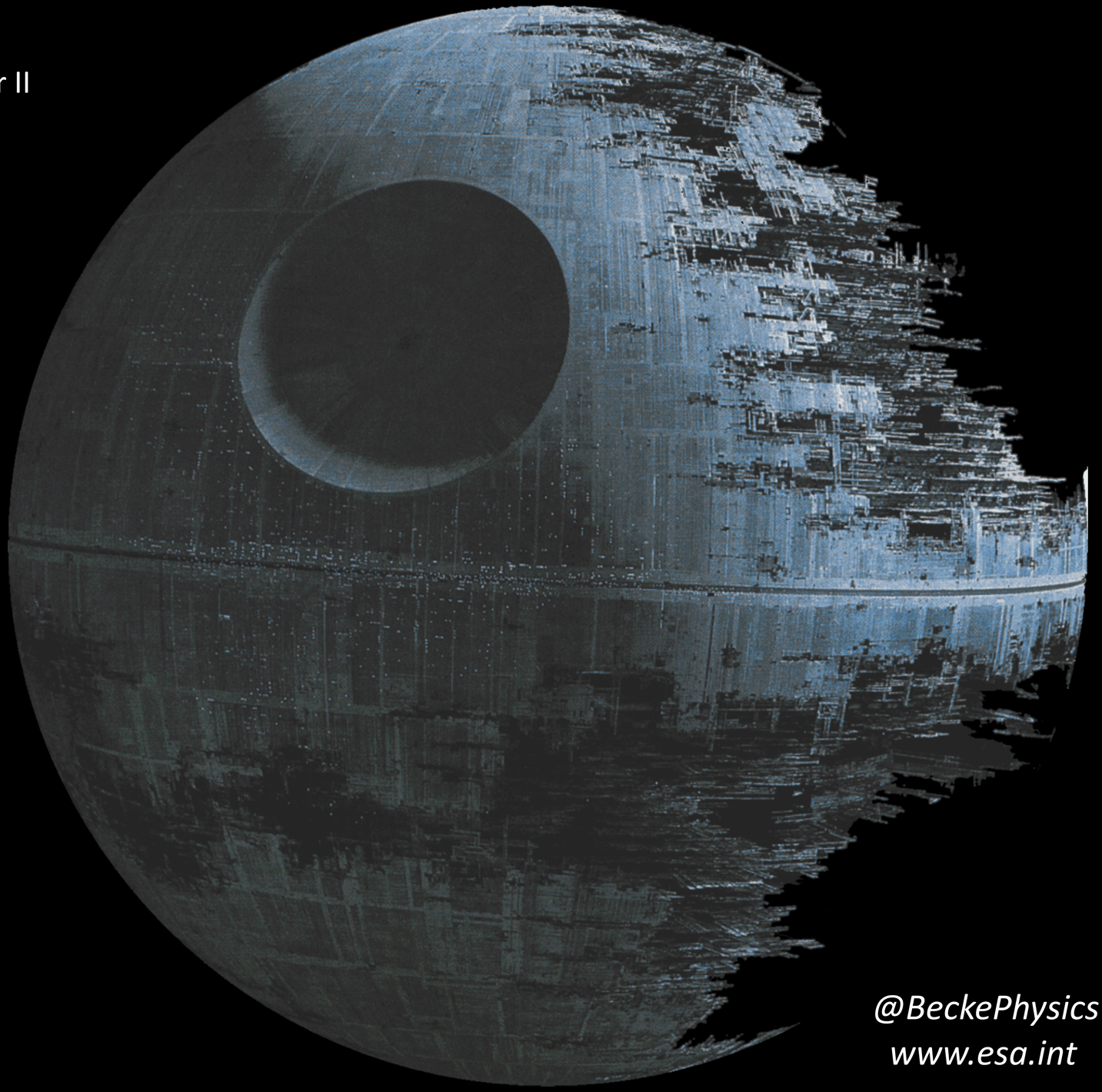
photo courtesy of D. Rowlandson

photo courtesy of D. Rowlandson



Courtesy of Christopher Becke
@BeckePhysics

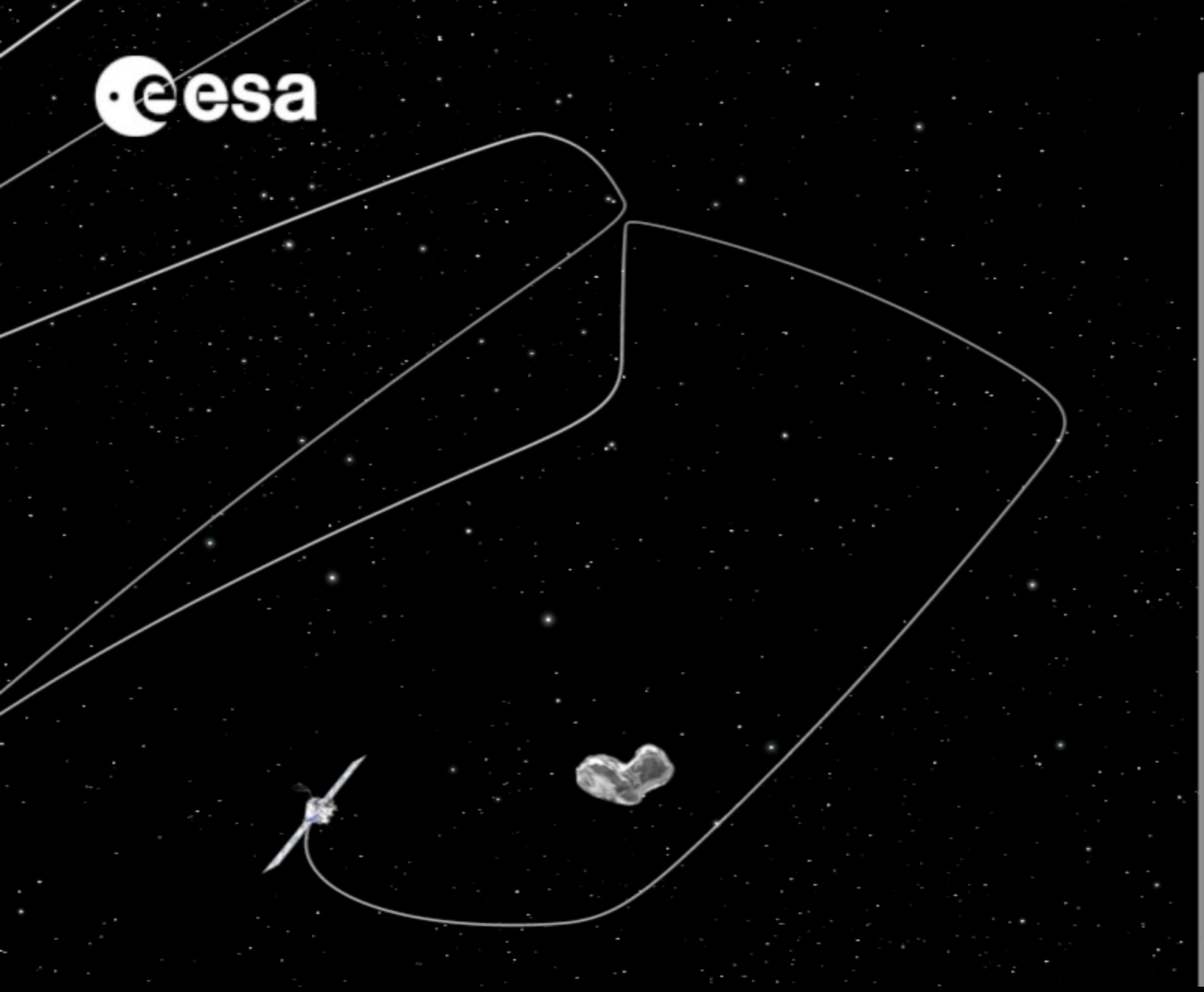
Death Star II



Comet 67P

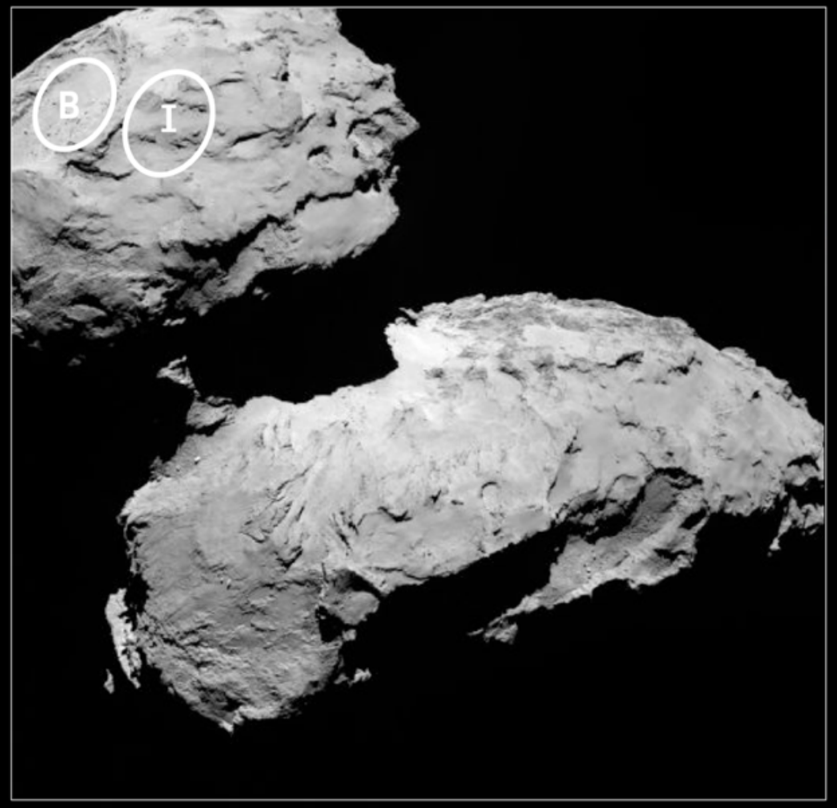
Super Star Destroyer

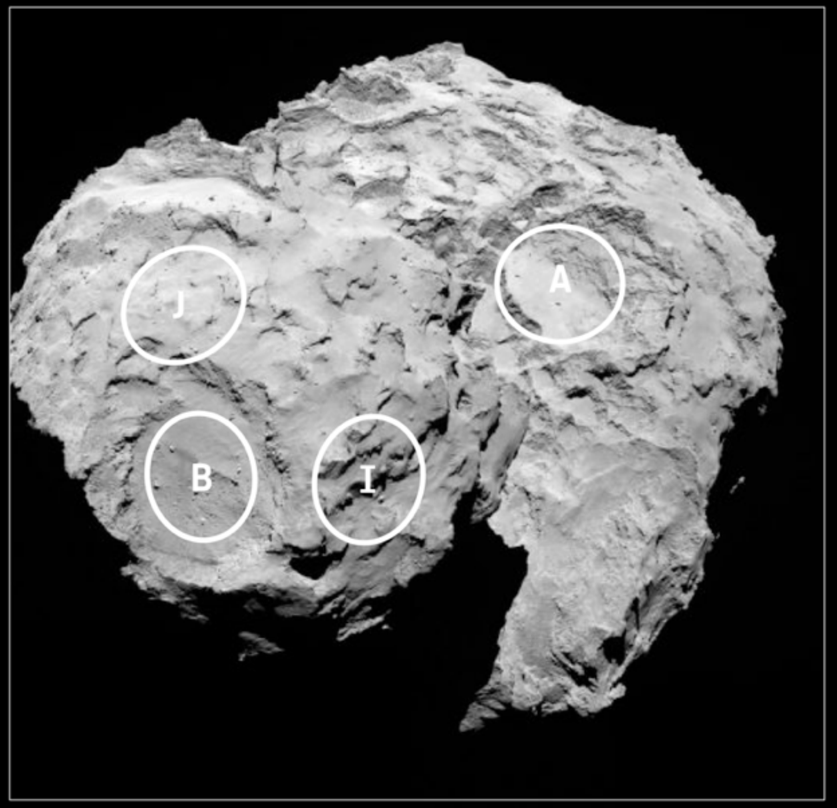
@BeckePhysics Images http://www.merzo.net/
www.esa.int



6 Aug – arrive at 100 km
10 Aug – second leg at 100 km
13 Aug – third leg at 100 km
17 Aug – start transfer
20 Aug – 80 km
24 Aug – first leg at 50 km
27 Aug – second leg at 50 km
31 Aug – third leg at 50 km
3 Sep – transfer to global mapping phase
10 Sep – global mapping at 30 km

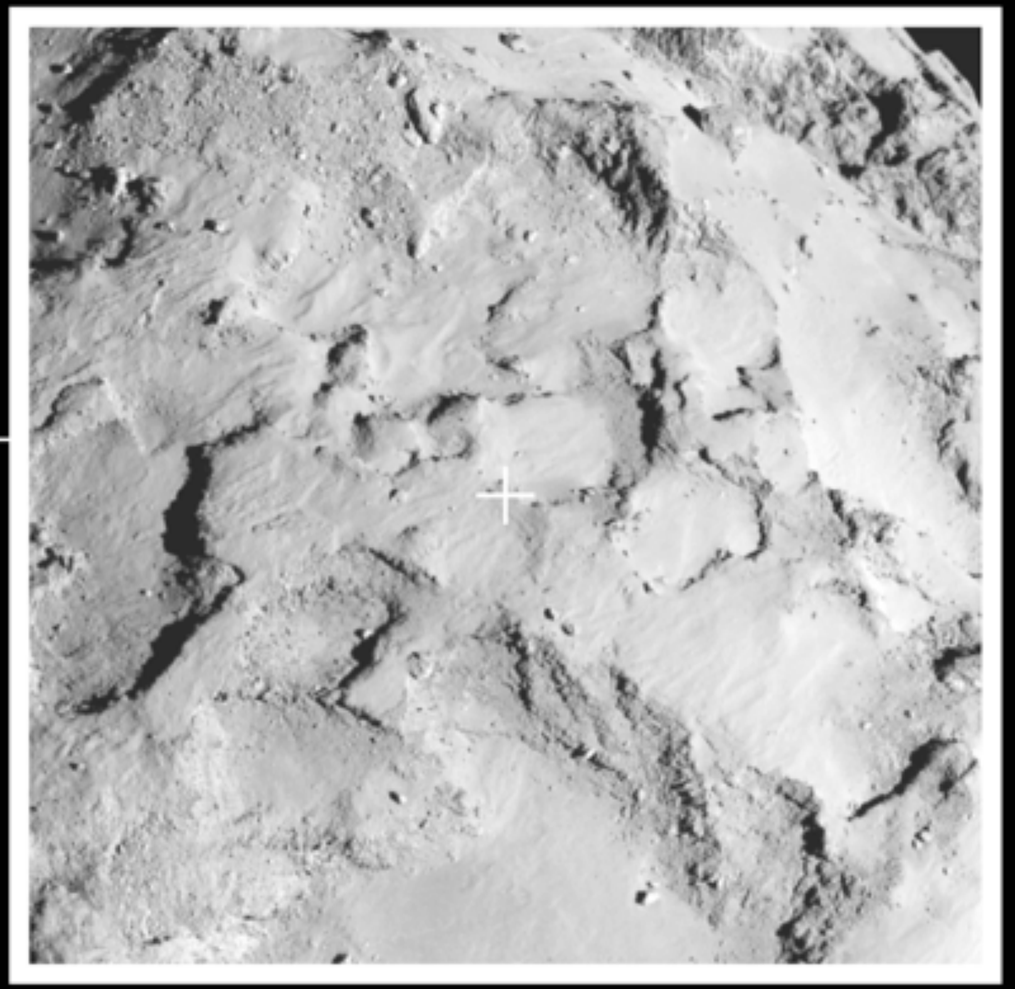
The most intense ESA science operations ever

