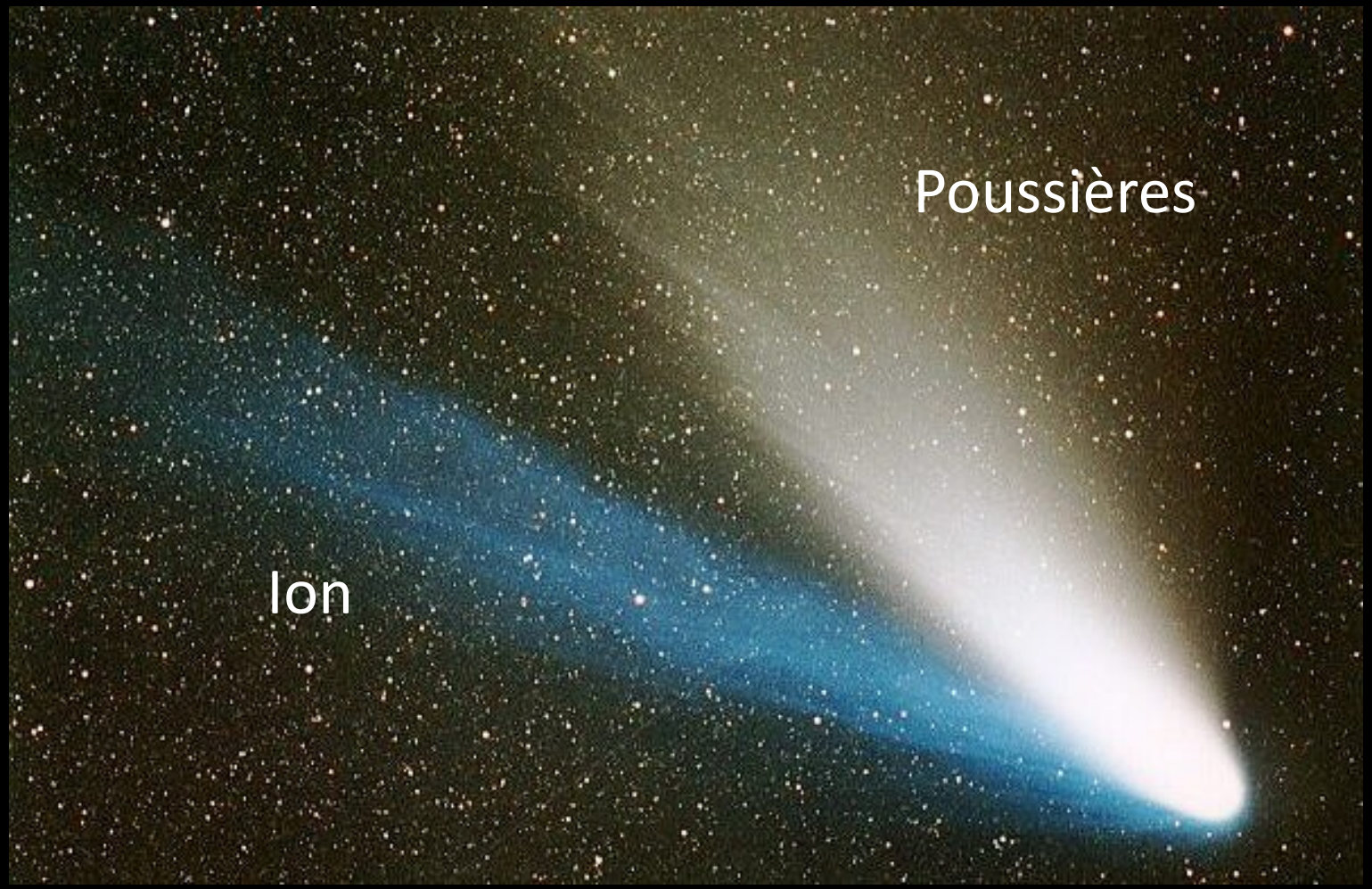
ROSETTA, QUE NOUS AS-TU APPRIS?

Origine de l'eau? Vie ?
Formation du système solaire?

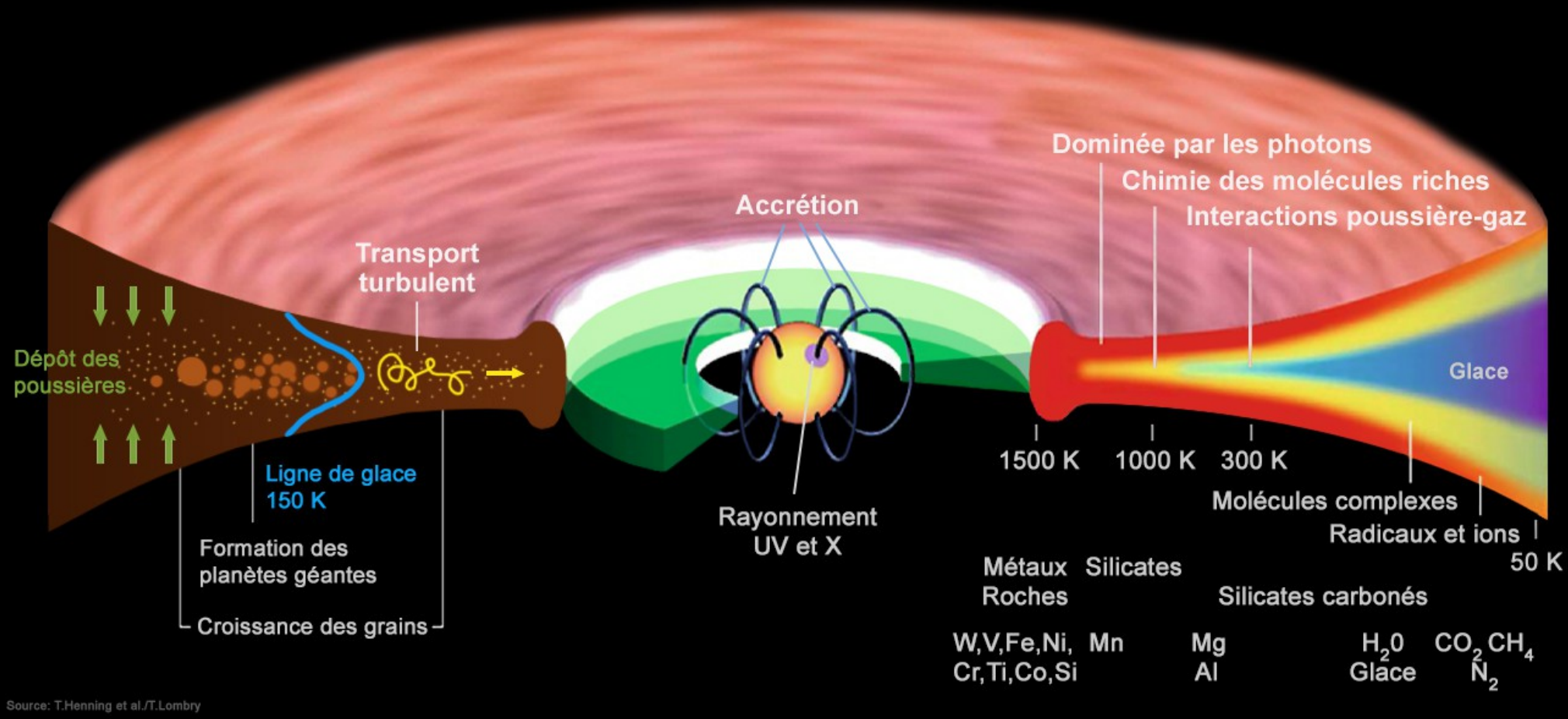
Arnaud BETH
Imperial College London, UK
abeth@ic.ac.uk

Une comète: c’est quoi?