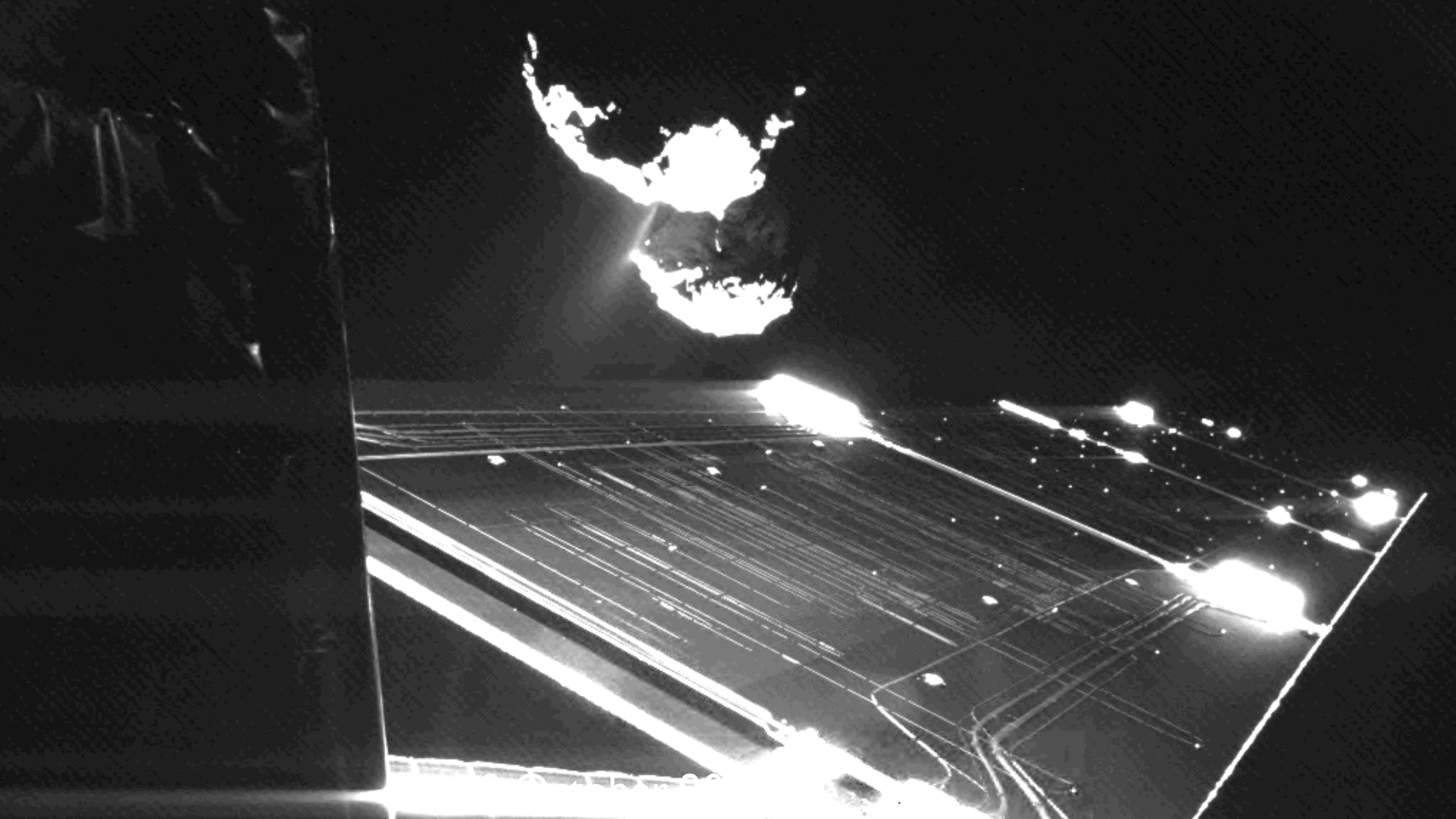

B
I


J
A
B
I

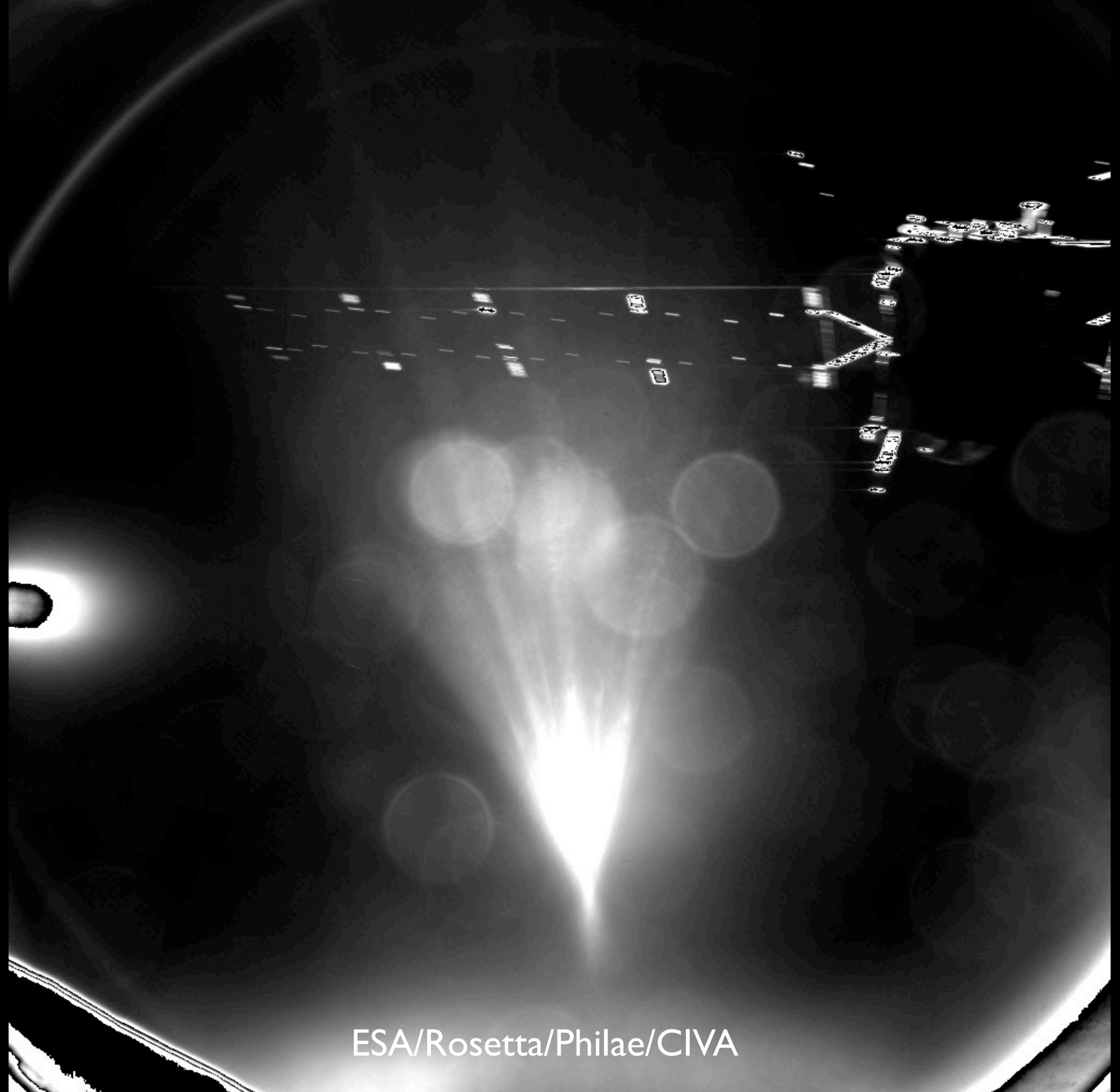
C
A

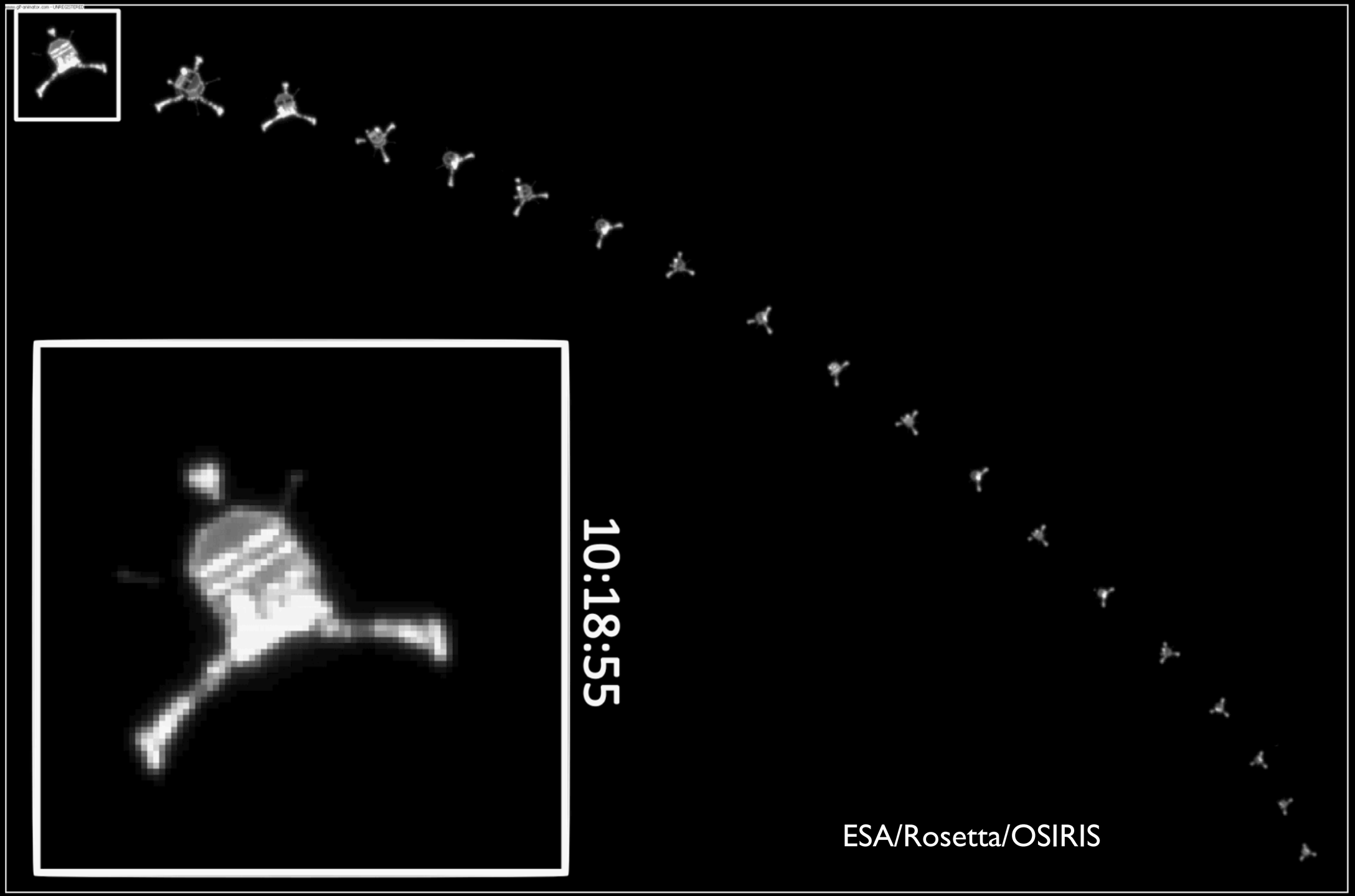
Agilkia





esa
esoc


ESA/Rosetta/Philae/CIVA


10:18:55
ESA/Rosetta/OSIRIS

67.4m

ESA/ROSETTA/PHILAE/ROLIS

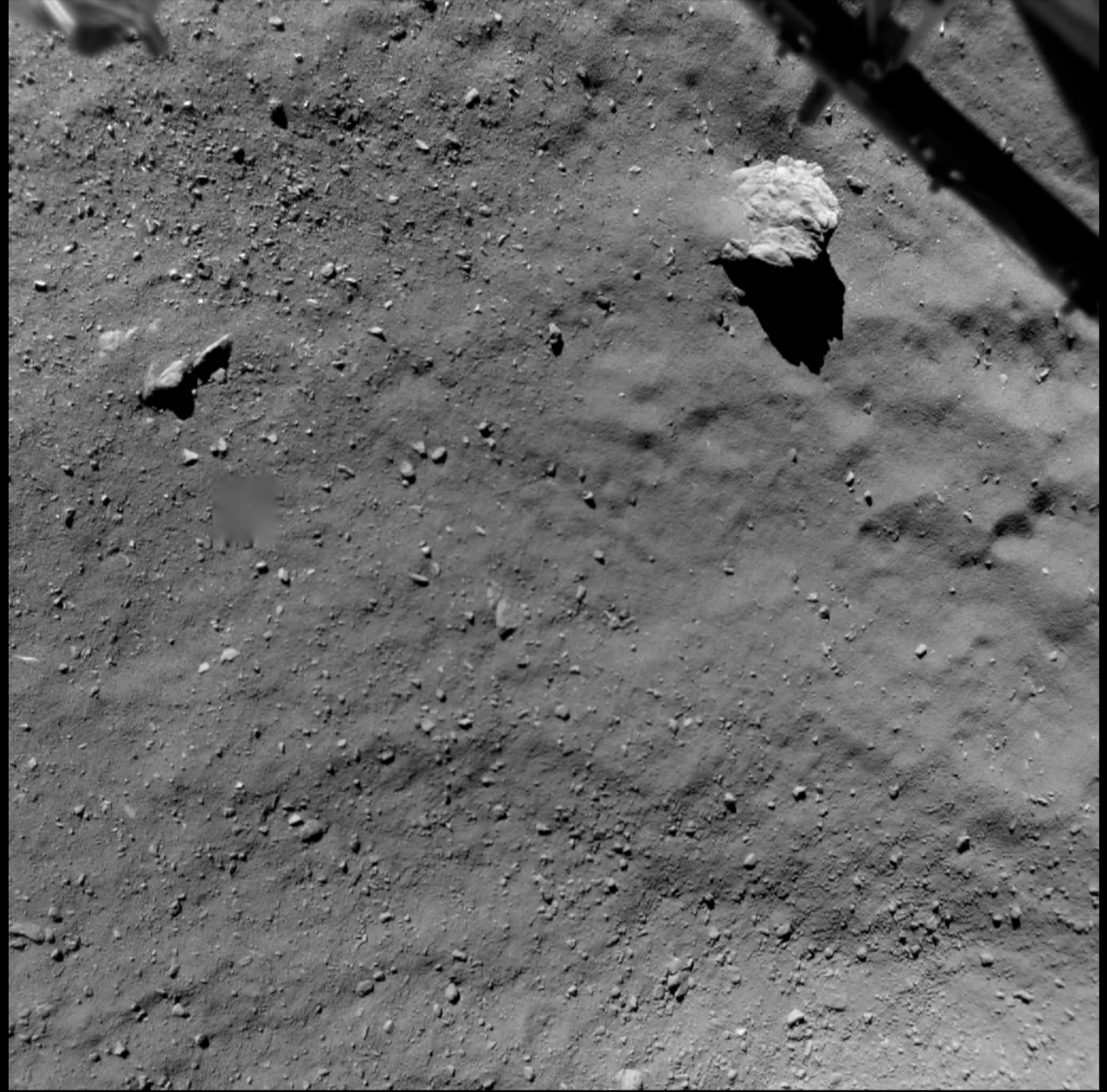
57.9m

ESA/ROSETTA/PHILAE/ROLIS

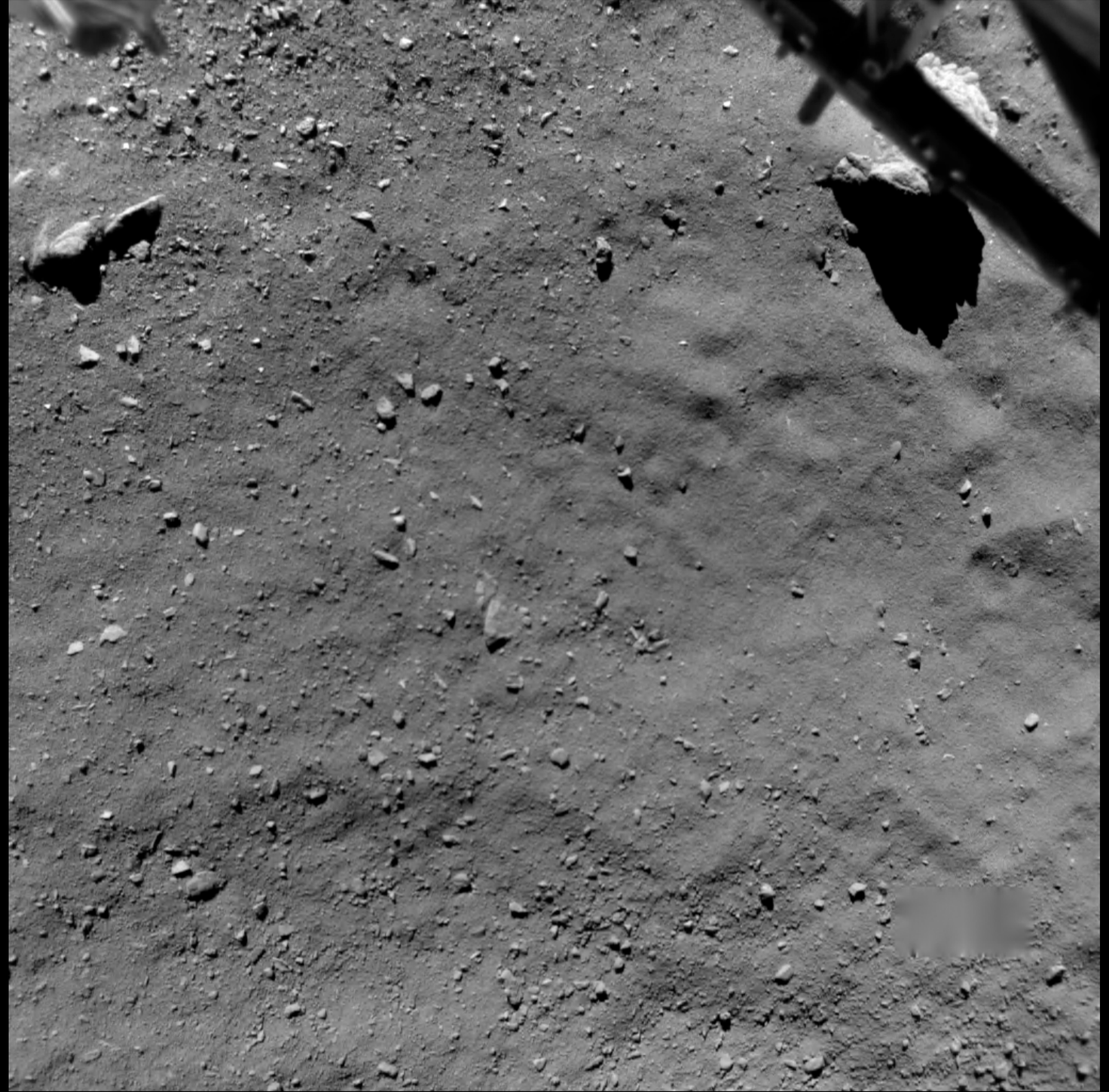
48.5m

ESA/ROSETTA/PHILAE/ROLIS

38.6m

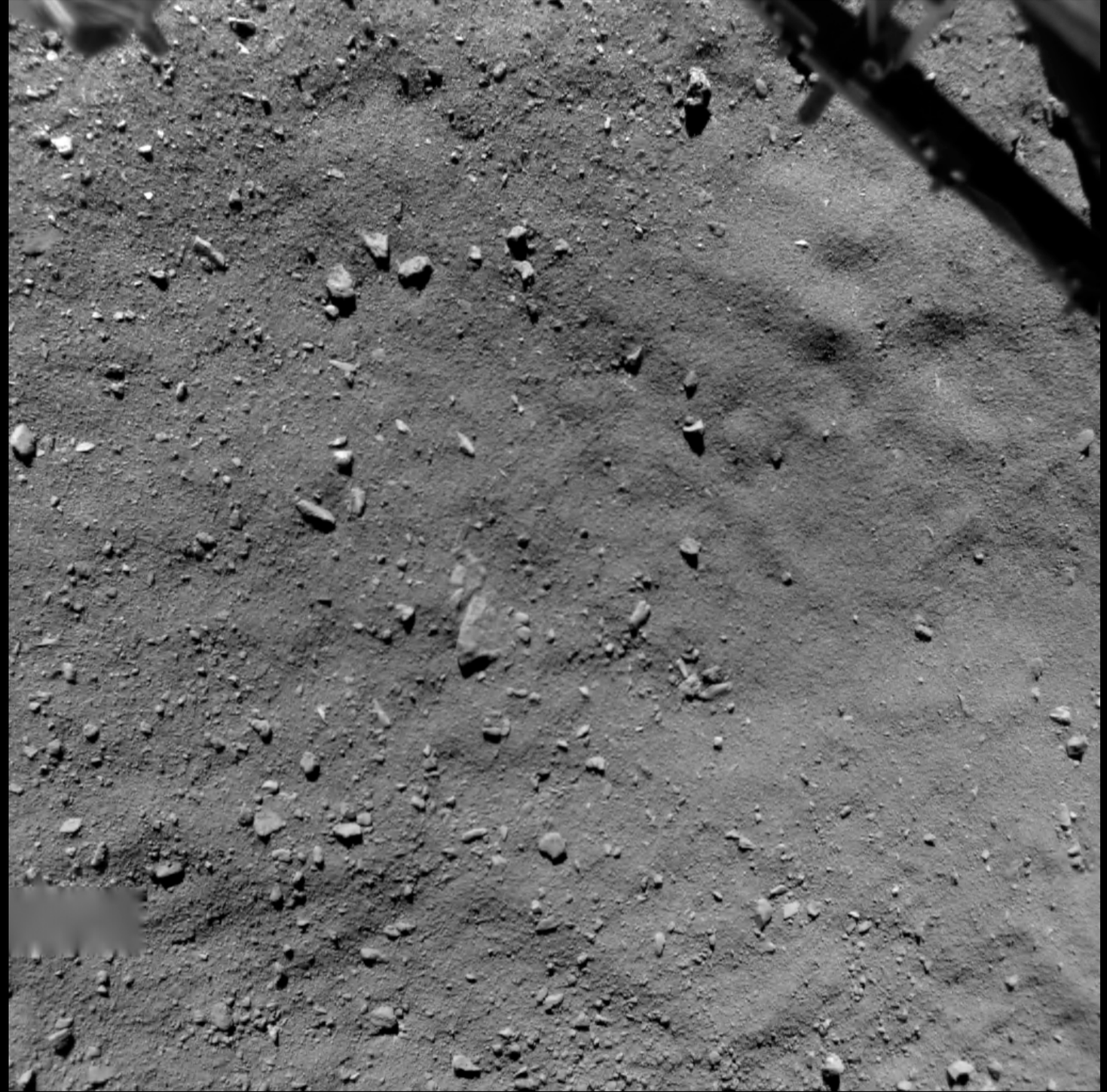


ESA/ROSETTA/PHILAE/ROLIS



28.9m

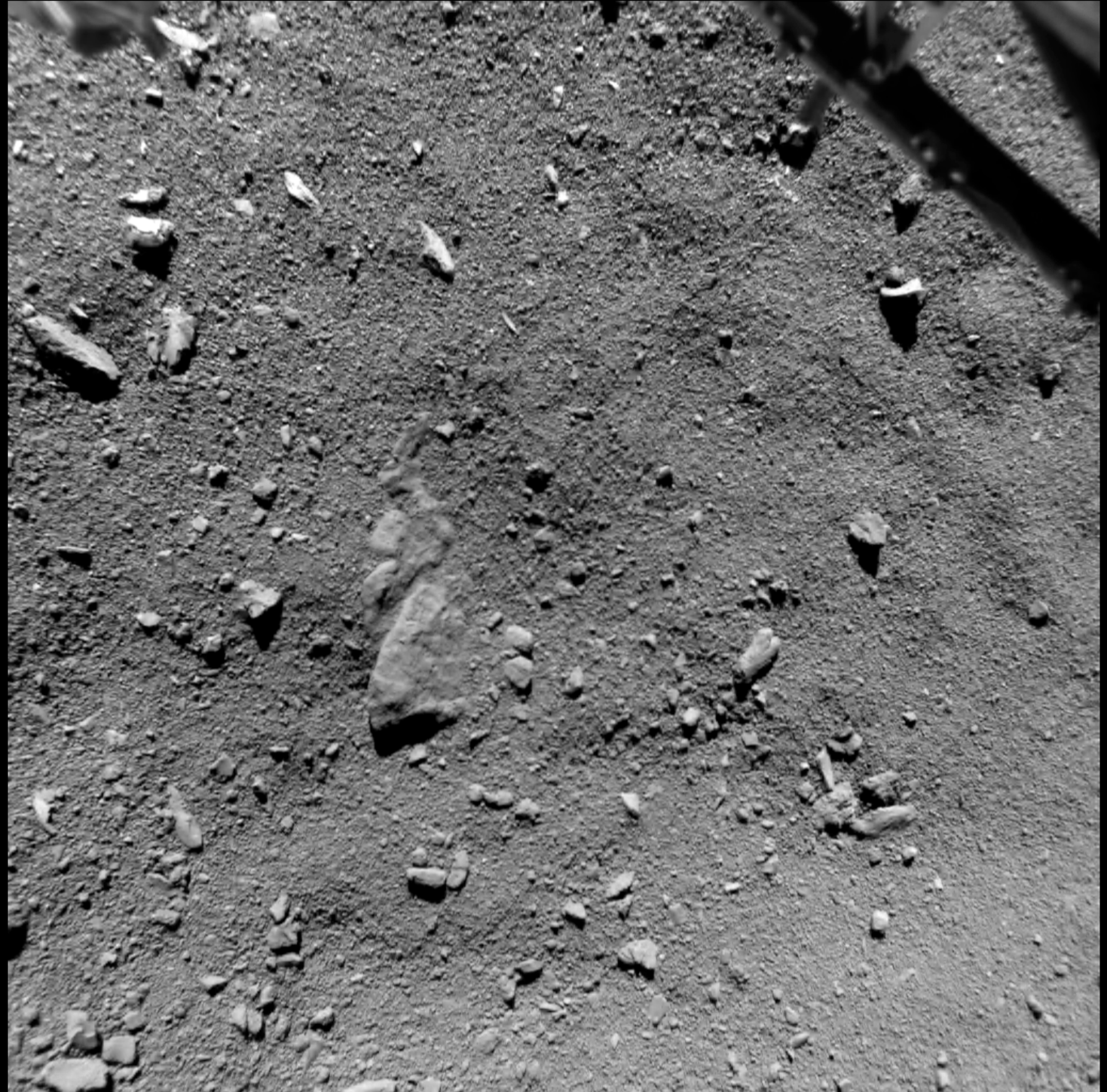
ESA/ROSETTA/PHILAE/ROLIS



18.8m

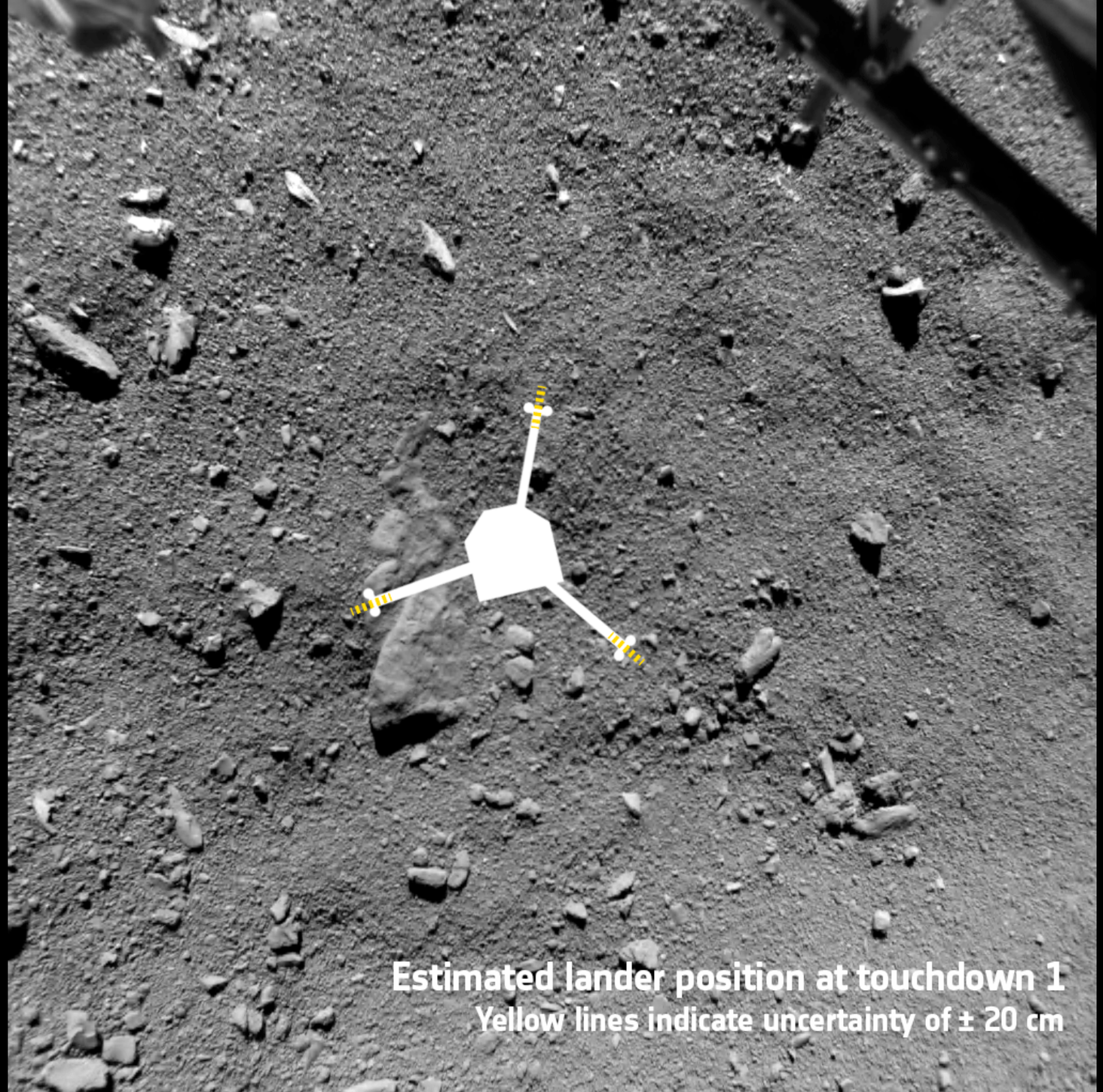
ESA/ROSETTA/PHILAE/ROLIS

9m



ESA/ROSETTA/PHILAE/ROLIS

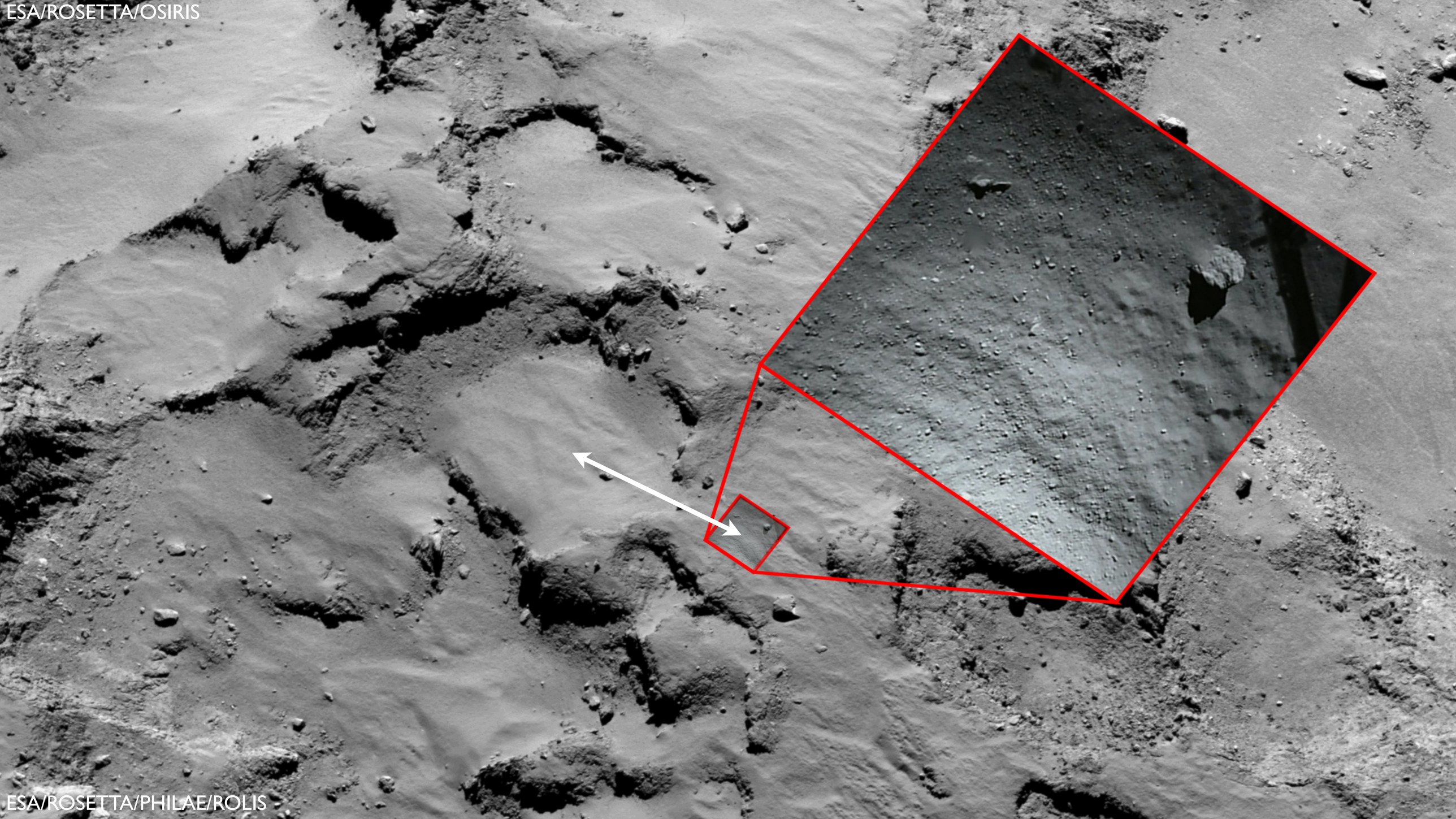
ESA/Rosetta/Philae/ROLIS



Mottola et al., 2015
Biele et al., 2015

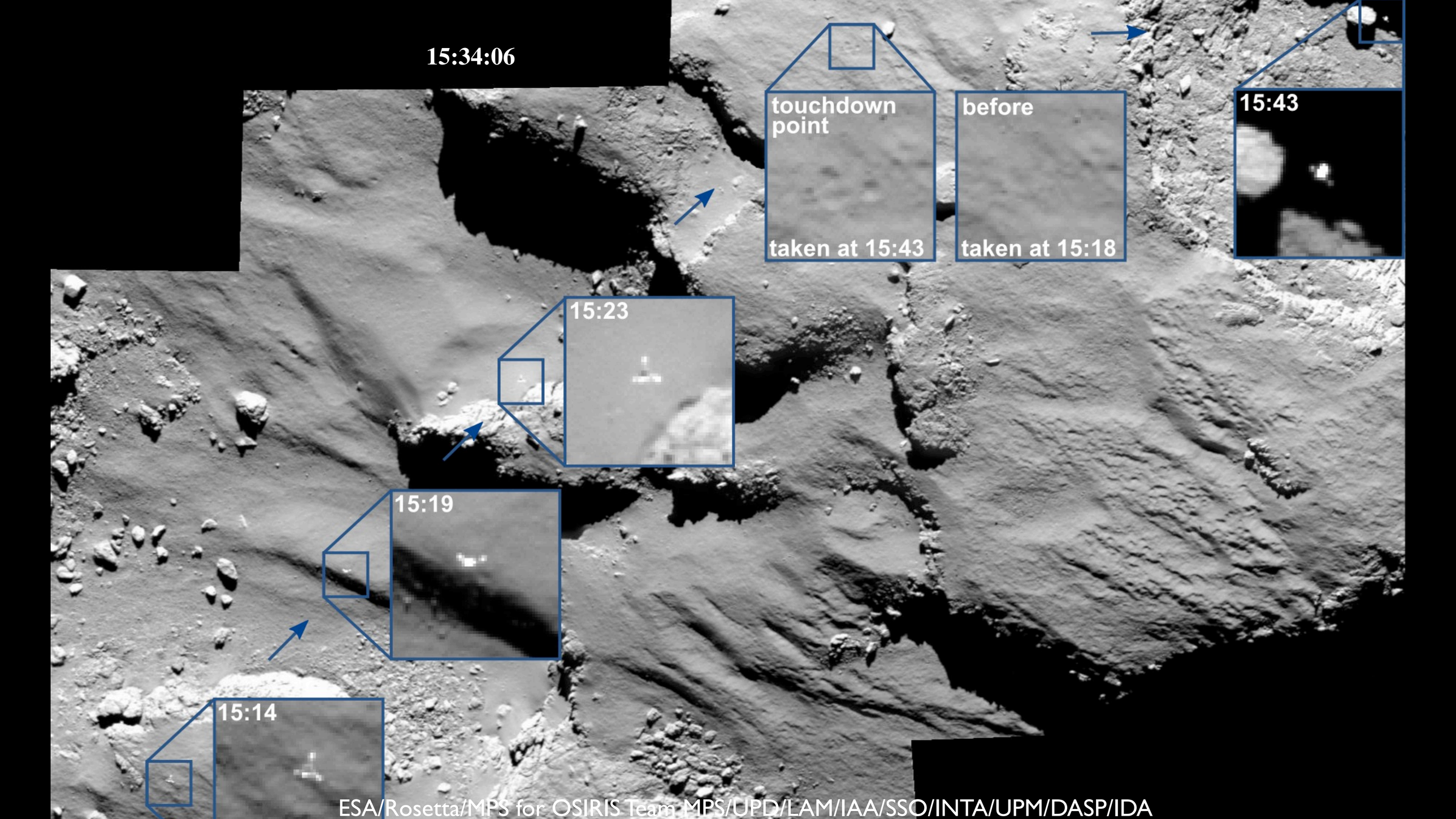
esa

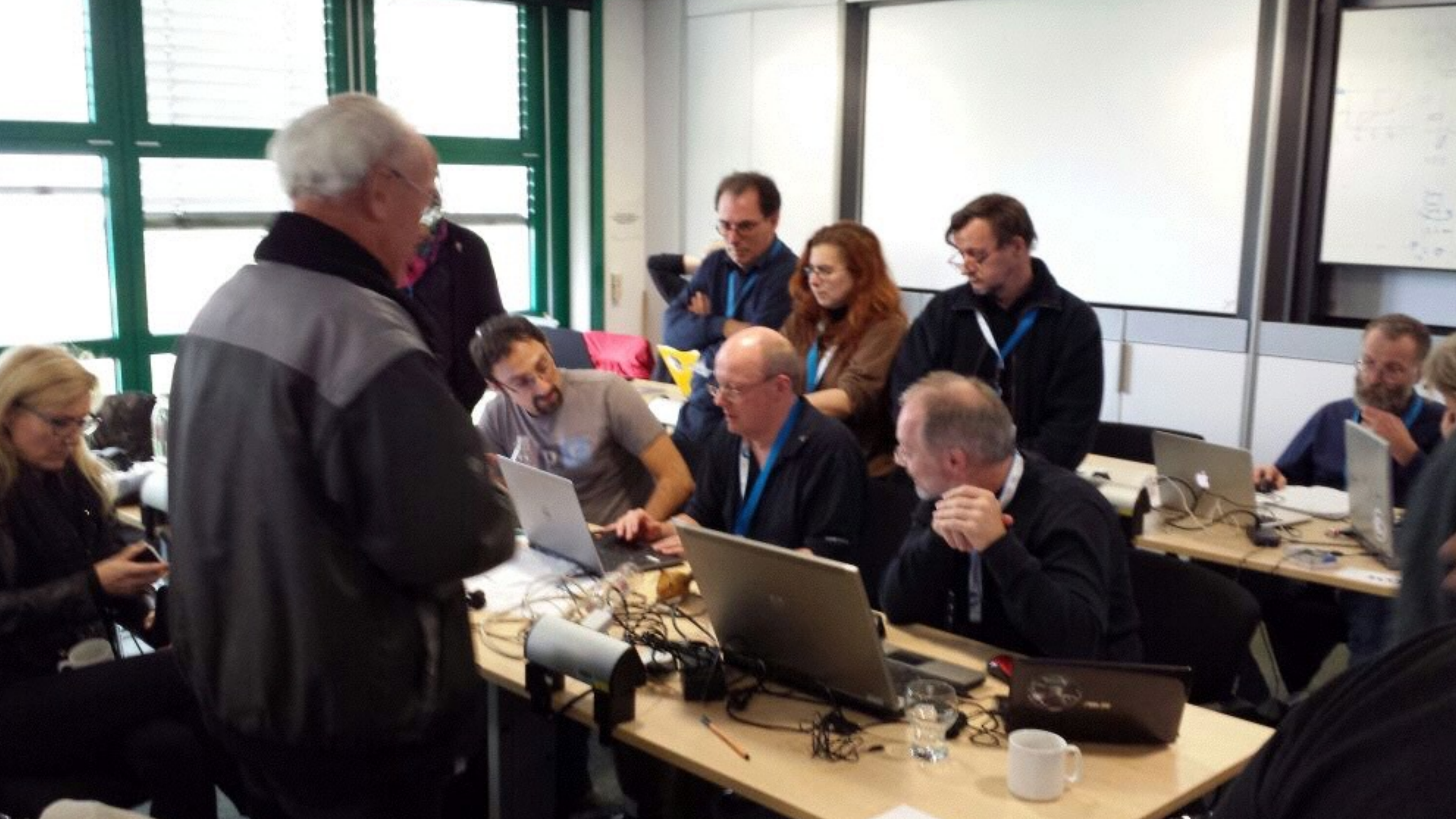
FOD
Flight Operations Director


ESA/ROSETTA/OSIRIS
ESA/ROSETTA/PHILAE/ROLIS

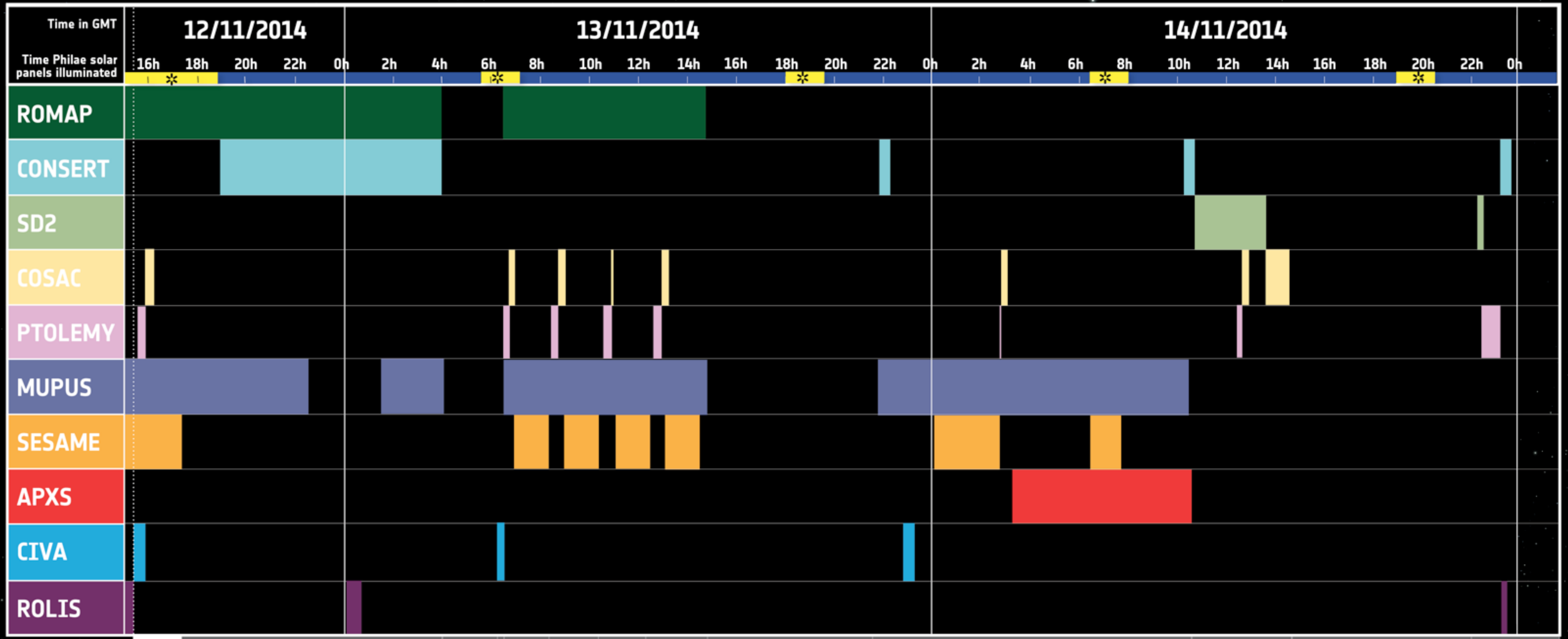
esa

ESA/Rosetta/Philae/CIVA


15:34:06
touchdown point
taken at 15:43
before
taken at 15:18
15:43
15:23
15:19
15:14
ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

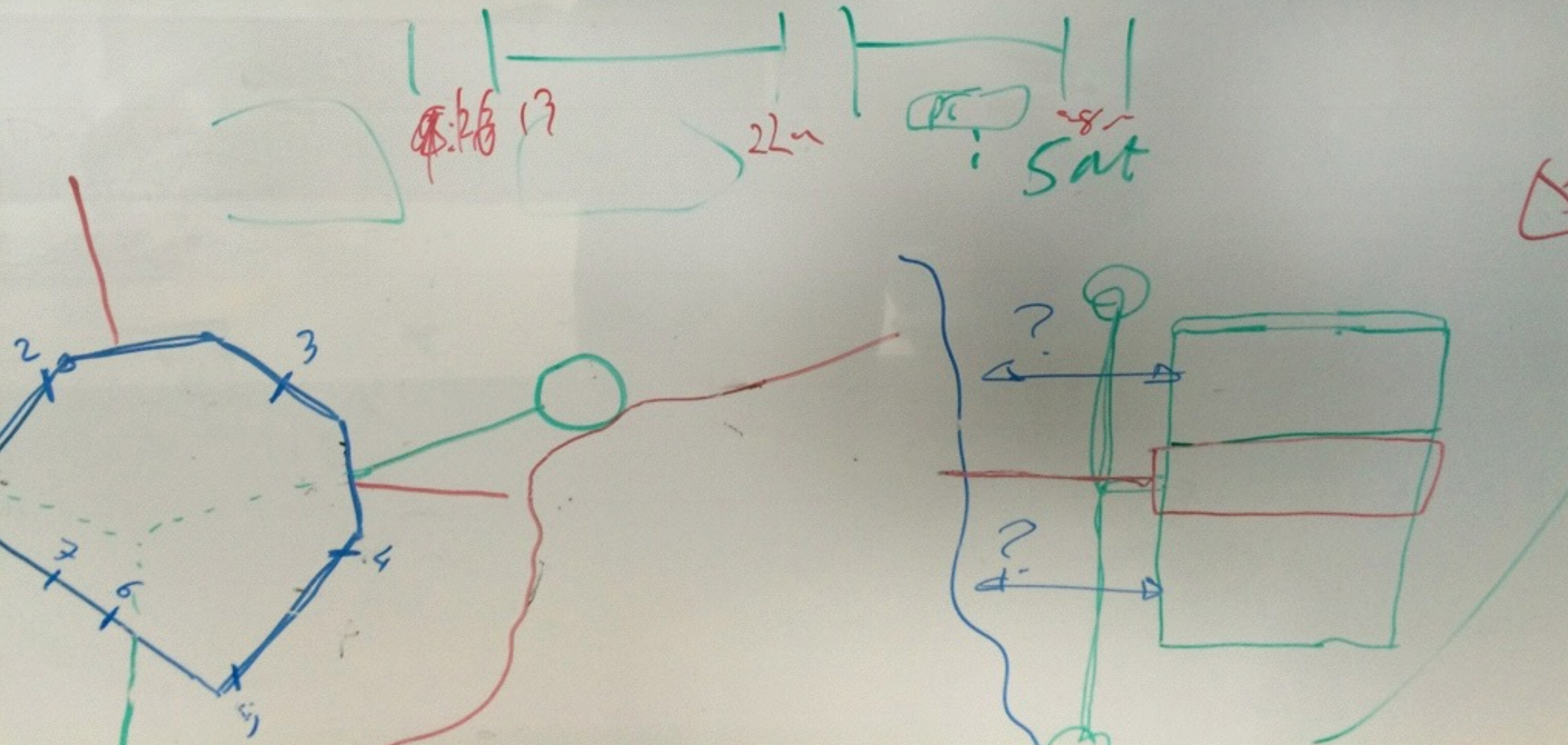


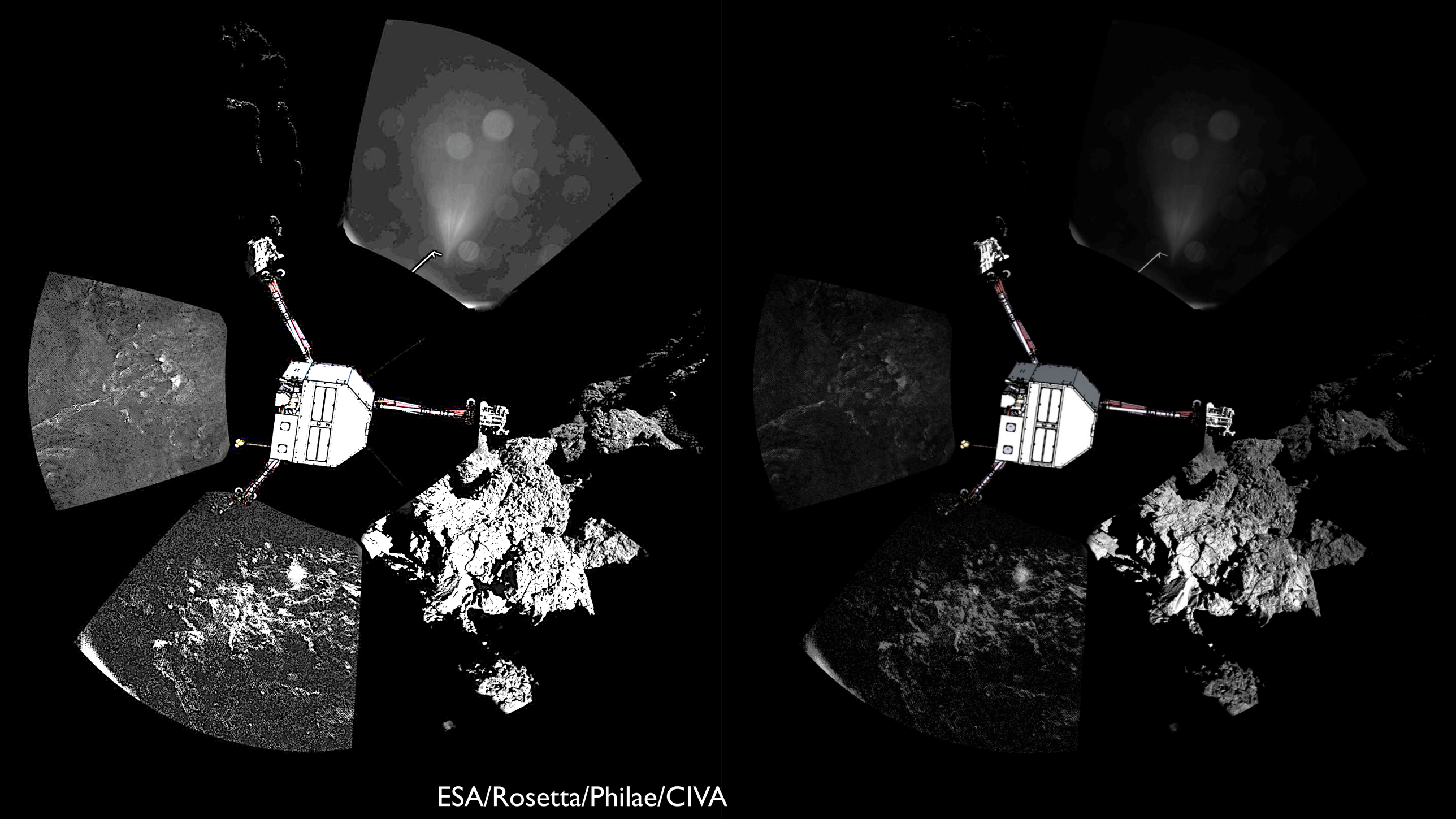
→ PHILAE'S ADAPTED FIRST SCIENCE SEQUENCE



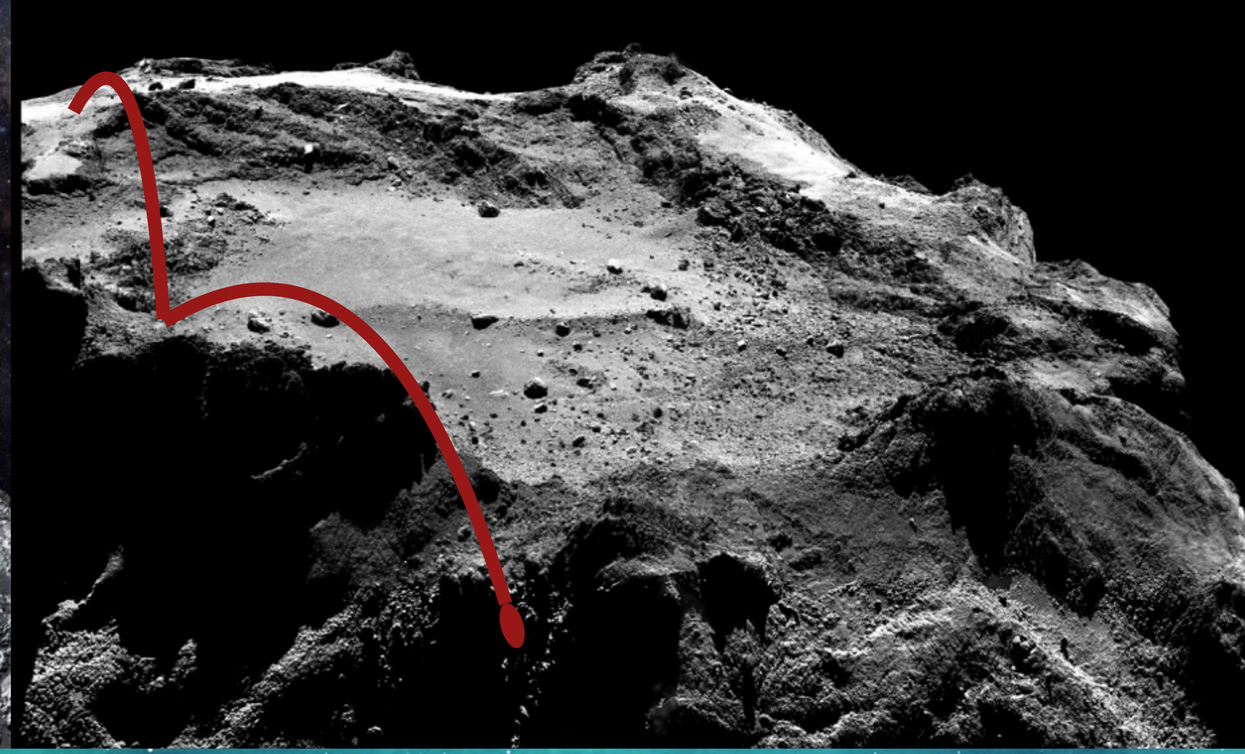
Touchdown 1: 15:34
Collision: 16:20
Touchdown 2: 17:25
Touchdown 3: 17:32

Time in GMT onboard Philae

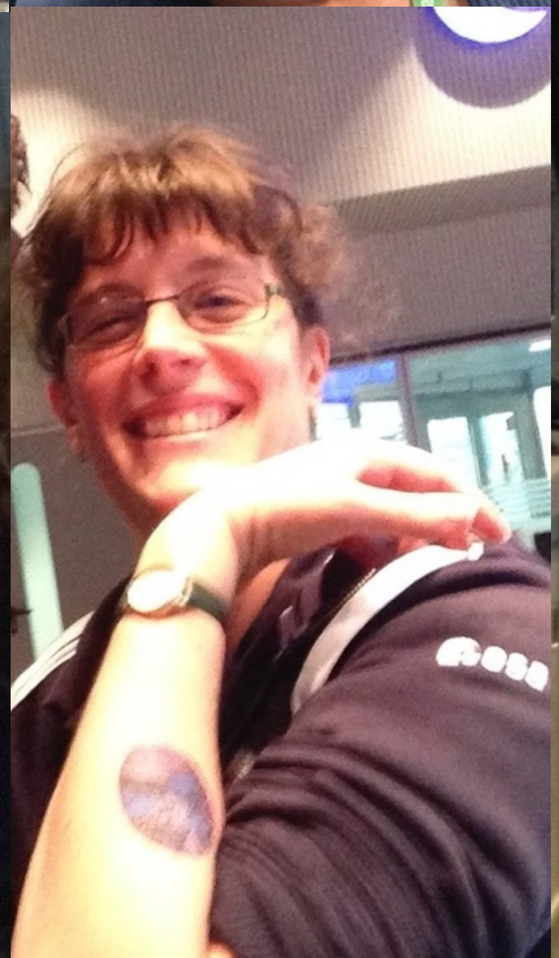

22m
Sat
2
3
4
5
6
7
?
?



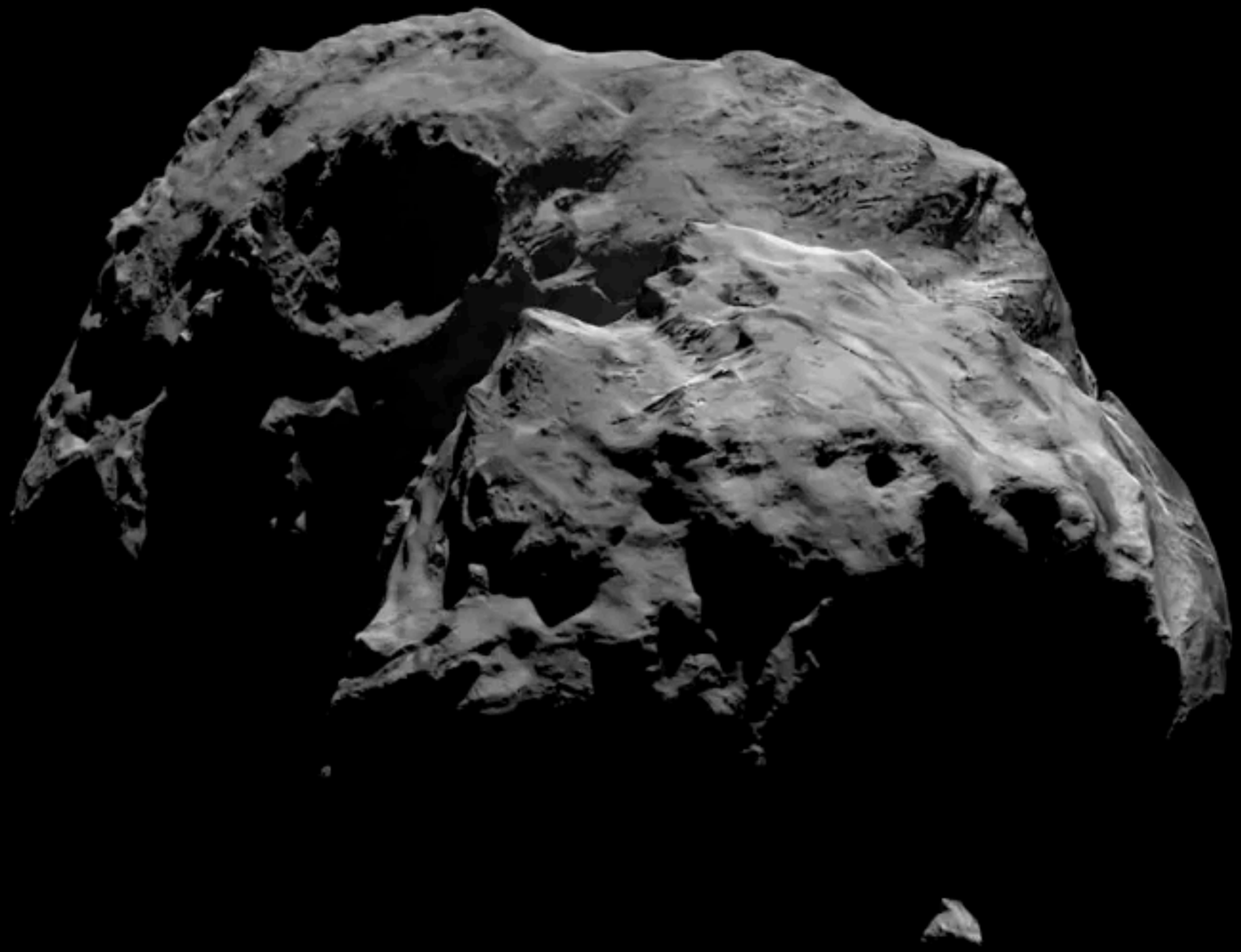
ESA/Rosetta/Philae/CIVA



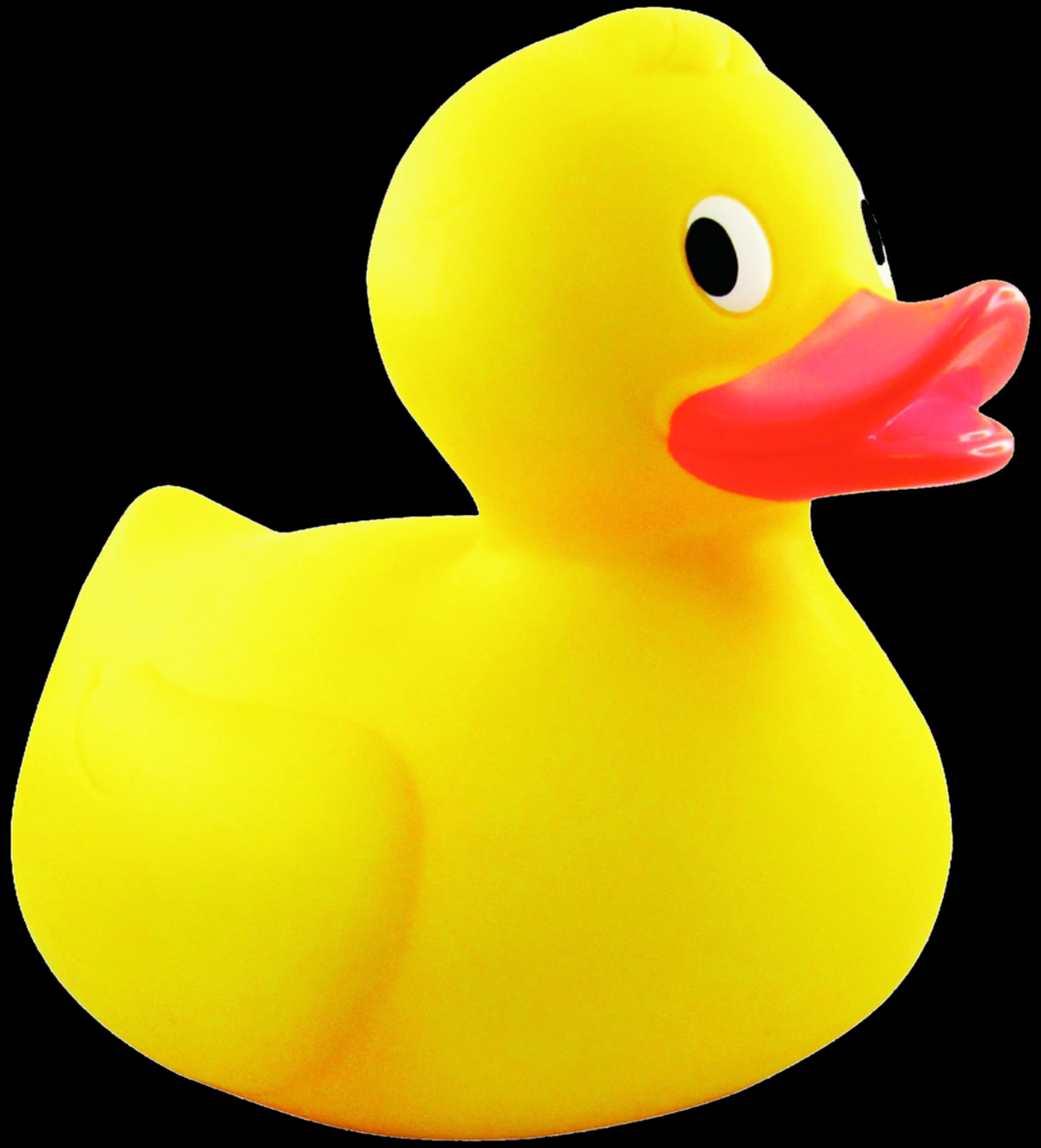
esa



esa
1
COMET LANDING
2
COMET LANDING
3
COMET LANDING
4
COMET LANDING
esa

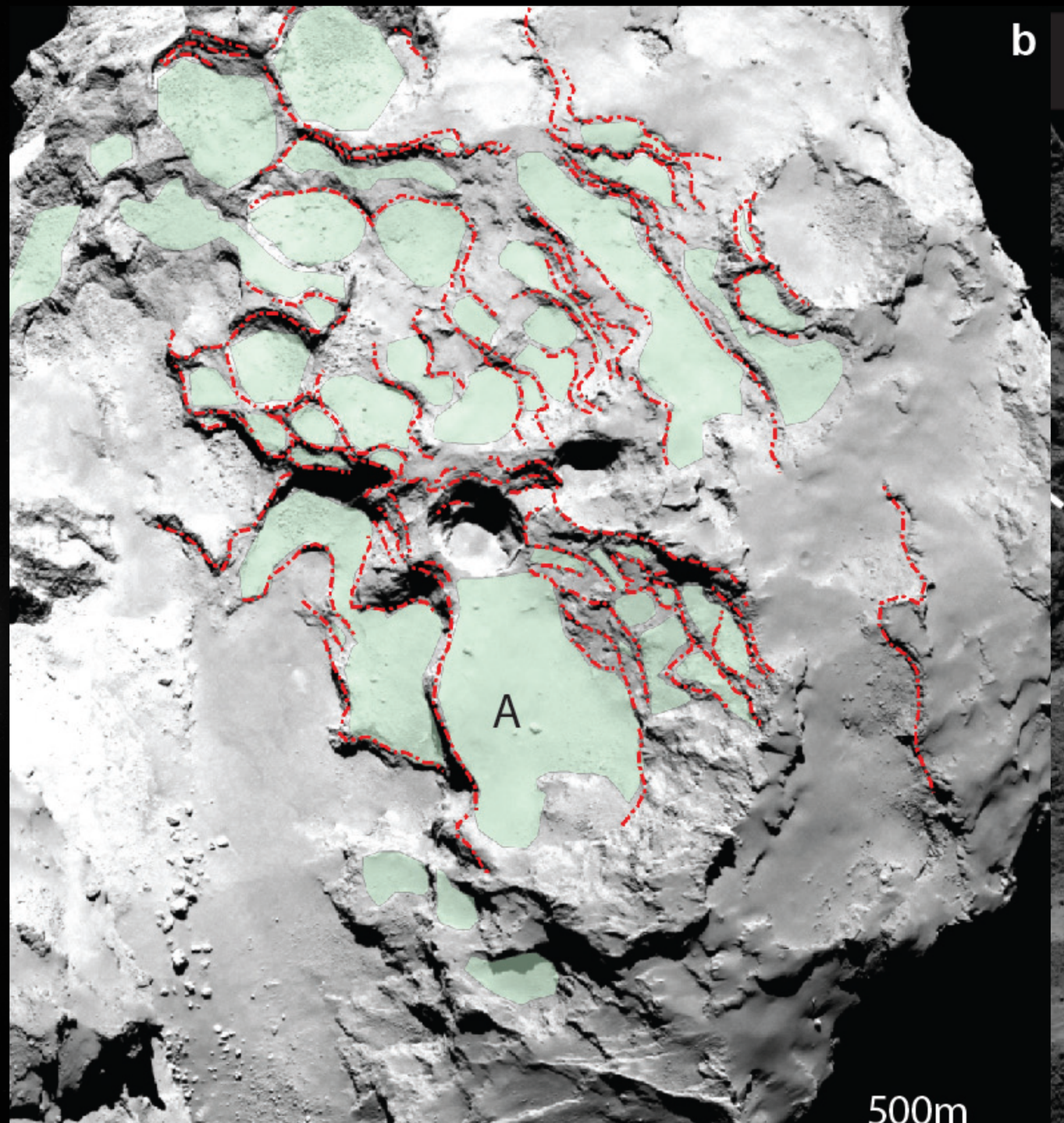


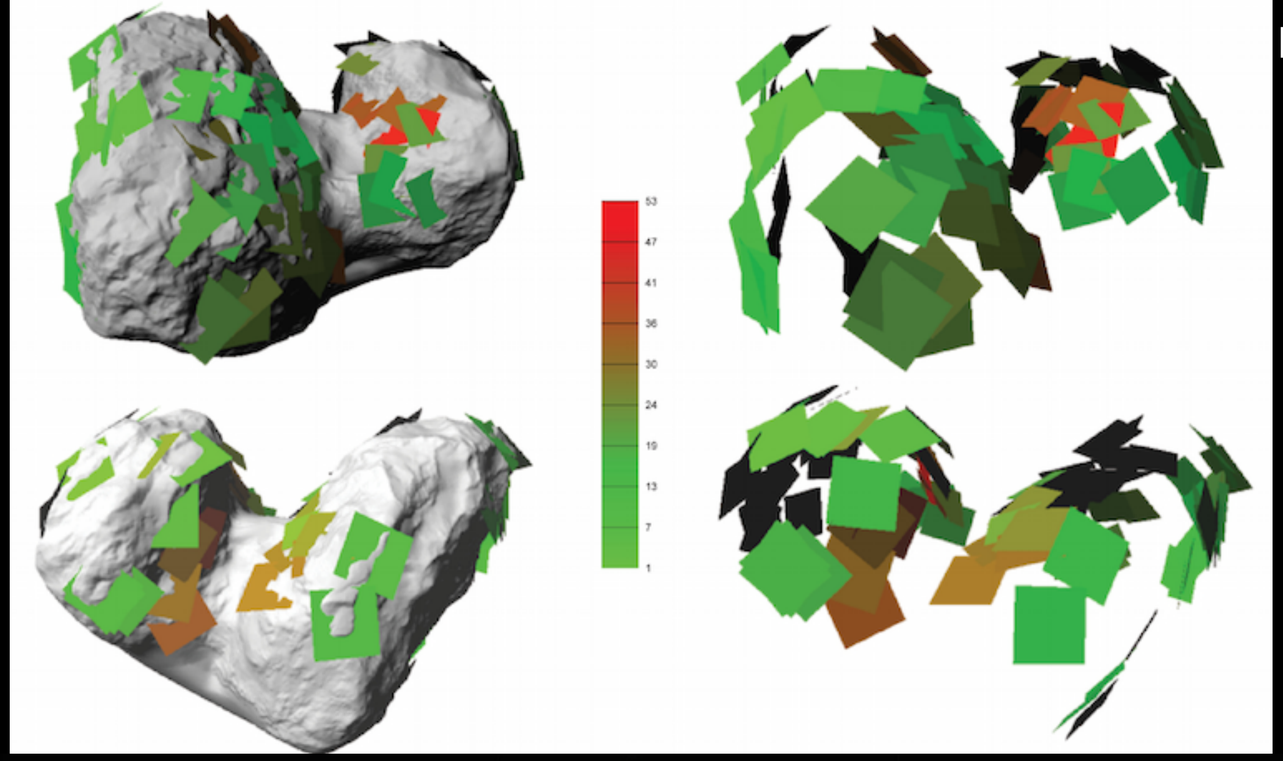
67P/C-G 3D shape model and surface model based on Rosetta images / Mattias Malmer, ESA/Rosetta/NAVCAM, MPS for OSIRIS team



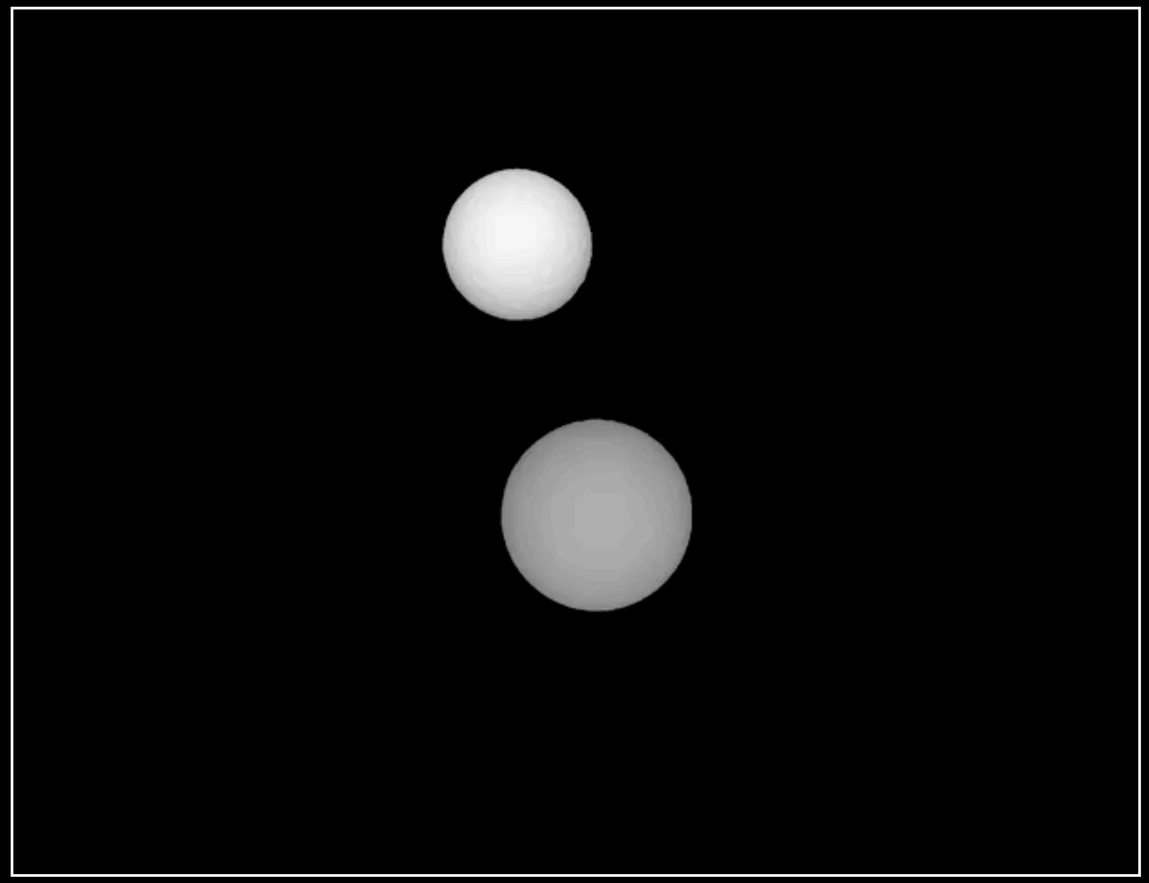
?

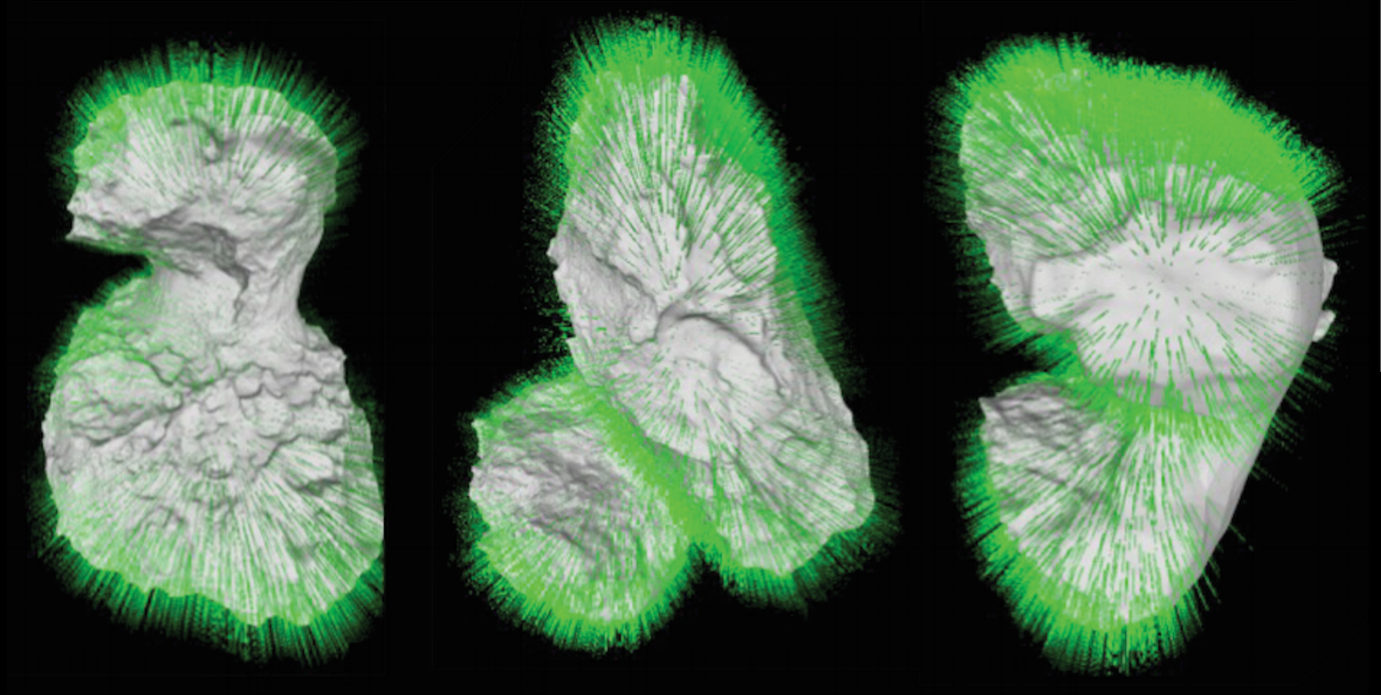
Massironi et al. 2015, Nature



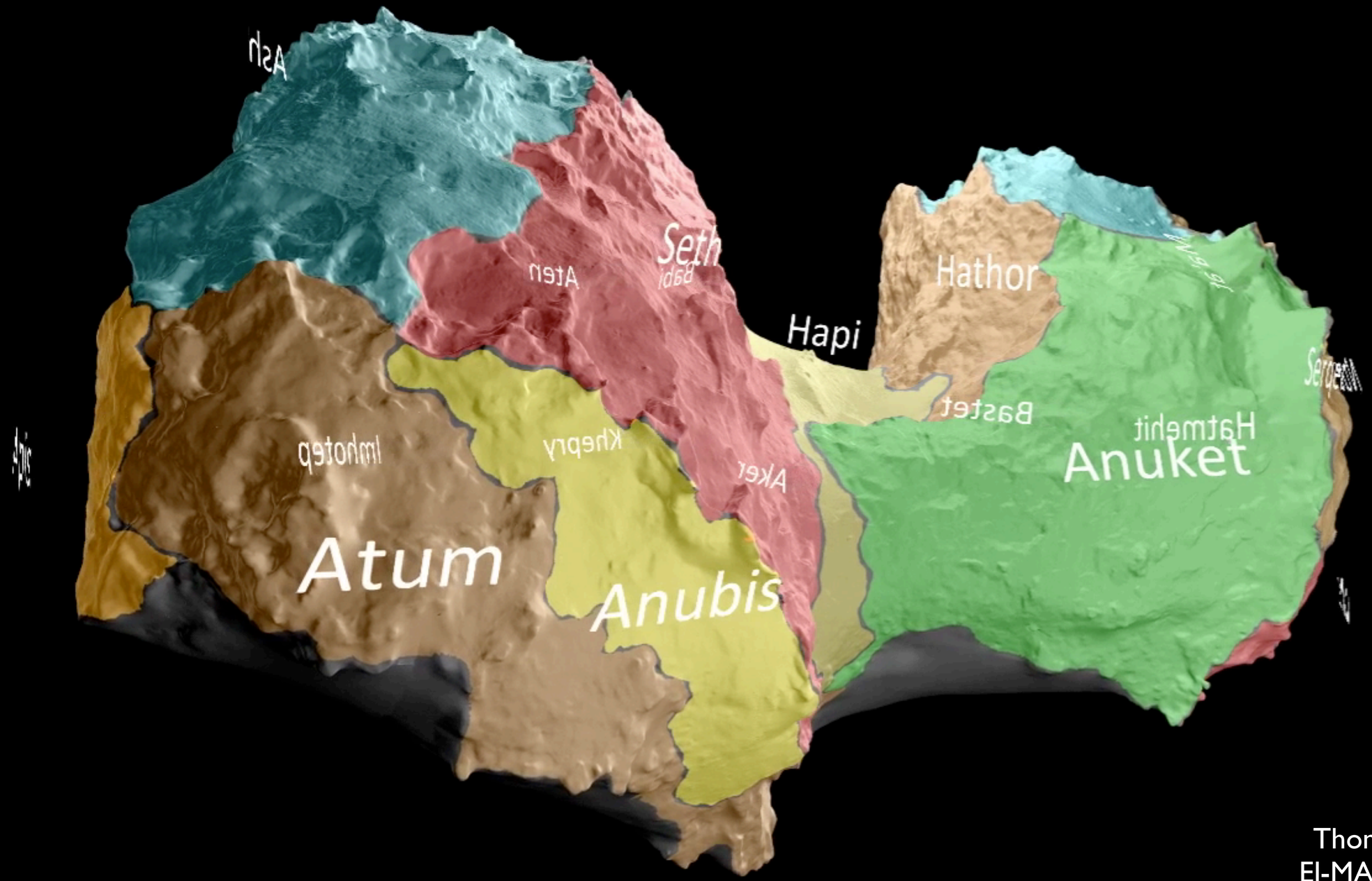


Massironi et al. 2015, Nature



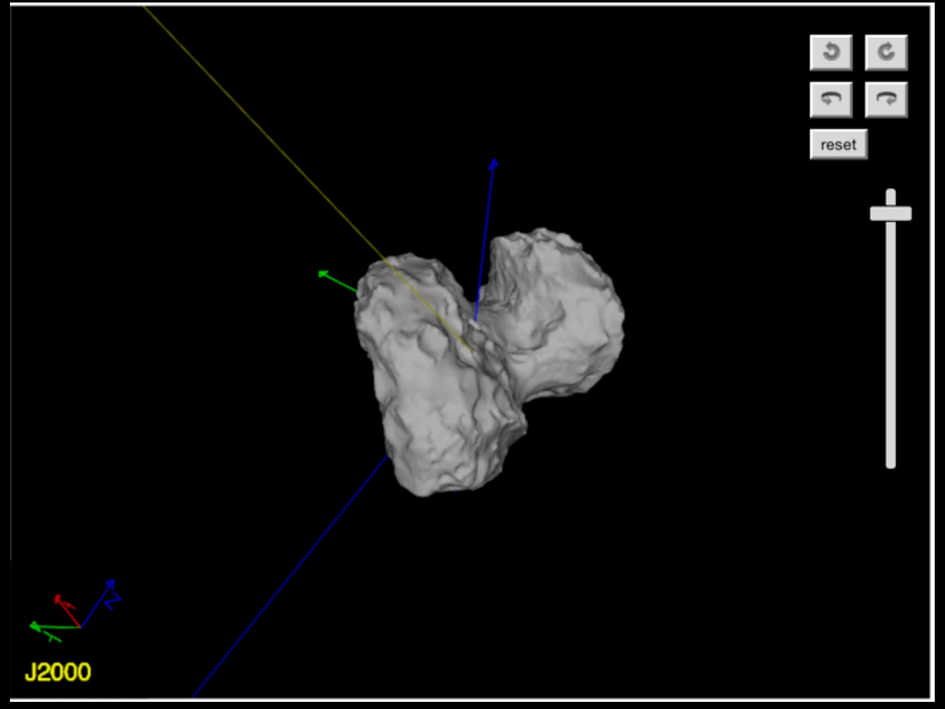


Jutzi and Asphaug, 2015 Science

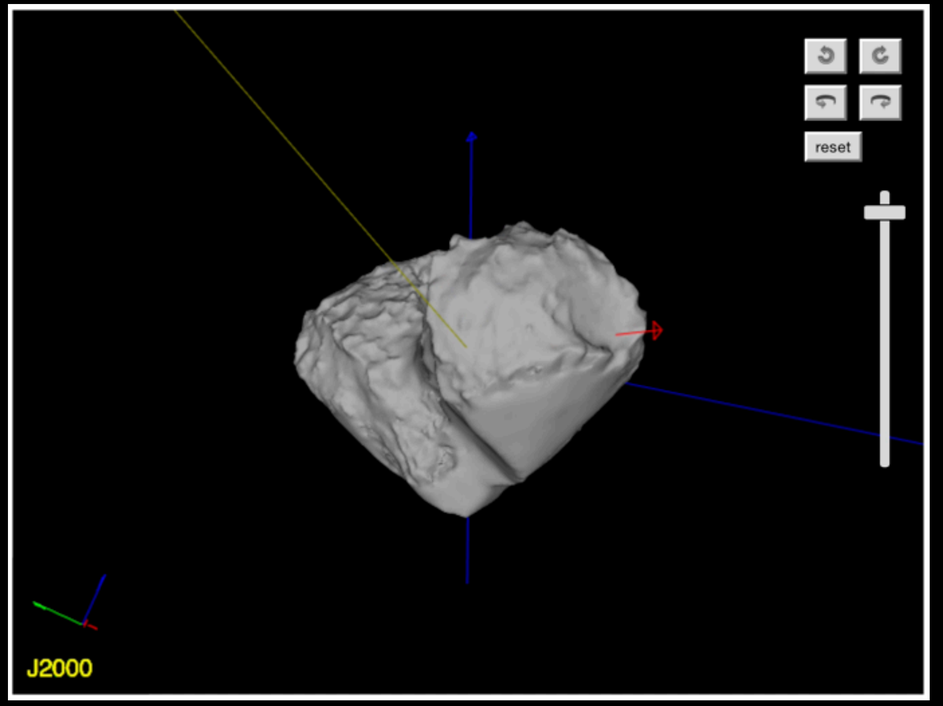


Thomas et al., A+A, 2015
El-MAarry et al., A+A, 2015

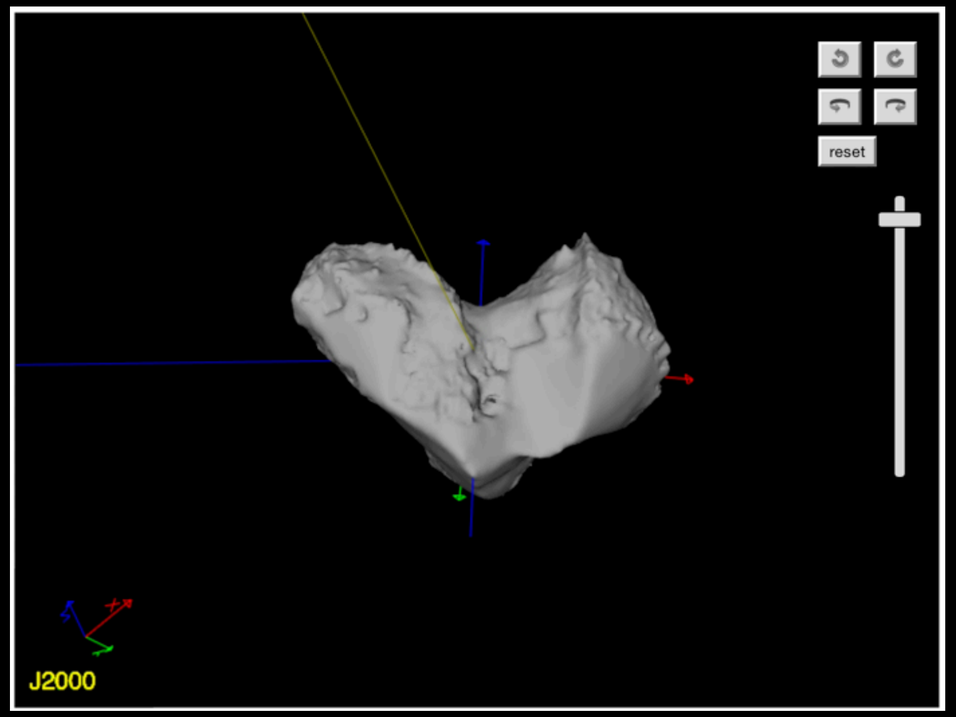
October 2014



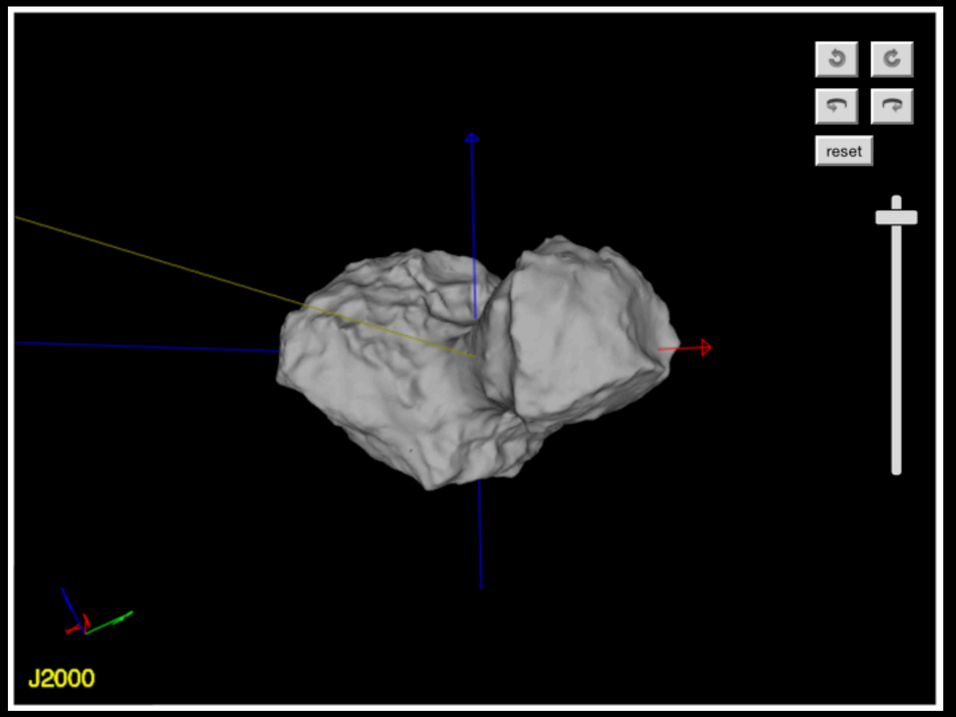
May 2015

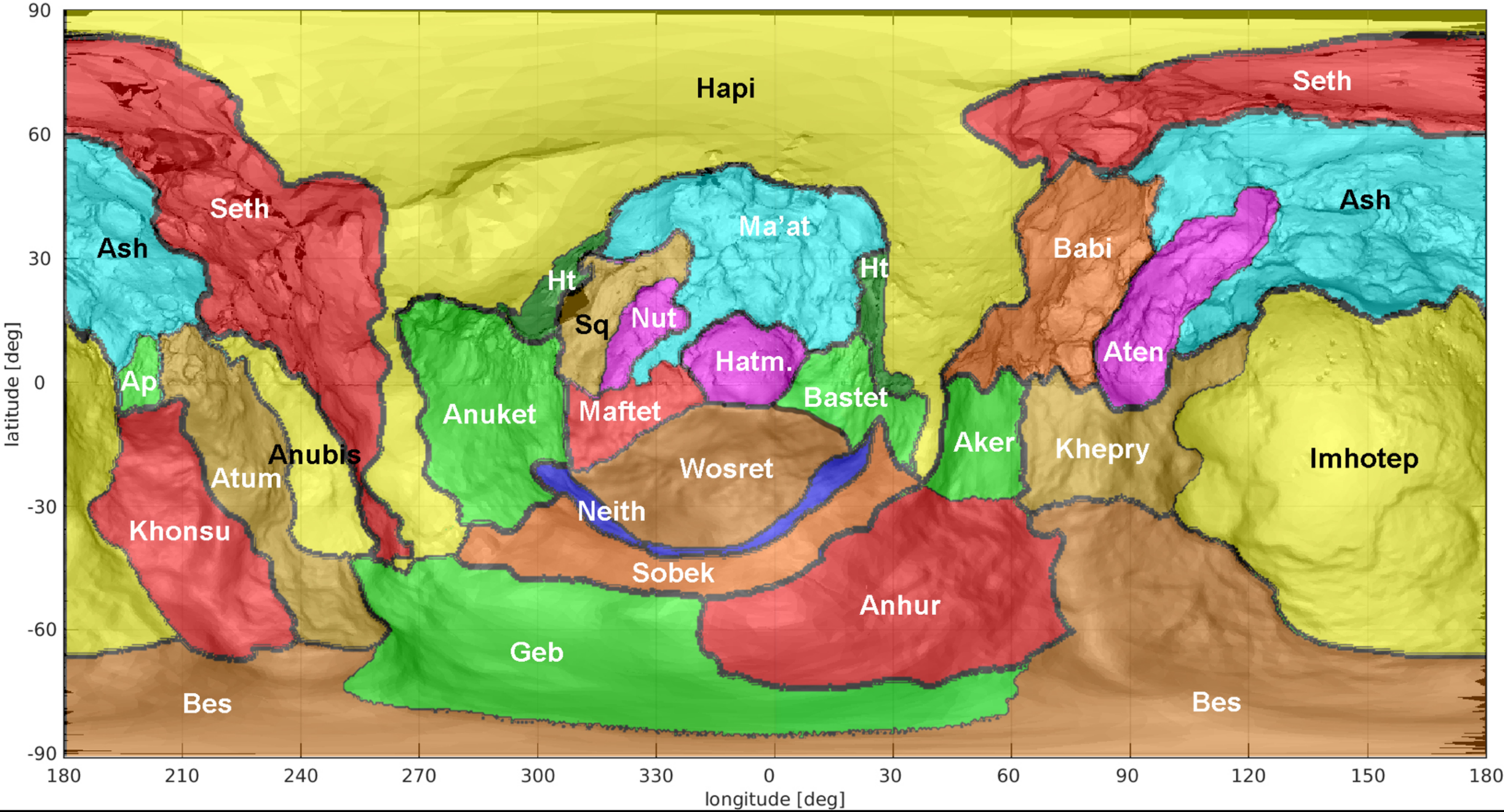


October 2015

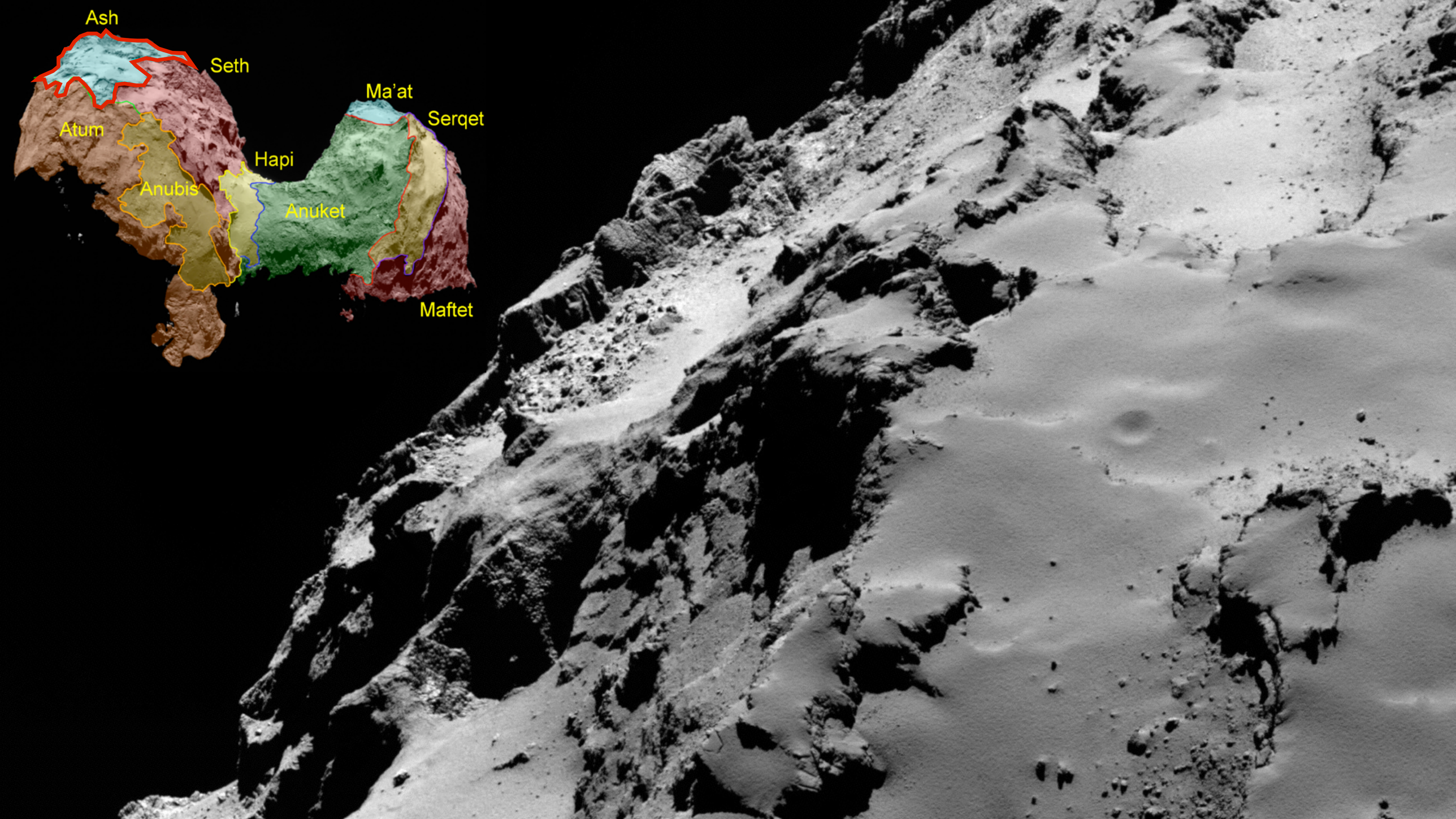


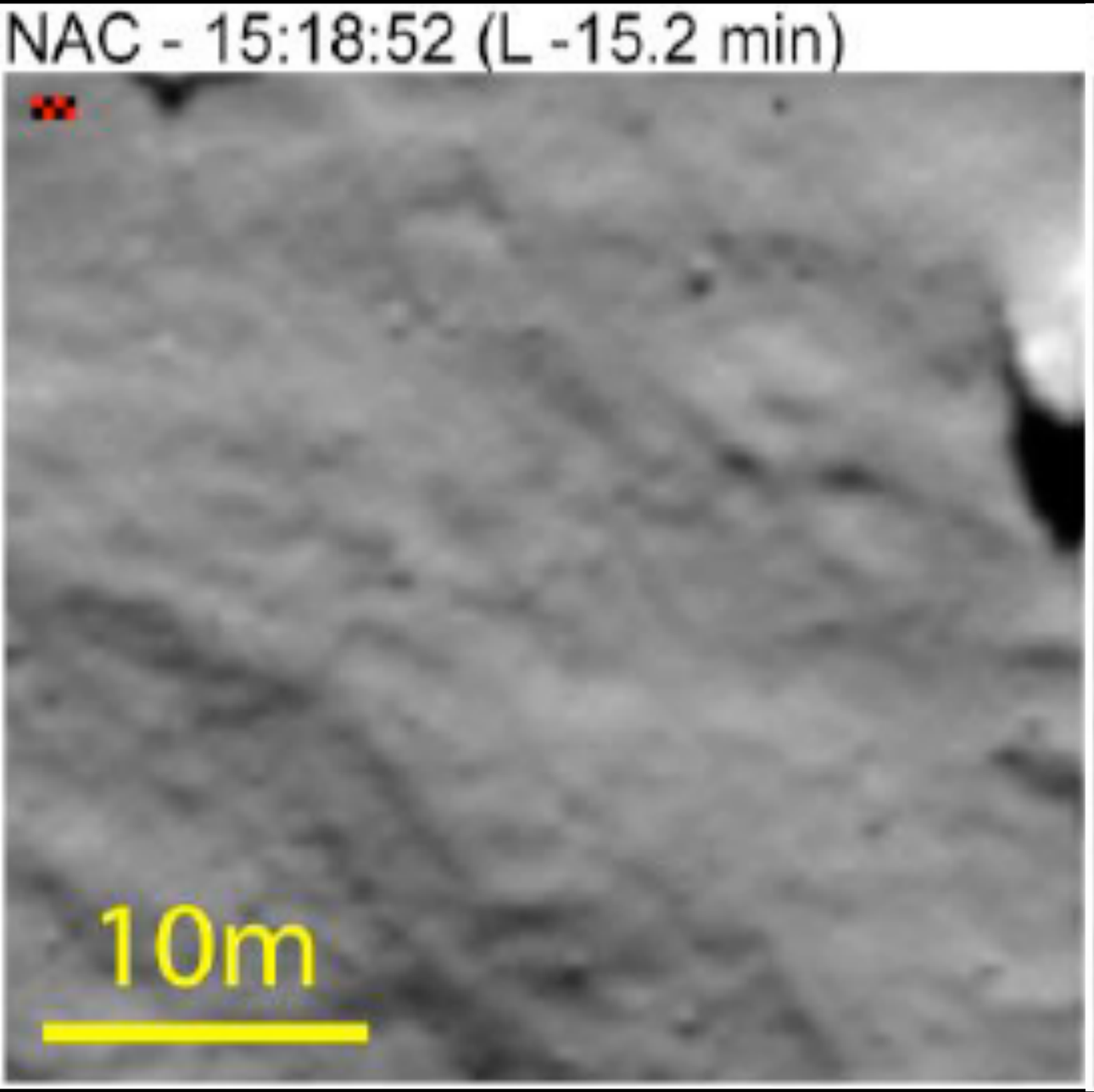
March 2016

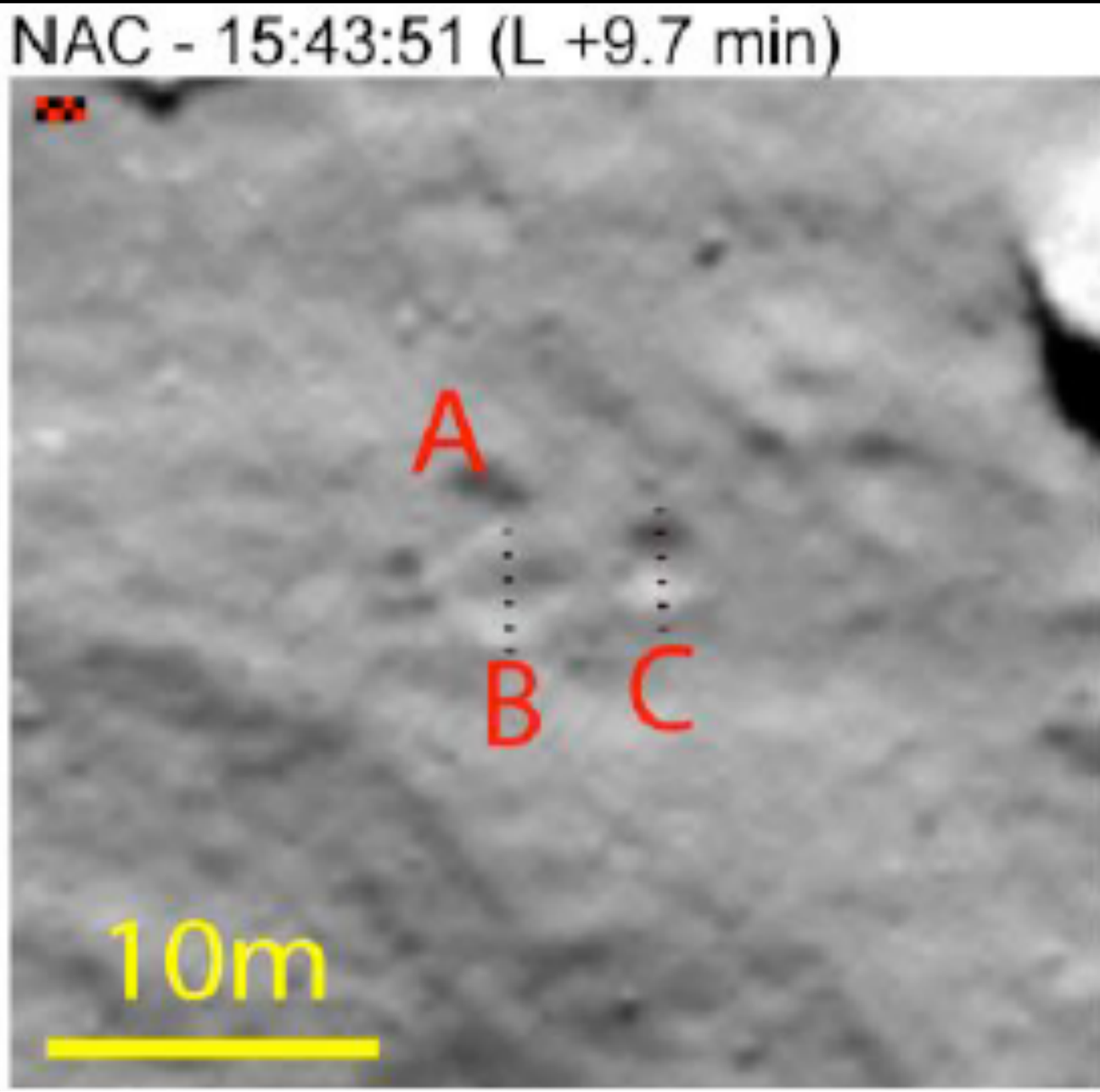




ESA/Rosetta/OSIRIS/El-Maarry et al (2016, in preparation)