Boule de neige sale acoompagnée de deux queues:
une d’ions, une de poussière

Le disque protoplanétaire



http://www.astrosurf.com/luxorion/sysol-generalites5.htm

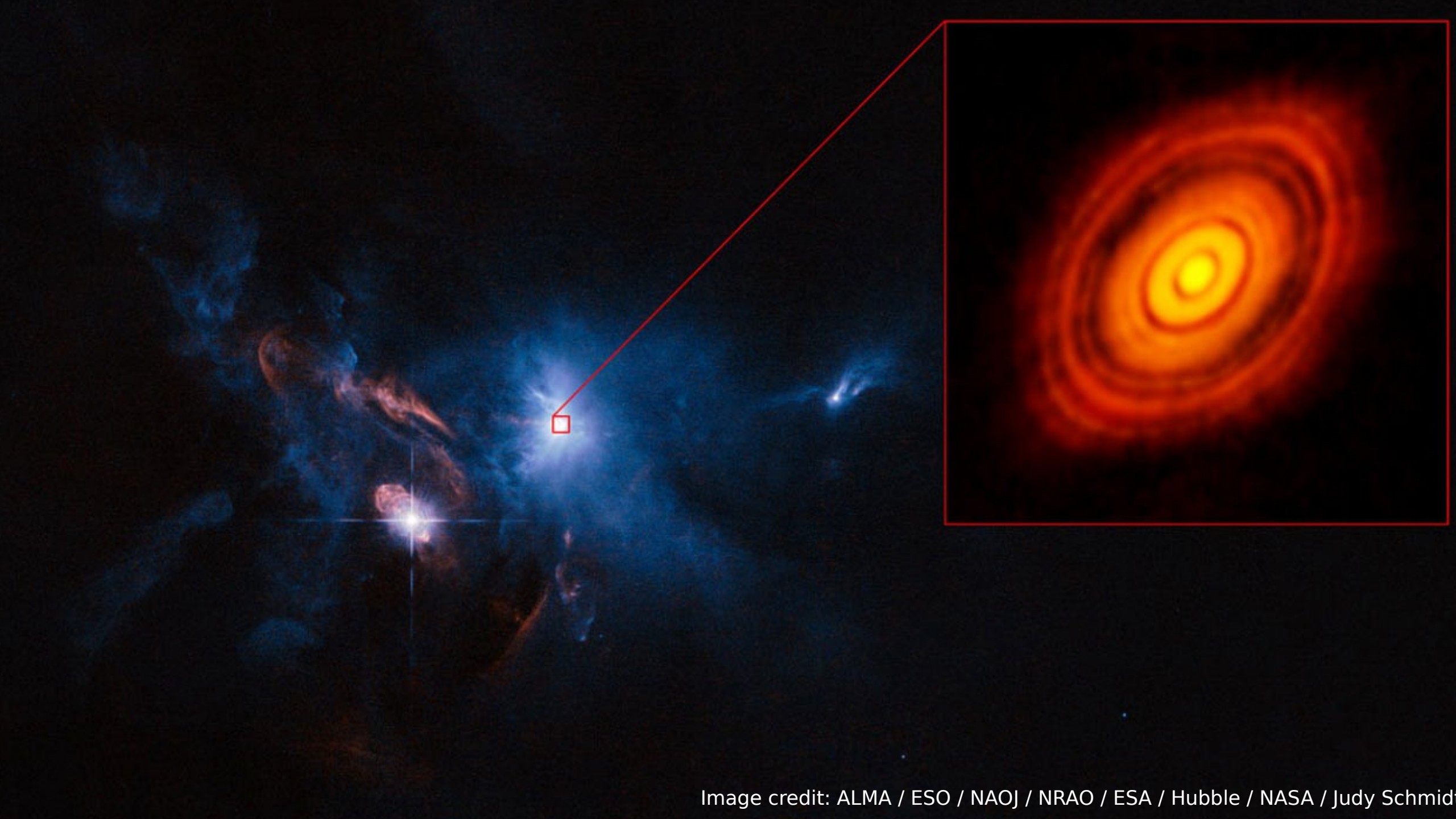
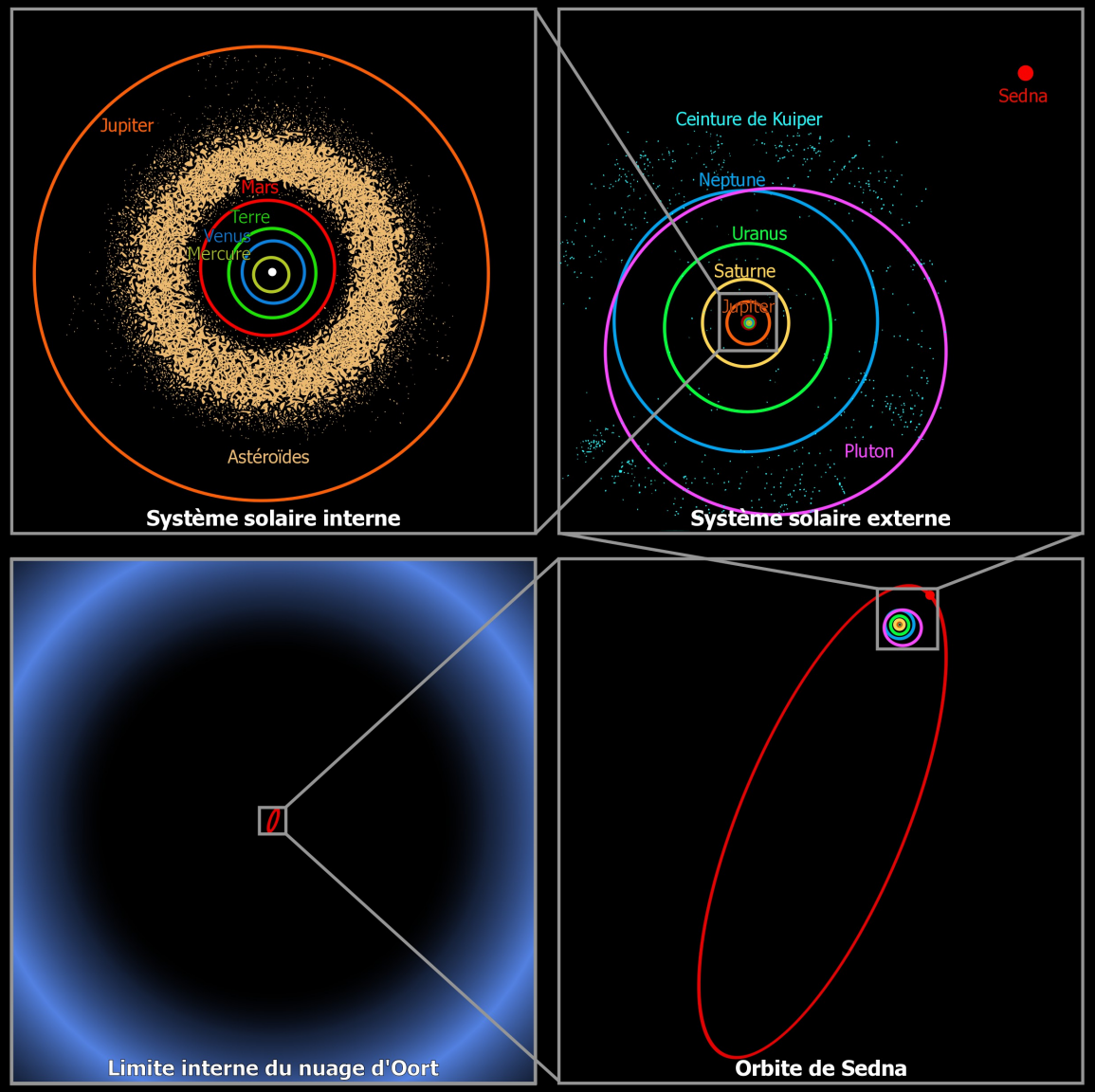
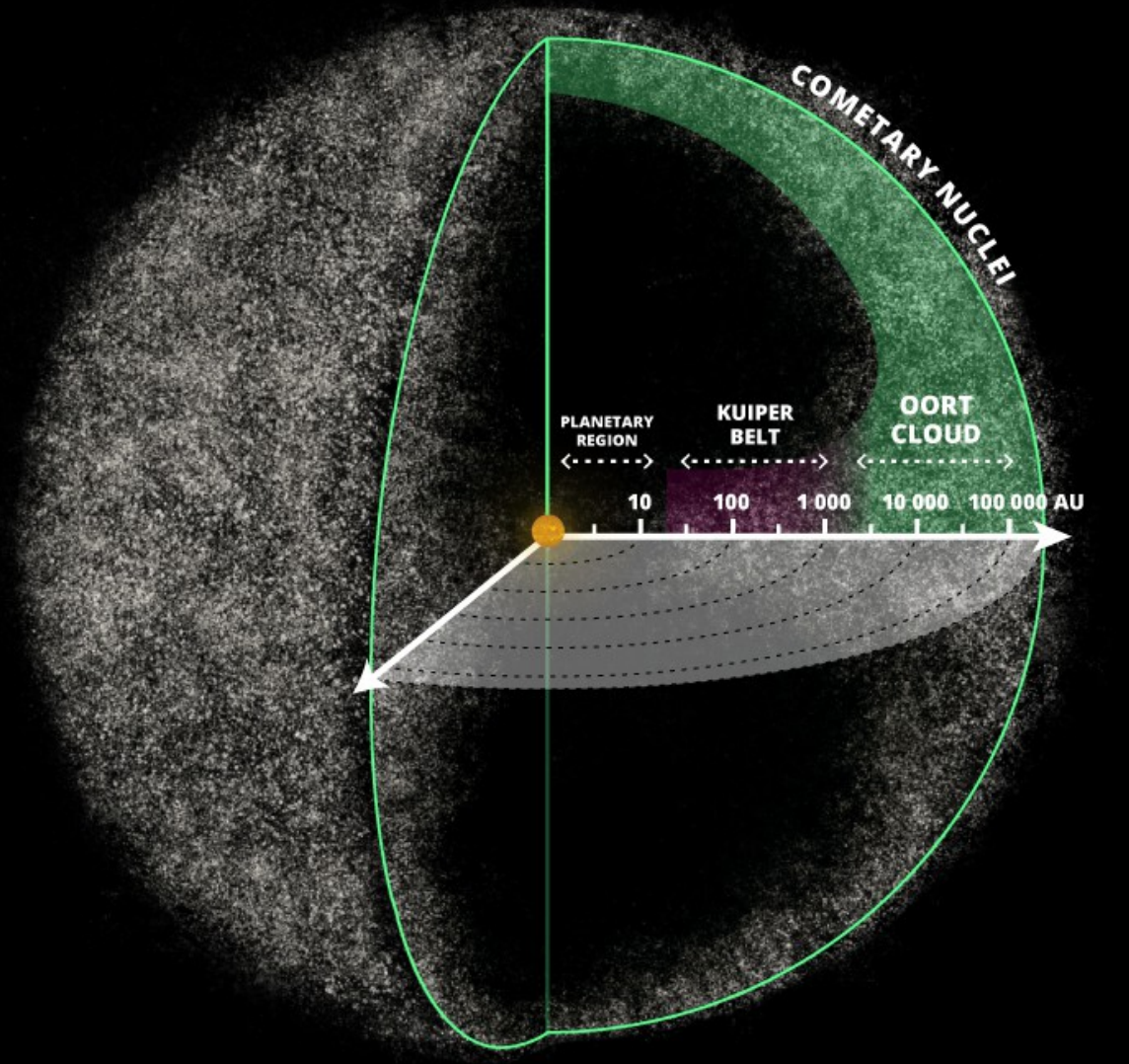