Ash
Seth
Ma'at
Serqet
Atum
Hapi
Anubis
Anuket
Maftet

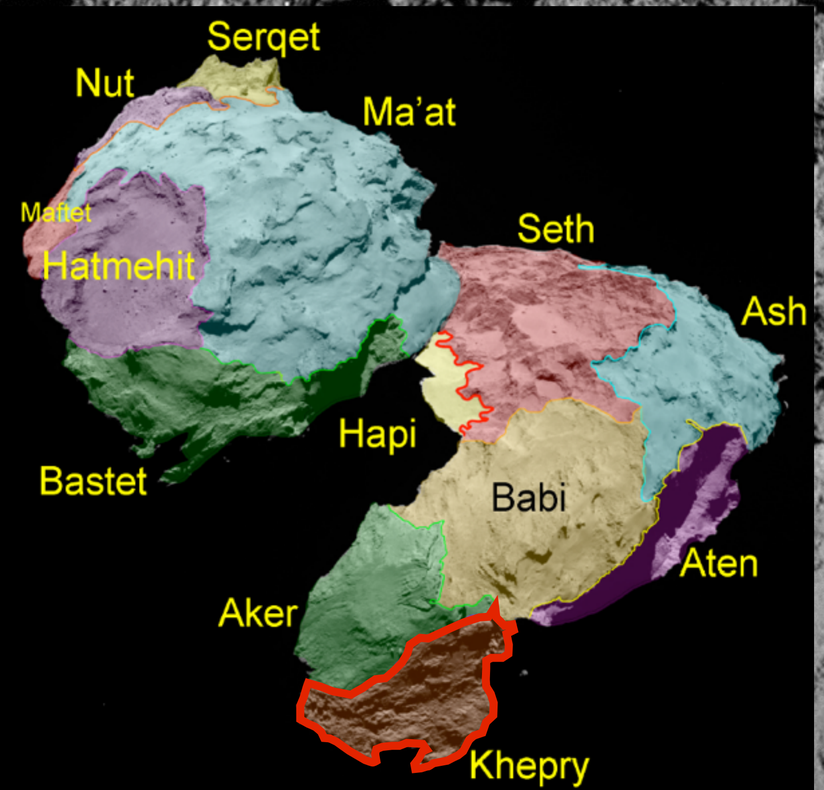




Biele et al., 2015

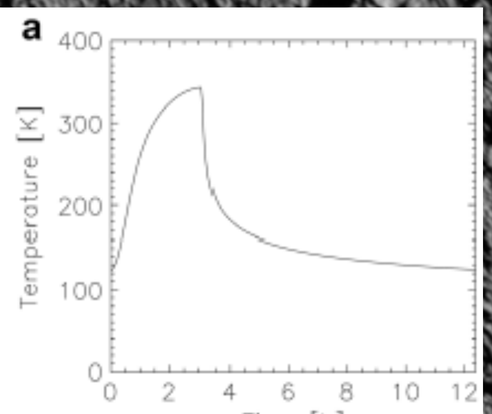
ESA/Rosetta/OSIRIS

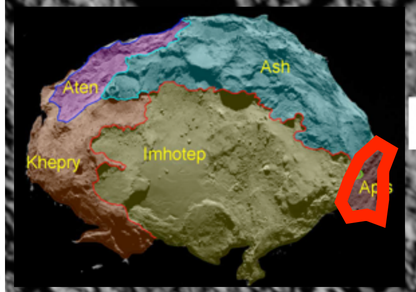
El Maarry et al., A+A, 2015



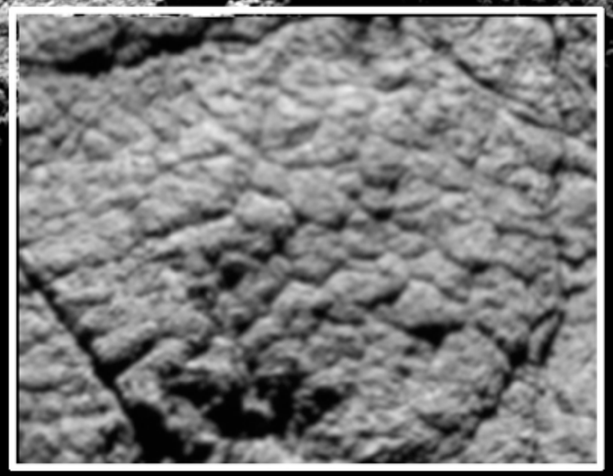
150m

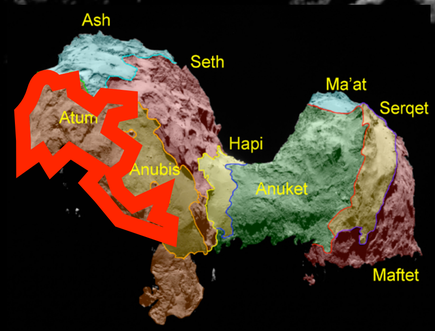
El-Maary et al., GRL, 2015





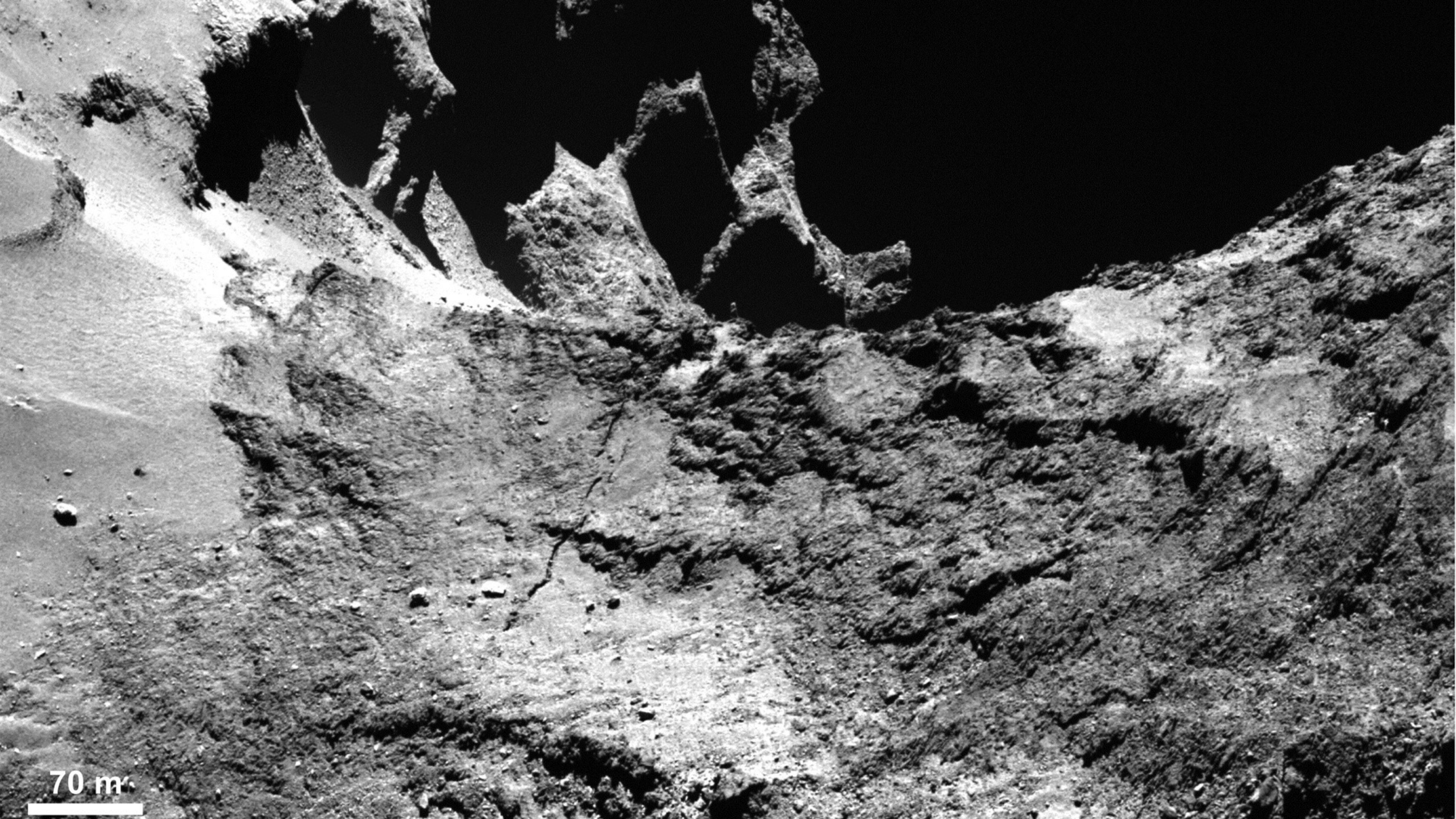
25m

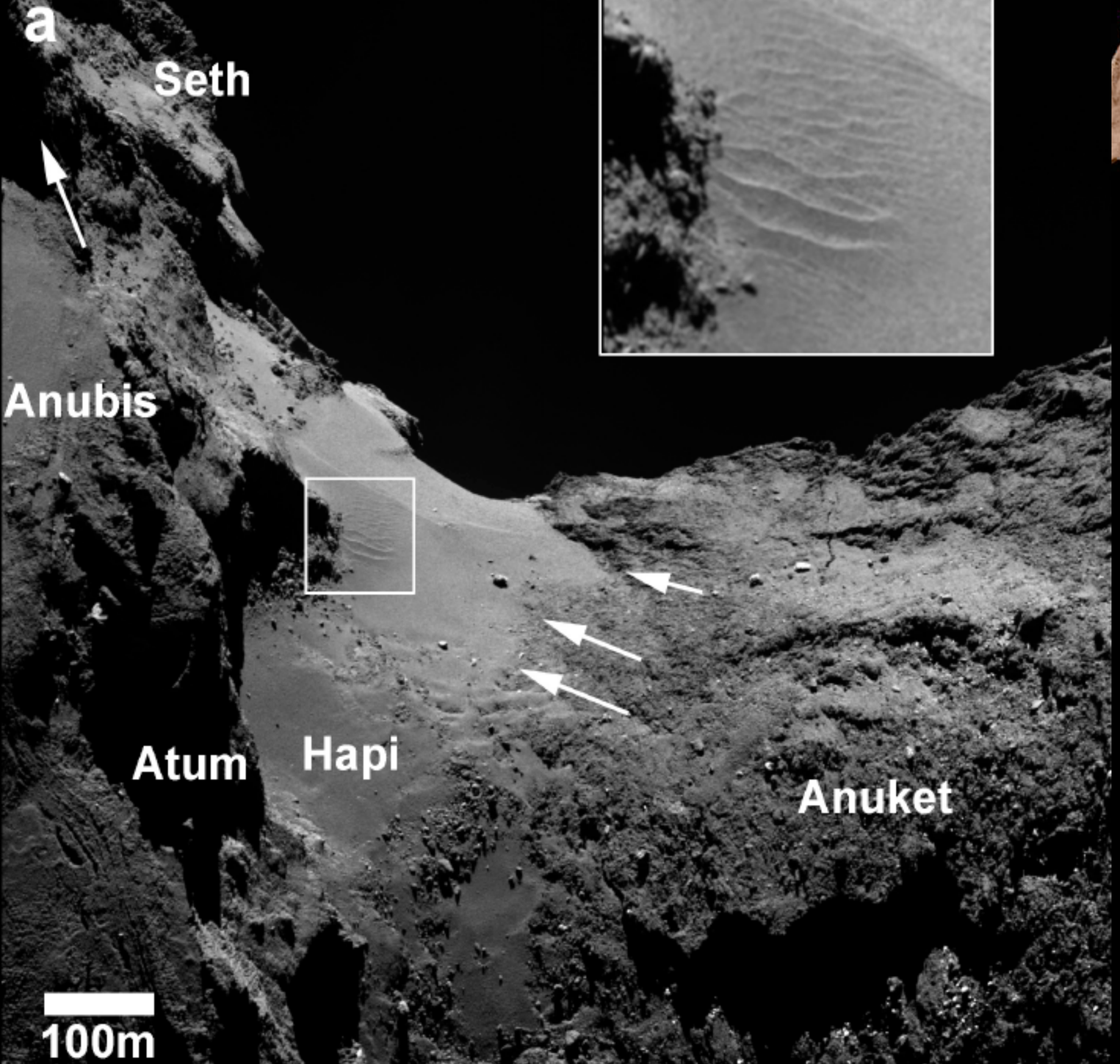


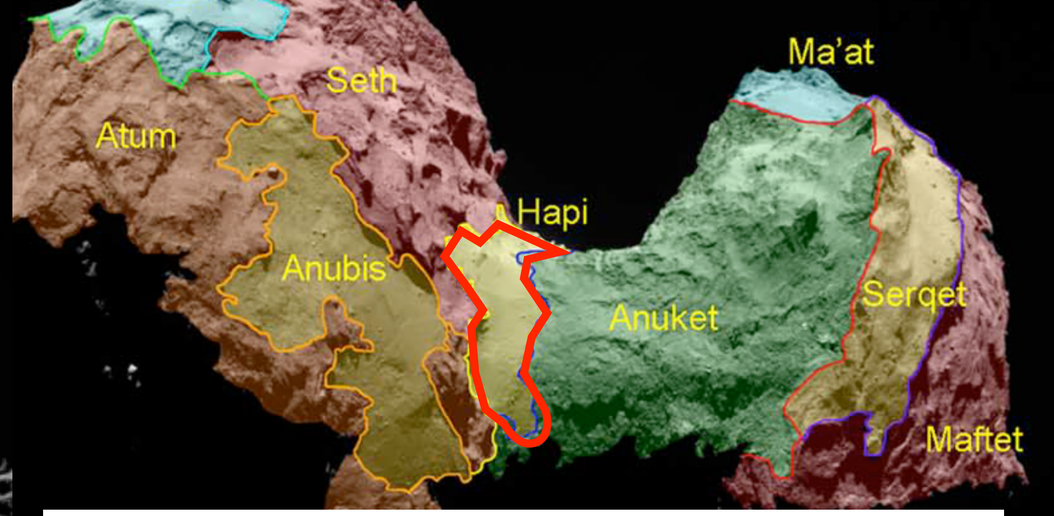


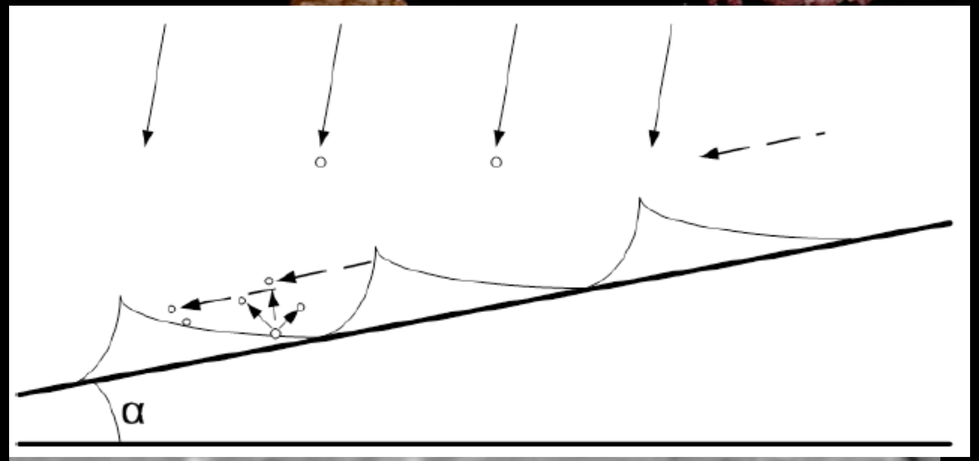
75m

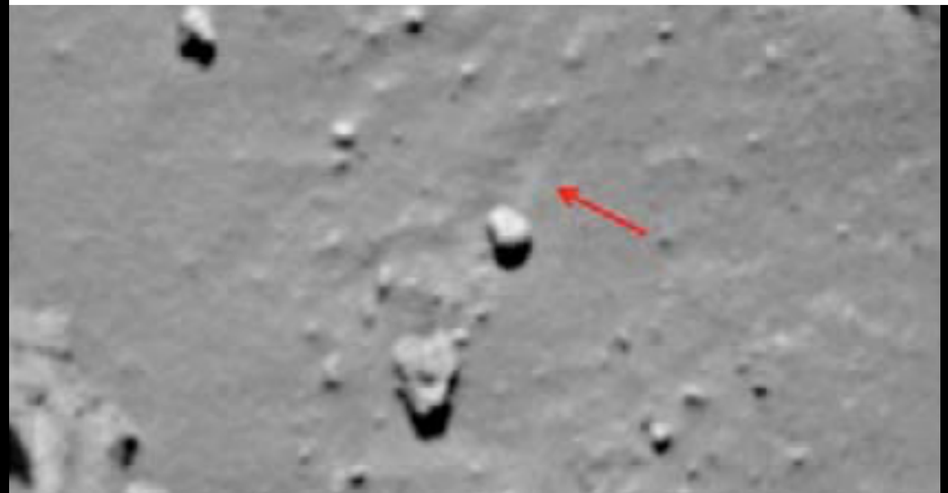
Bibring et al., 2015


70 m

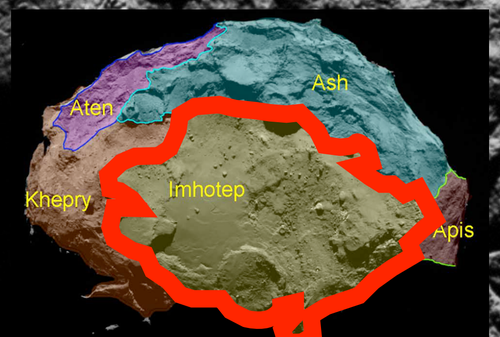

a
Seth
Anubis
Atum
Hapi
Anuket
100m


Ma'at
Seth
Atum
Hapi
Anubis
Anuket
Serqet
Maftet

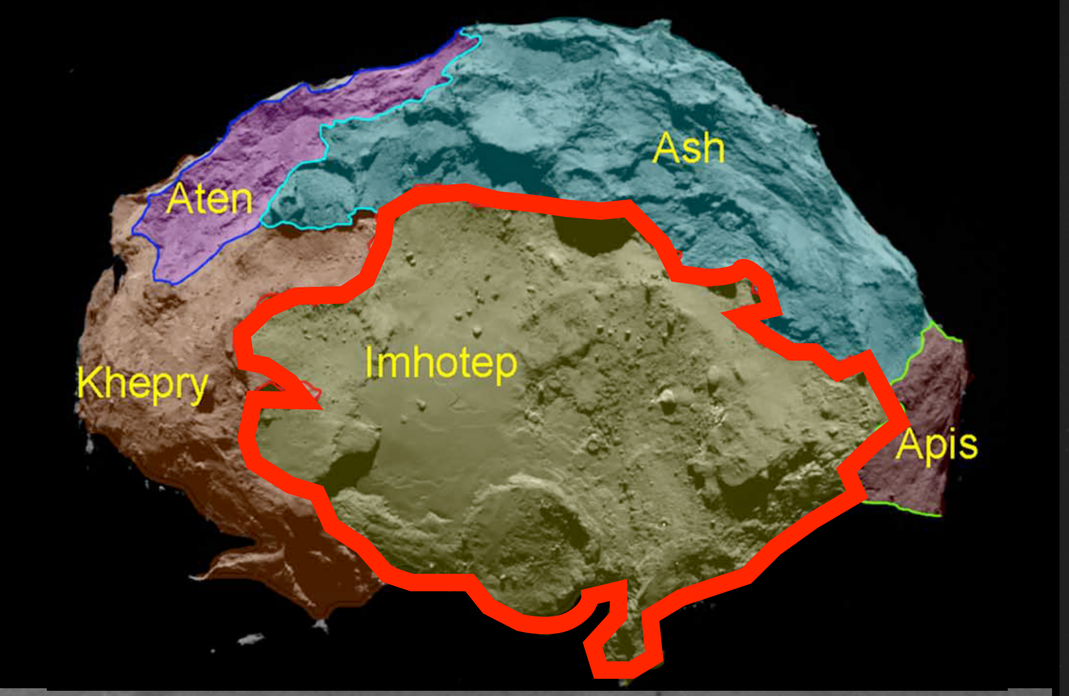

α

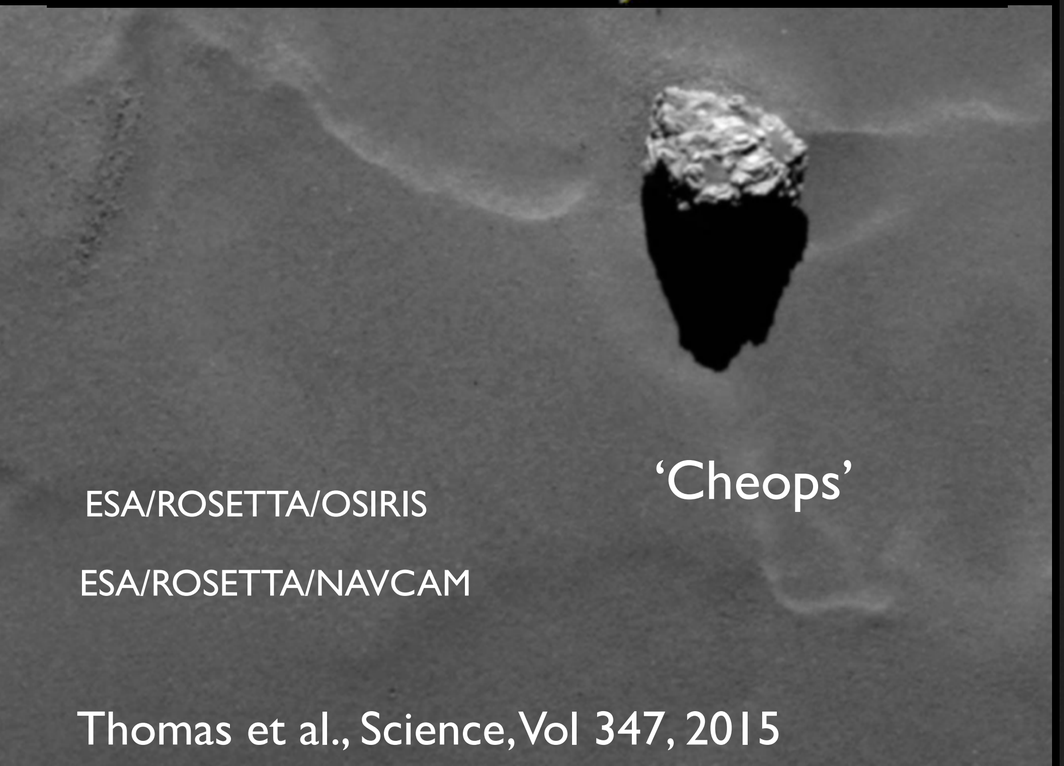


ESA/ROSETTA/OSIRIS



Thomas et al., Science, Vol 347, 2015



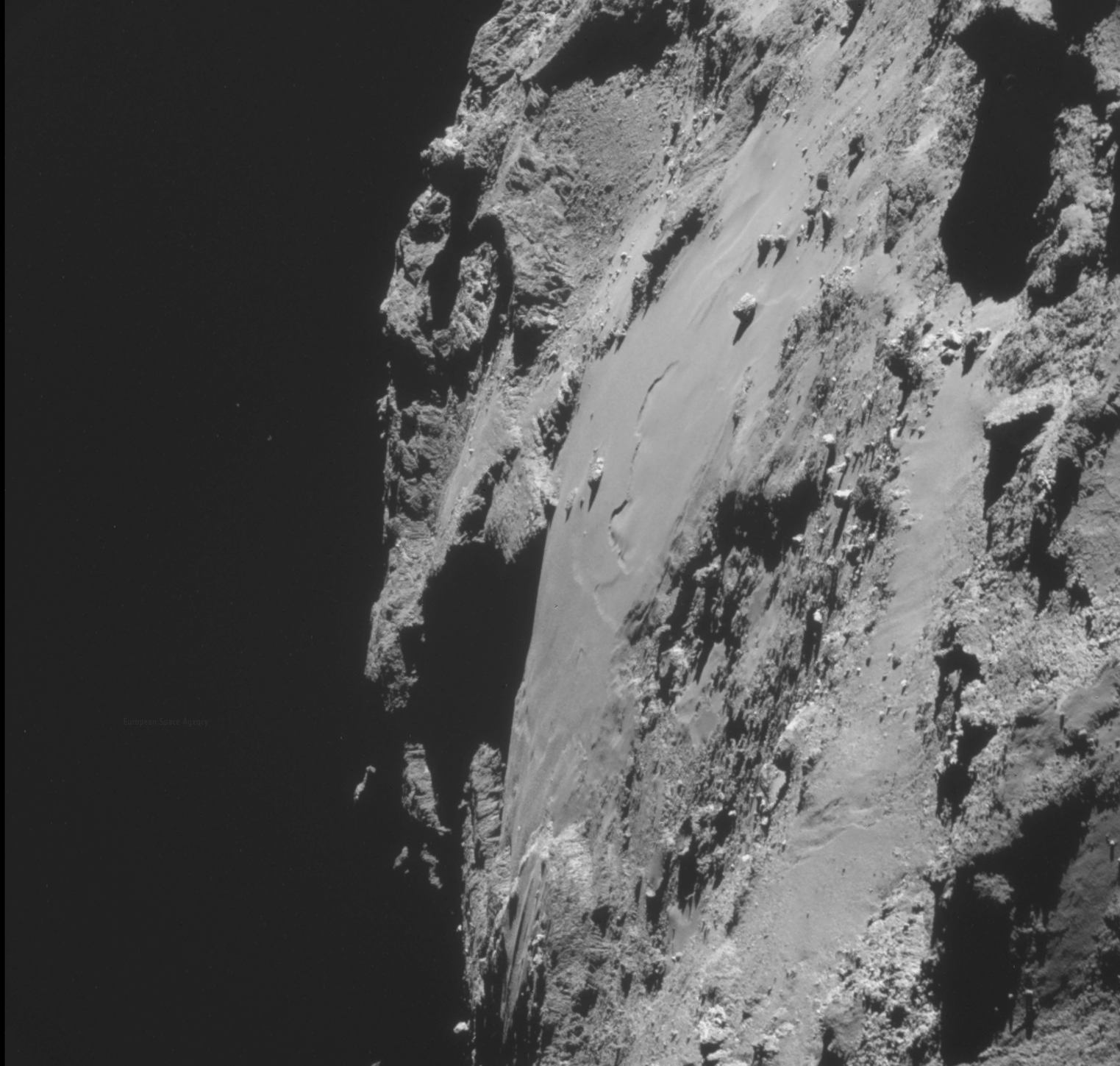


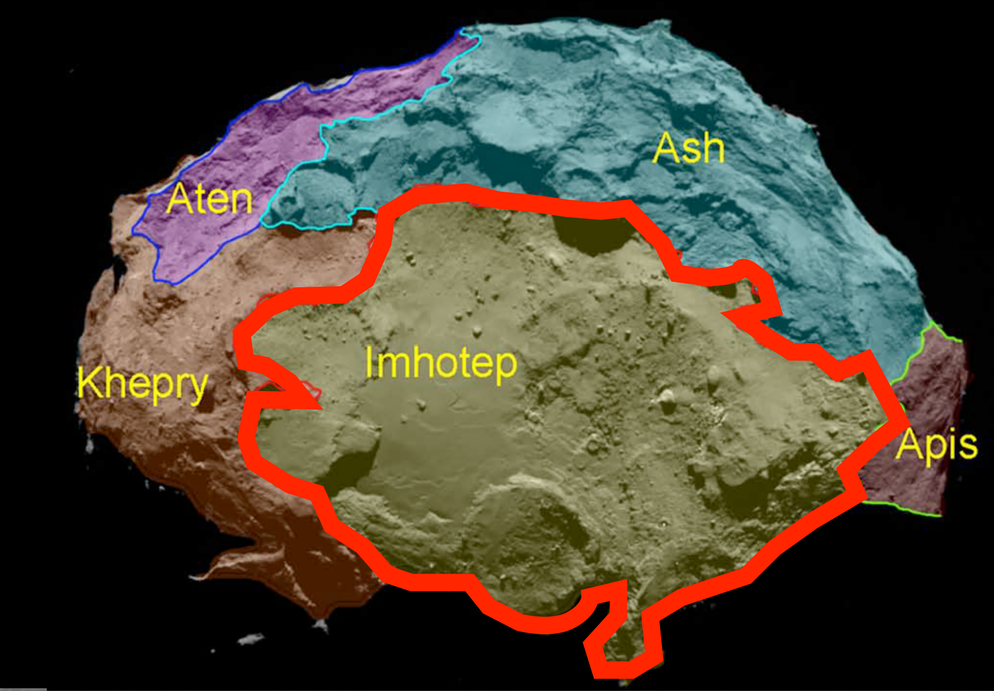
‘Cheops’

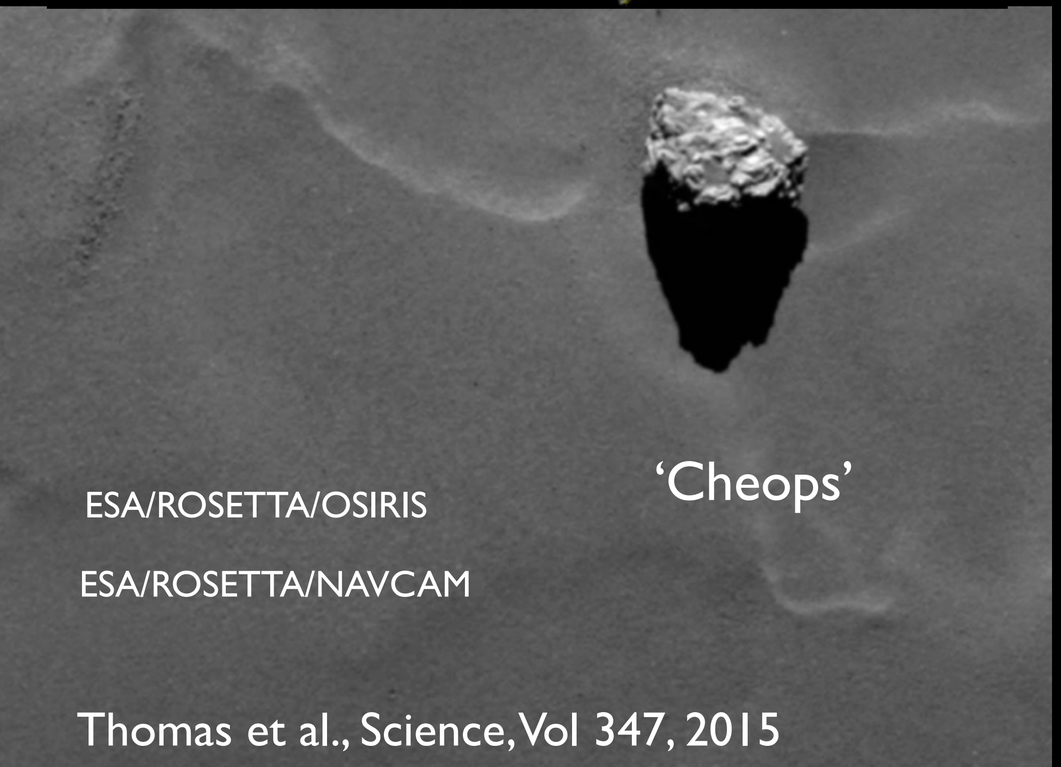
ESA/ROSETTA/OSIRIS

ESA/ROSETTA/NAVCAM

Thomas et al., Science, Vol 347, 2015





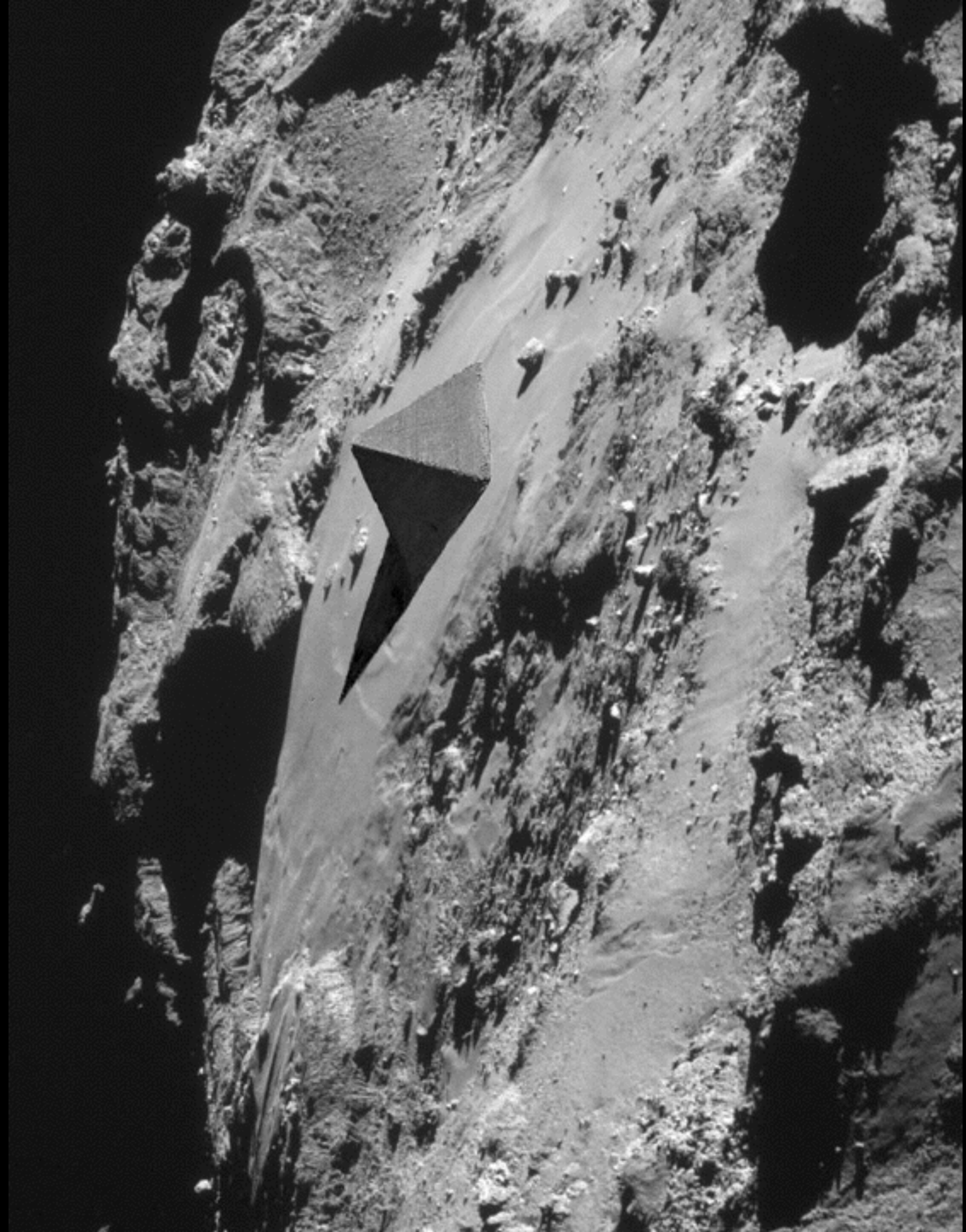


‘Cheops’

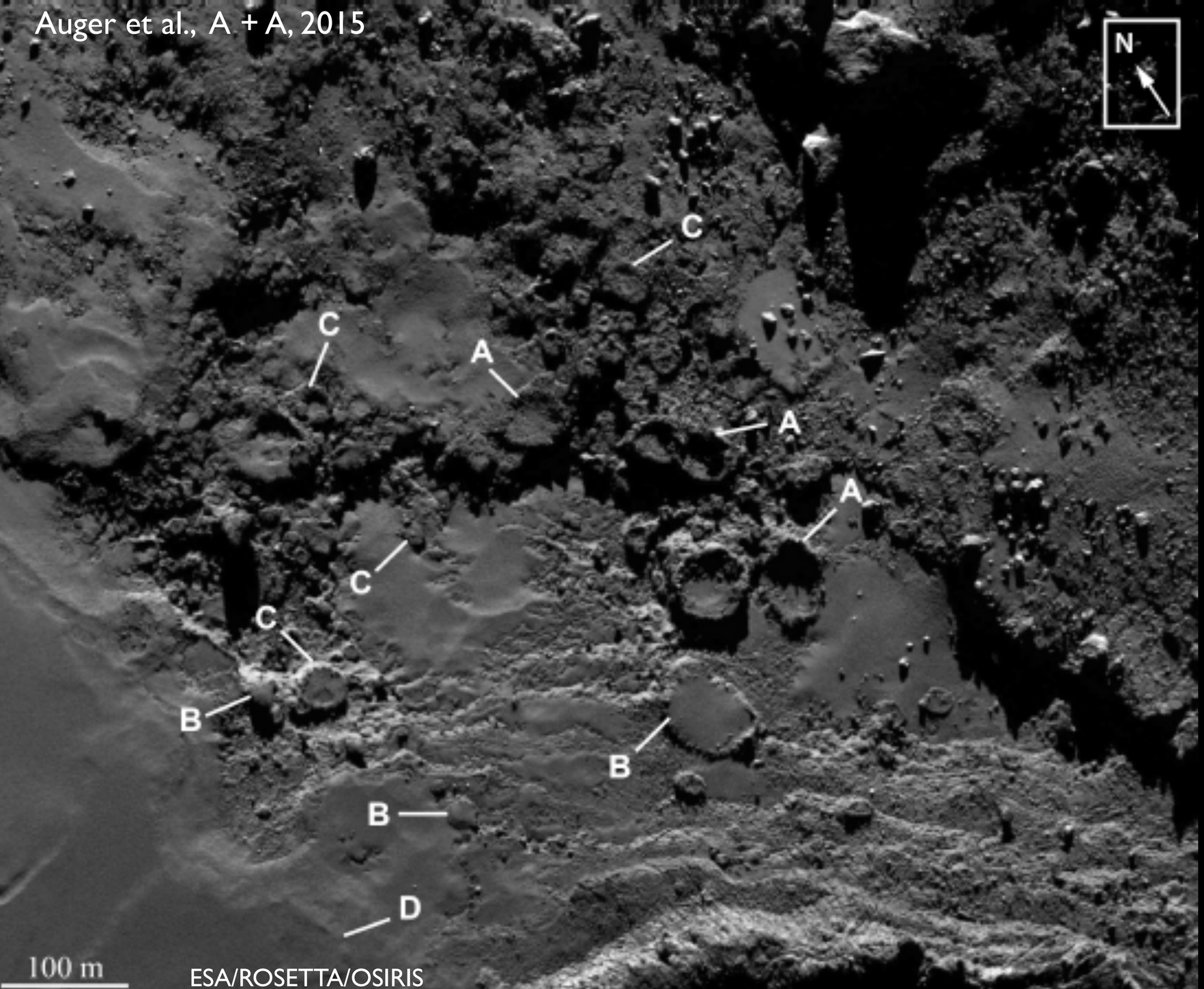
ESA/ROSETTA/OSIRIS

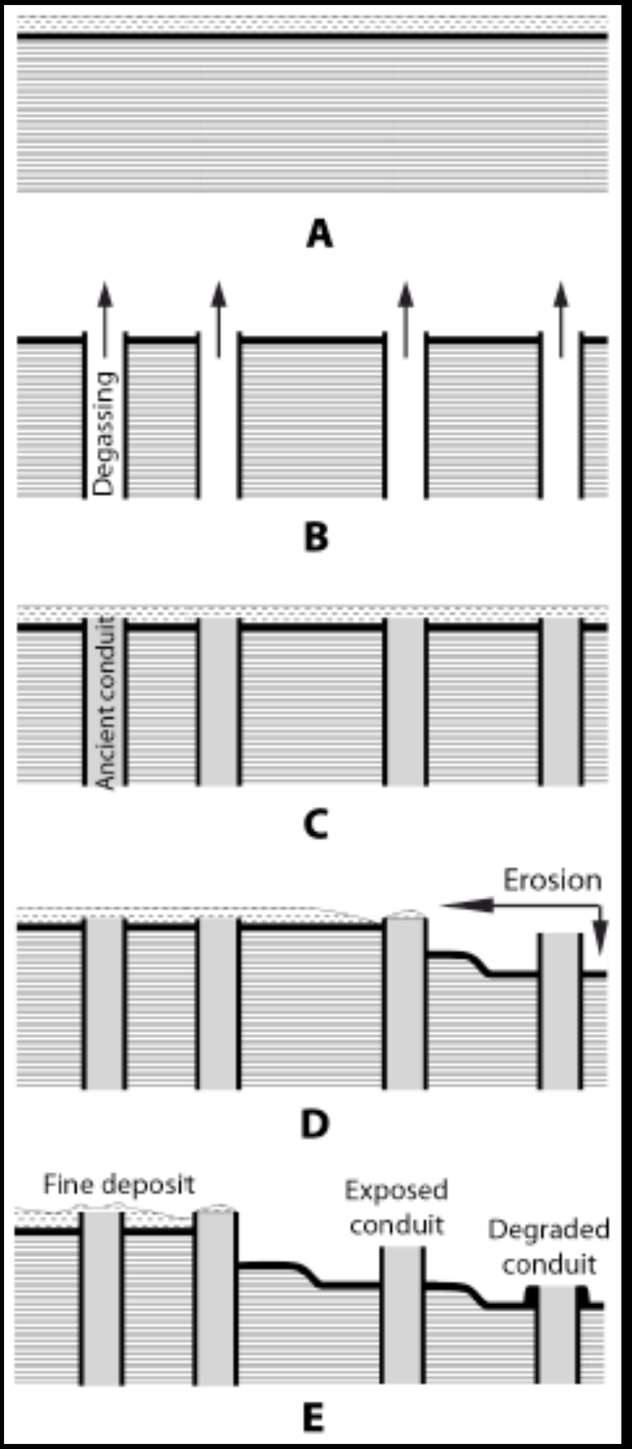
ESA/ROSETTA/NAVCAM

Thomas et al., Science, Vol 347, 2015

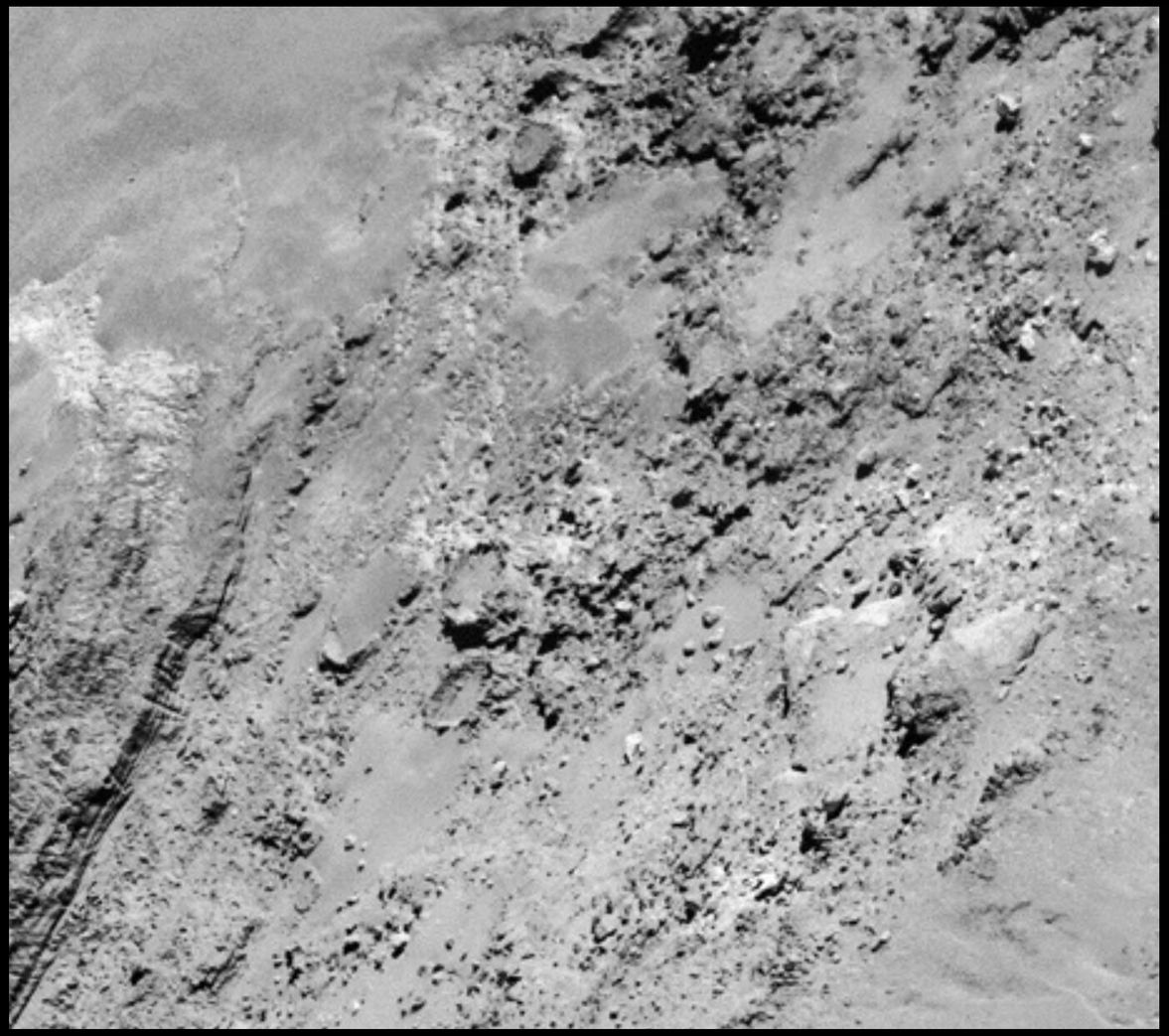


Auger et al., A + A, 2015





Auger et al., A + A, 2015

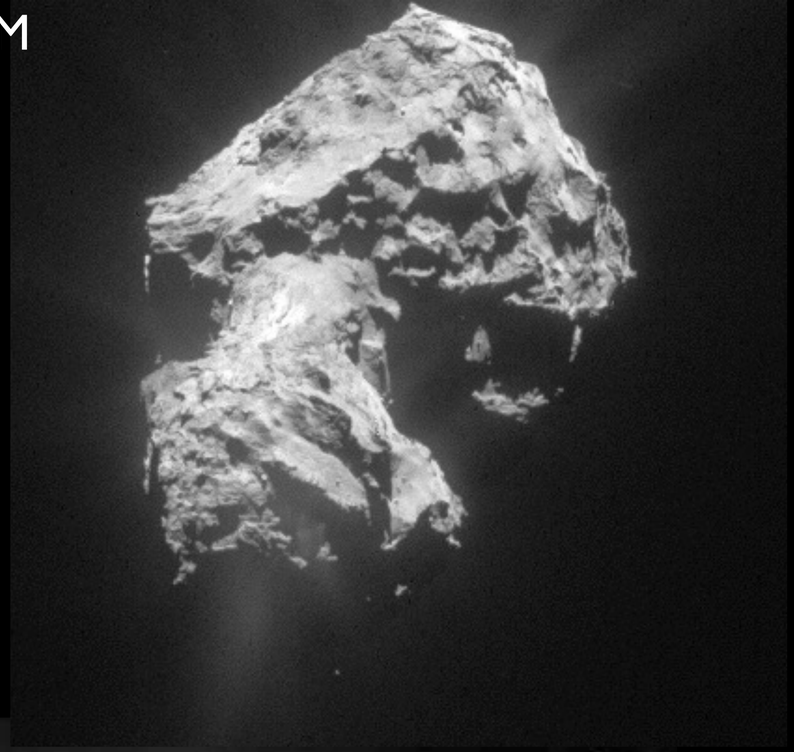


ESA/ROSETTA/OSIRIS

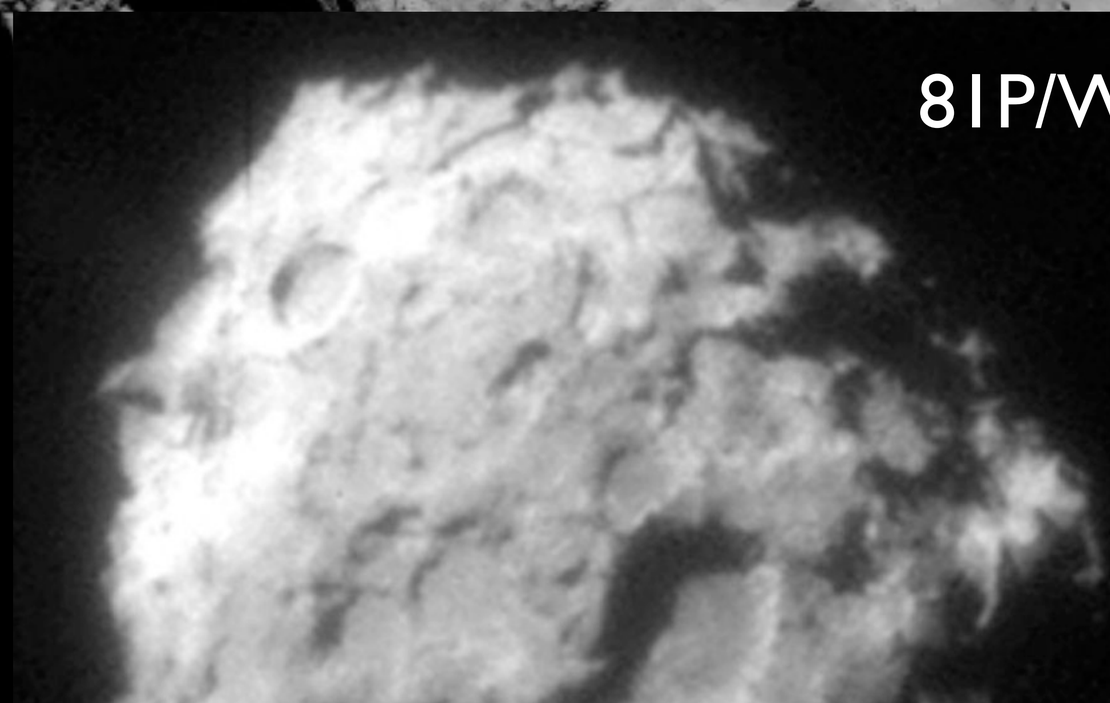
9P/Tempel 1

NASA/JPL-Caltech/UMD

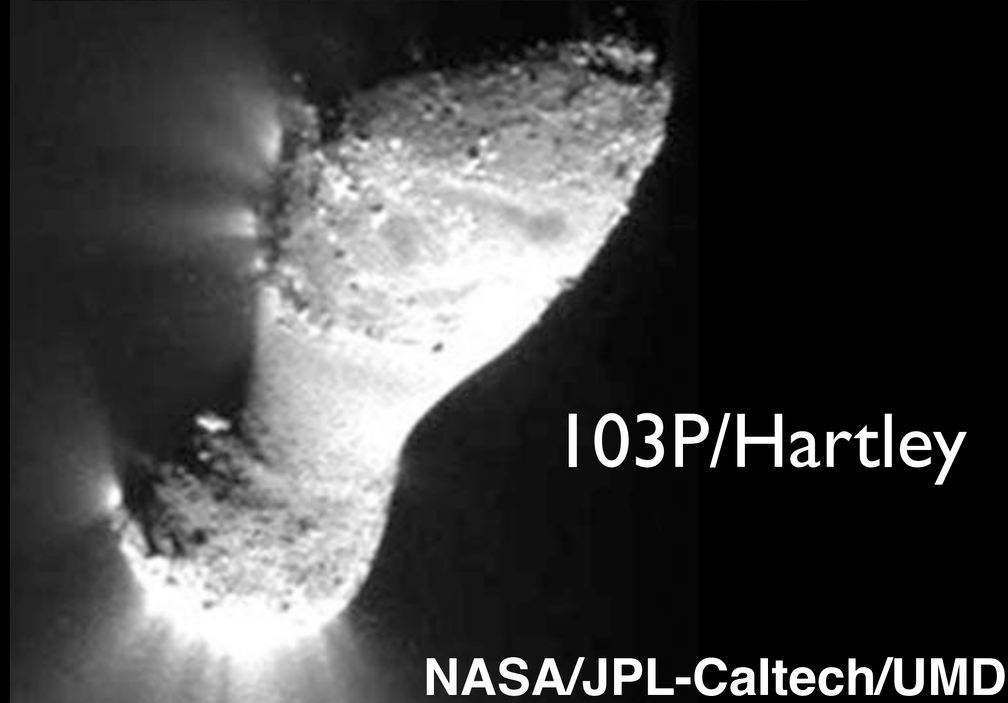
ESA/Rosetta/NAVCAM



81P/Wild

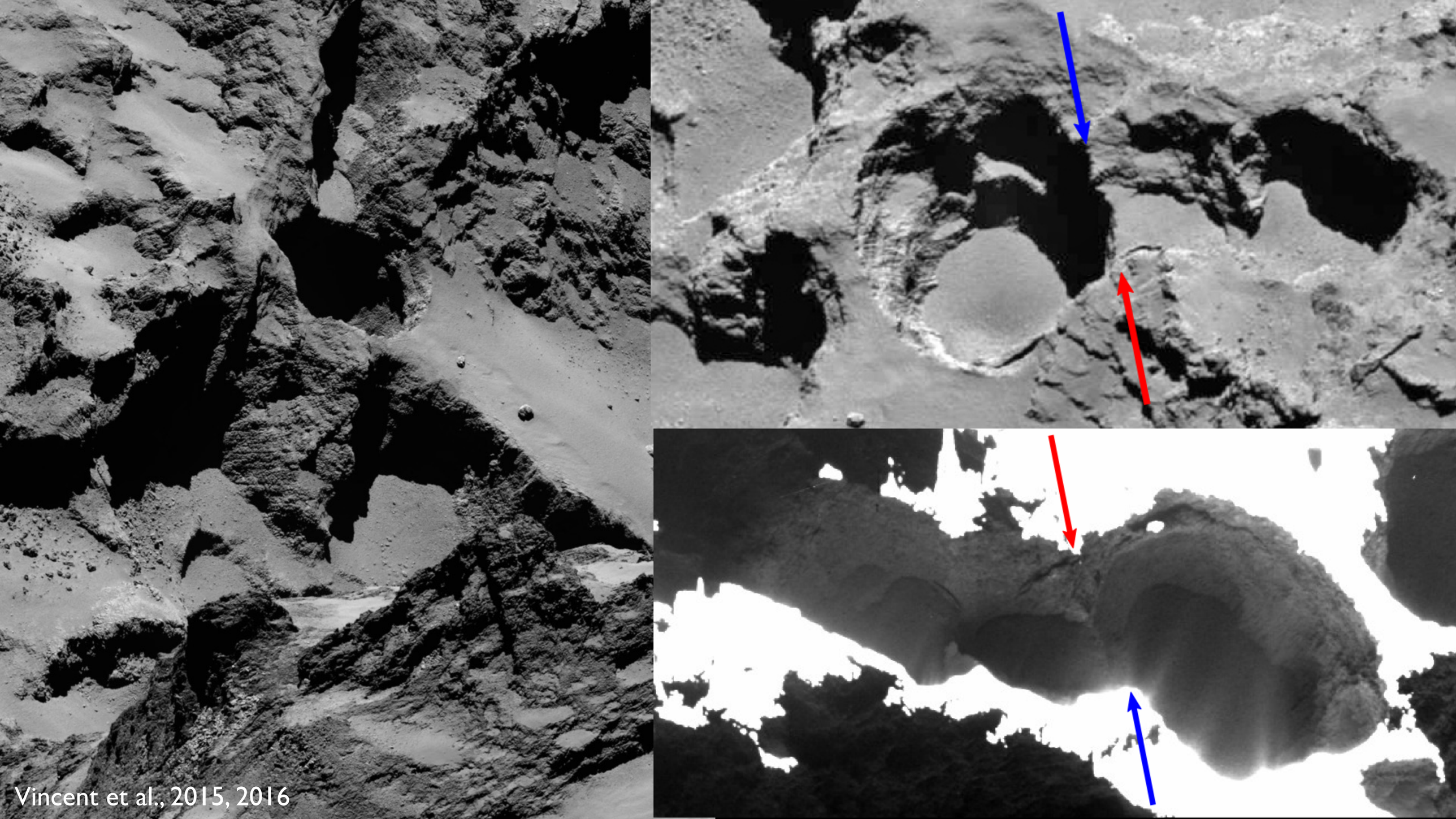


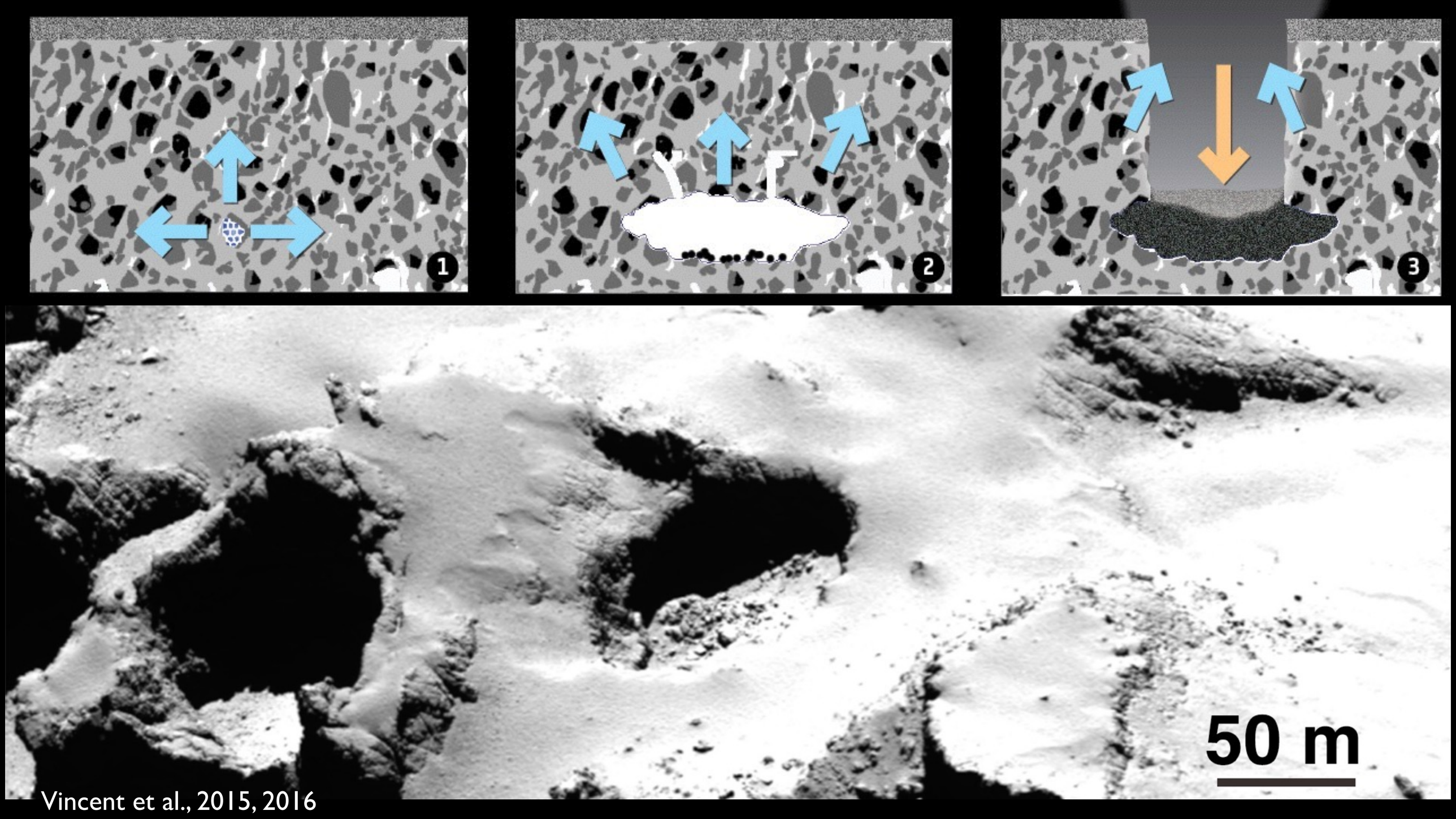
NASA - NSSDC



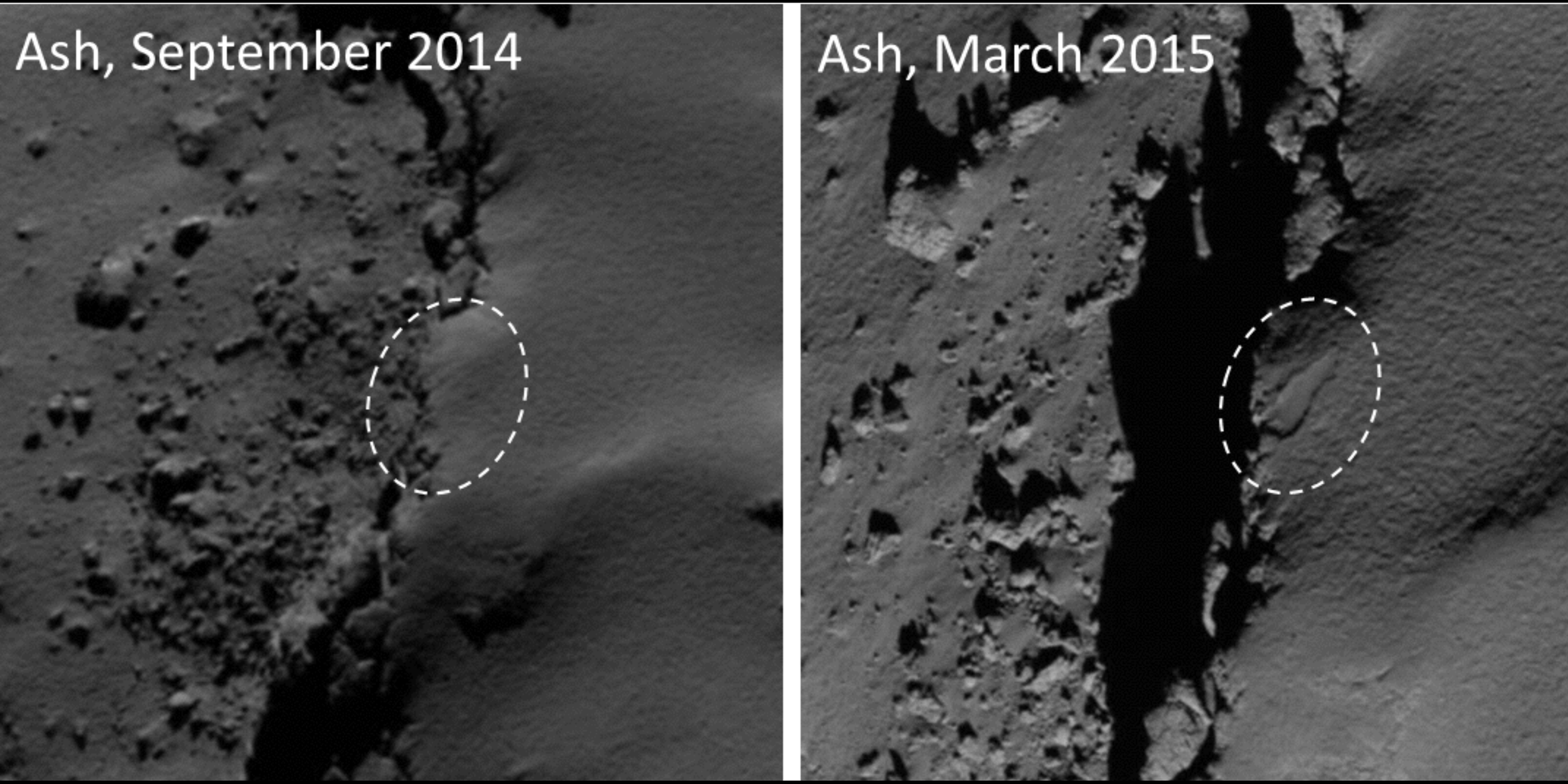
103P/Hartley

NASA/JPL-Caltech/UMD


Vincent et al., 2015, 2016

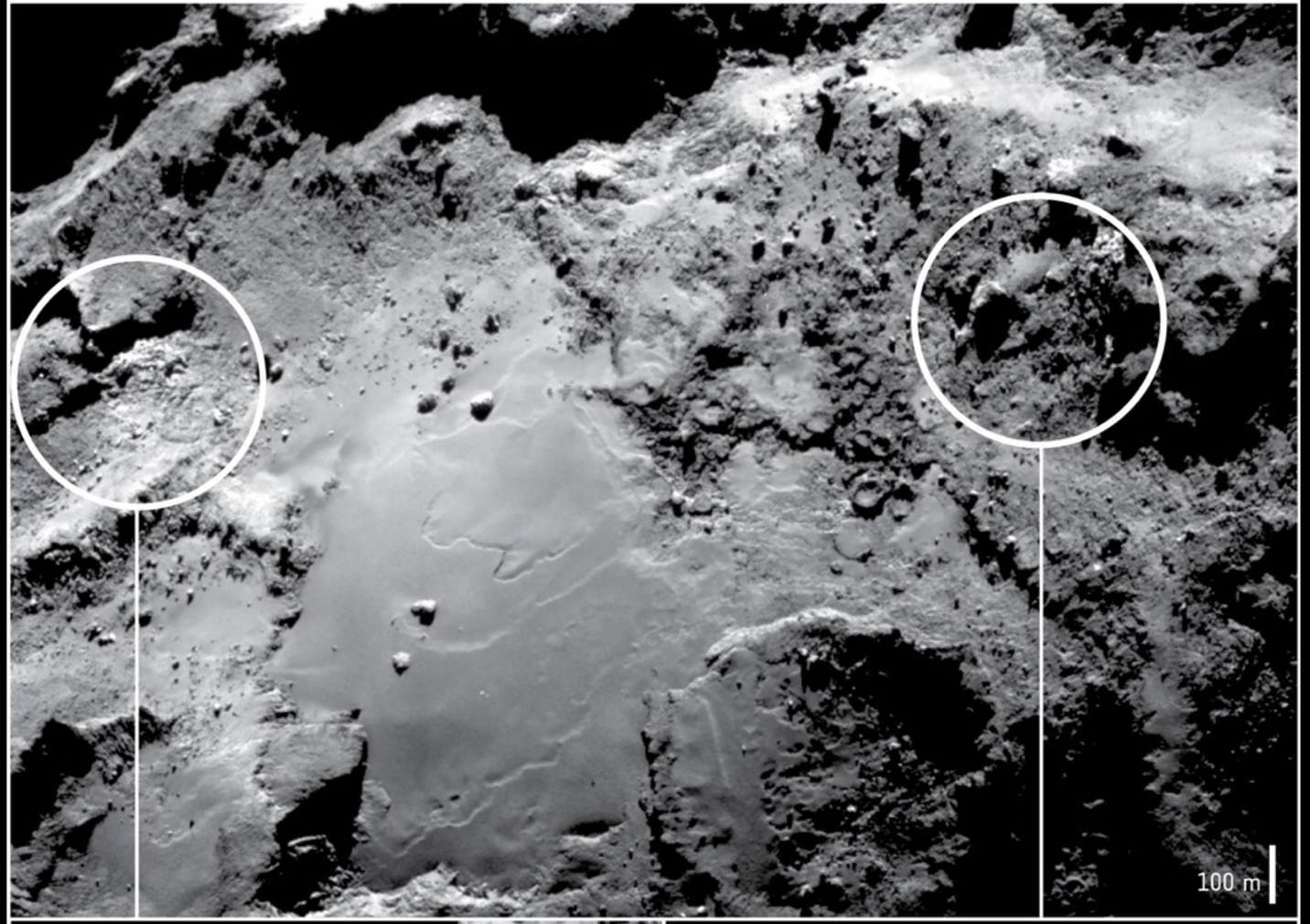


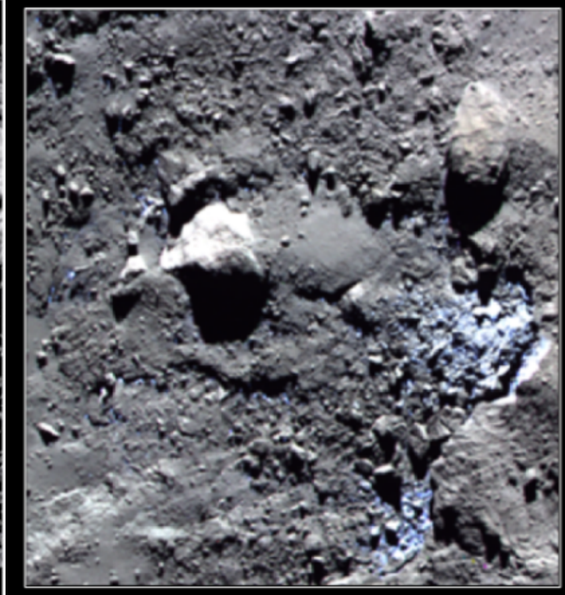
Vincent et al., 2015, 2016



Vincent et al., A+A, 2015

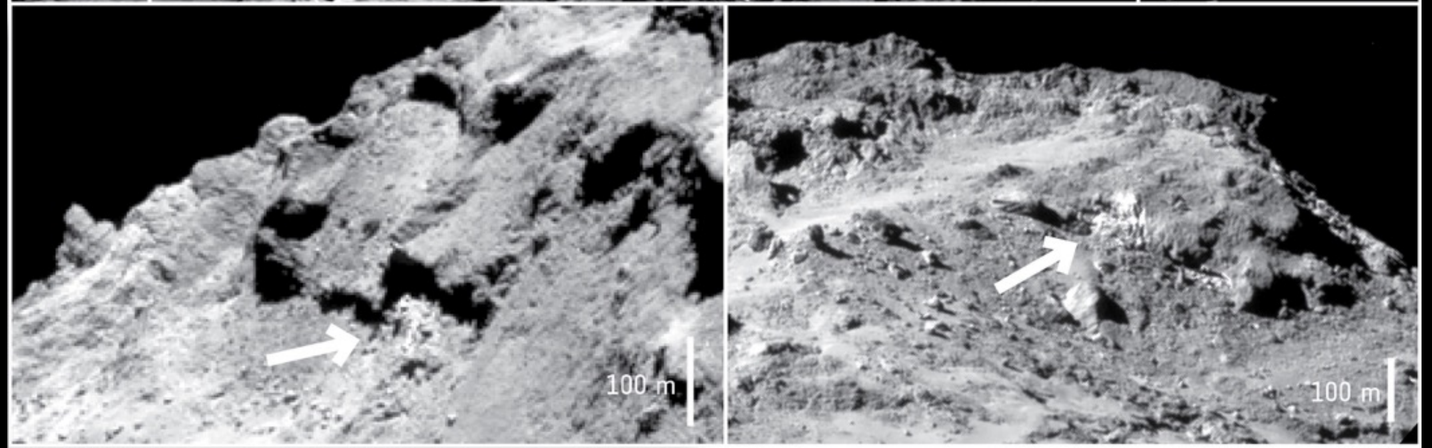
Filacchione et al, 2016.