Image credit: ALMA / ESO / NAOJ / NRAO / ESA / Hubble / NASA / Judy Schmidt

SKY & TELESCOPE

Nuage d’Oort:
un immense réservoir de comètes





Space Facts / Laurine Moreau

Des morphologies très différentes

~6000 identifiés

~350 avec une période <200 ans

exemple de la Comet C/2006 P1 (McNaught) à l’oeil nu

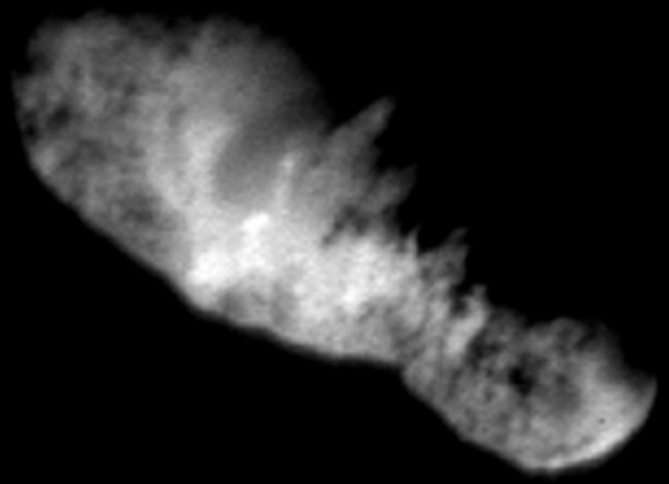
Des morphologies très différentes

1P/Halley

”Halley Armada” en 1986

5 sondes:
Giotto
Vega 1
Vega 2
Suisei
Sakigake

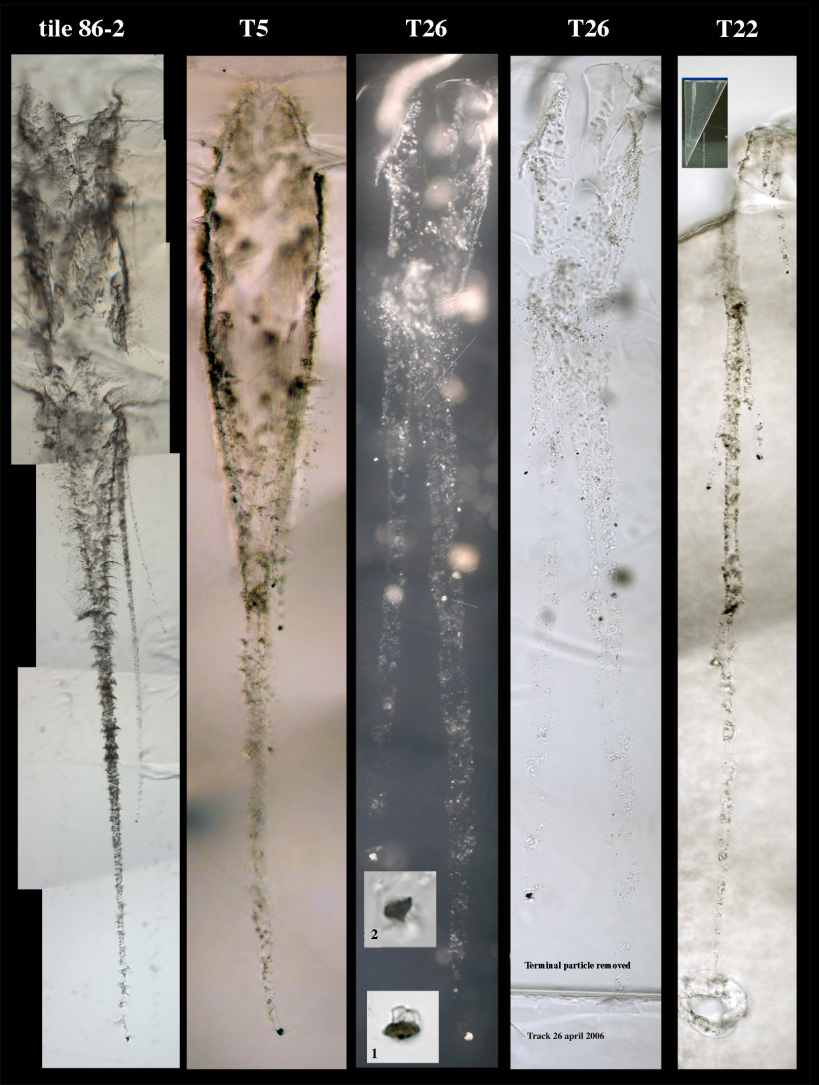
Des morphologies très différentes



19P/Borrelly

Survolé par Deep Space 1 en 2001

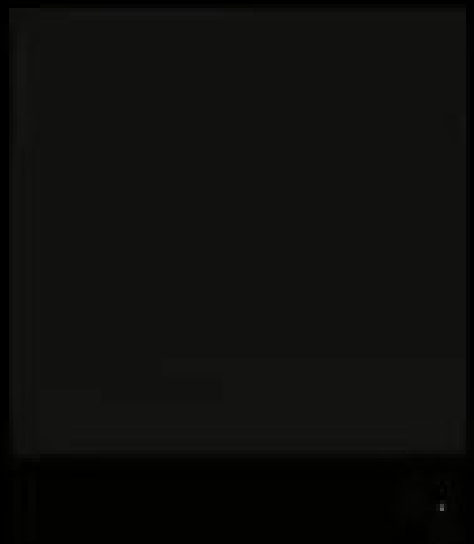
Des morphologies très différentes



81P/Wild

Survolée par Stardust en 2004

Des morphologies très différentes



9P/Tempel 1

Survolée par Deep Impact en 2005

Des morphologies très différentes

103P/Hartley 2

Survolée par EPOXI en 2010

Des morphologies très différentes

Petit historique sur les comètes

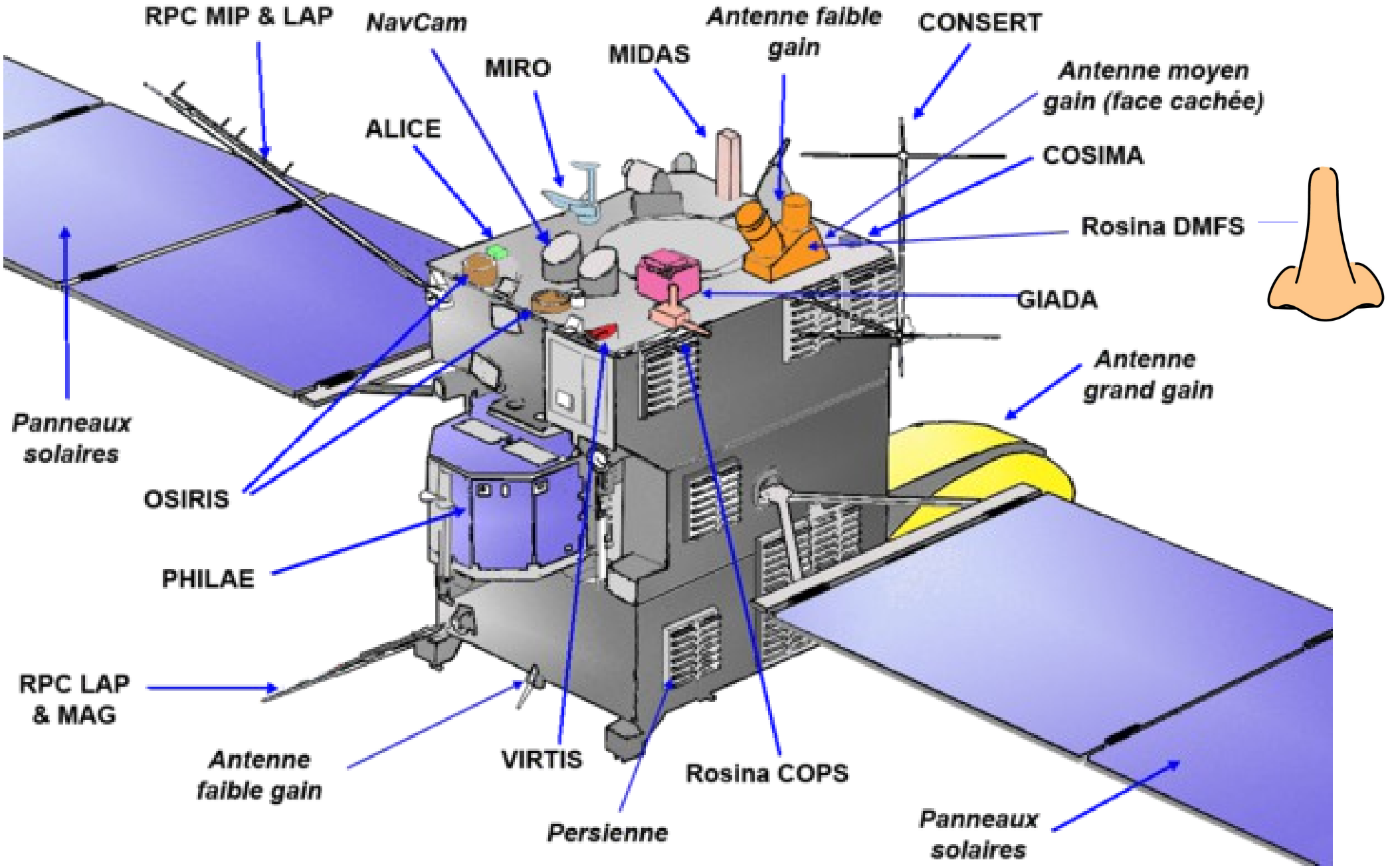
Première comète à être caractériser en tant que telle: 1P/Halley