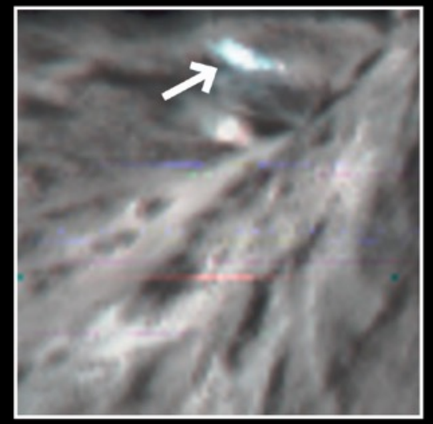


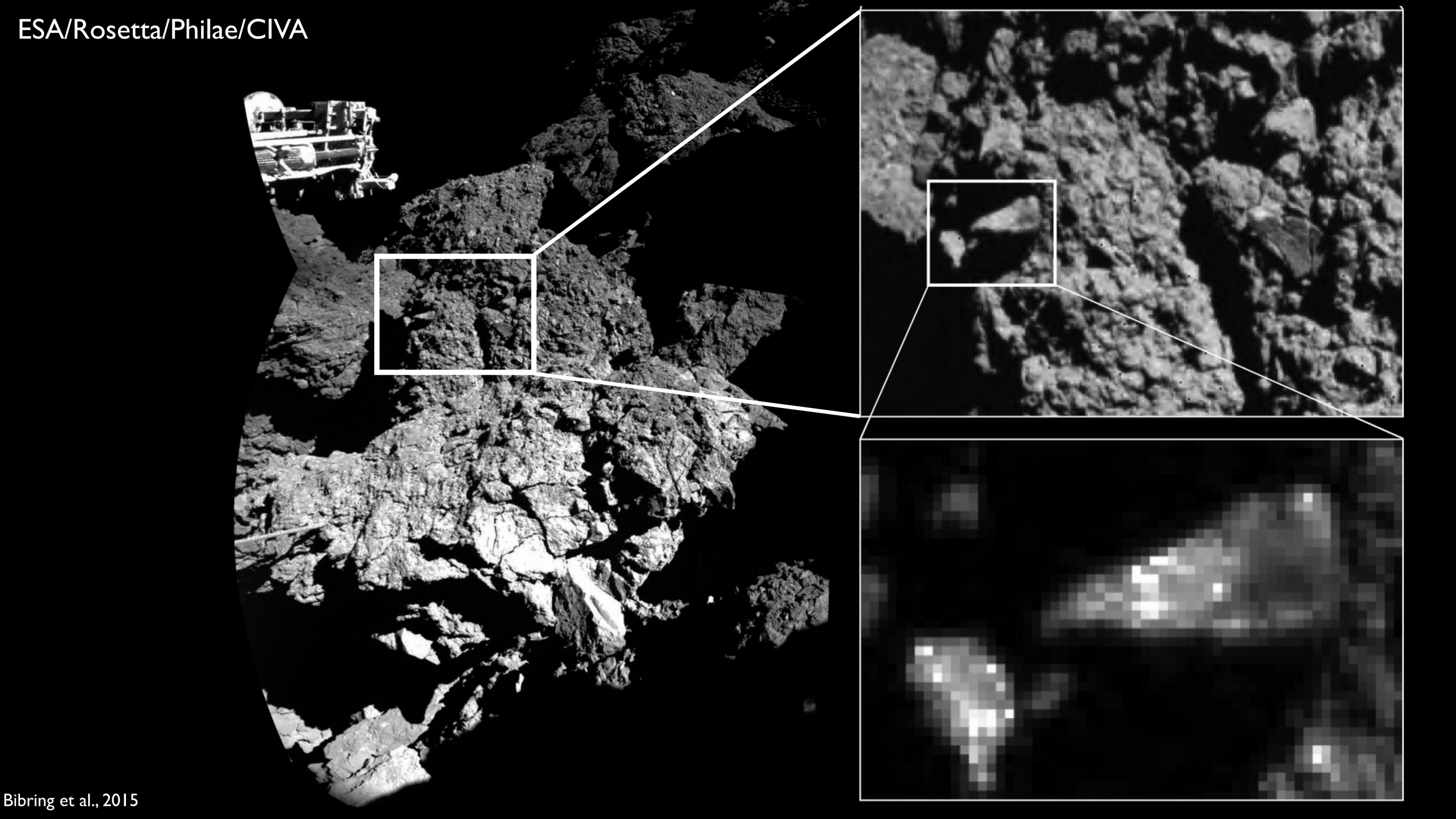
Vincent et al., 2016

VIRTIS colour image

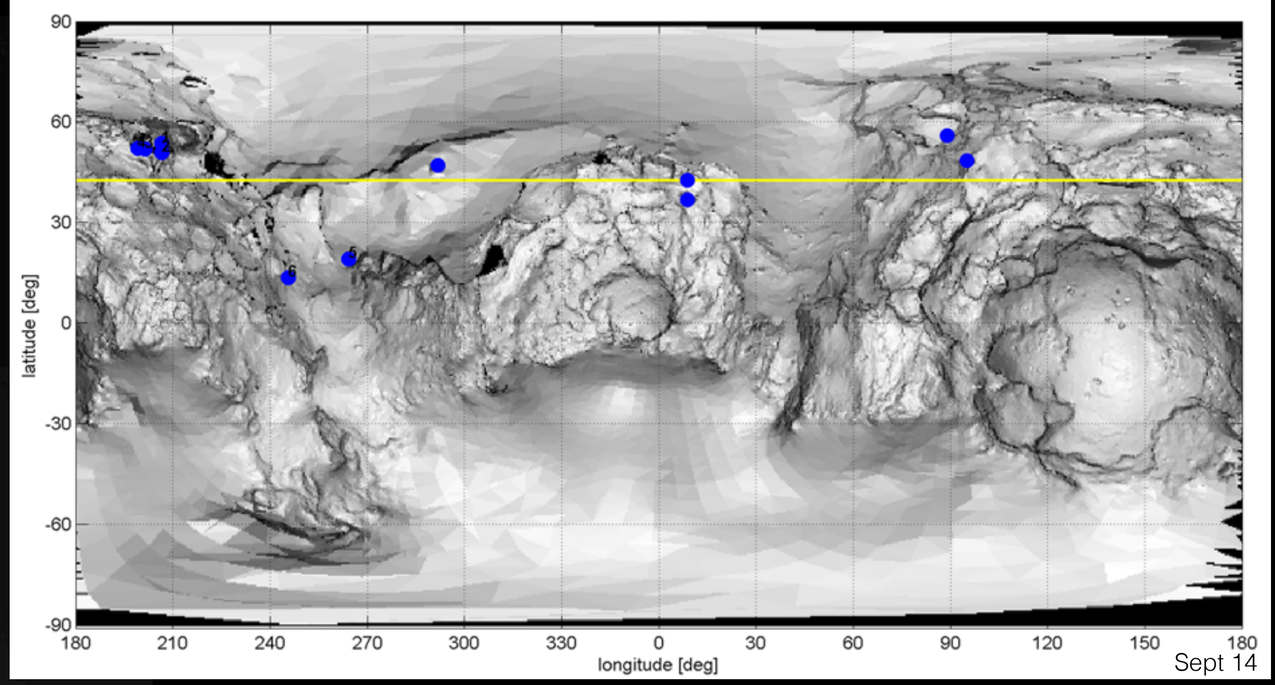


VIRTIS colour image

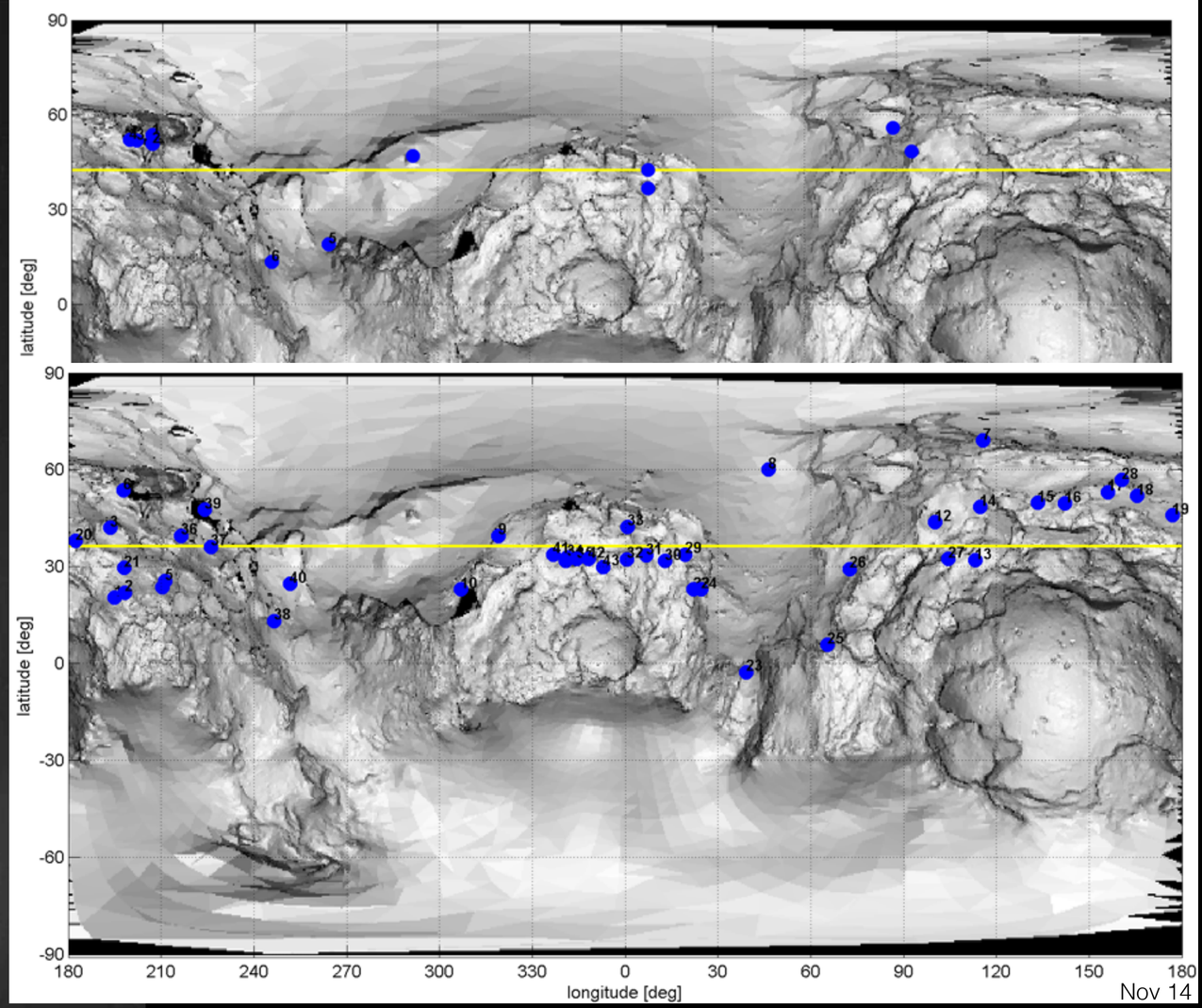



ESA/Rosetta/Philae/CIVA
Bibring et al., 2015

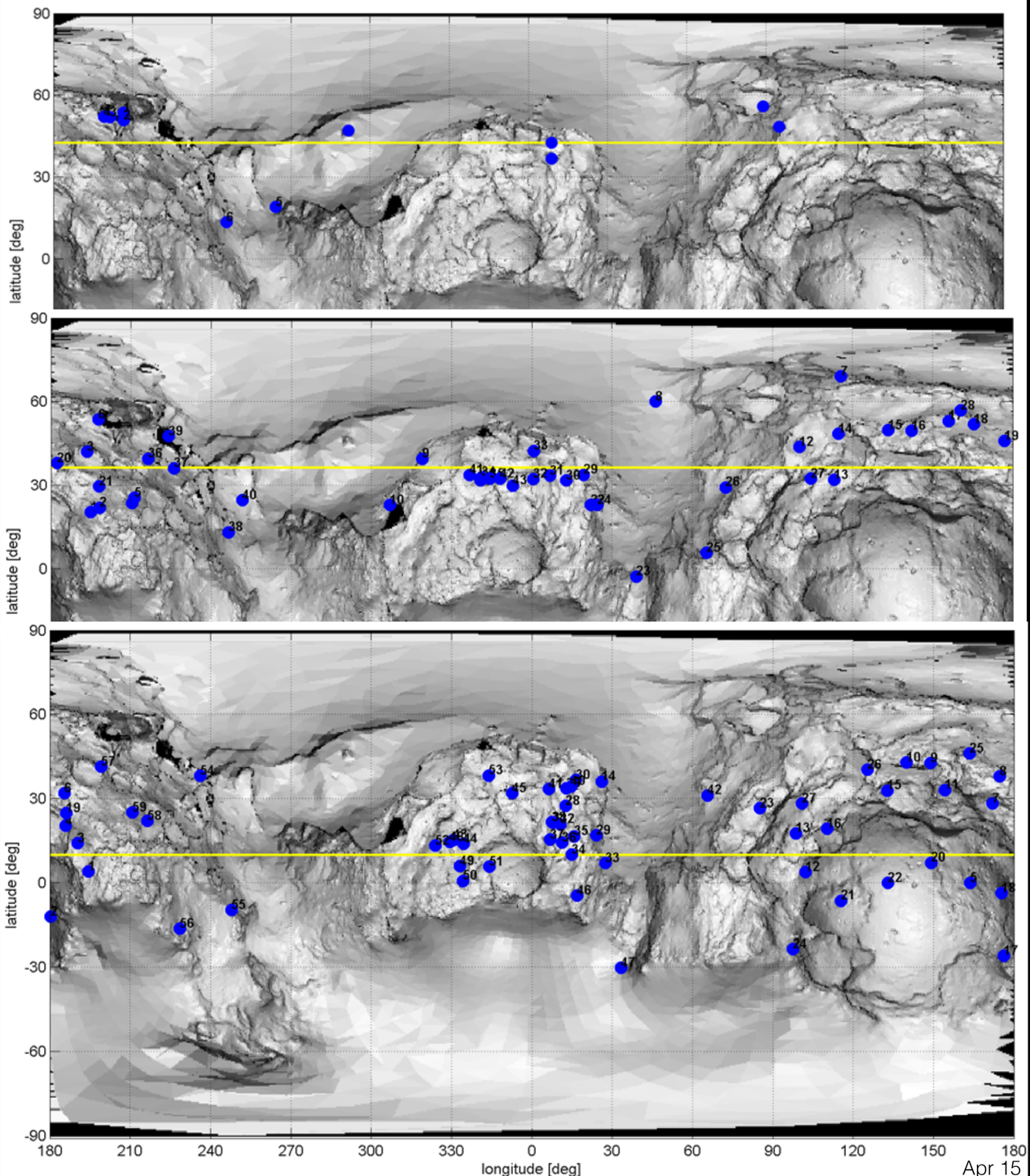
Vincent et al., 2016

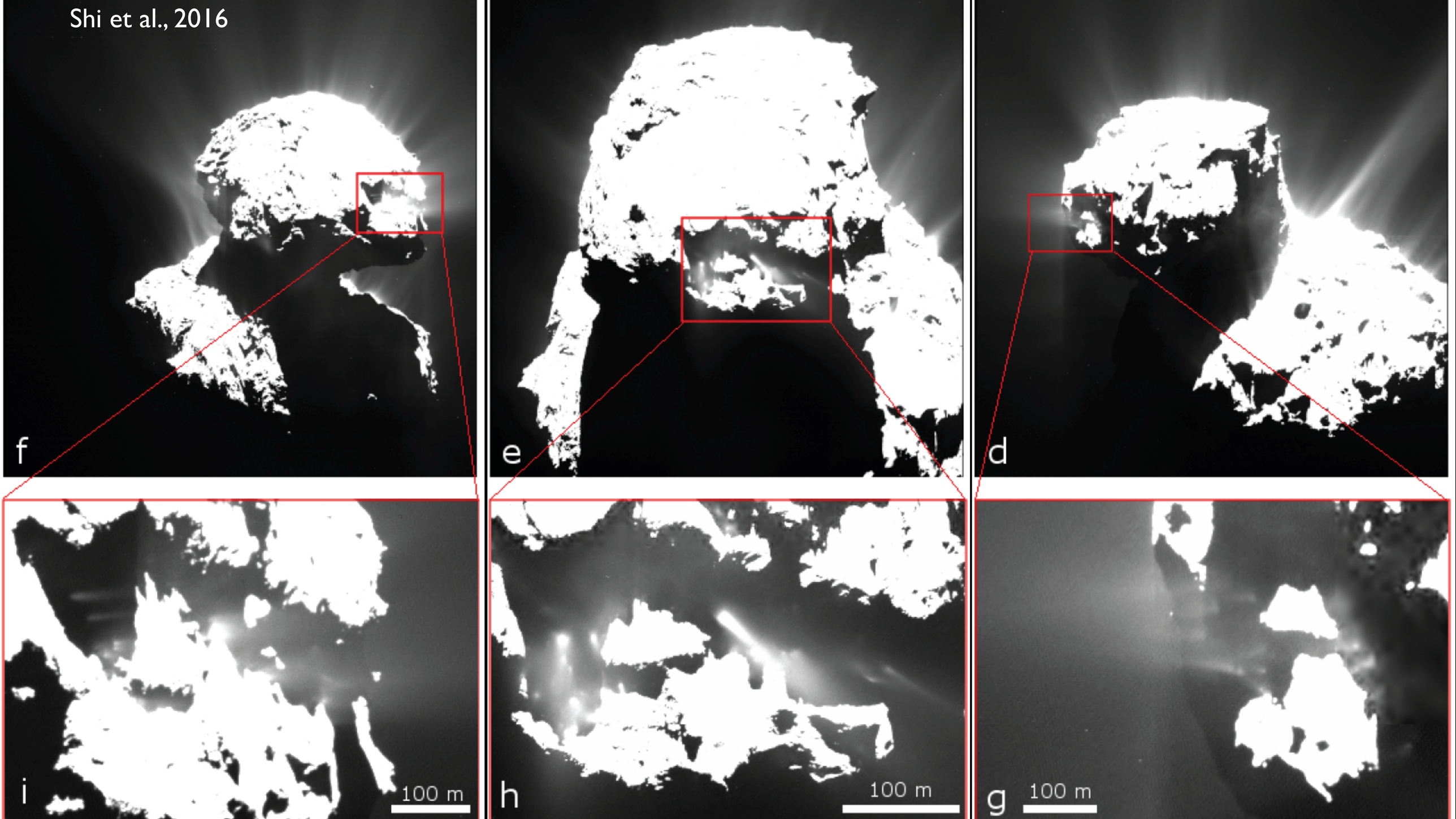


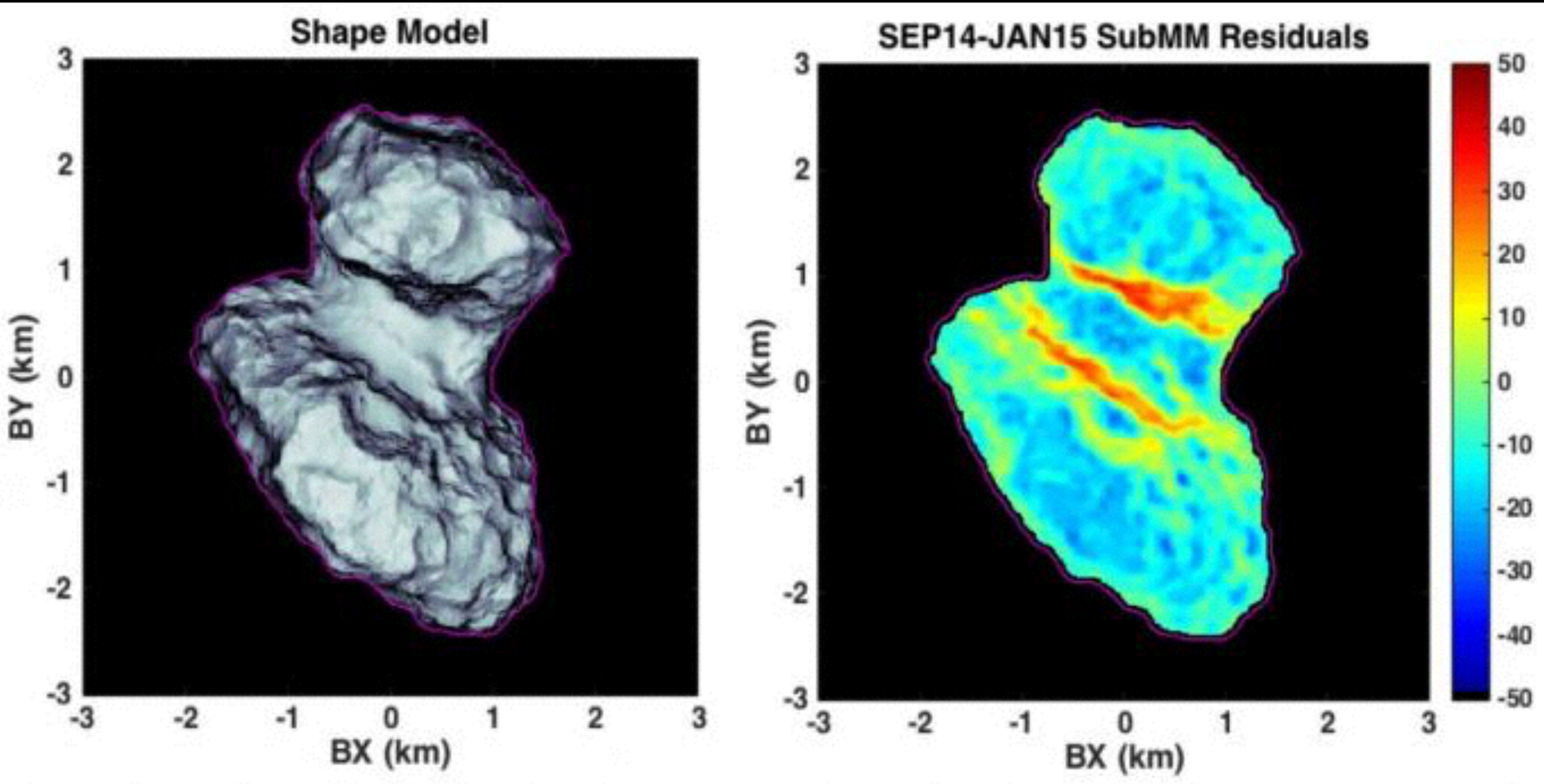
Vincent et al., 2016



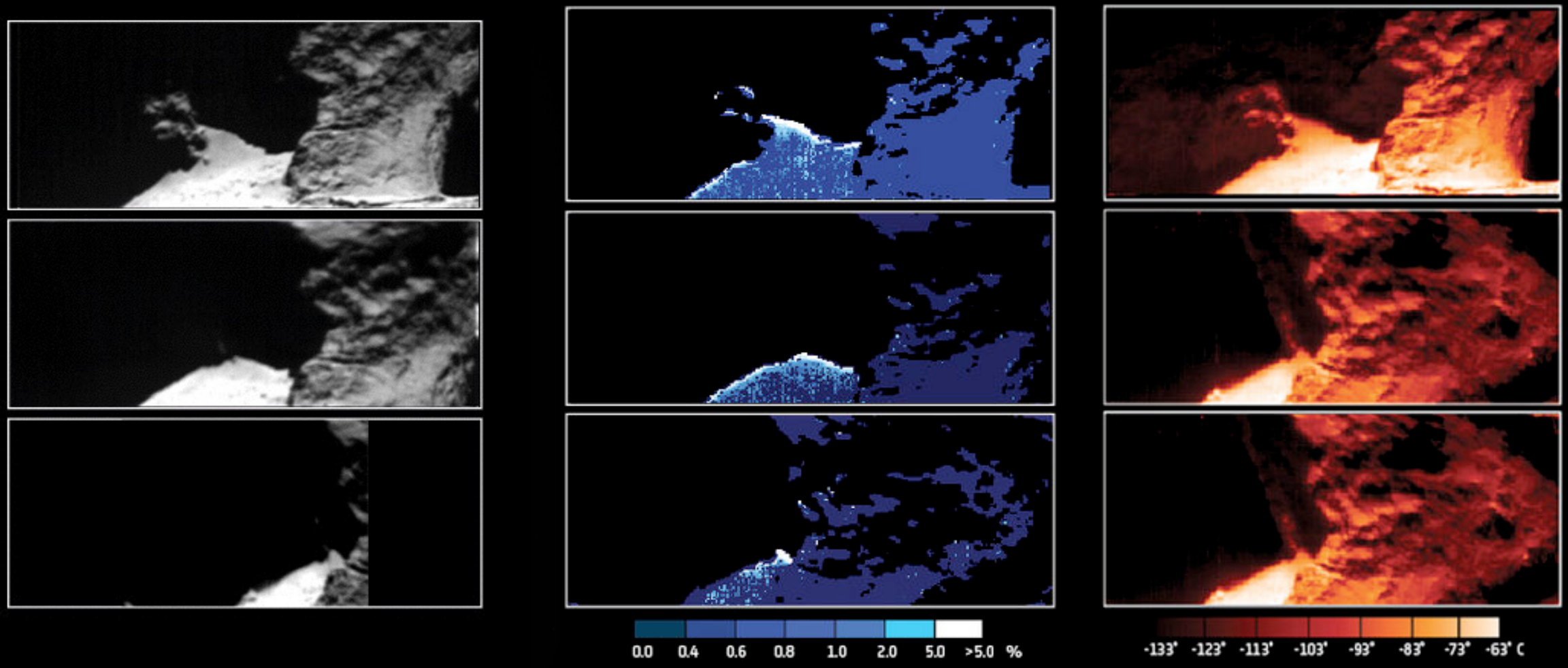
Vincent et al., 2016



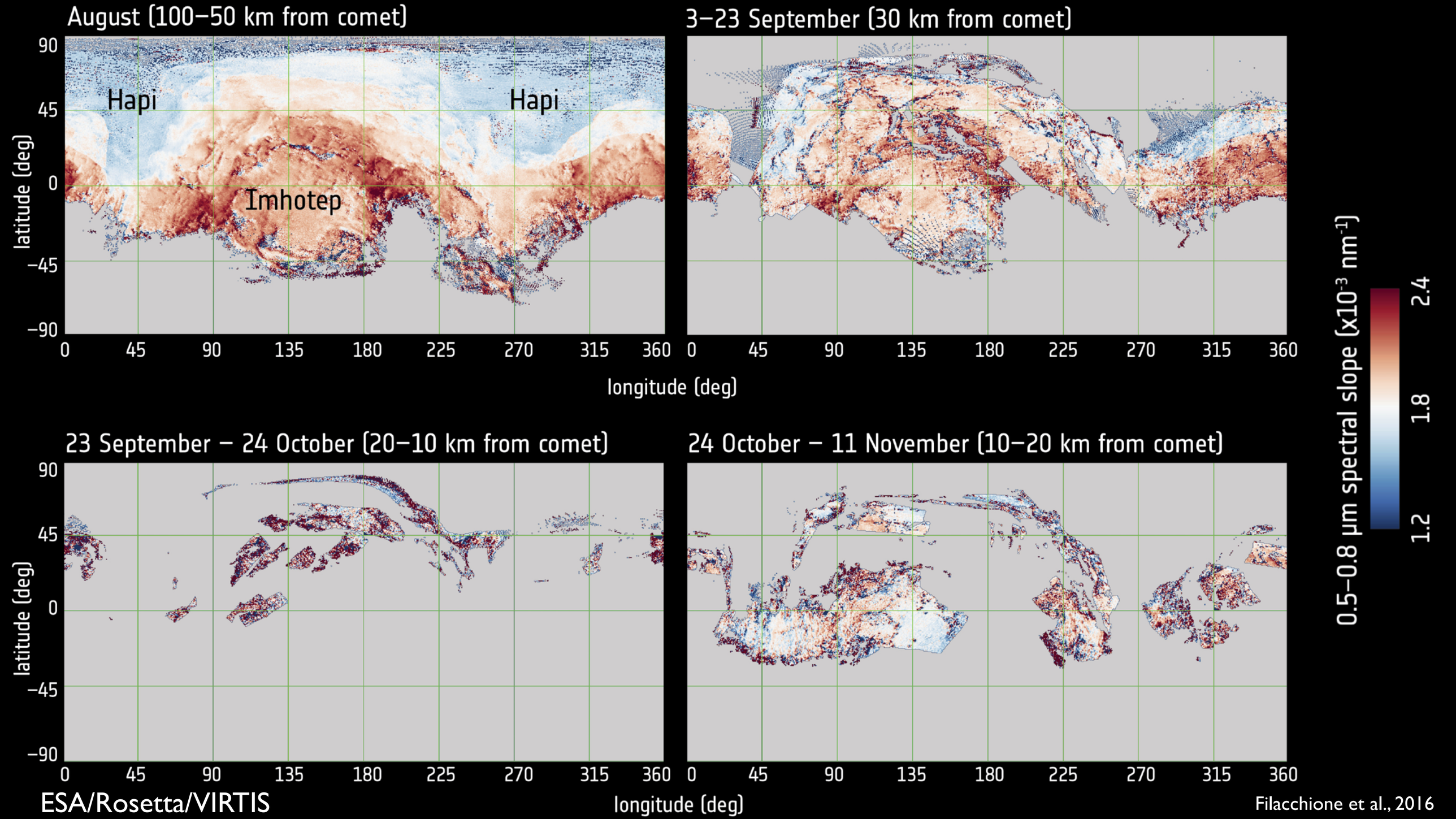

Shi et al., 2016
f
e
d
i
100 m
h
100 m
g
100 m

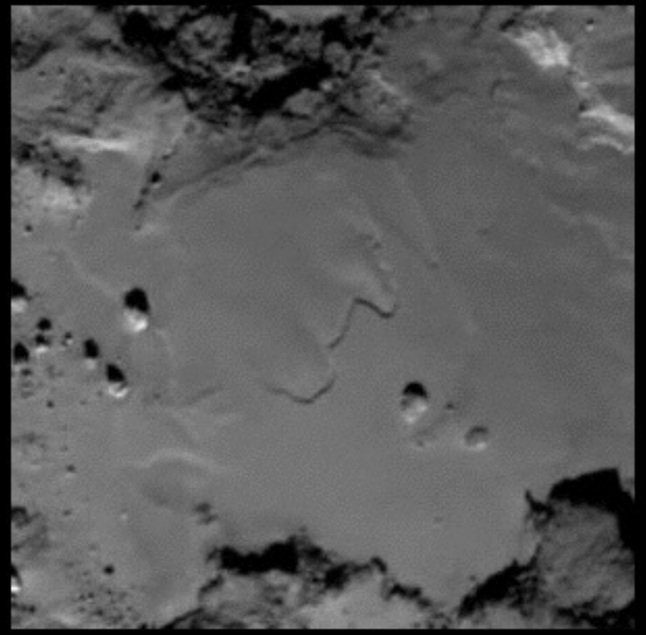


Schloerb et al, 2015.

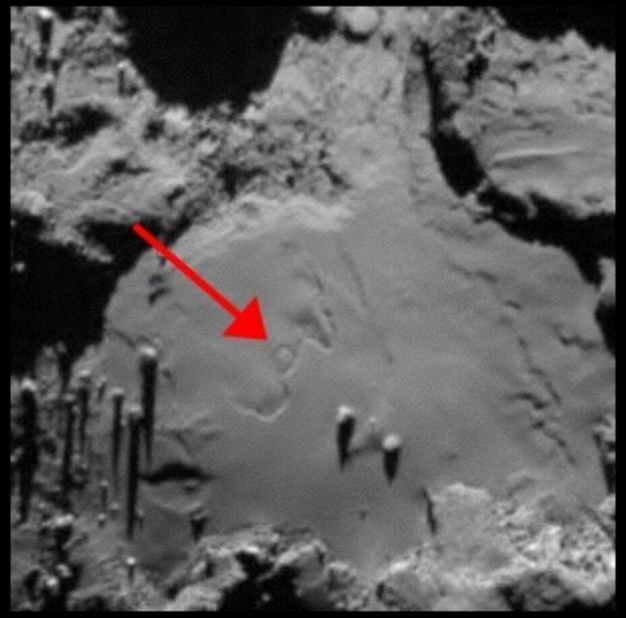


De Sanctis et al, 2015.

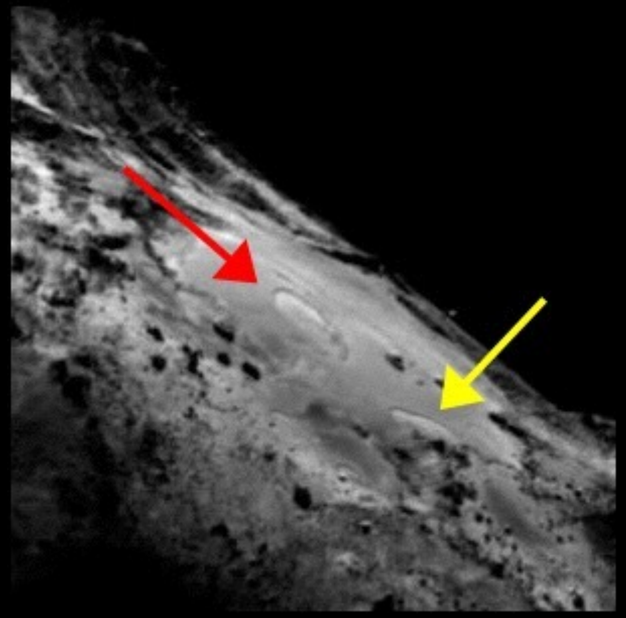

August (100–50 km from comet)
3–23 September (30 km from comet)
23 September – 24 October (20–10 km from comet)
24 October – 11 November (10–20 km from comet)
Hapi
Hapi
Imhotep
latitude (deg)
longitude (deg)
90
45
0
−45
−90
0
45
90
135
180
225
270
315
360
0.5–0.8 μm spectral slope (x10⁻³ nm⁻¹)
2.4
1.8
1.2
ESA/Rosetta/VIRTIS
Filacchione et al., 2016



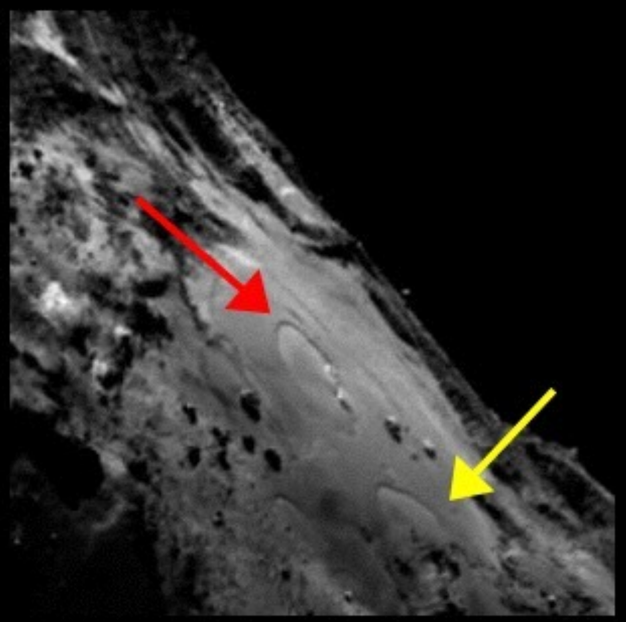
24 May 2015



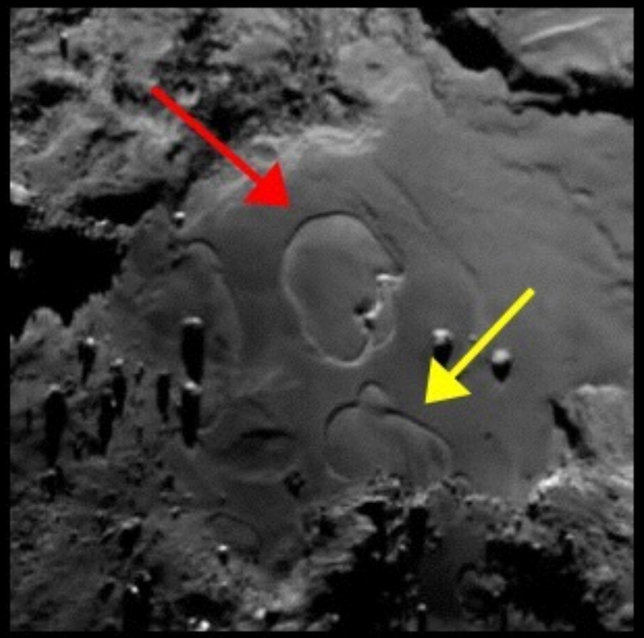
5 June 2015



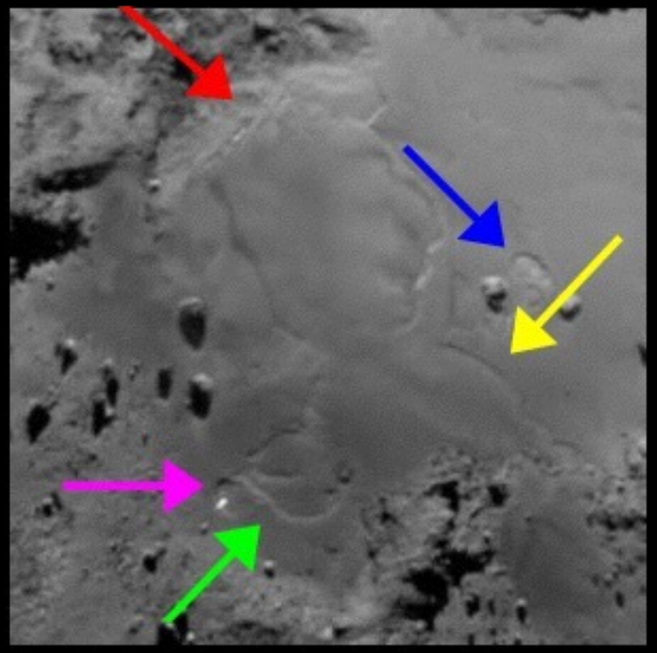
18 June 2015



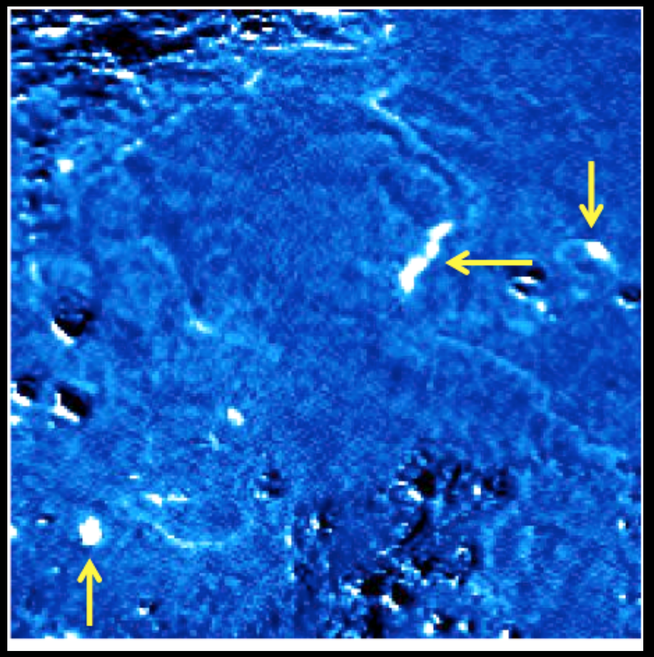
23 June 2015



27 June 2015

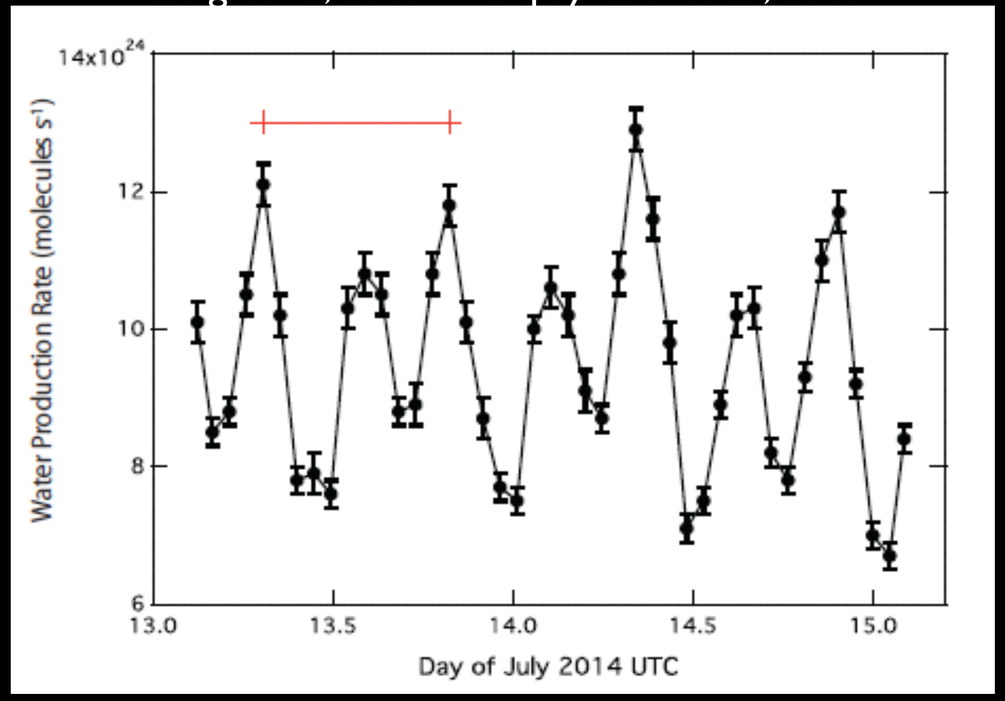


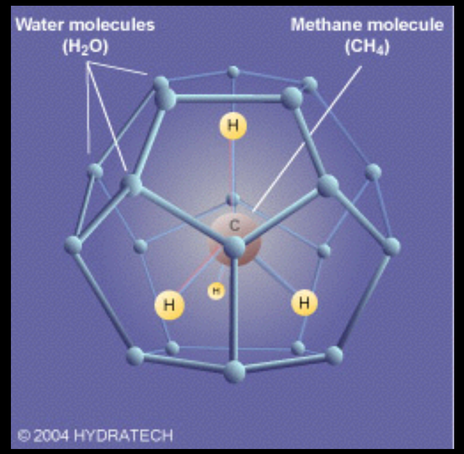
11 July 2015

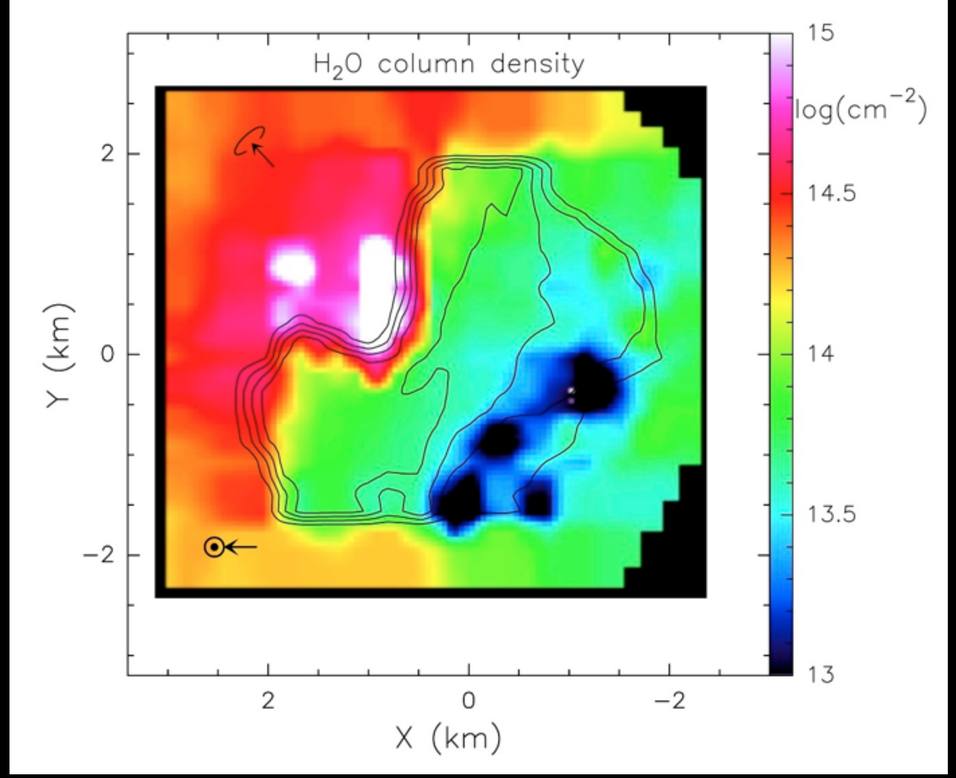


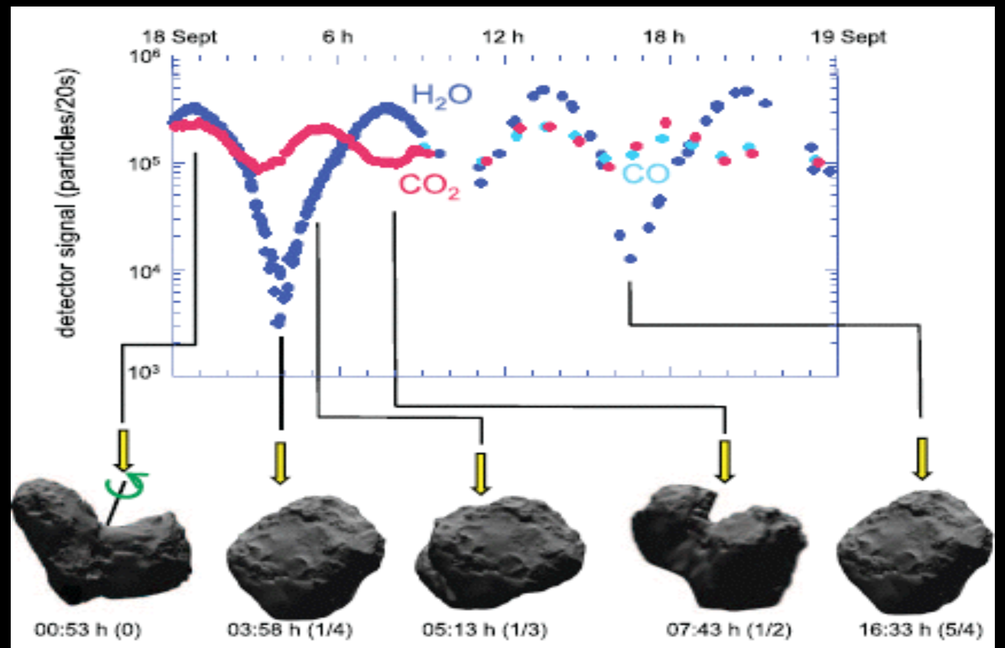
Groussin et al. 2015

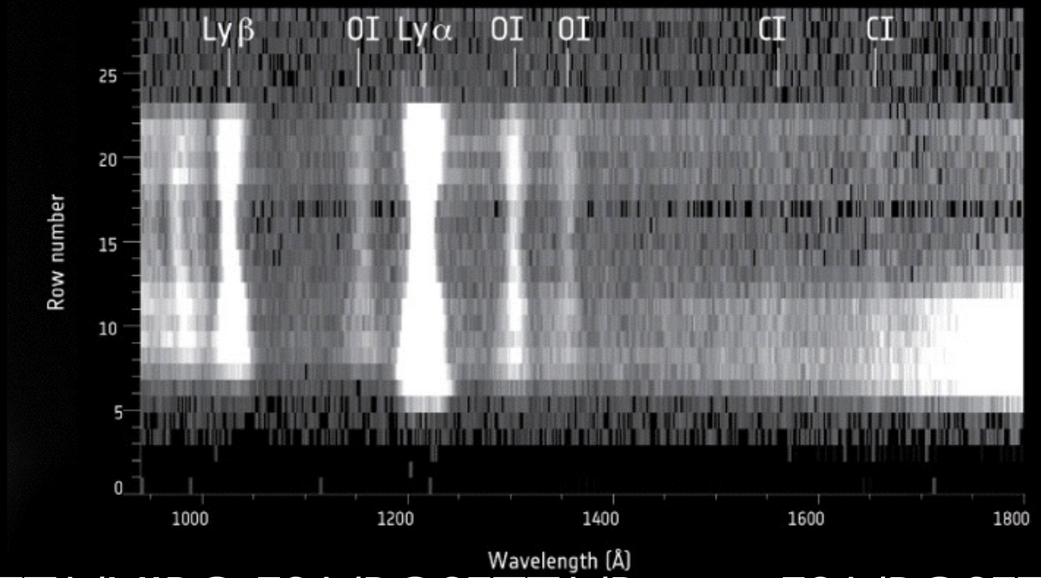
Biver et al., A&A, 2015 Gulkis et al., Science, Vol 347, 2015 Feldman et al., 2015
Hassig et al., 2015 Kuspay-Luti et al., 2016