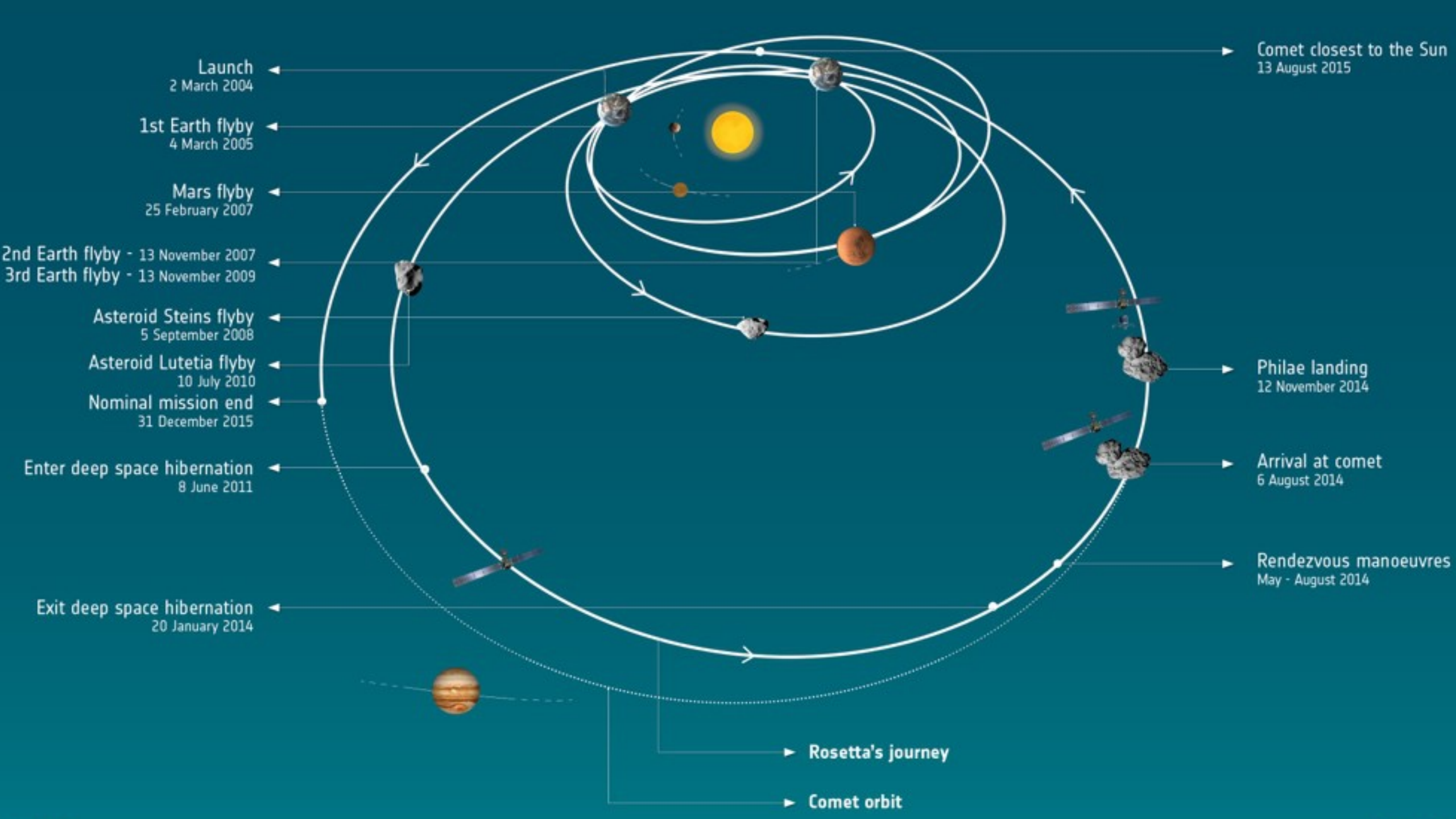
Son retour a été prédit par Halley 20 ans après sa mort

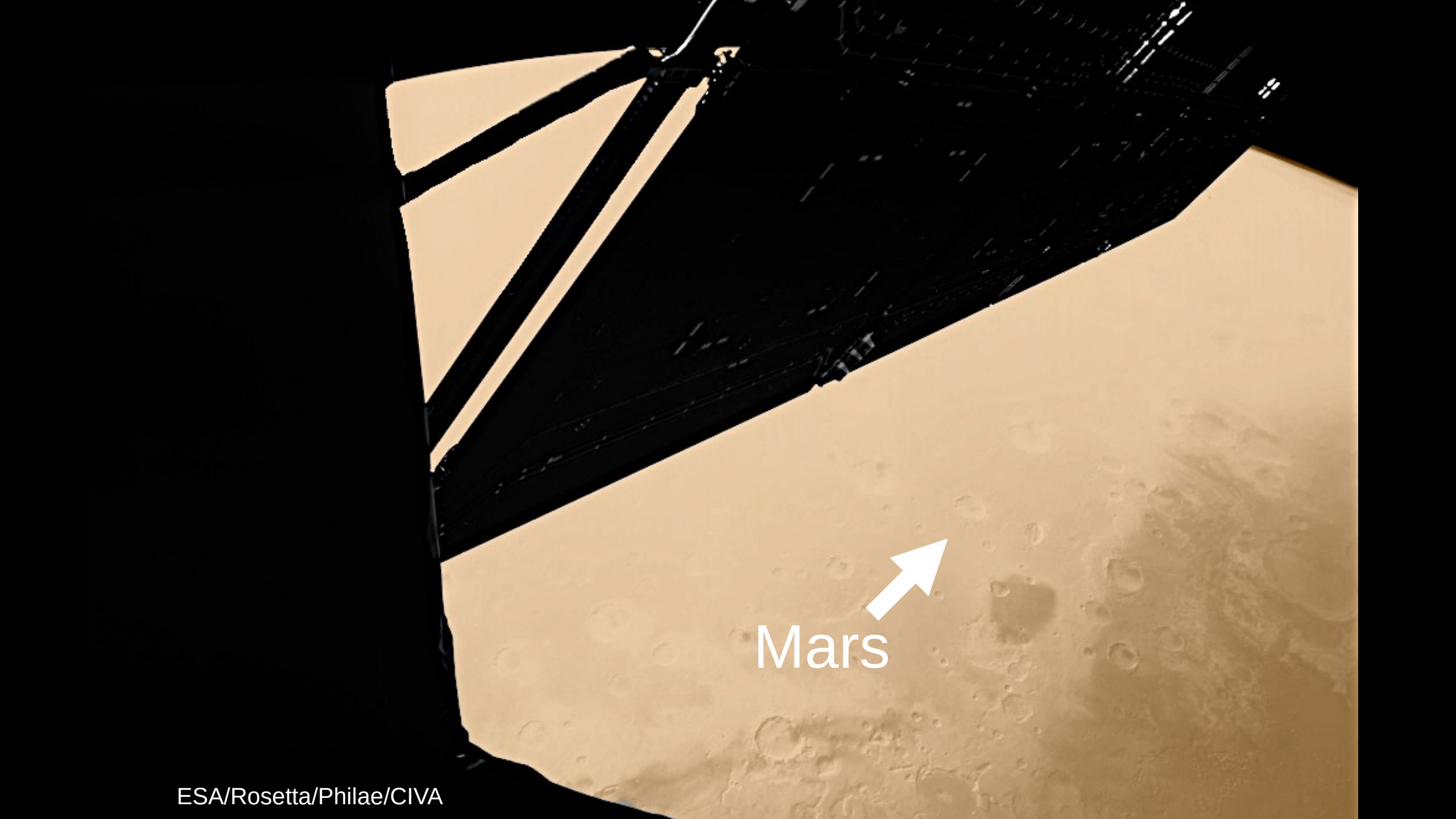
Première mention (611 av JC)

Représentée sur la tapisserie de Bayeux (1066 ap JC)