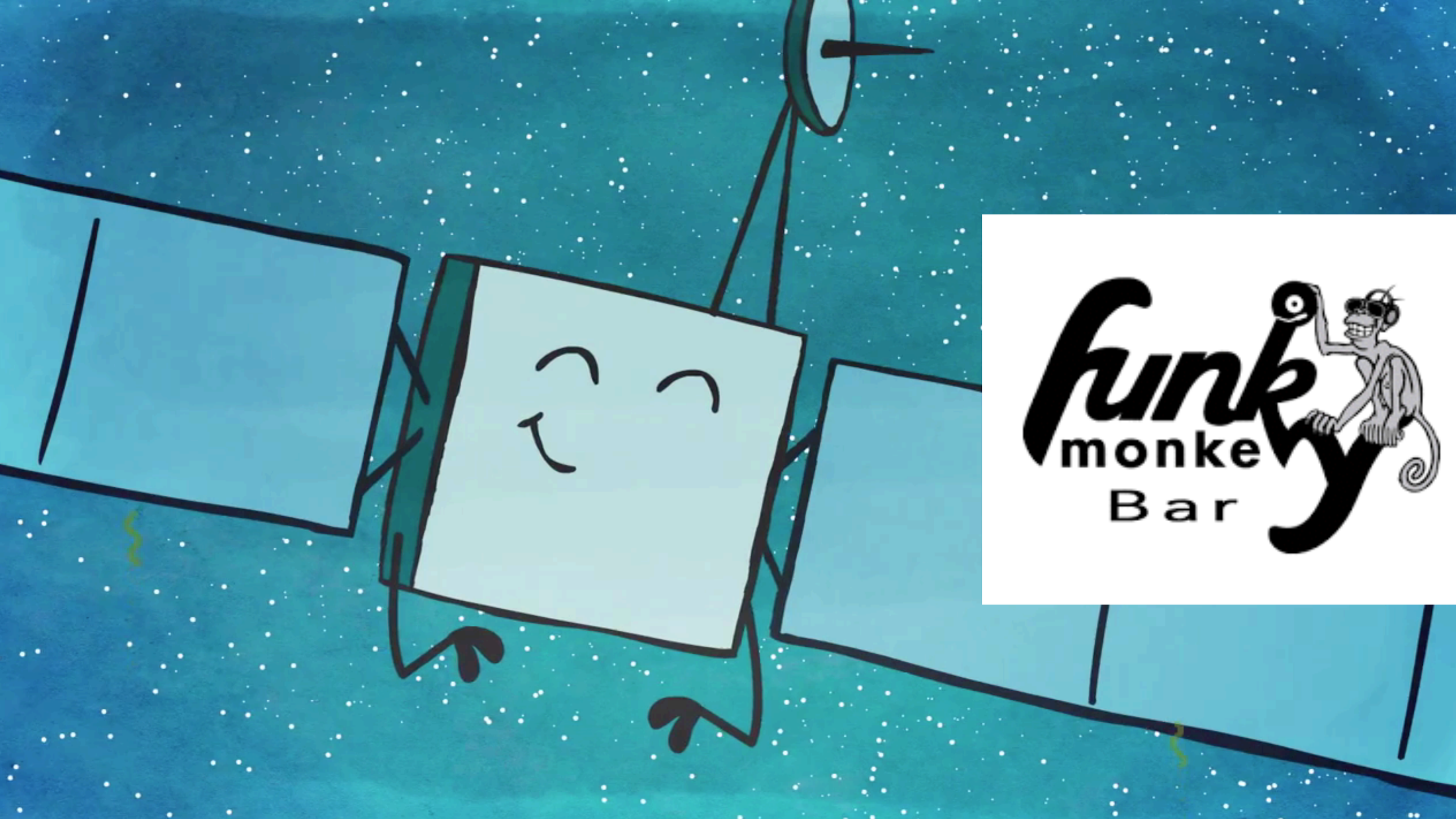


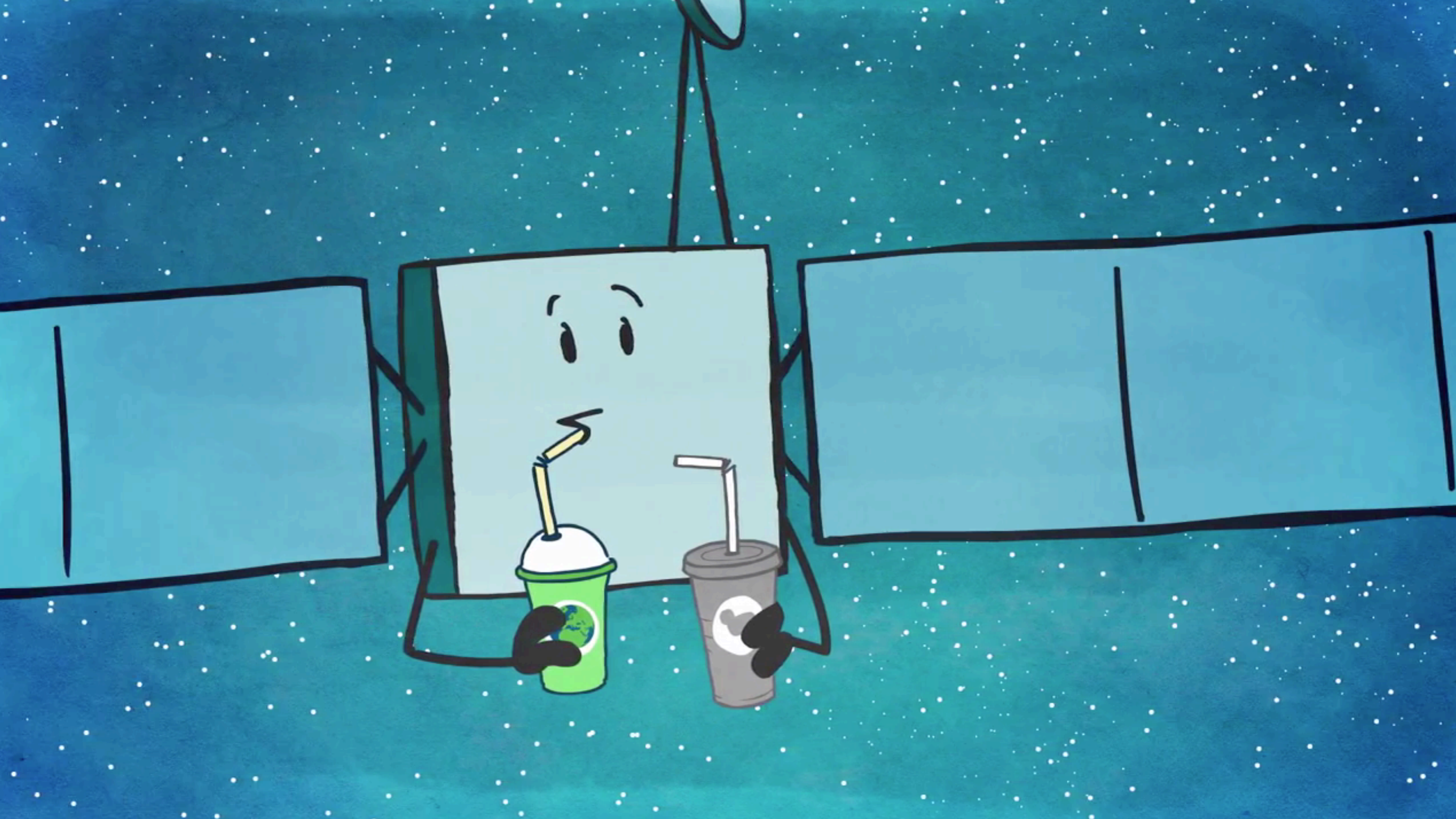


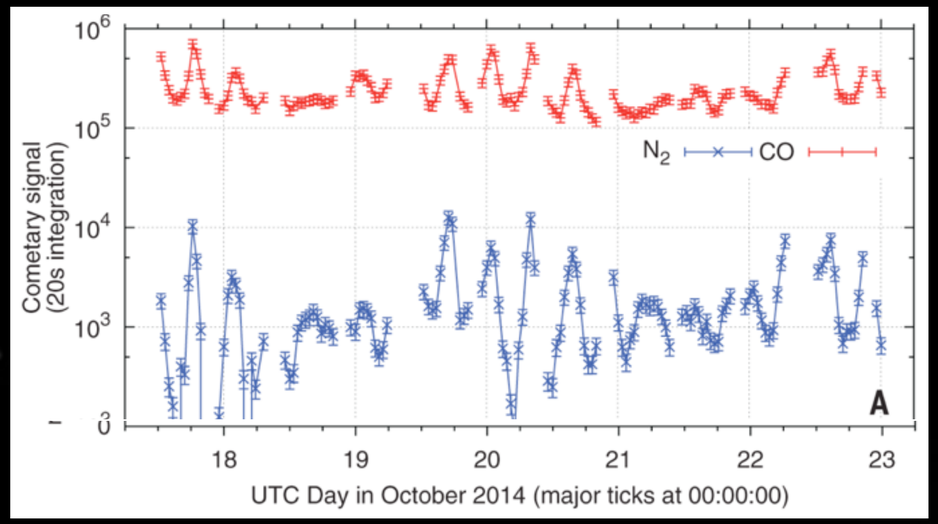


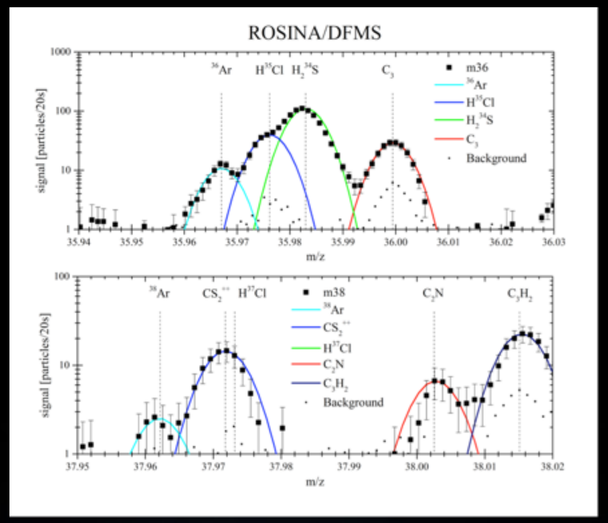


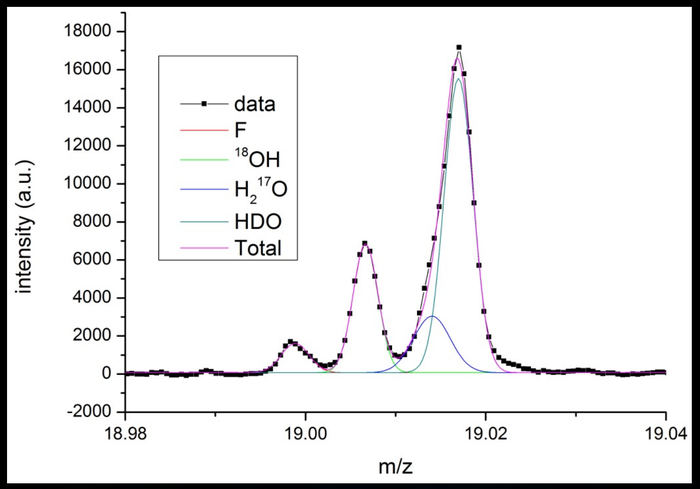
ESA/ROSETTA/MIRO ESA/ROSETTA/Rosina ESA/ROSETTA/ALICE

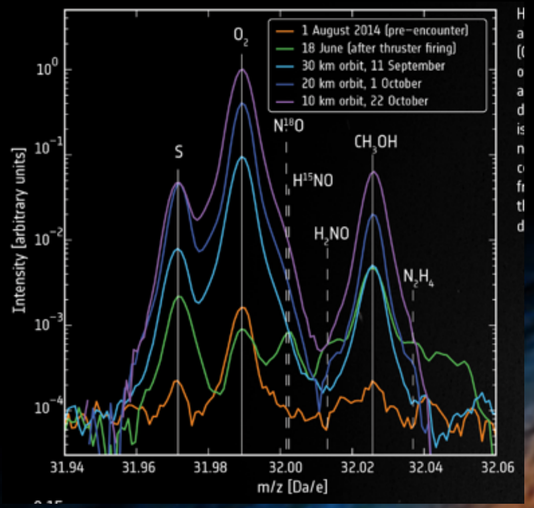

funky
monke
Bar





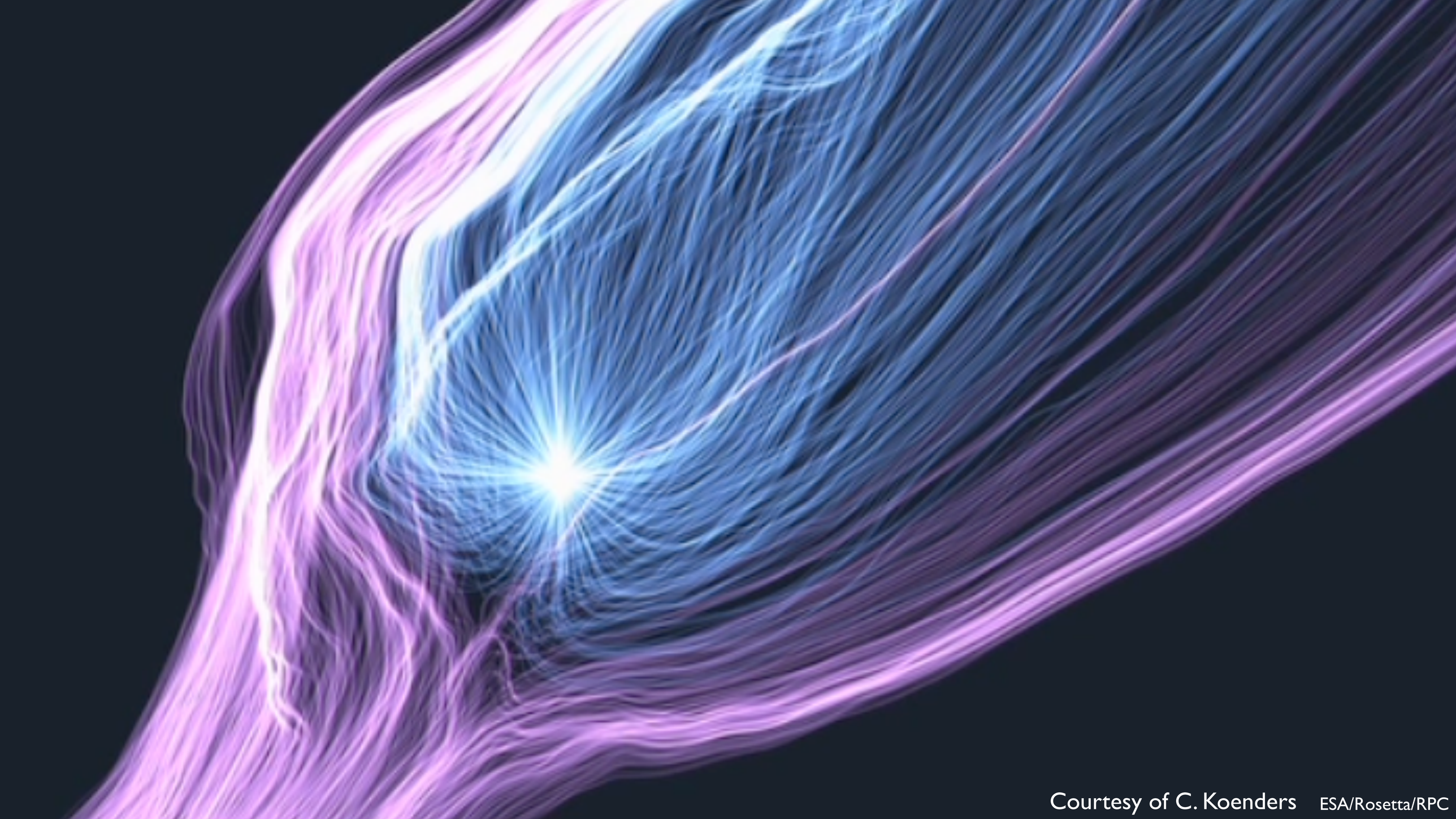






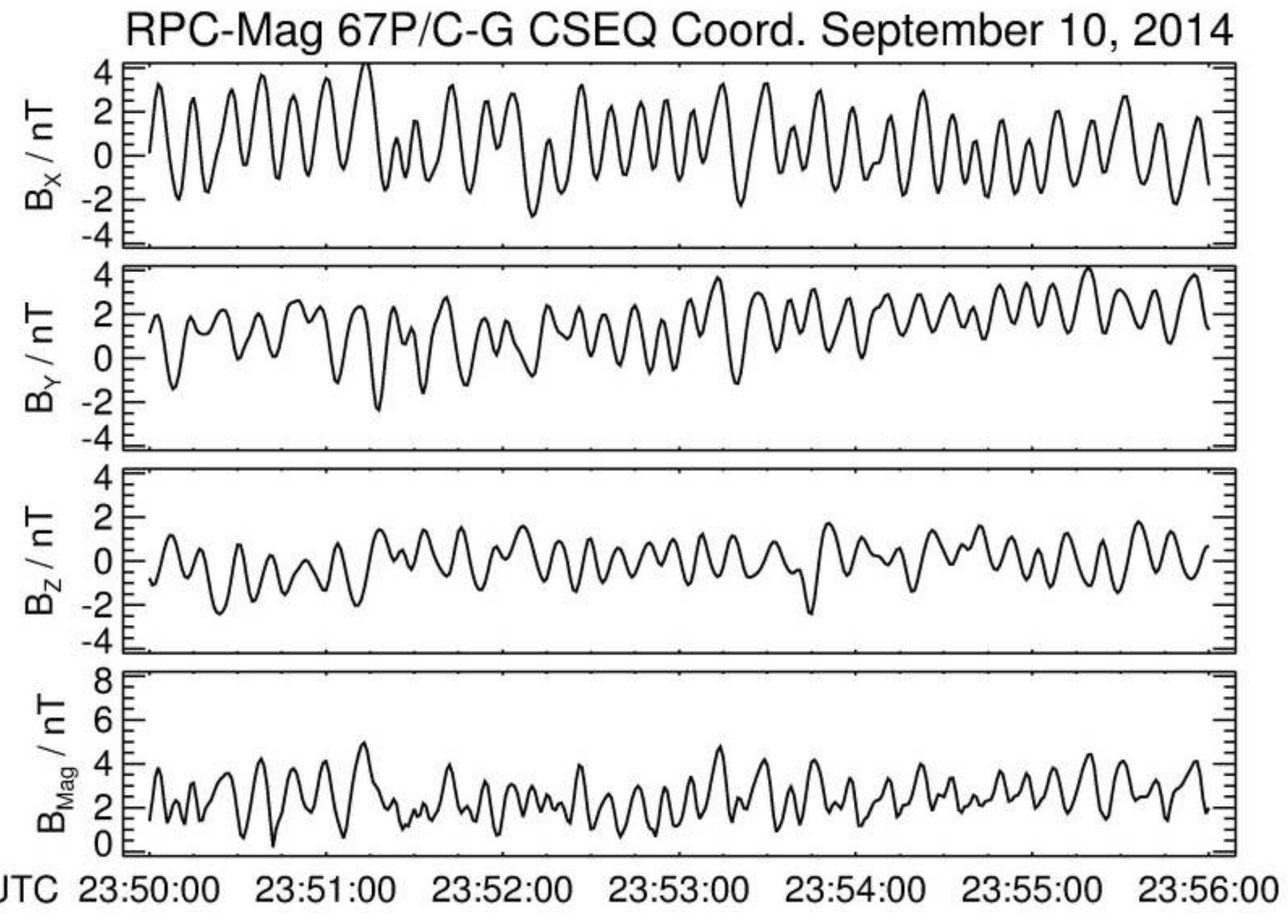
ESA/Rosetta/ROSINA

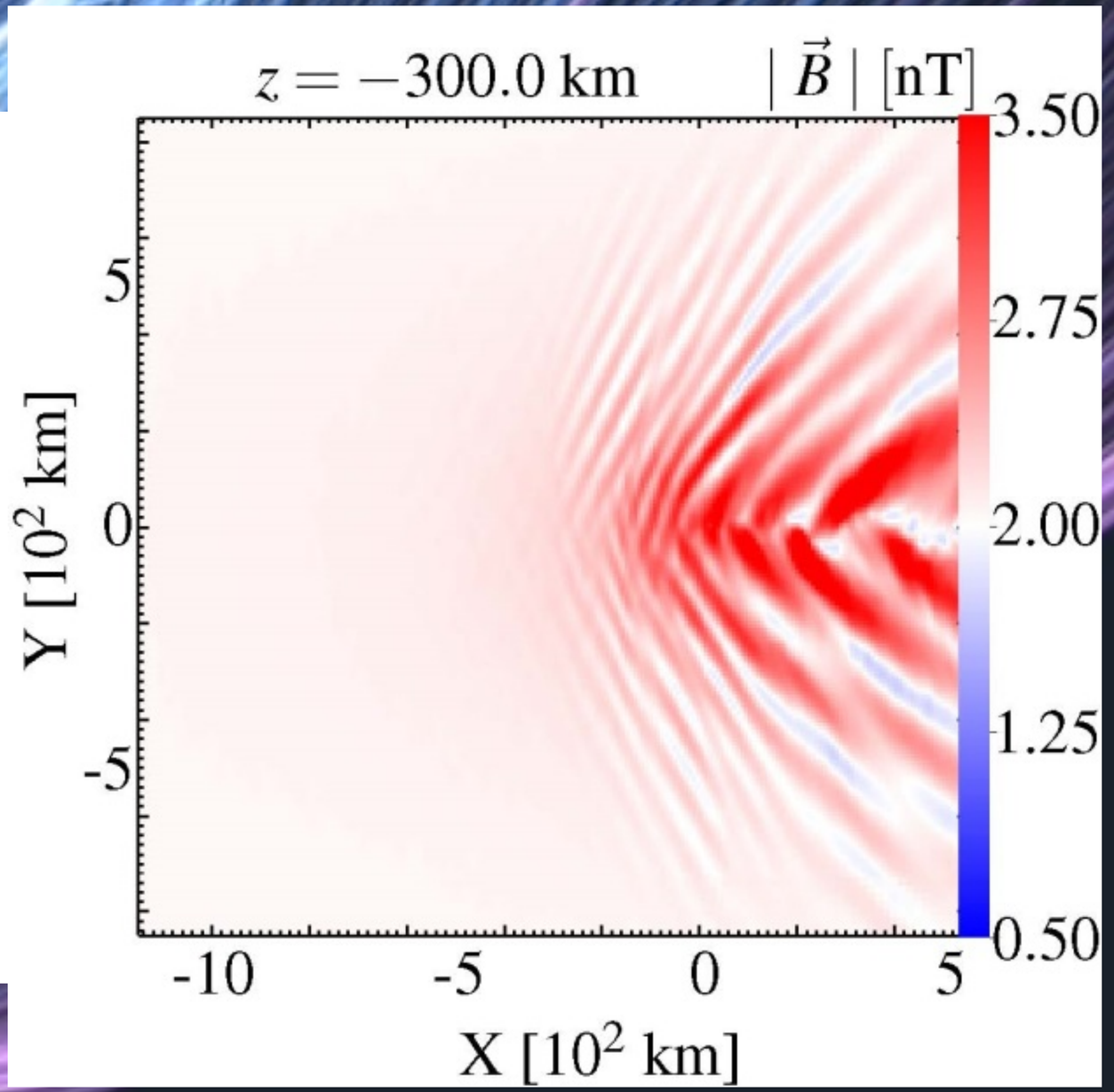
Altwegg et al., 2015, Balsiger et al., 2015, Rubin et al., 2015, Bieler et al., 2015



Courtesy of C. Koenders ESA/Rosetta/RPC

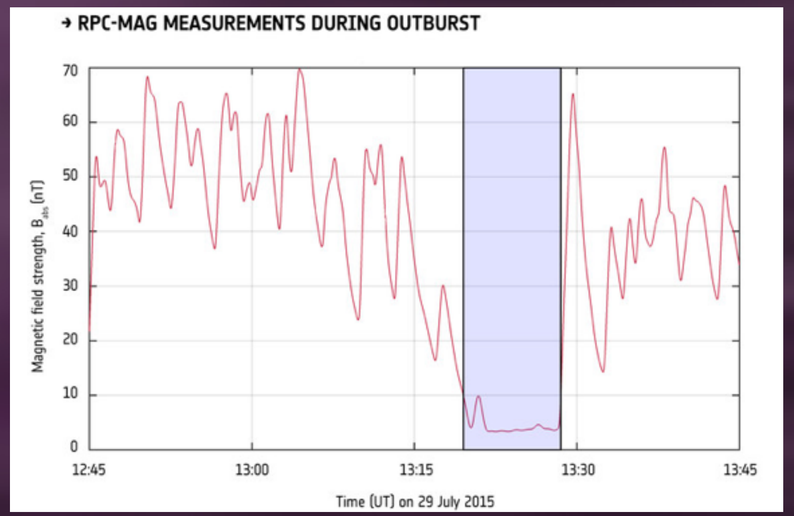
ESA/Rosetta/RPC

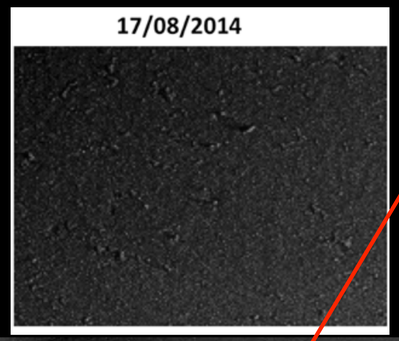


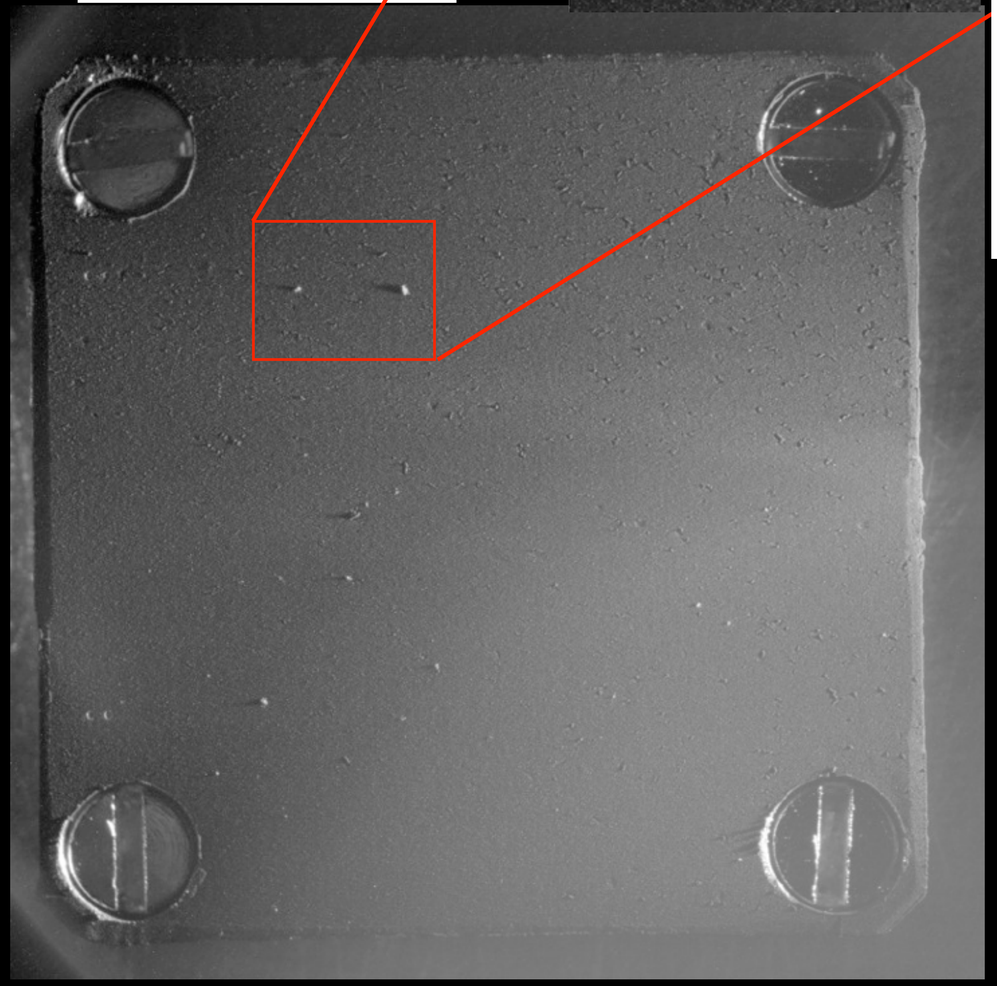


Courtesy of C. Koenders

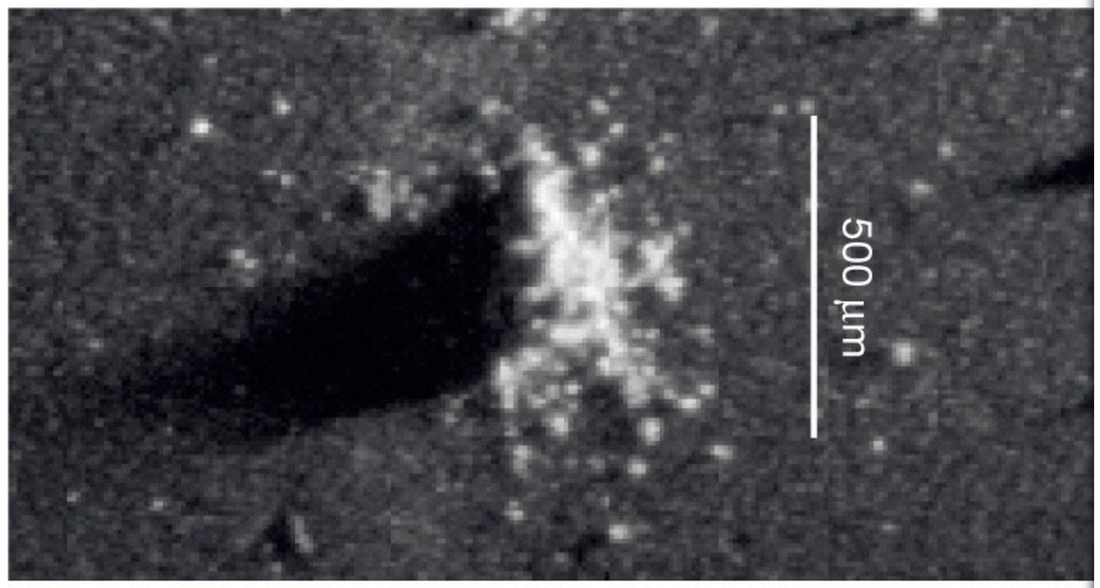
Nilsson et al., Science, Vol 347, 2015


→ RPC-MAG MEASUREMENTS DURING OUTBURST
Magnetic field strength, B_{abs} (nT)
70
60
50
40
30
20
10
0
12:45
13:00
13:15
13:30
13:45
Time (UT) on 29 July 2015

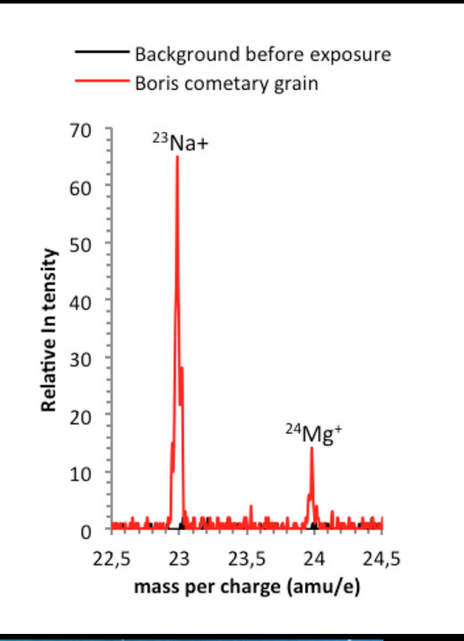


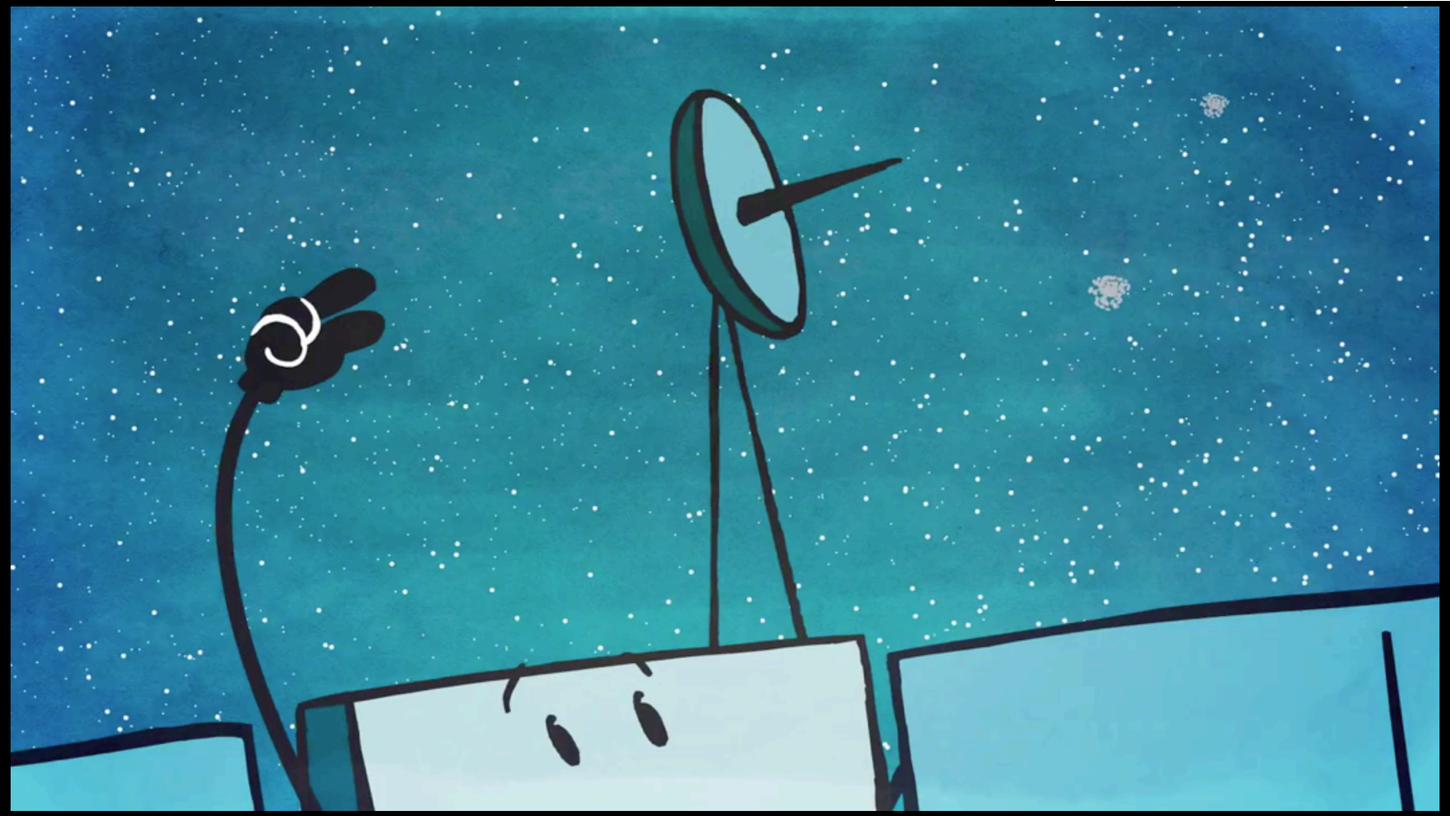


ESA/Rosetta/COSIMA

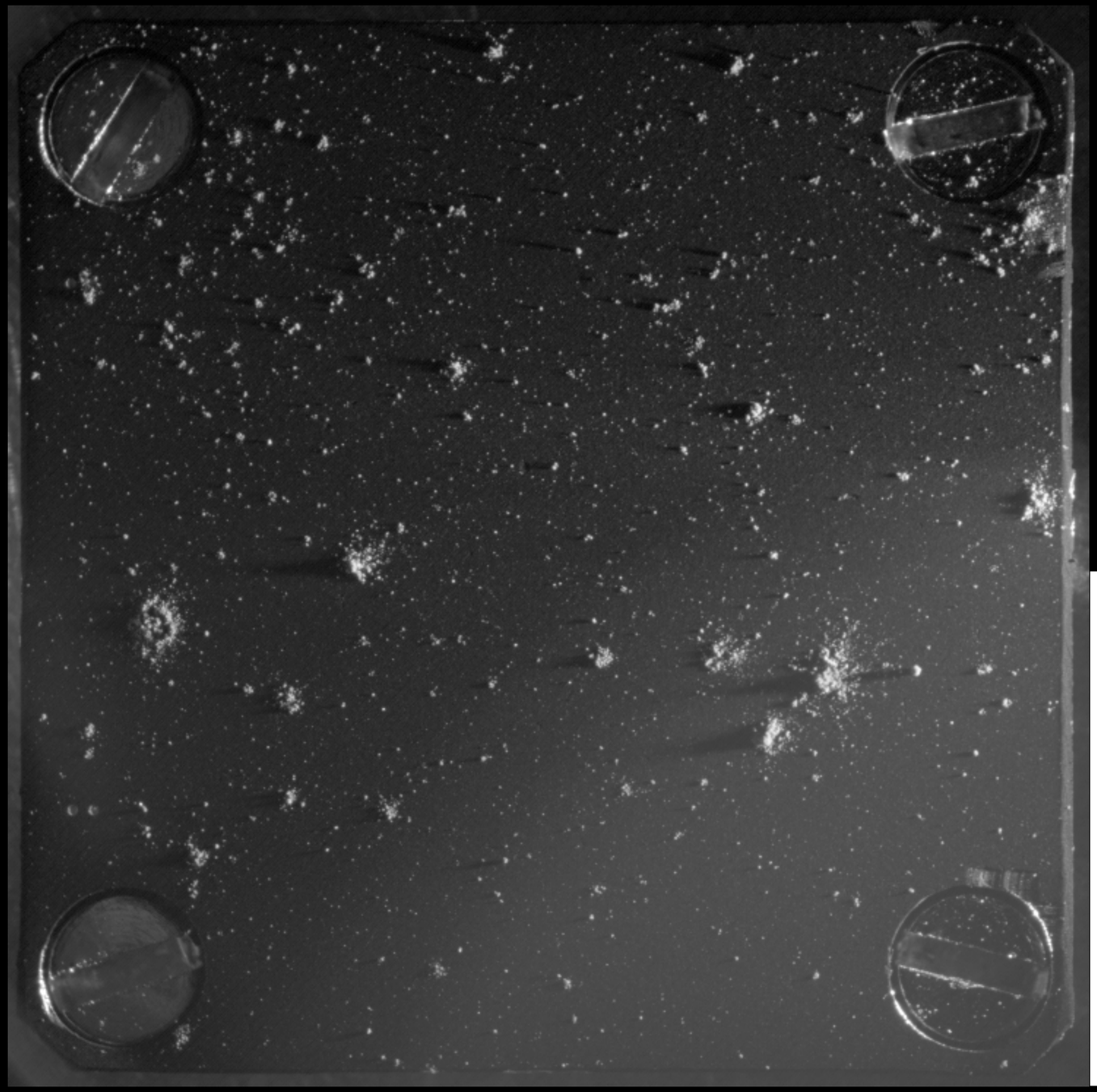


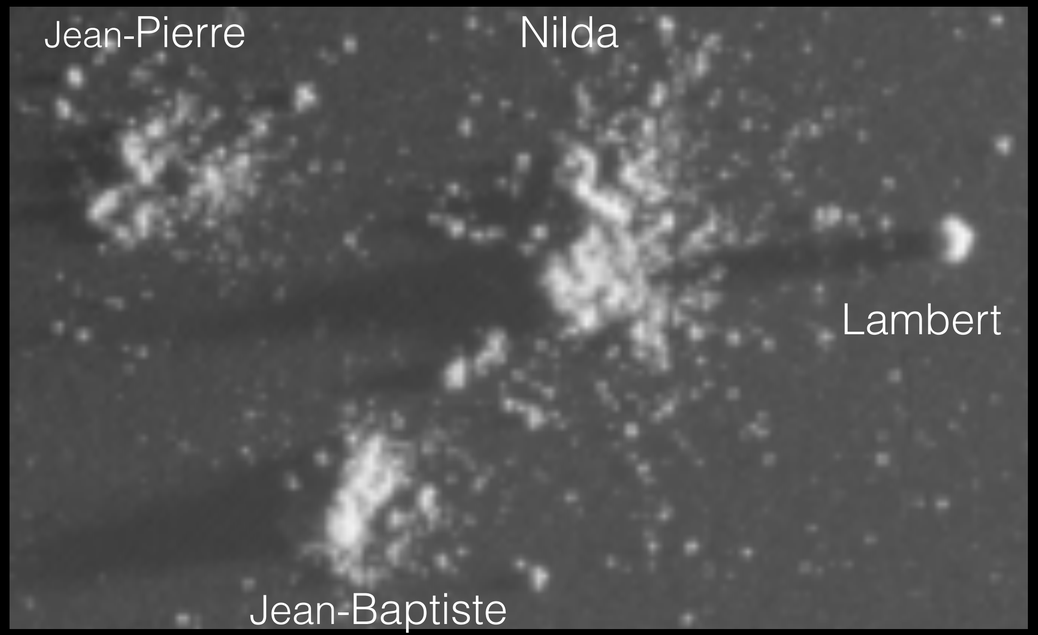
ESA/Rosetta/GIADA

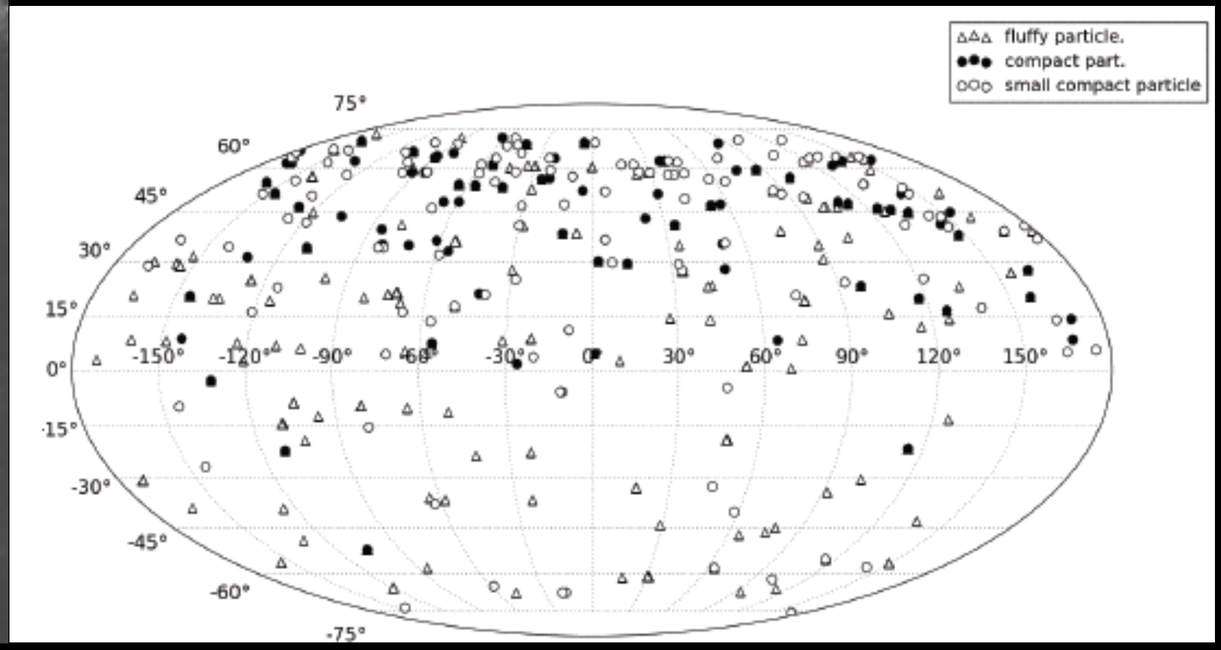




Schulz et al., 2015, Rotundi et al., 2015, Fulle et al., 2015







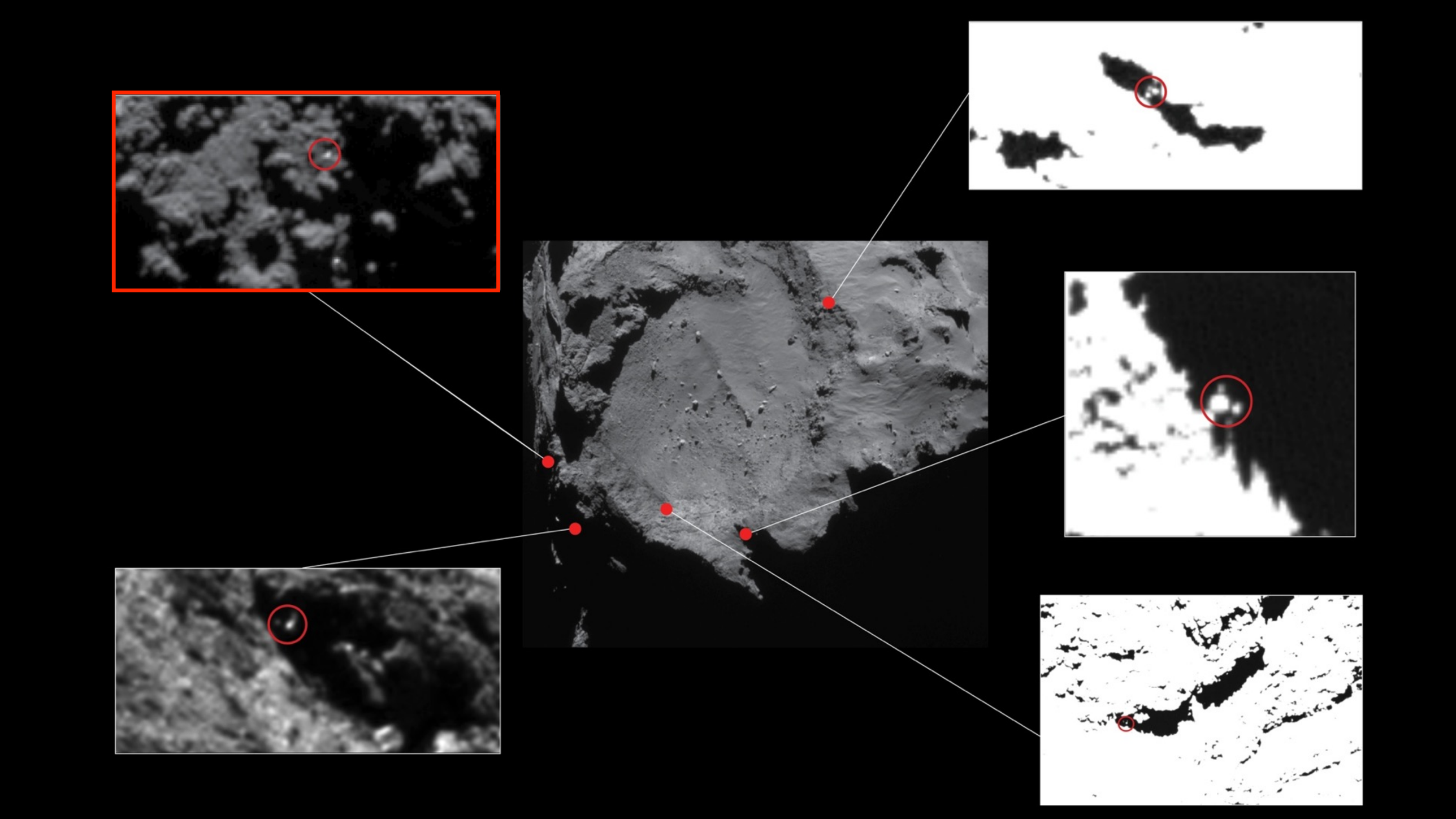
Schulz et al., 2015, Rotundi et al., 2015, Fulle et al., 2015, 2016, Della Corte et al., 2016, Langevin et al., 2016