rosetta
esa

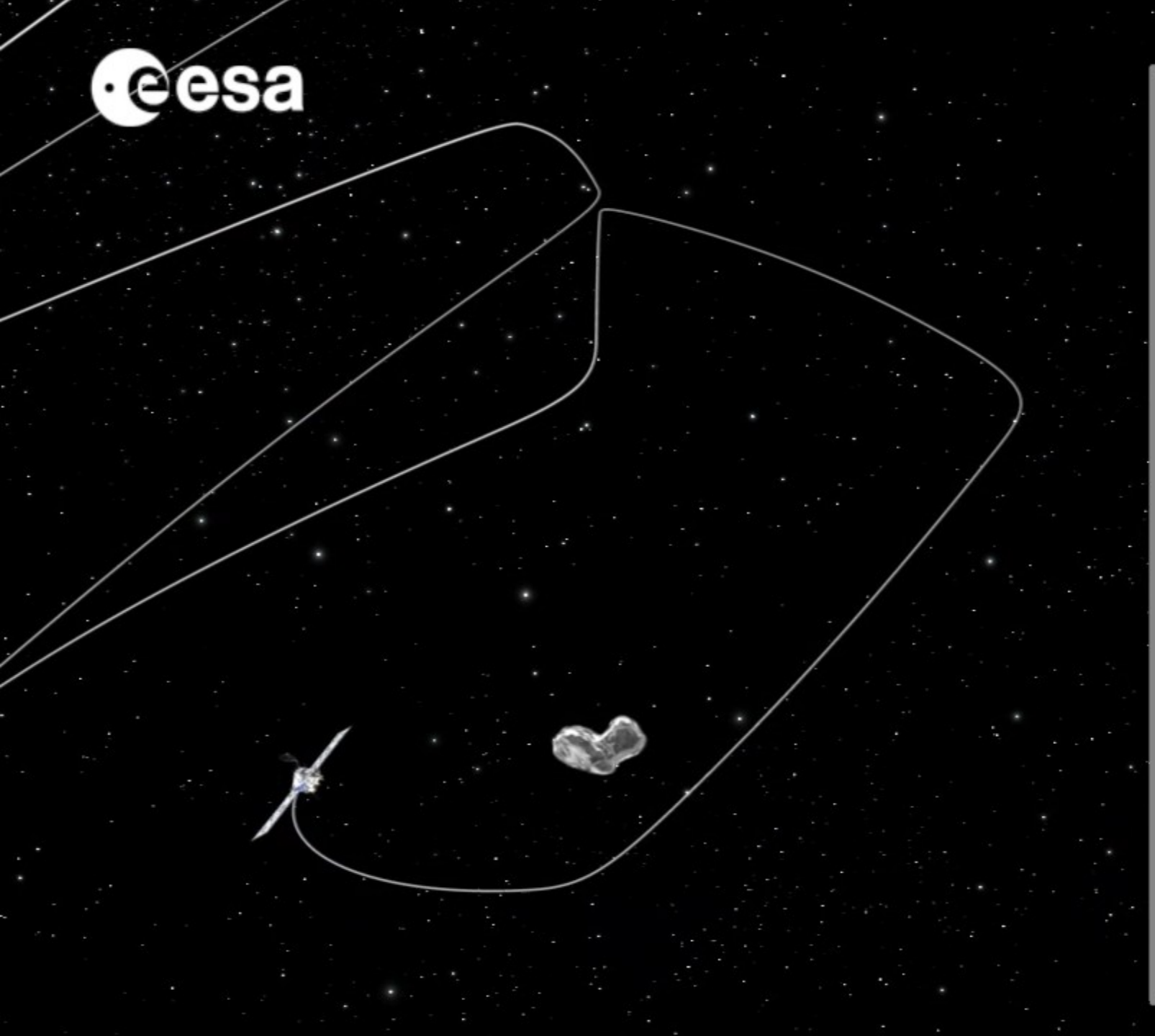

RPC MIP & LAP
NavCam
MIRO
MIDAS
Antenne faible gain
CONSERT
Antenne moyen gain (face cachée)
ALICE
COSIMA
Rosina DMFS
GIADA
Antenne grand gain
Panneaux solaires
OSIRIS
PHILAE
RPC LAP & MAG
Antenne faible gain
VIRTIS
Rosina COPS
Persienne
Panneaux solaires