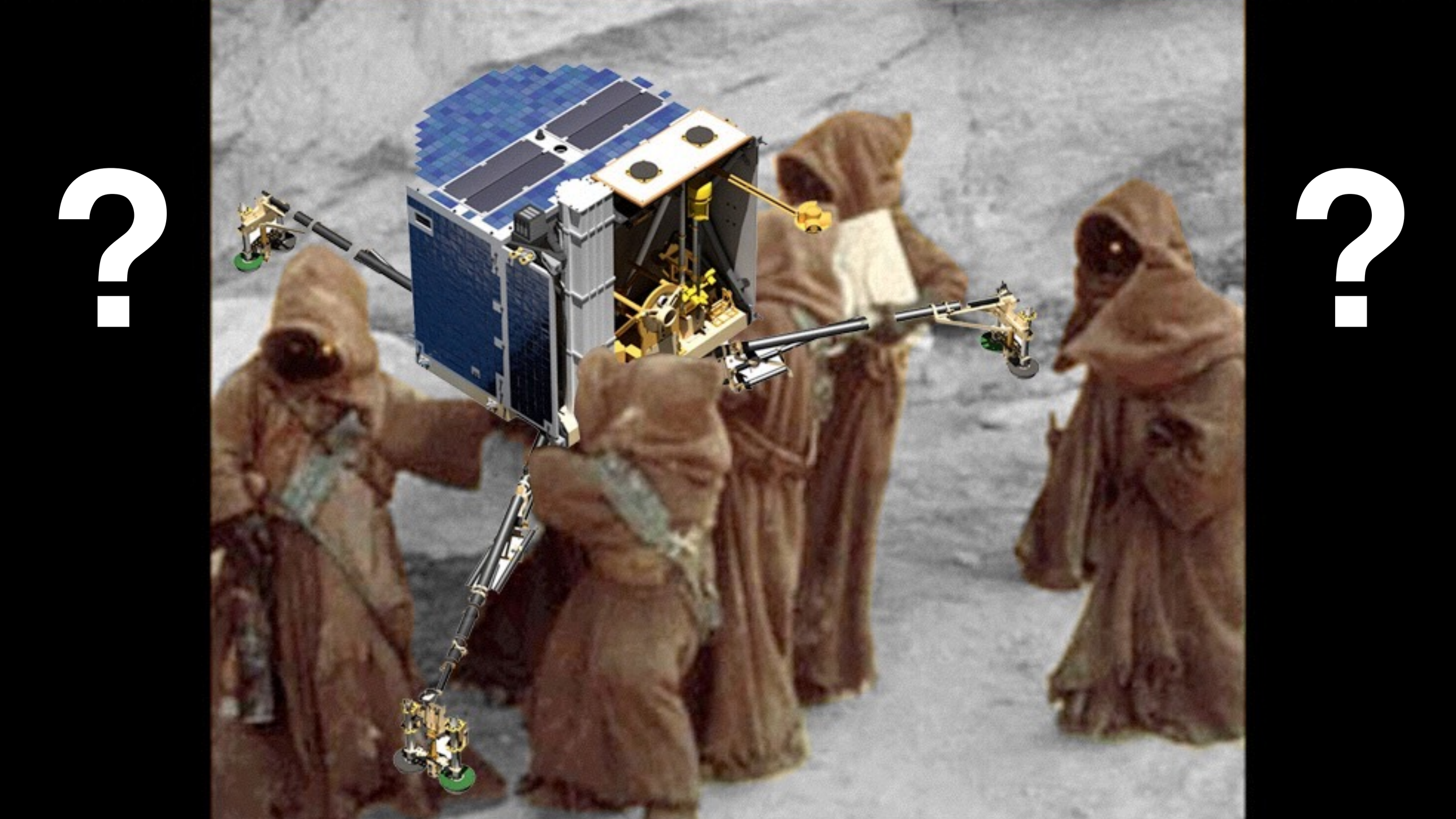
ESA/Rosetta/COSIMA

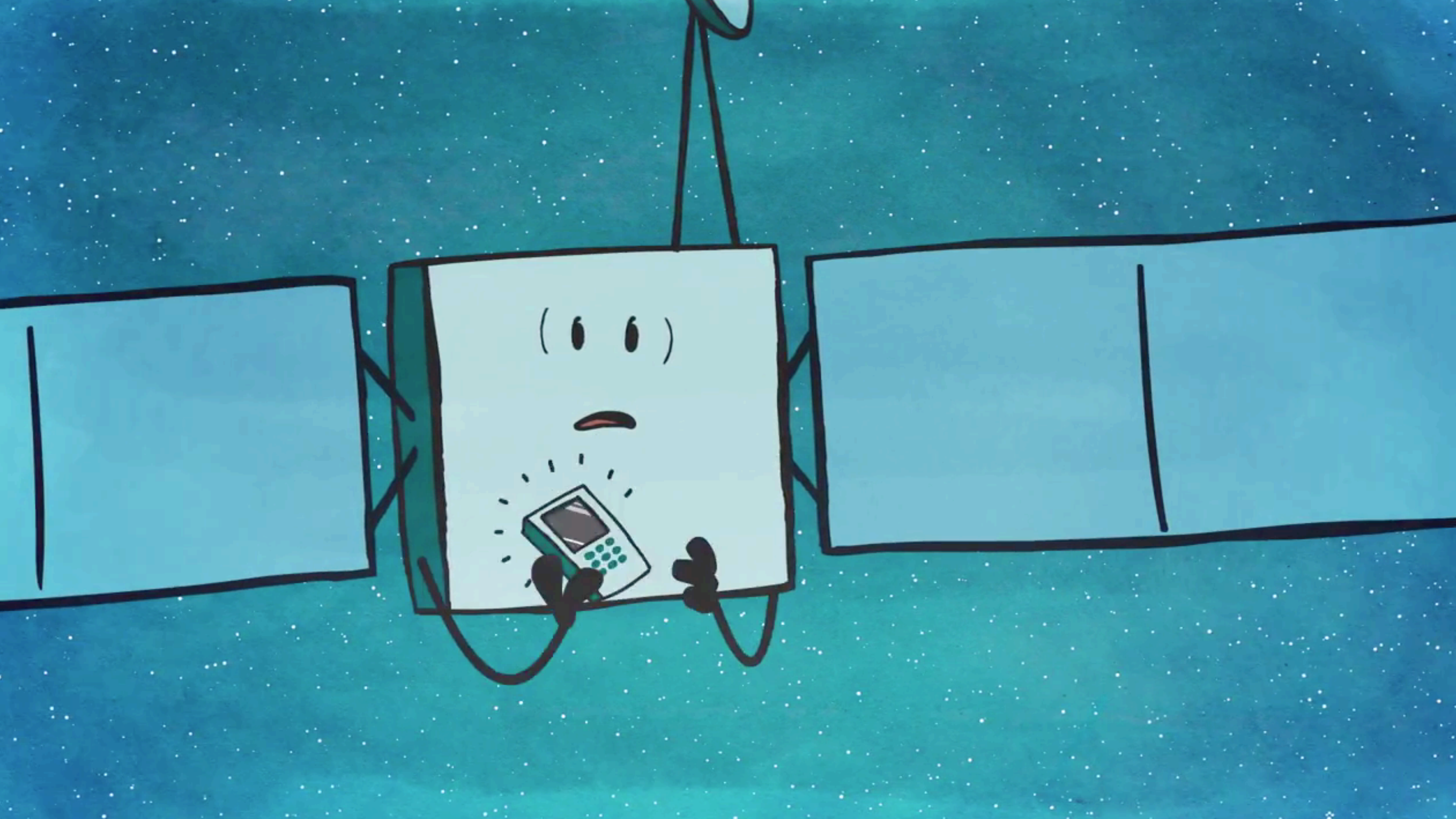
ESA/Rosetta/GIADA

ESA/Rosetta/MIDAS

esa
1
COMET LANDING
2
COMET LANDING
3
COMET LANDING
4
COMET LANDING
?







Sylvain is writing an official email to you and Patrick. Check your mail !!! We got IT !!!! 23:53

Got what???!!! 23:54

What do you think ? 23:54

It s got 3 legs 23:54

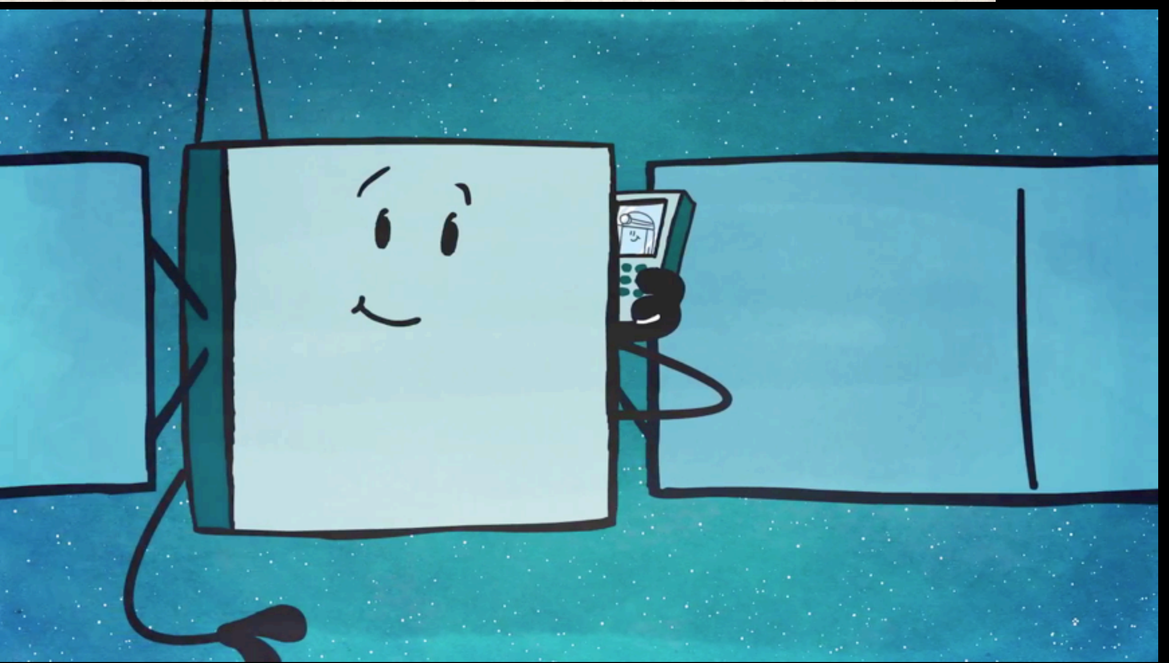
I've just seen on the DLR page!!! 23:55

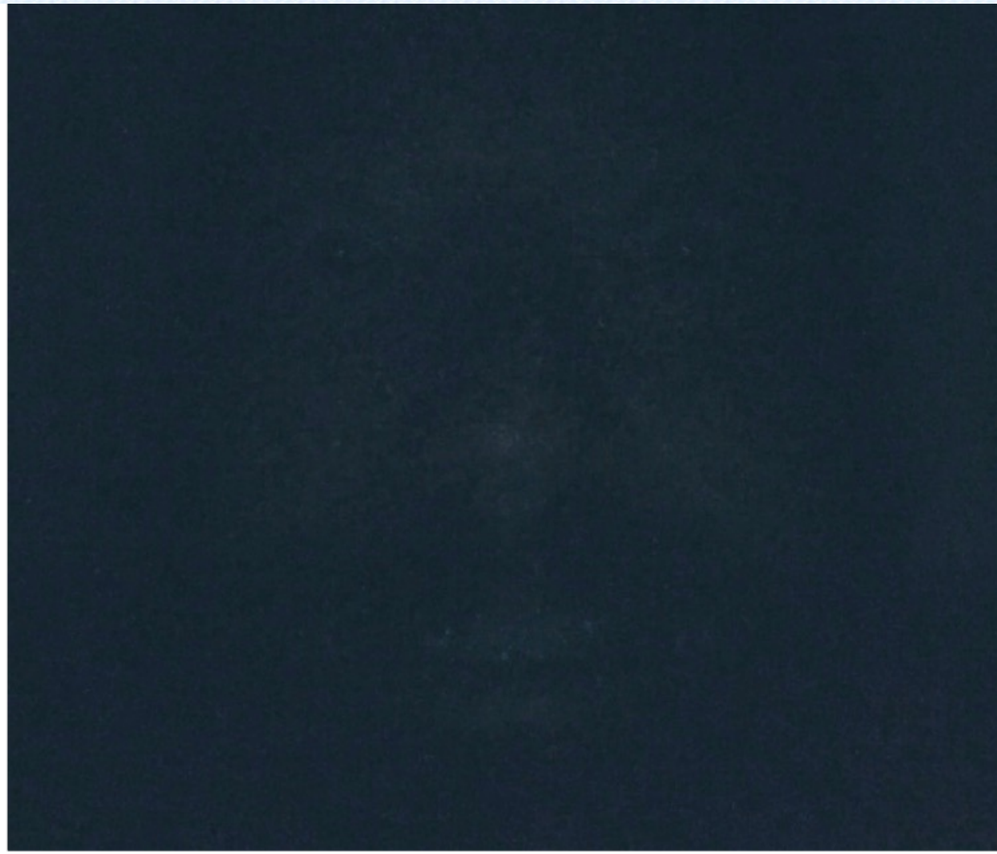
Thanks!!!! 23:55

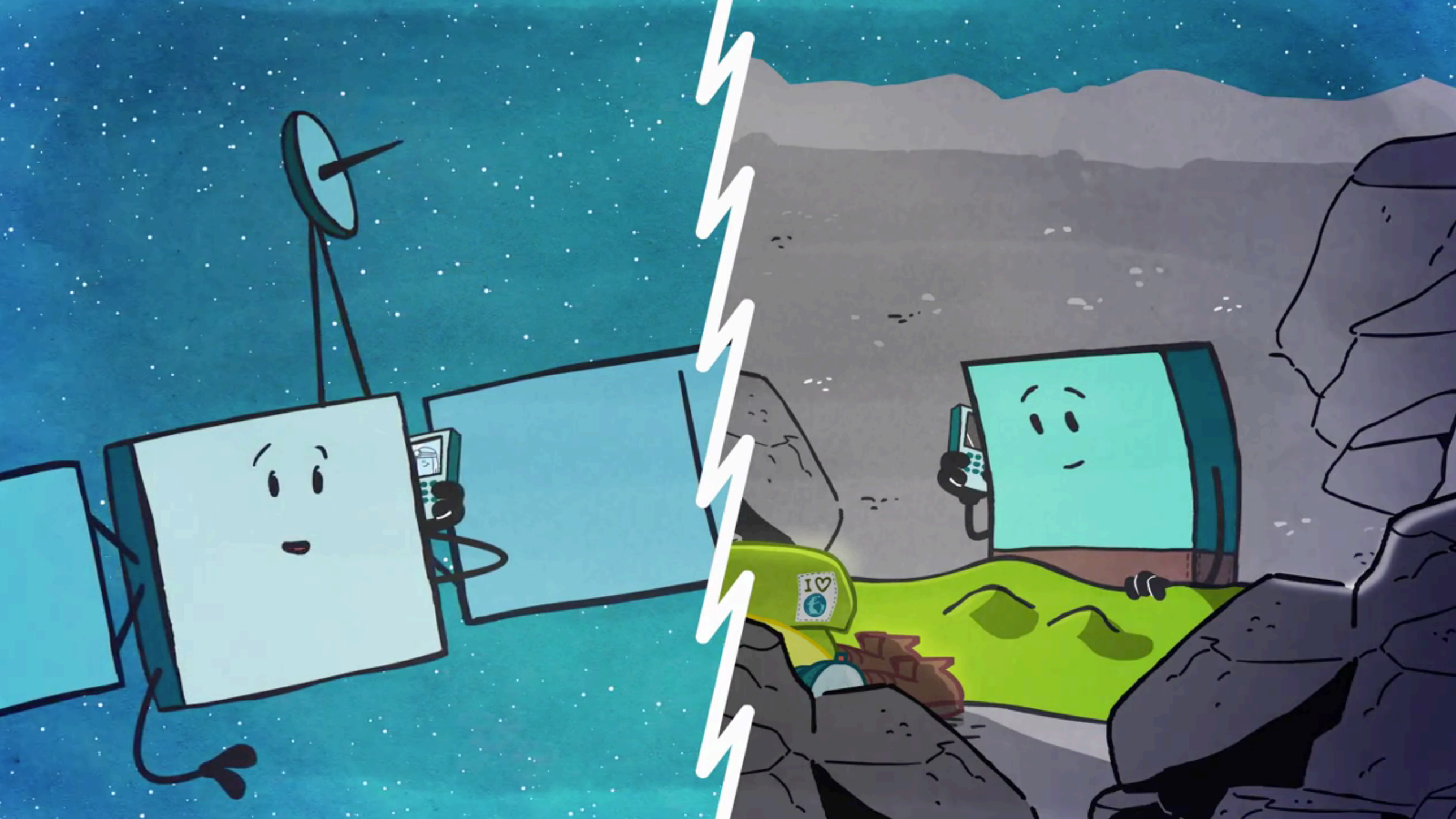
:D 23:55

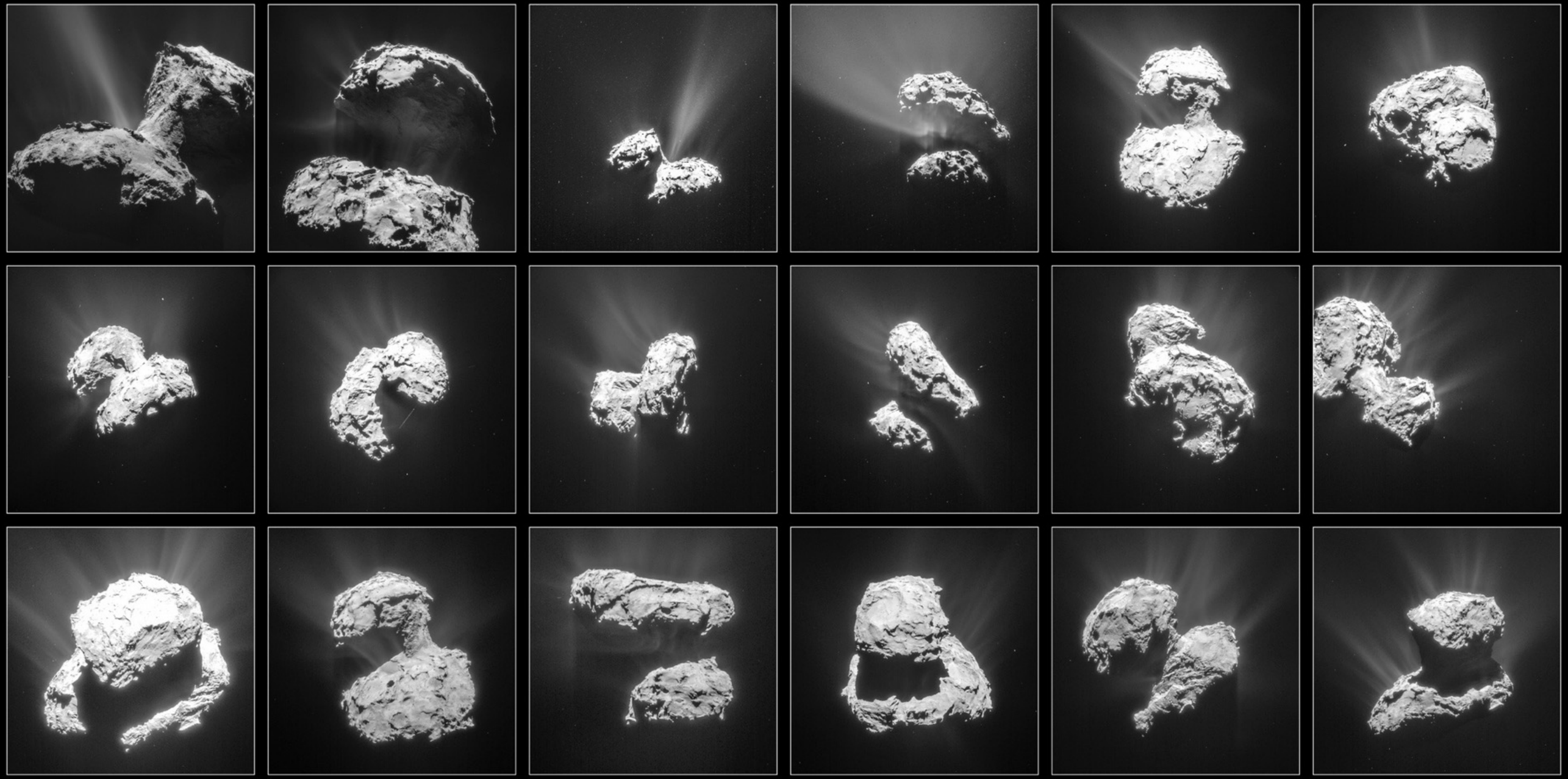
Text Message
Sat 13 Jun 23:53

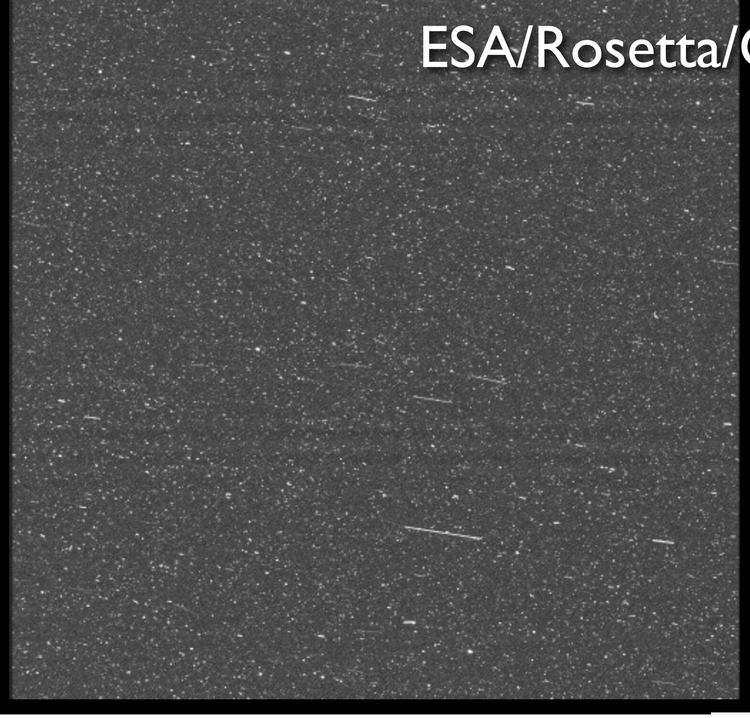
it seems philae is back!
2 min contact
info to be taken with care

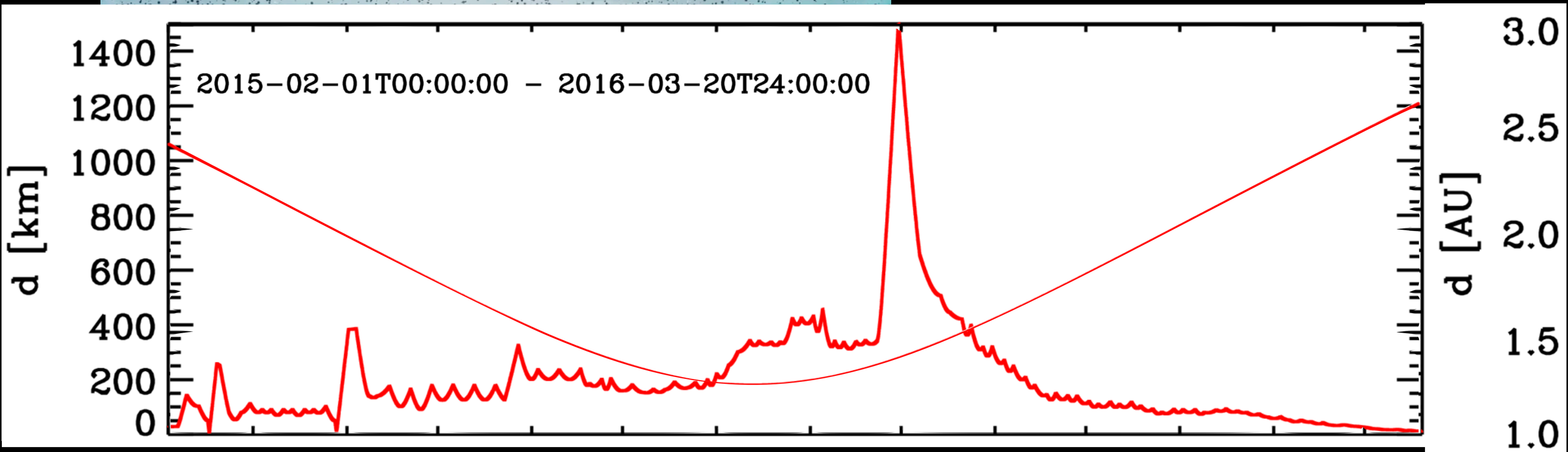


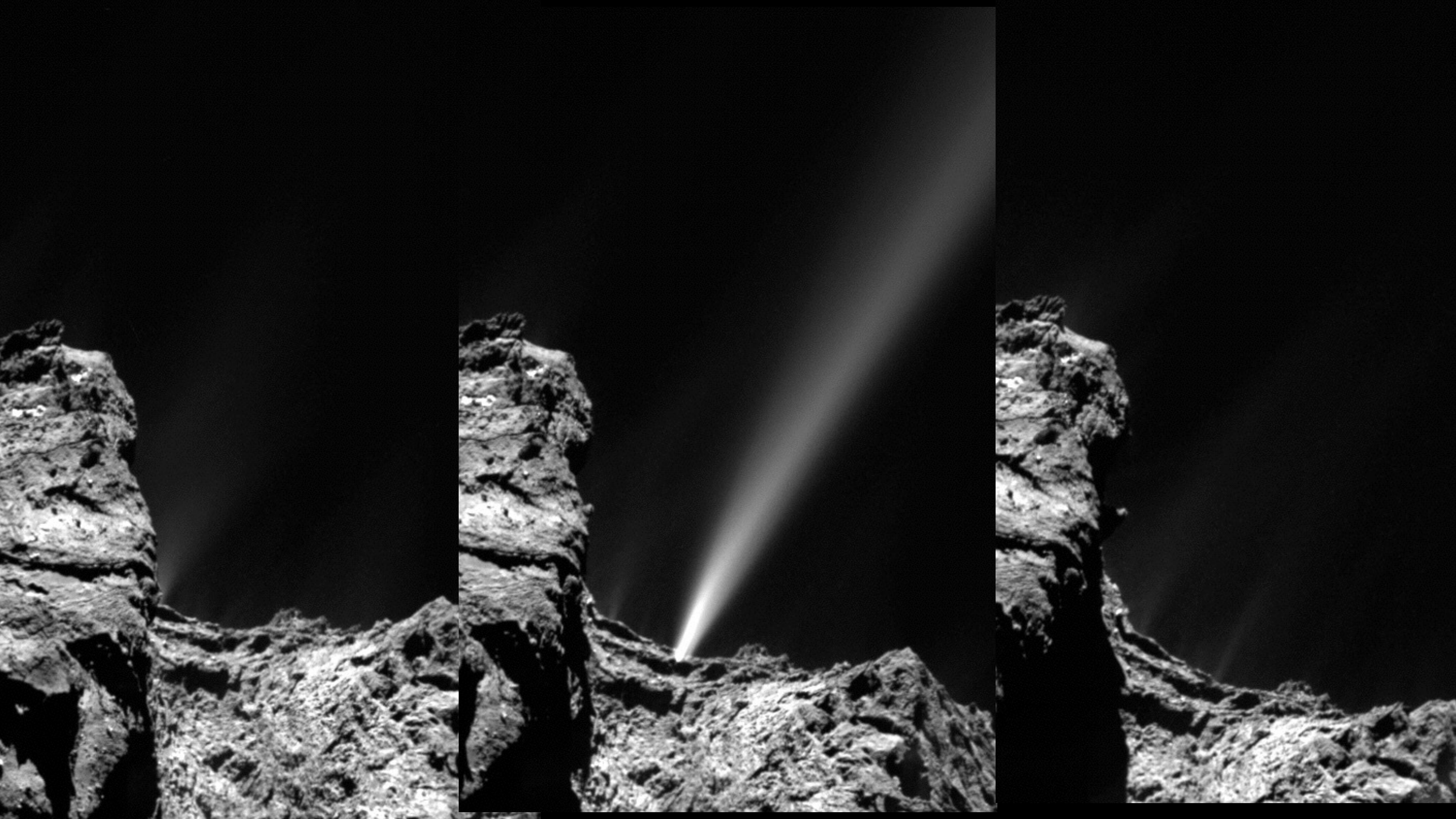



I ♡




ESA/Rosetta/OSIRIS


2015-02-01T00:00:00 – 2016-03-20T24:00:00
d [km]
1400
1200
1000
800
600
400
200
0
d [AU]
3.0
2.5
2.0
1.5
1.0

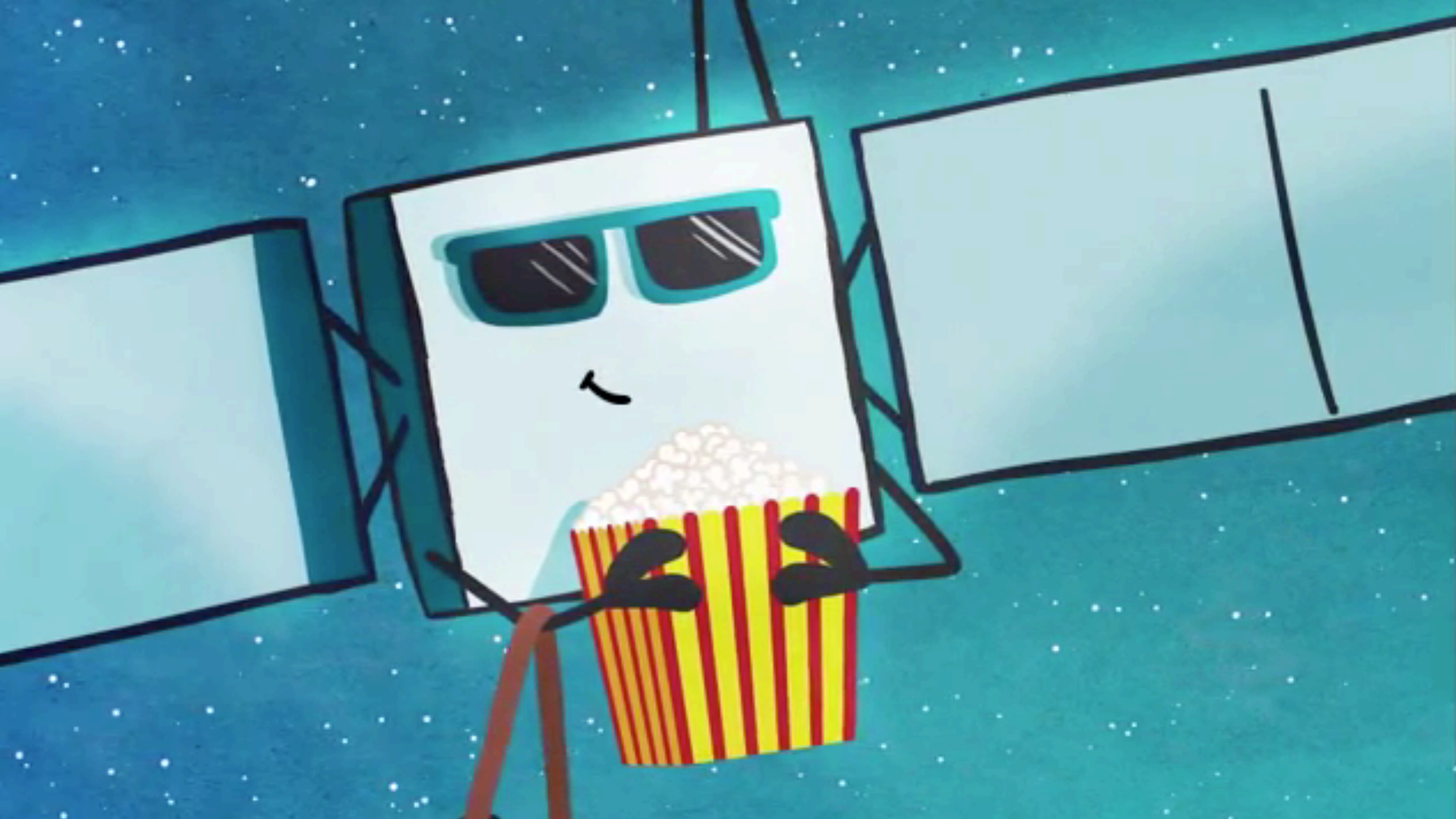


ESA/ROSETTA/OSIRIS

ESA/ROSETTA/OSIRIS

?

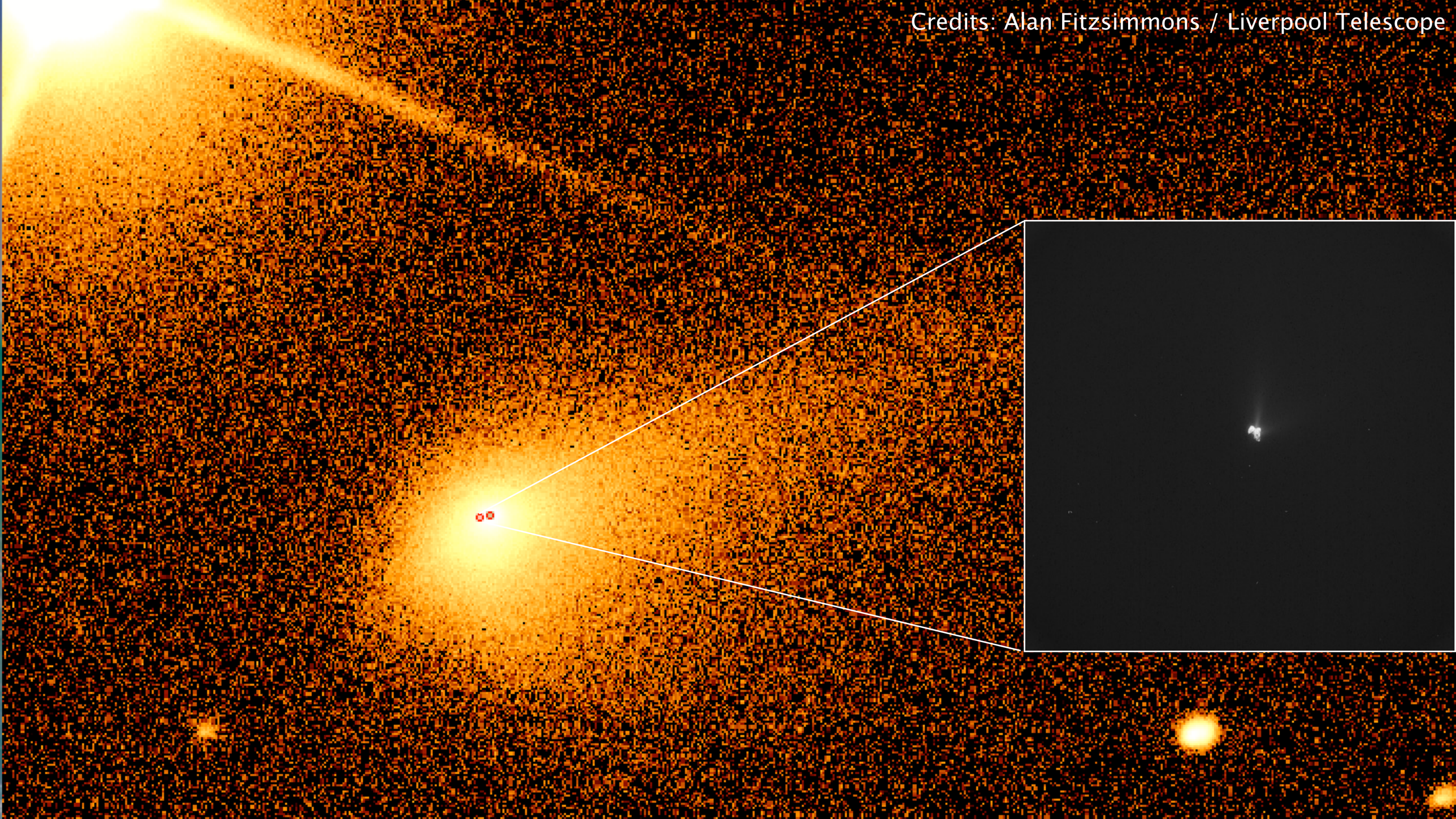
ESA/ROSETTA/OSIRIS

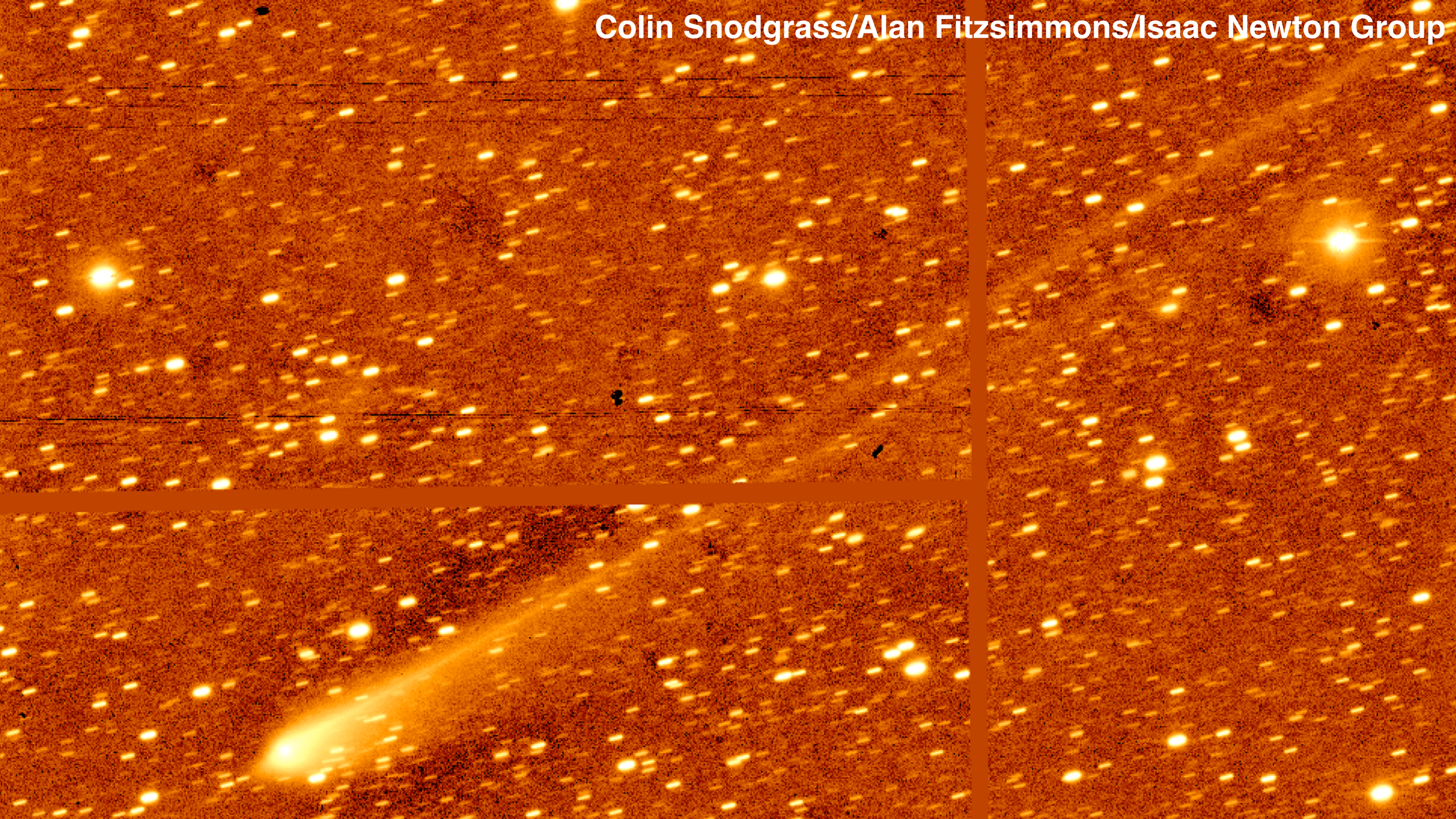


ESA/ROSETTA/OSIRIS

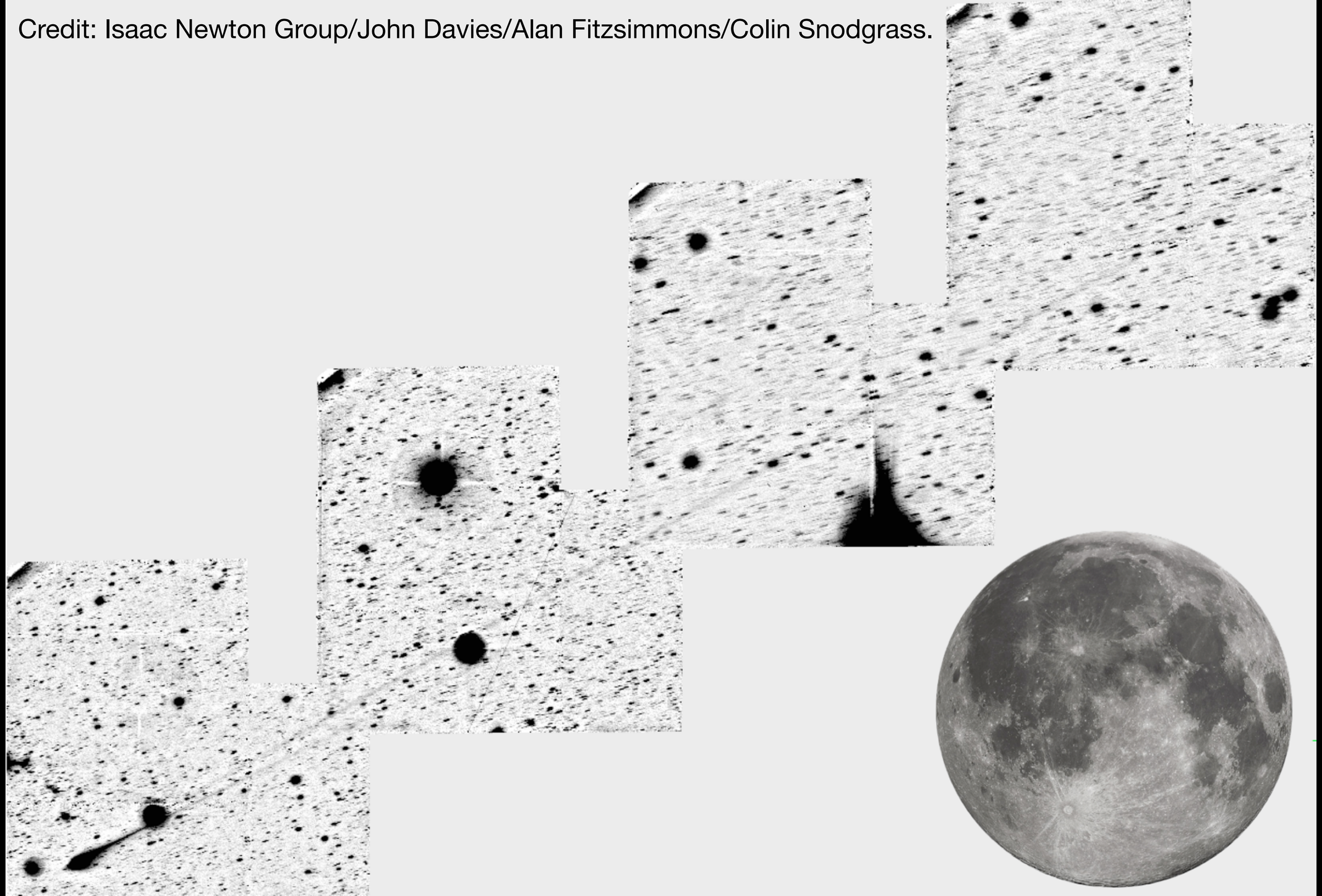
The PACA Project
Rosetta
67P/Churyumov-Gerasimenko
Connecting Professional and Amateur Astronomers