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

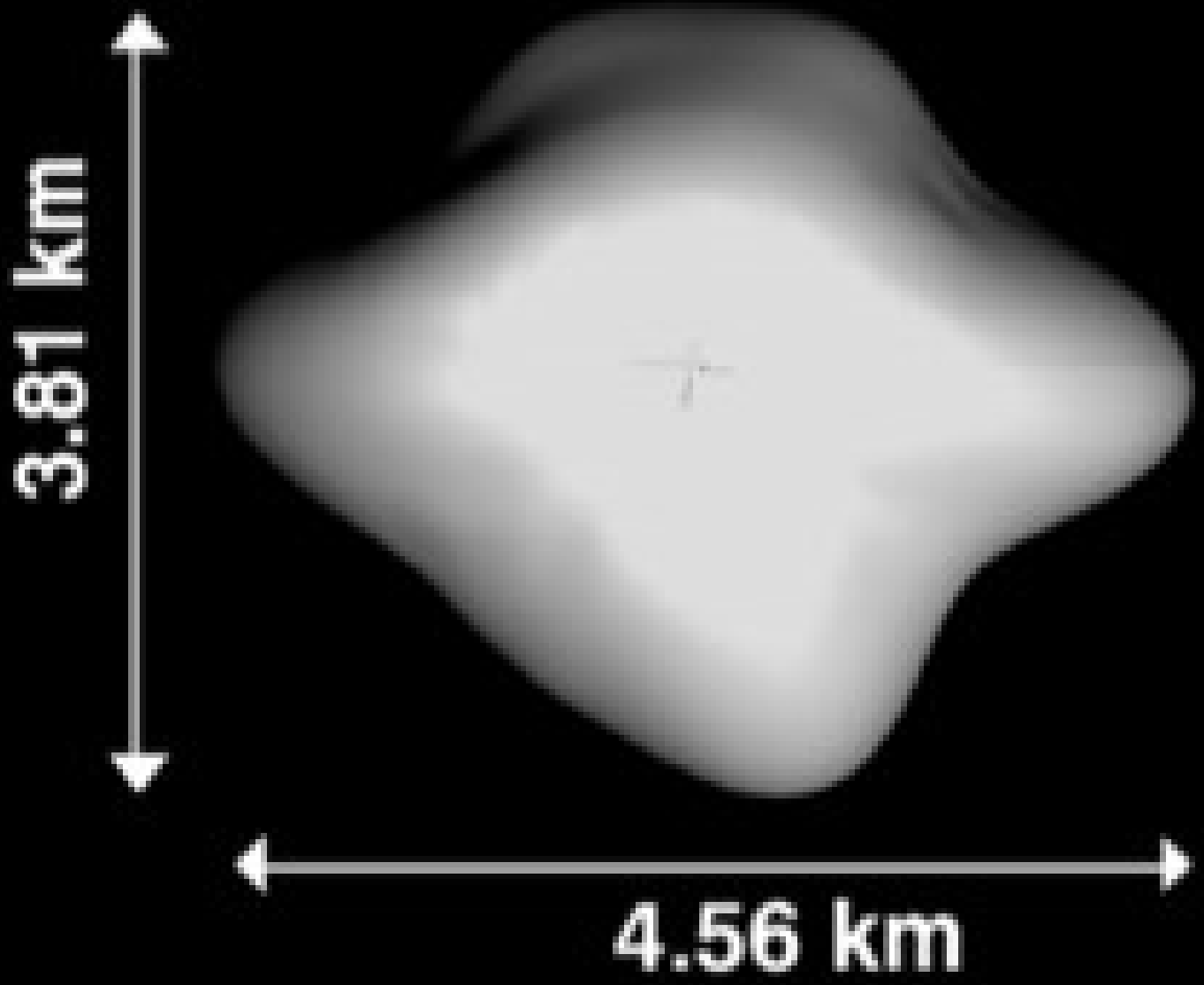


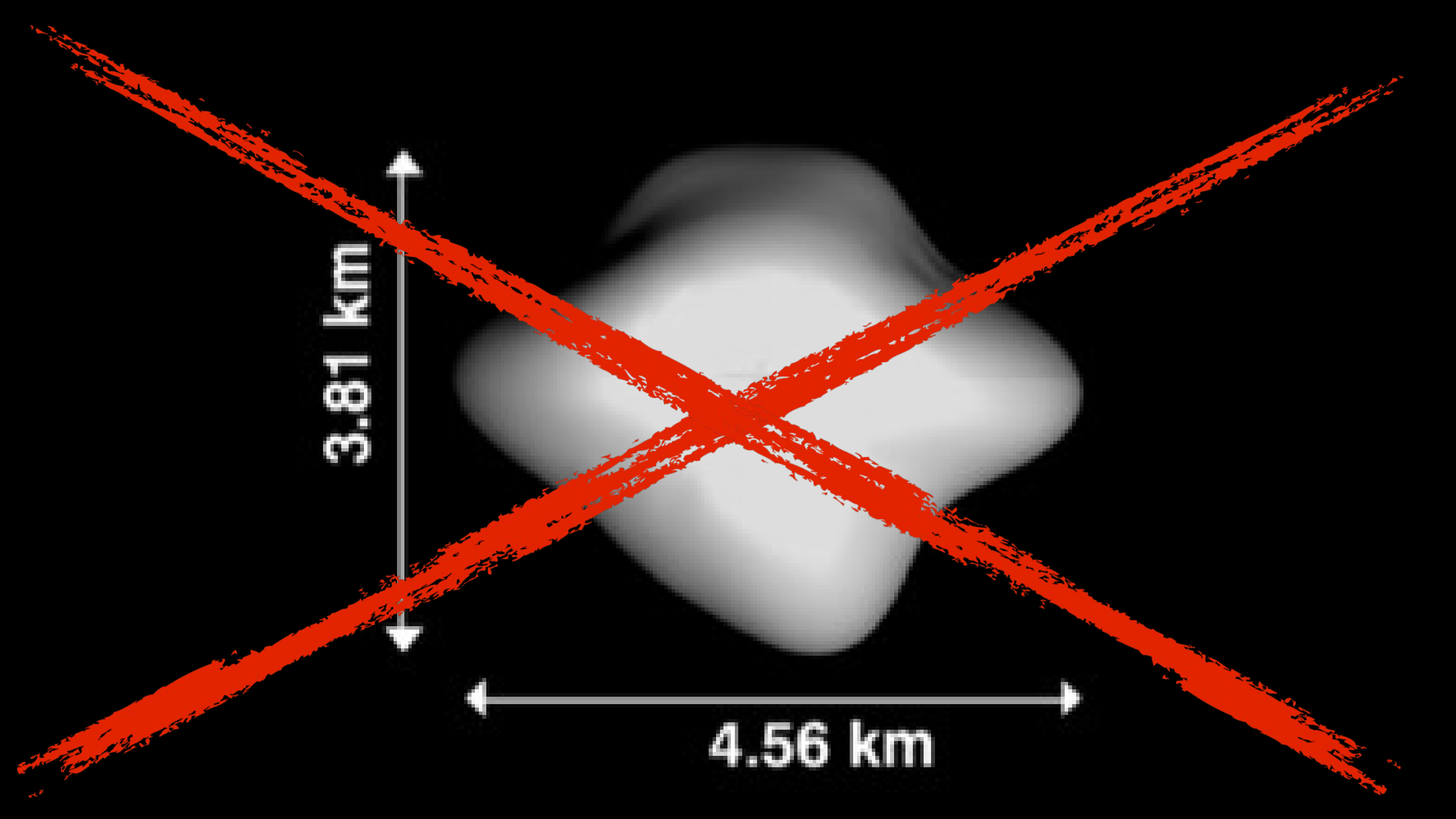
ESA/Rosetta/Philae/CIVA

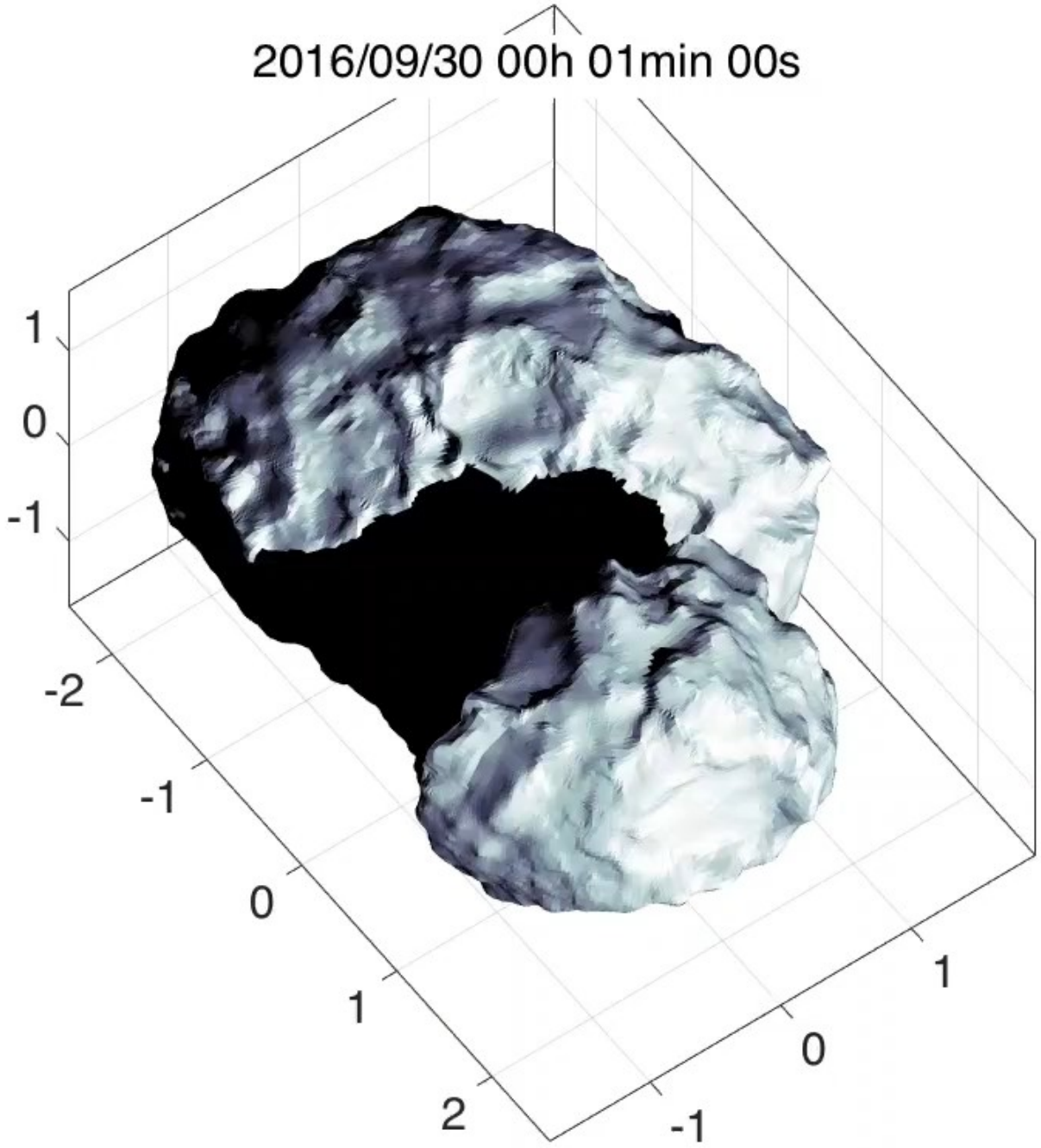

ESA Rosetta Mission
@ESA_Rosetta
“Hello, world!"
RETWEETS
4,939
LIKES
1,824
10:18 a.m. - 20 Jan 2014

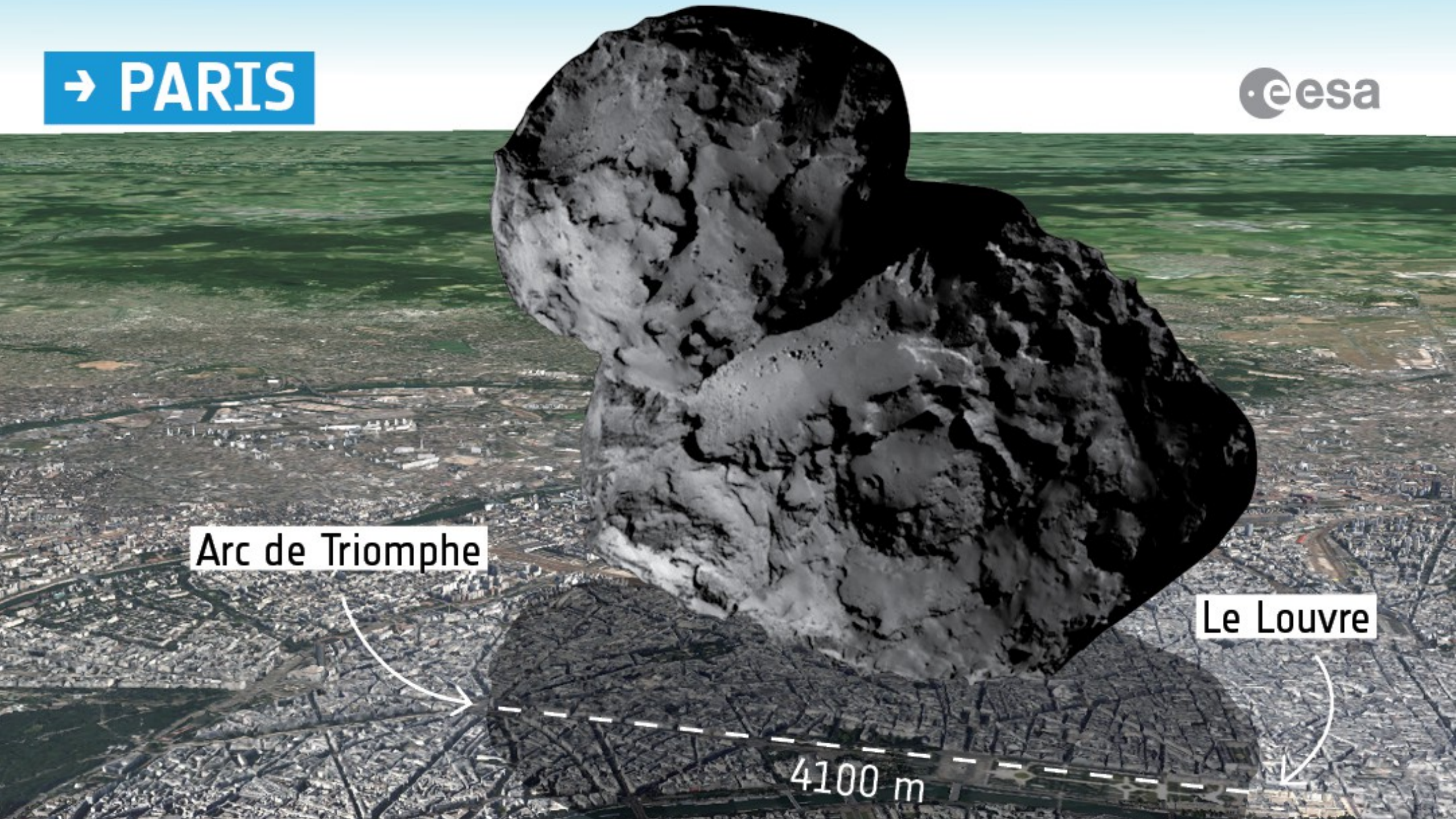