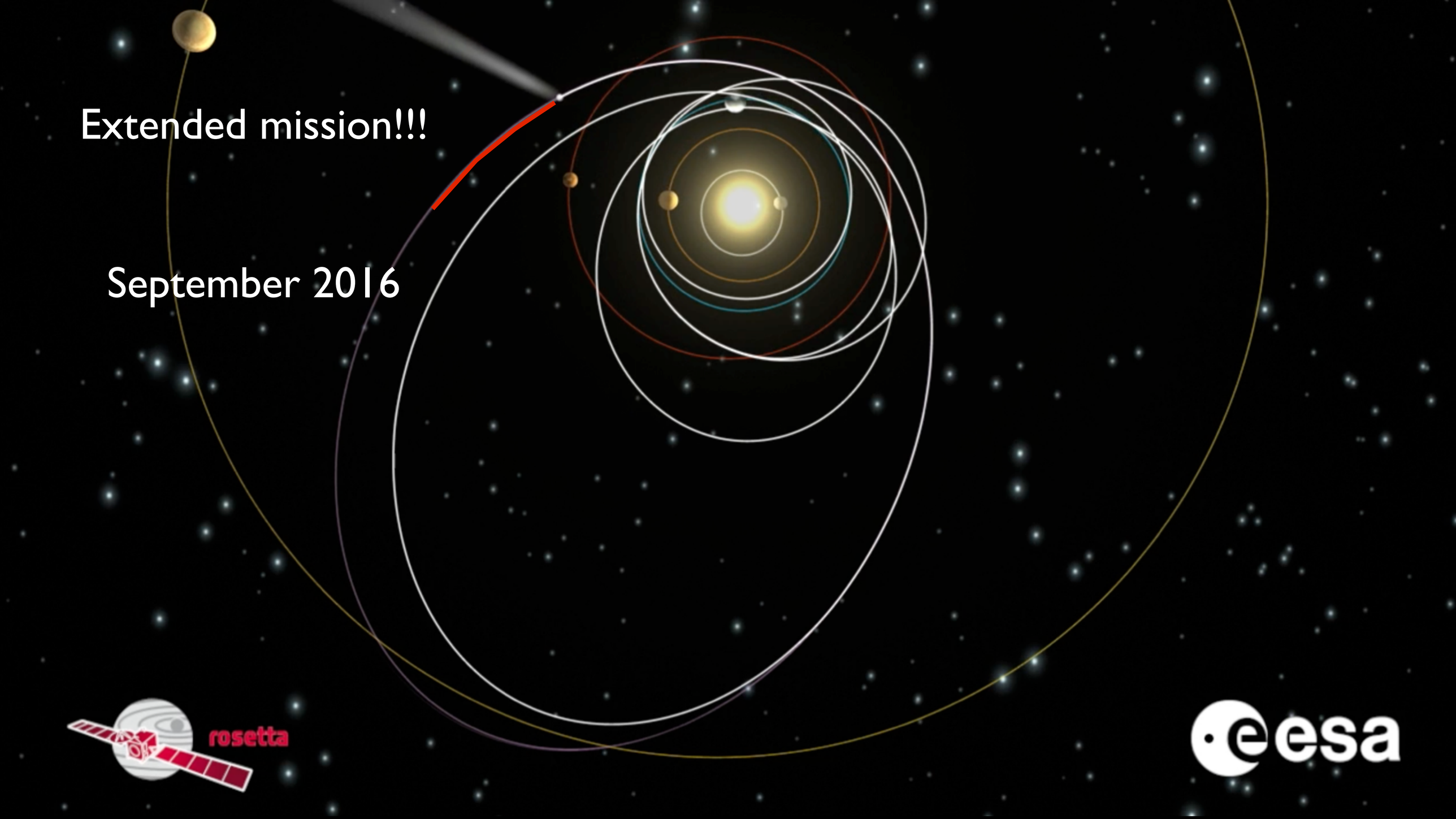
Tony Angel

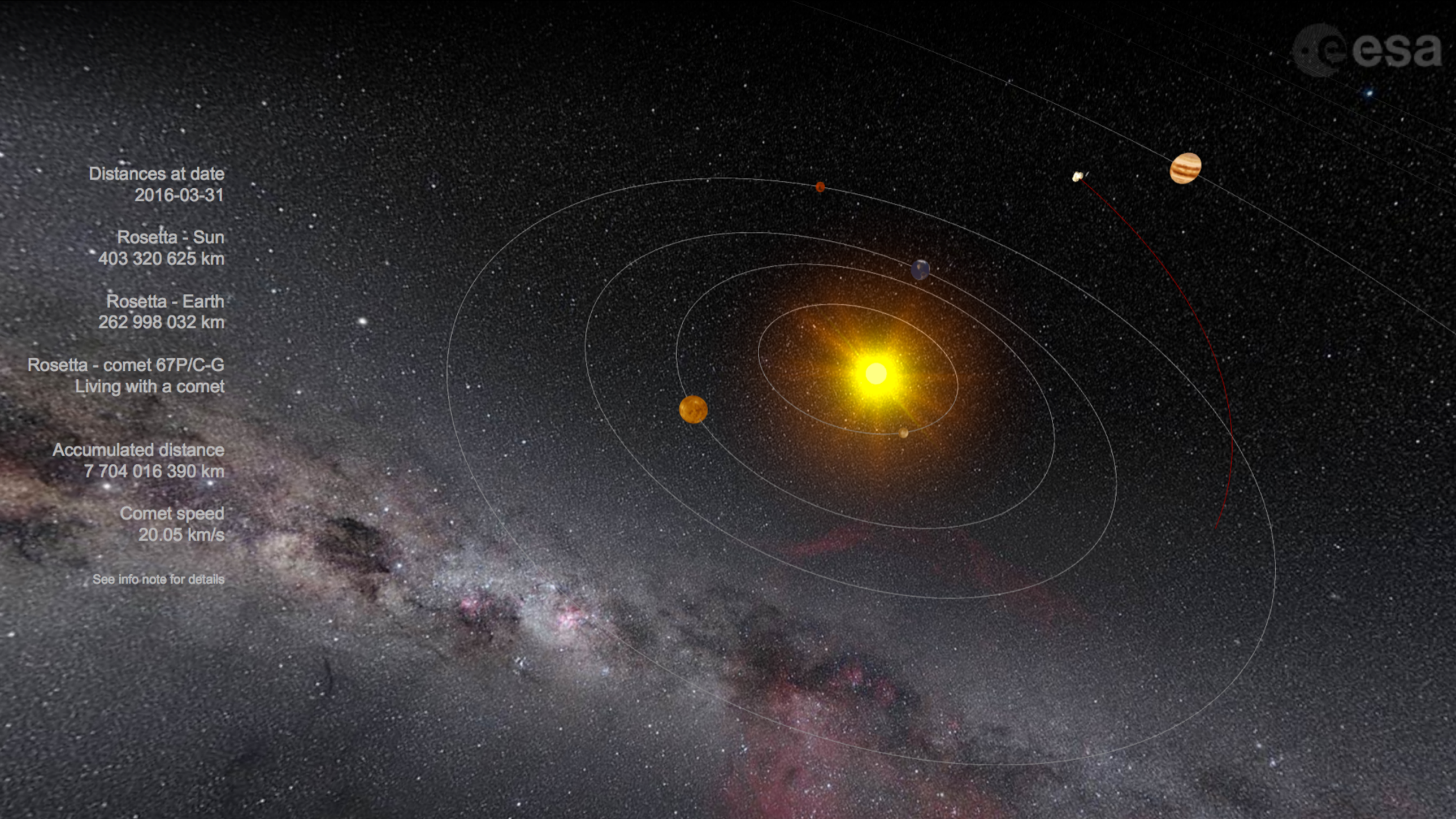

Credits: Alan Fitzsimmons / Liverpool Telescope

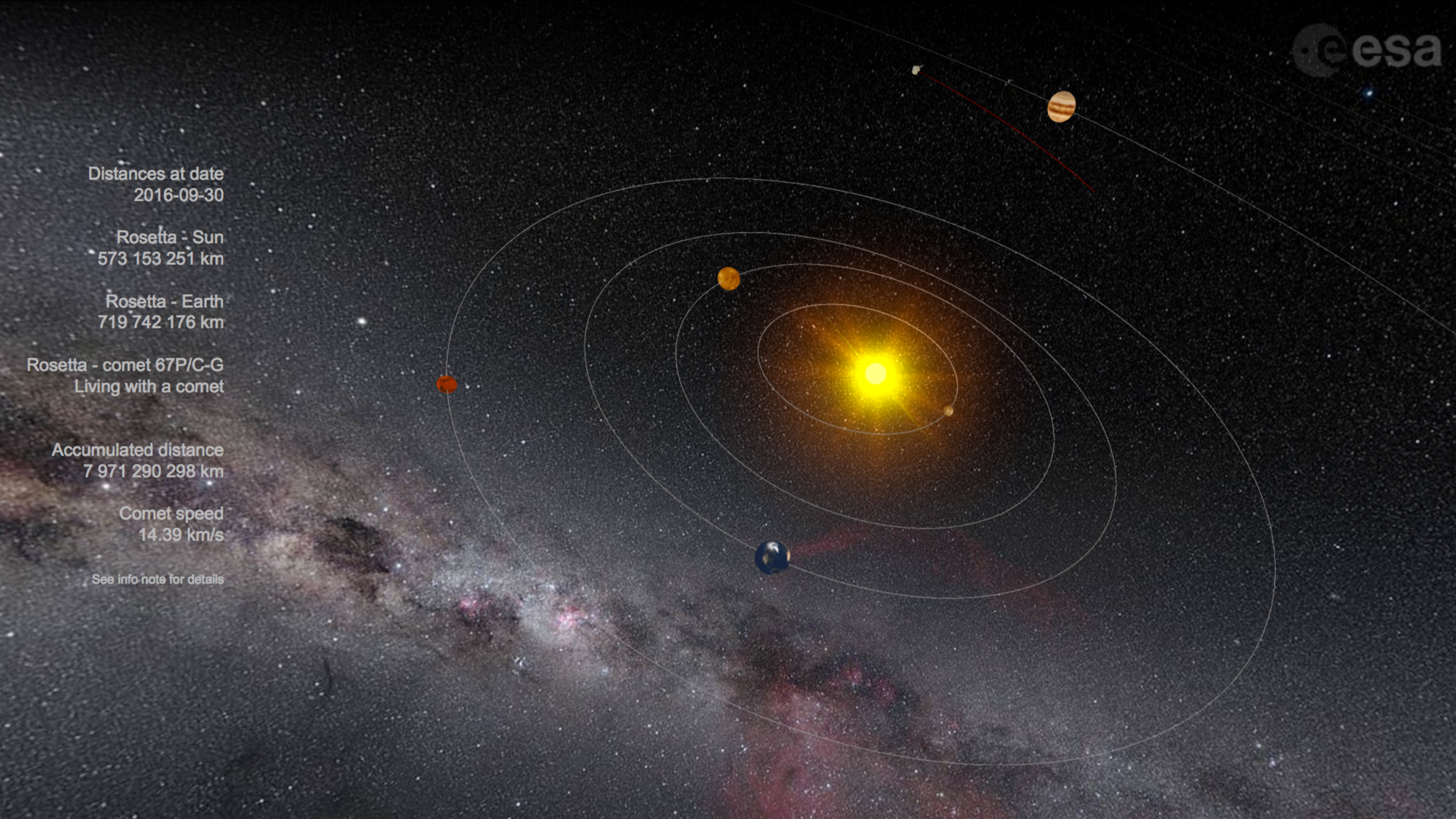

Colin Snodgrass/Alan Fitzsimmons/Isaac Newton Group

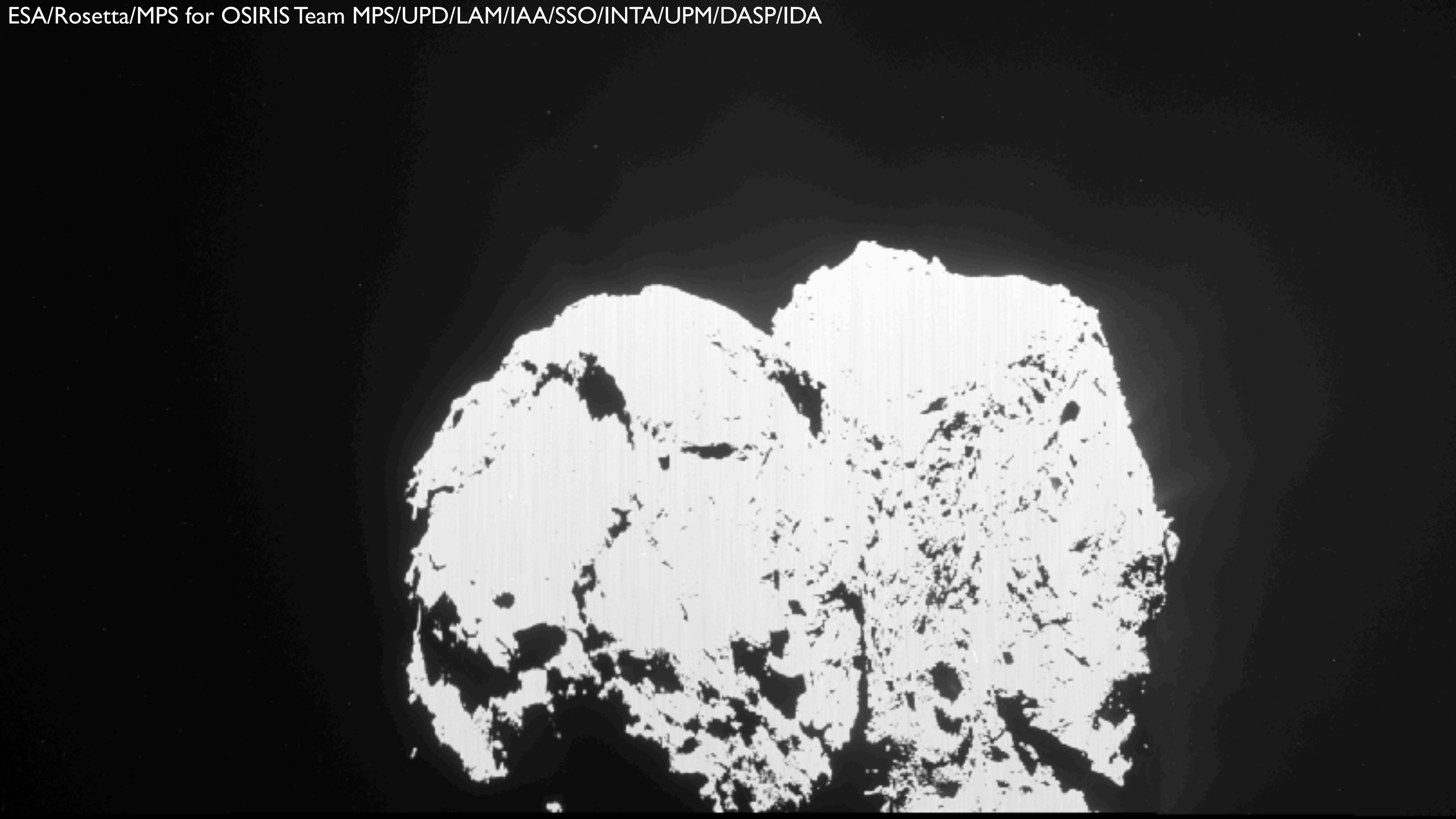
Credit: Isaac Newton Group/John Davies/Alan Fitzsimmons/Colin Snodgrass.



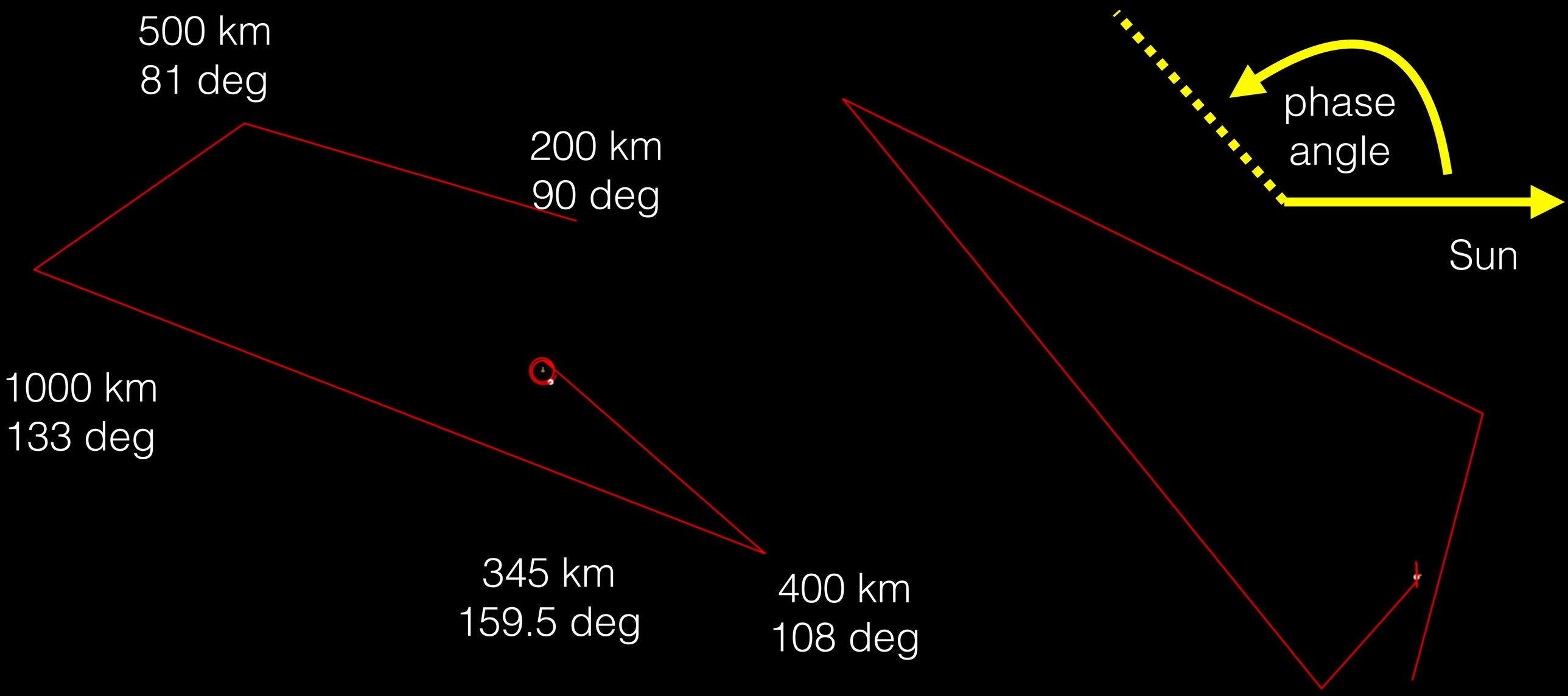

Extended mission!!!
September 2016
rosetta
esa

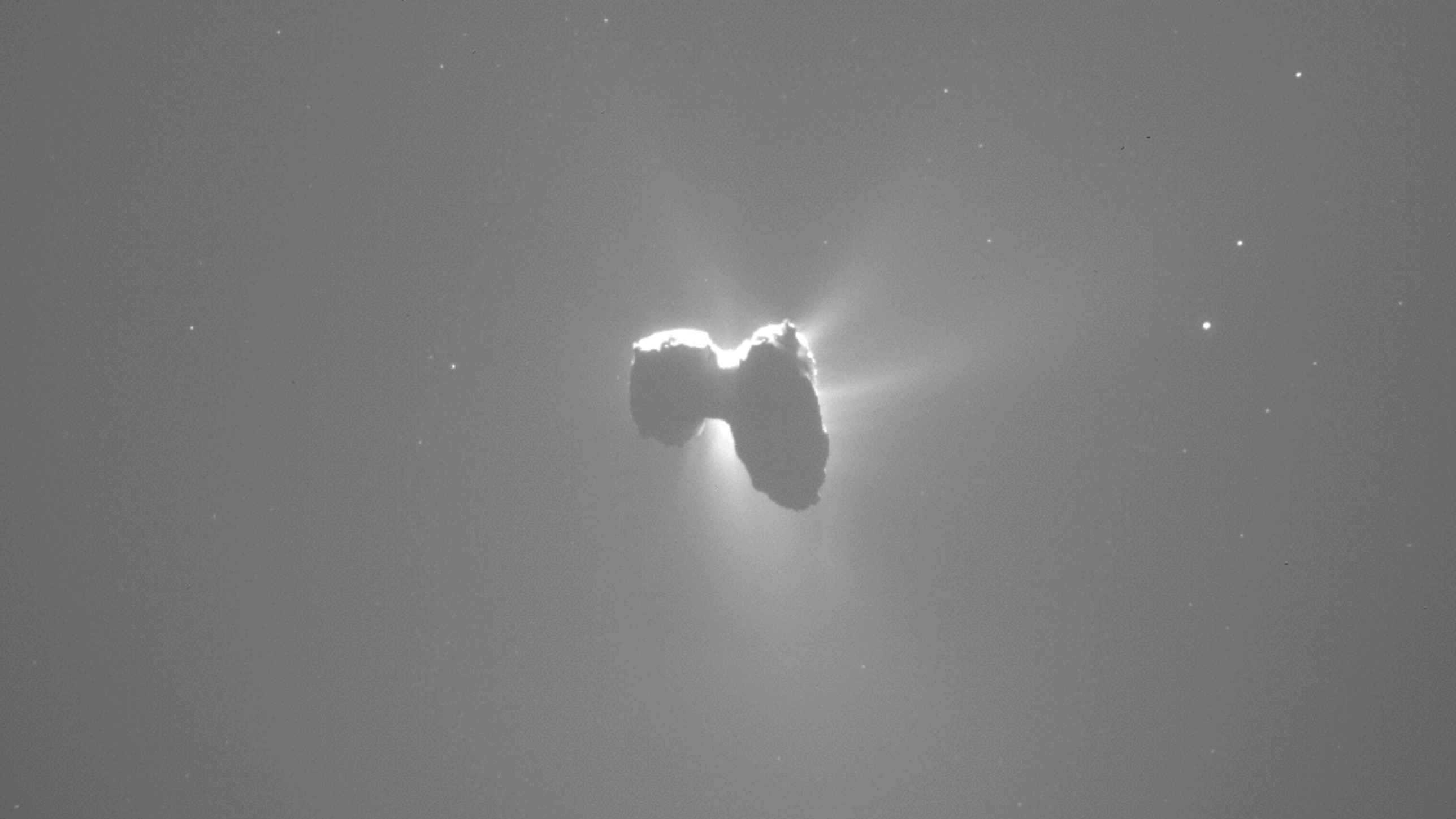

esa
Distances at date
2016-03-31
Rosetta - Sun
403 320 625 km
Rosetta - Earth
262 998 032 km
Rosetta - comet 67P/C-G
Living with a comet
Accumulated distance
7 704 016 390 km
Comet speed
20.05 km/s
See info note for details


esa
Distances at date
2016-09-30
Rosetta - Sun
573 153 251 km
Rosetta - Earth
719 742 176 km
Rosetta - comet 67P/C-G
Living with a comet
Accumulated distance
7 971 290 298 km
Comet speed
14.39 km/s
See info note for details


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

March - April Tail excursion, ~1000 km downtail





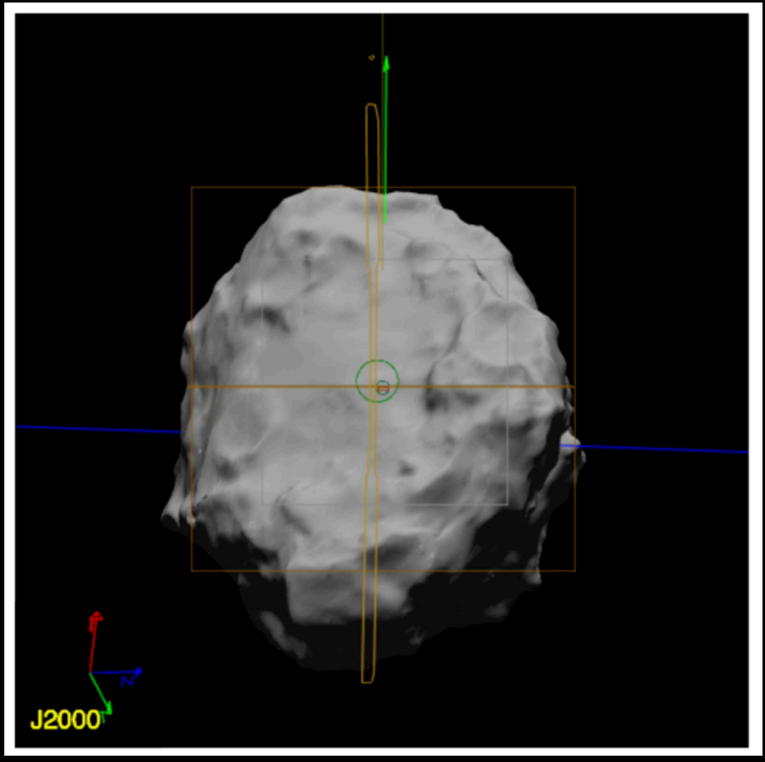
from 200 km

zero phase crossing, ~30 km April

70km

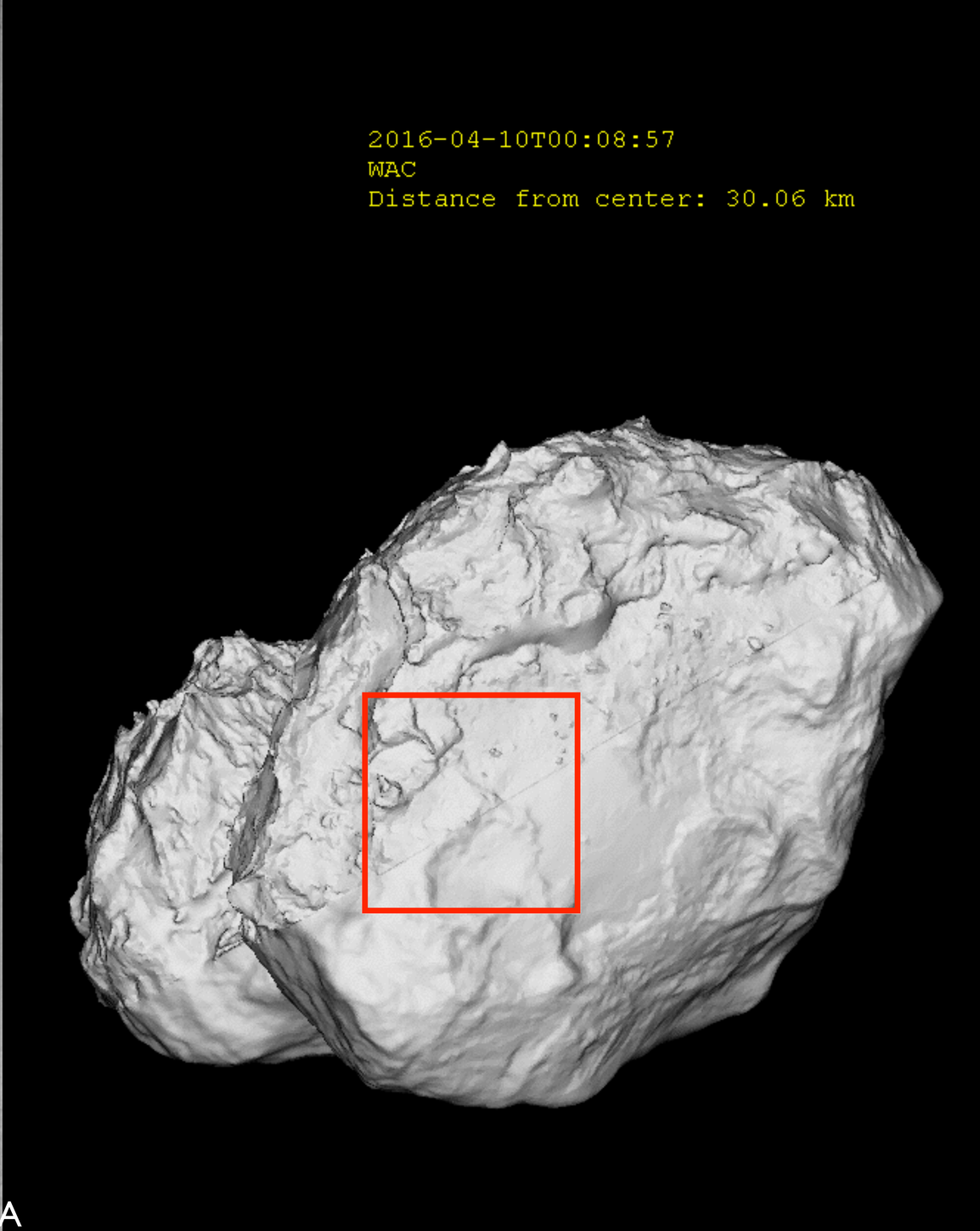
120 km

80 km

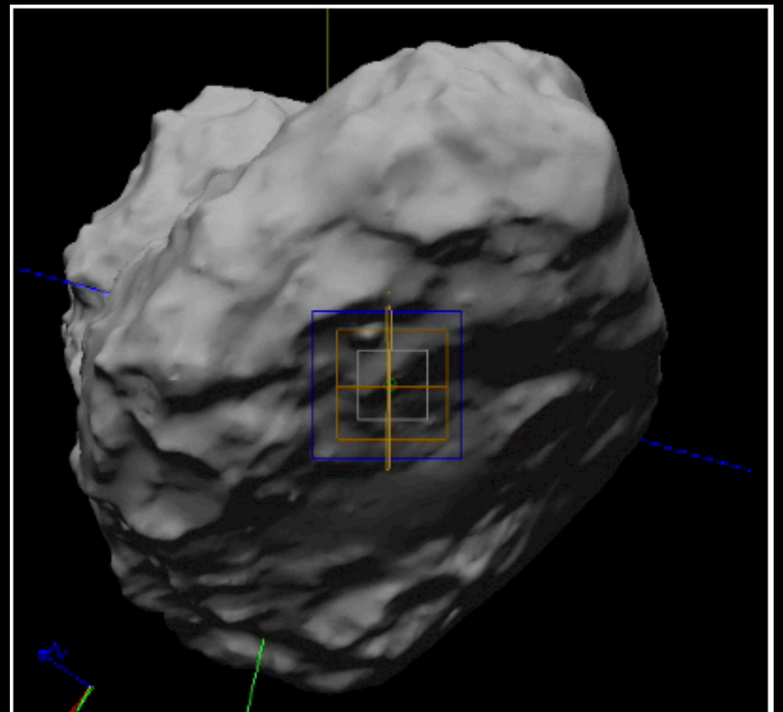


Sun

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



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



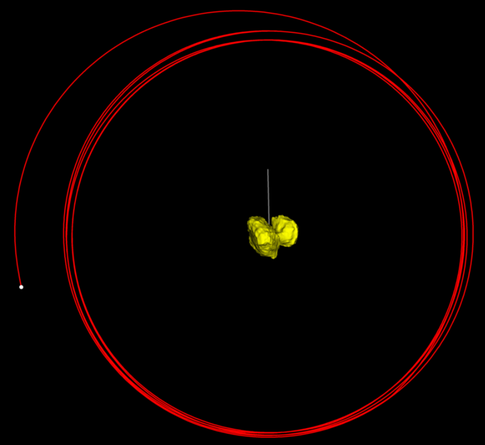
compare and contrast with February 2014

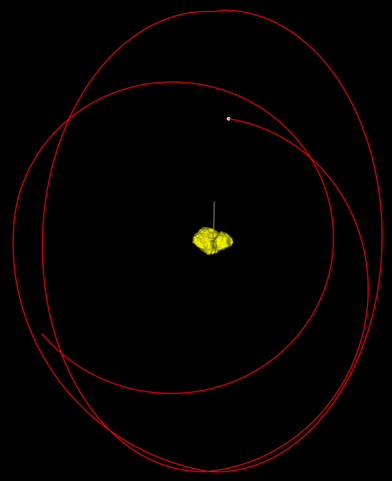
May

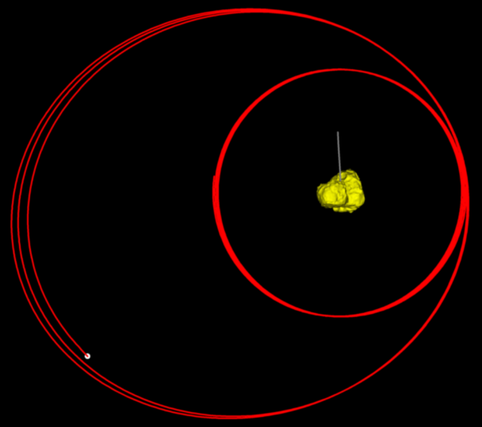
June

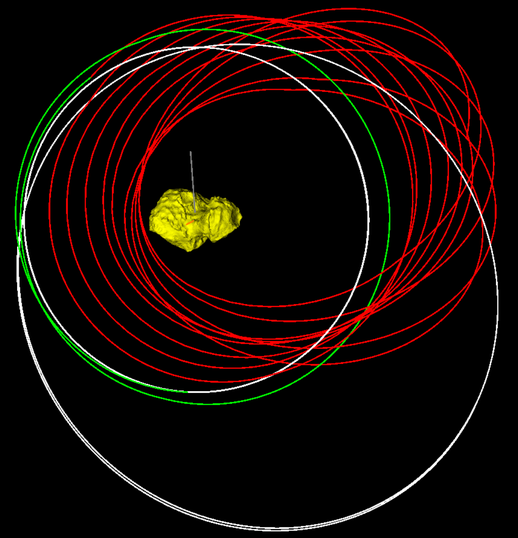
July

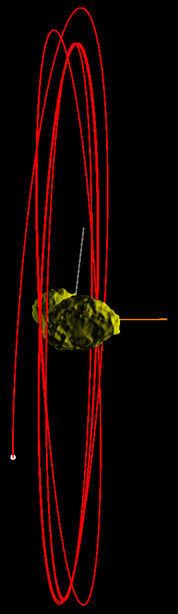
August-Sept

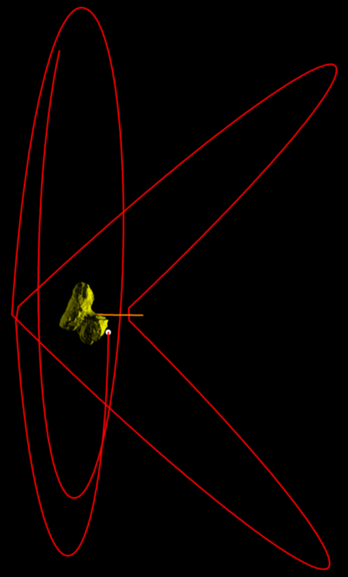


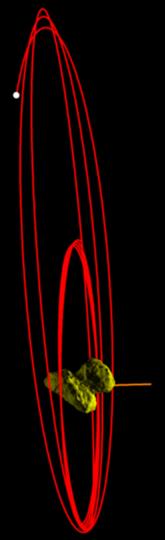


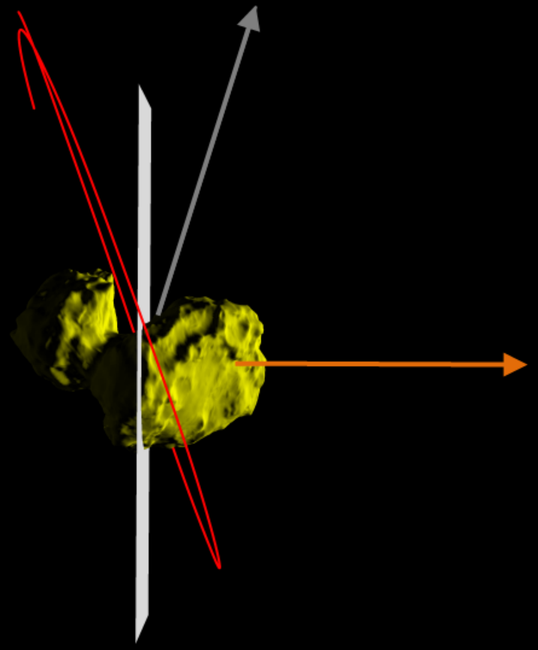






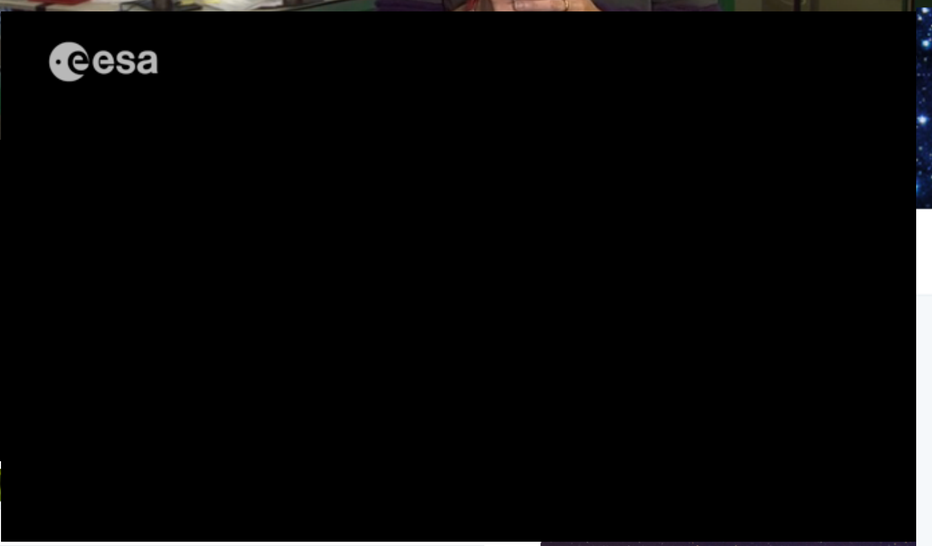






ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

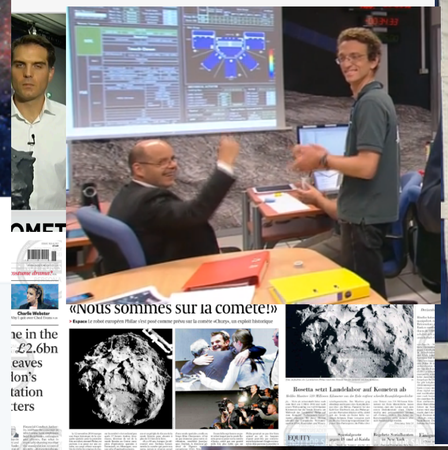
December 31, 2014 - New Year's Eve 2014 Google Doodle

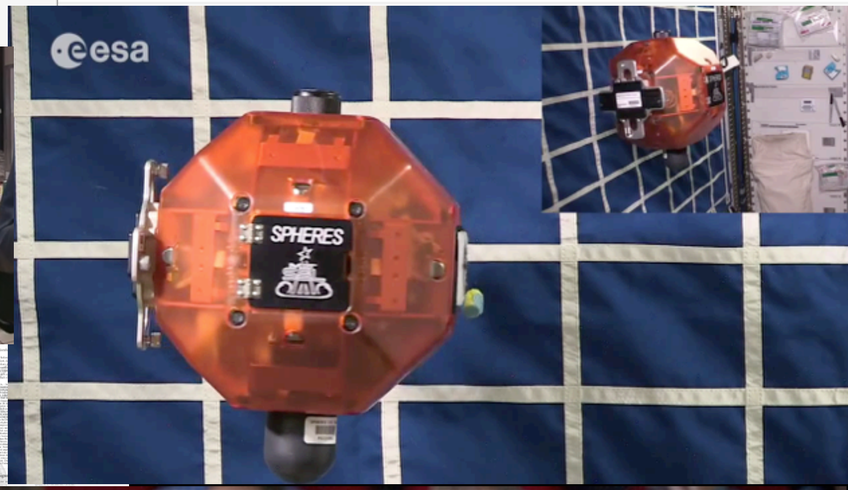


Comet 67P
@IamComet67P

I am Comet #67P. Big Bang SURVIVOR. Oort Cloud REJECT. Unpaid BABYSITTER. Twitter BOSS. Friend of the STARS. Enemy of ASTEROIDS. Managed by @IamTheHuman

WARNING: Highly Humorous



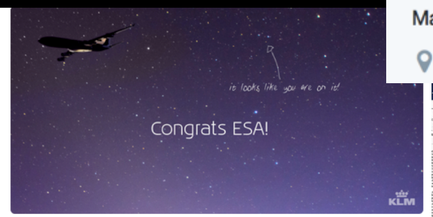


David Cameron @David_Cameron · Nov 12
#CometLanding marks a new chapter in the exploration of our Solar System. Congratulations to @ESA_Rosetta & UK figures who played a key role
338 387

Matteo Renzi @matteorenzi · Nov 12
È un giorno storico,dobbiamo essere orgogliosi che la tecnologia italiana abbia contribuito a portare @ESA_Rosetta fin laggiù #CometLanding
691 856

Élysée @Elysee · Nov 12
Le président @fhollande : "Pour ceux qui se posent la question, à quoi sert l'Europe, #Rosetta a donné la réponse"

Intel @intel · Nov 13
From our engineers to yours, job well done! Congratulations, @esa! #cometlanding



294 256

Royal Mail News @royalmailnews · Nov 14
Who's excited about our #CometLanding postmark? We are! Celebrating the amazing @esa @ESA_Rosetta @Philae2014 mission

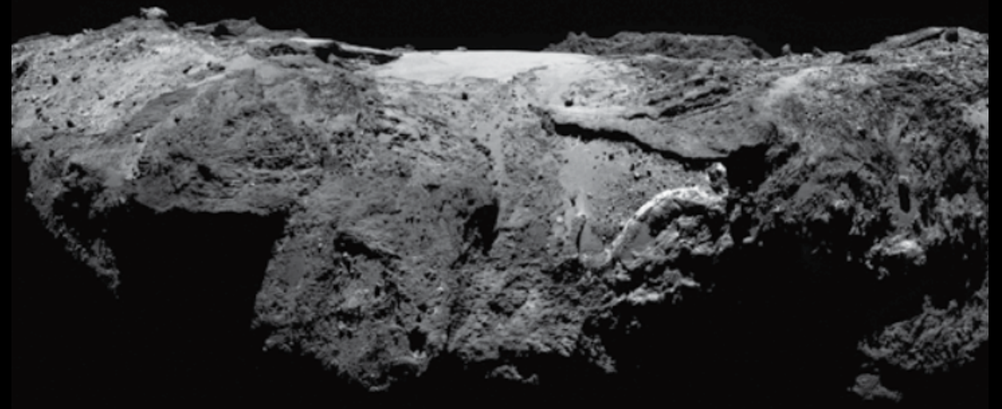
Celebrating the first ever

Prompted Awareness	Germany	France	Italy	UK
Rosetta	75%	72%	70%	69%

photos courtesy of C. Carreau

CAP journal
Issue 19 | March 2016
Communicating Astronomy with the Public

Rosetta
special



Exclusive behind-the-scenes look at the outreach surrounding ESA's iconic *Rosetta* mission

Want to keep receiving *CAPjournal* by post?
You must confirm your subscription using the URL on the envelope!
Details of how to confirm on page 28
www.capjournal.org

IAU

http://www.ekaterina-smirnova.com

Courtesy of Brian May

ESA/ROSETTA/OSIRIS

PPARC

NAPALM DEATH
SATANIST

Courtesy of David Weedon,
https://www.youtube.com/watch?v=2d6WaobBrb0
"This one's for all the scientists in the audience"

PS4.1 Comets, Asteroids and dust
PS4.2 Rosetta

https://planetgate.mps.mpg.de:8114/Image_of_the_Day/public/IofD_archive.html

for a short time only

@ESA_Rosetta

http://blogs.esa.int/rosetta/

http://www.rosetta-campaign.net