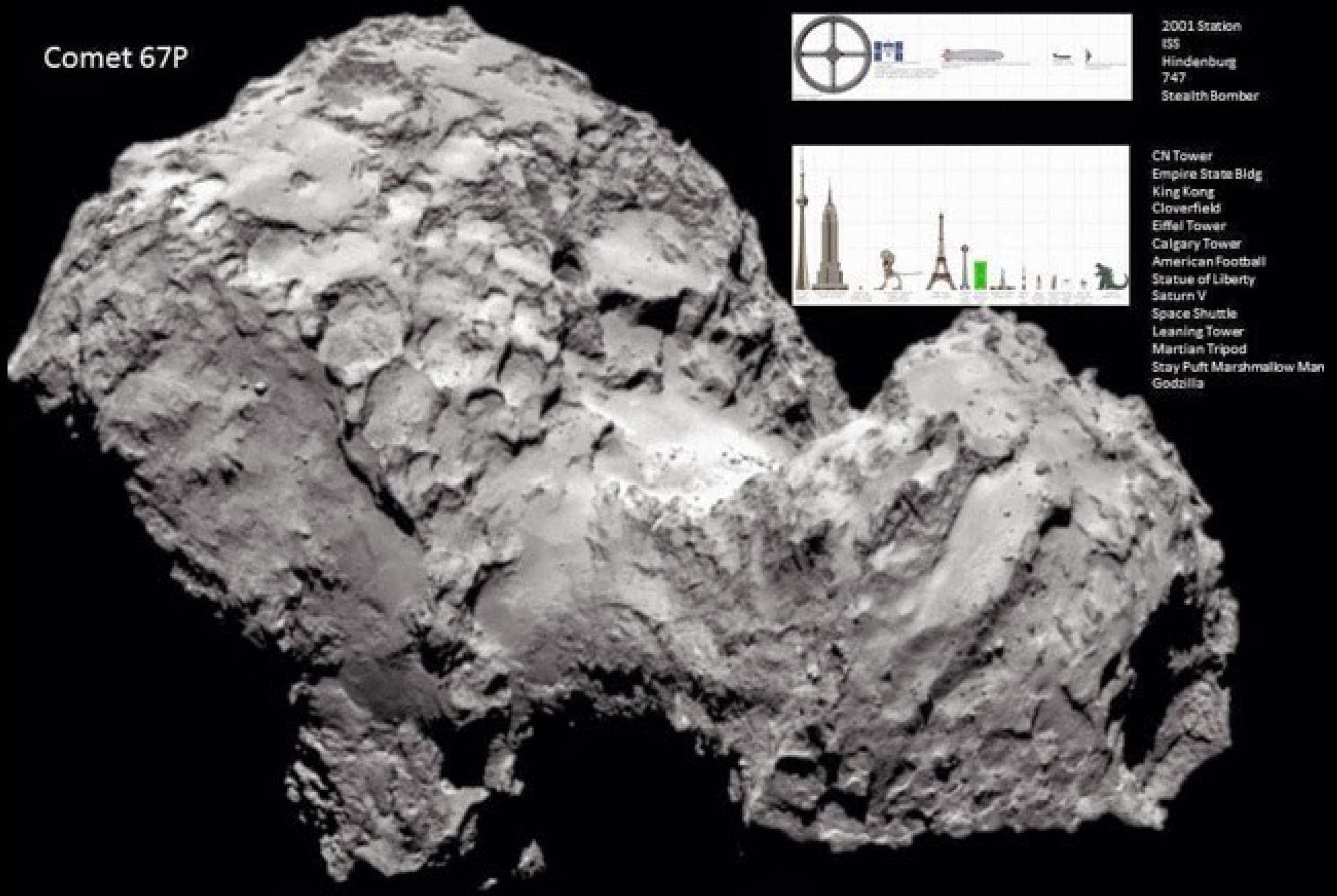
6 Aug – arrive at 100 km
10 Aug – second leg at 100 km
13 Aug – third leg at 100 km
17 Aug – start transfer
20 Aug – 80 km
24 Aug – first leg at 50 km
27 Aug – second leg at 50 km
31 Aug – third leg at 50 km
3 Sep – transfer to global mapping phase
10 Sep – global mapping at 30 km

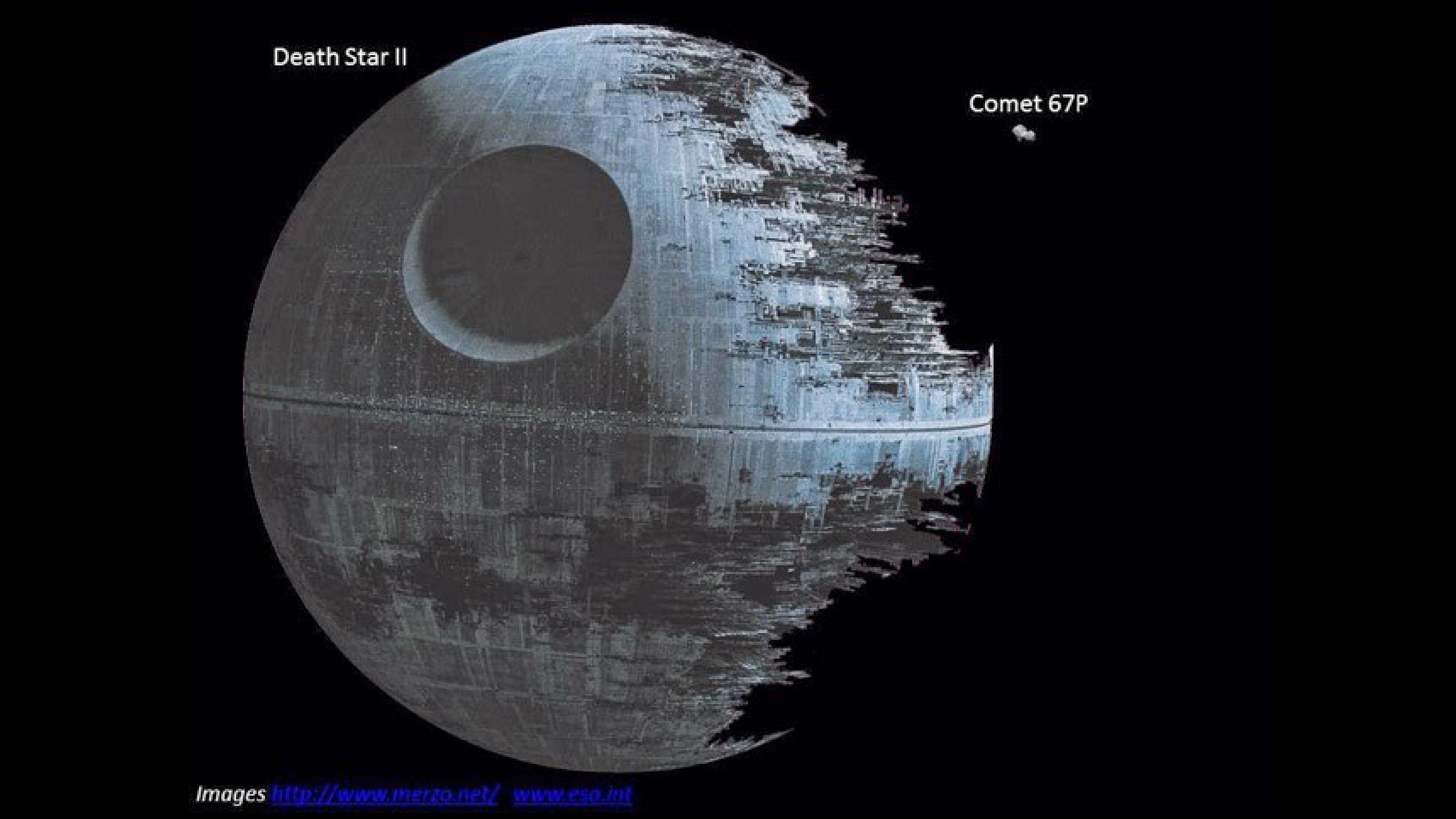

3.81 km
4.56 km


3.81 km
4.56 km

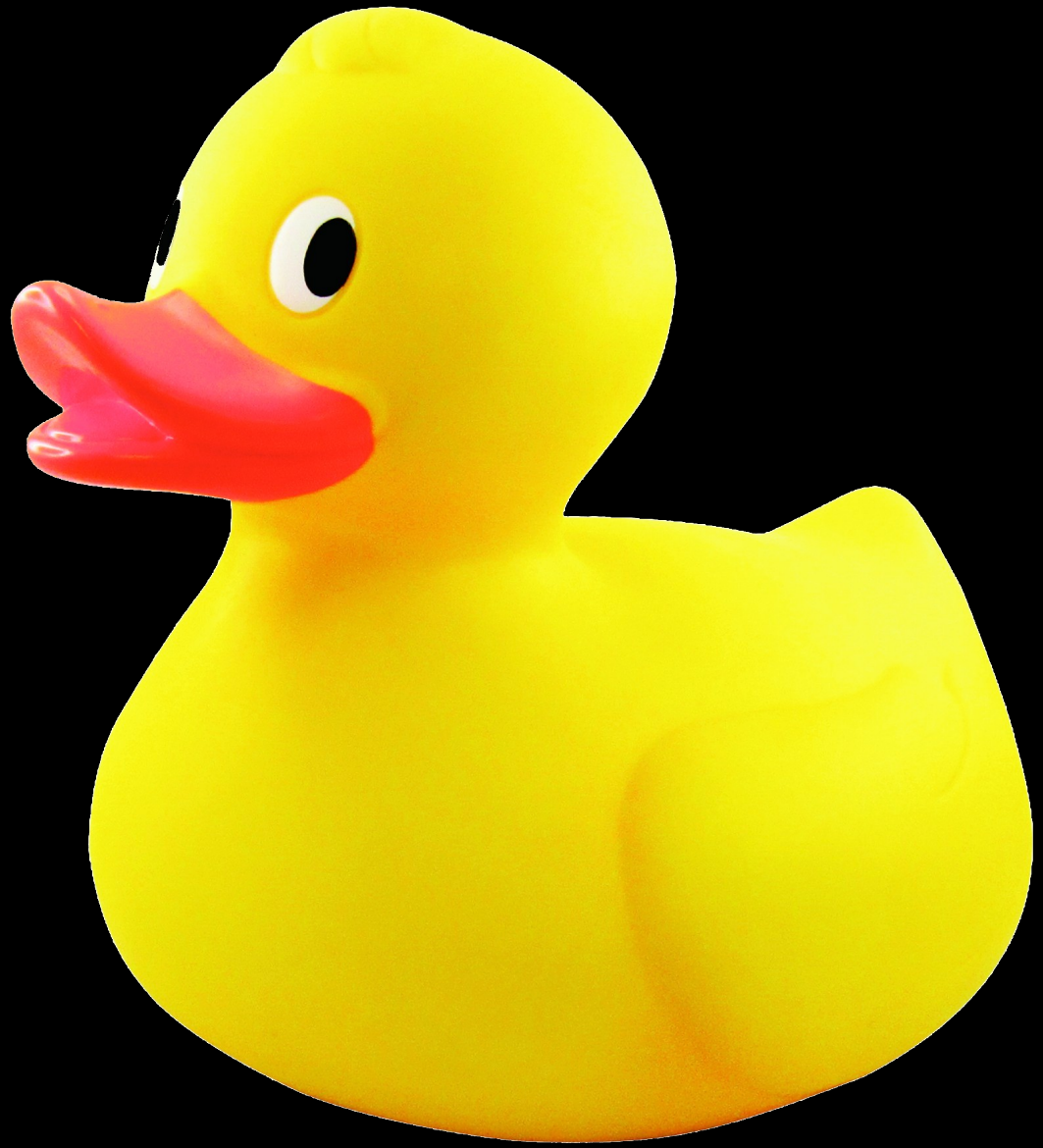

2016/09/30 00h 01min 00s
1
0
-1
-2
-1
0
1
2
-1
0
1


→ PARIS
esa
Arc de Triomphe
Le Louvre
4100 m

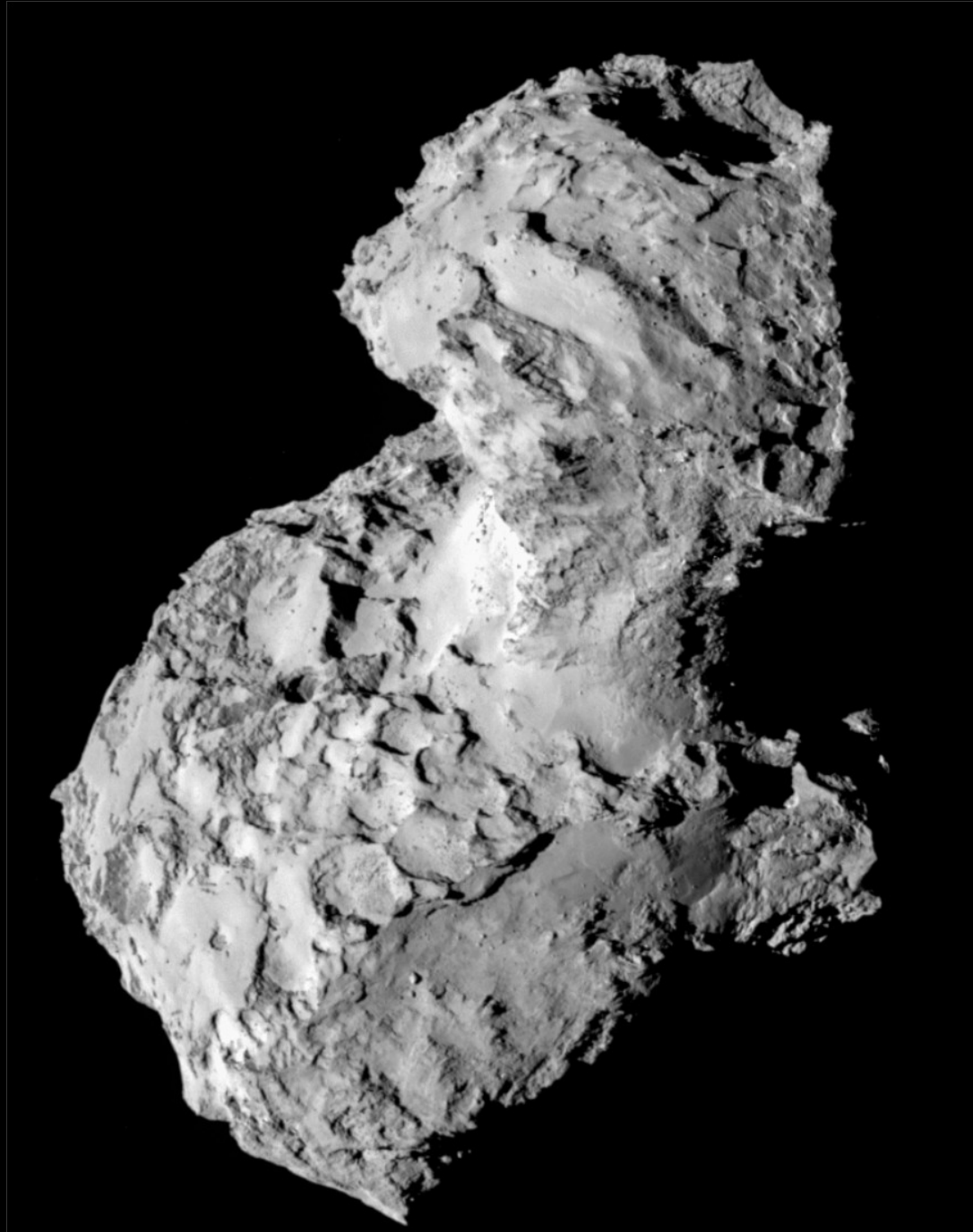

Comet 67P
2001 Station
ISS
Hindenburg
747
Stealth Bomber
CN Tower
Empire State Bldg
King Kong
Cloverfield
Eiffel Tower
Calgary Tower
American Football
Statue of Liberty
Saturn V
Space Shuttle
Leaning Tower
Martian Tripod
Stay Puft Marshmallow Man
Godzilla
Images http://www.merzo.net/ www.esa.int
500 m

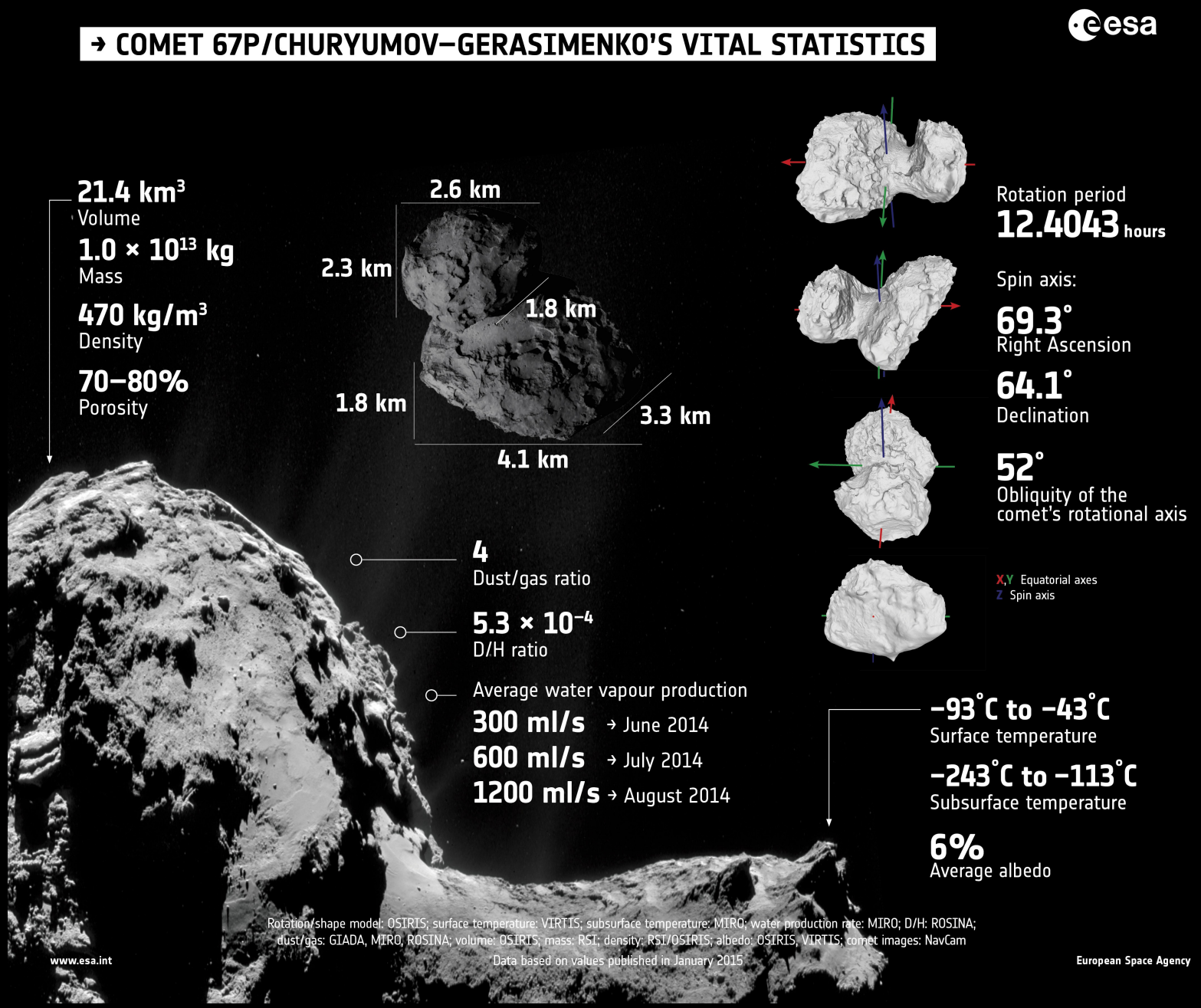


Images http://www.merzo.net/ www.esa.int



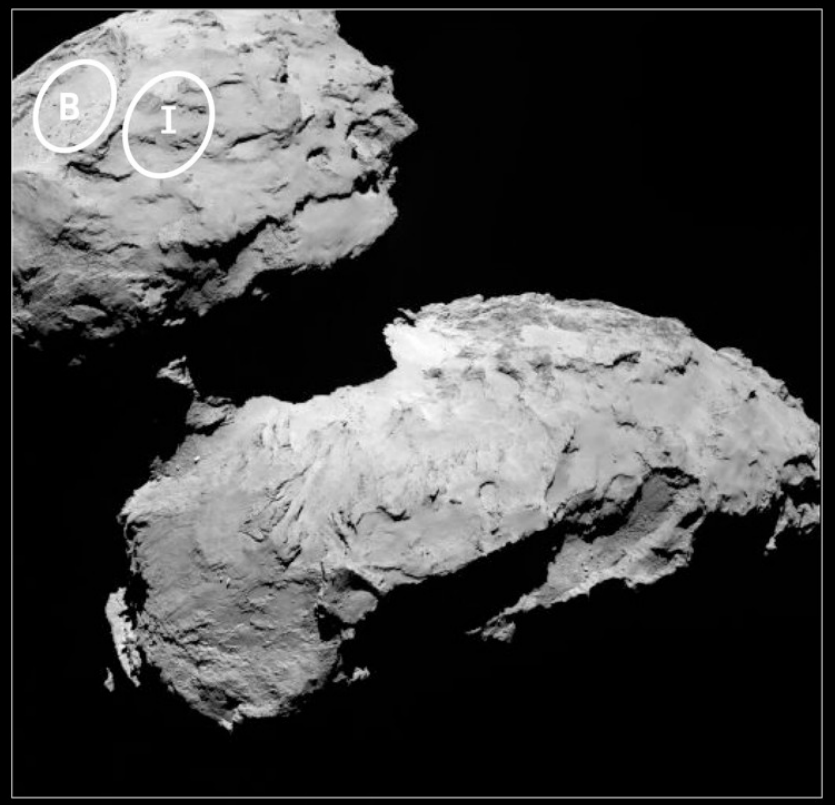
?

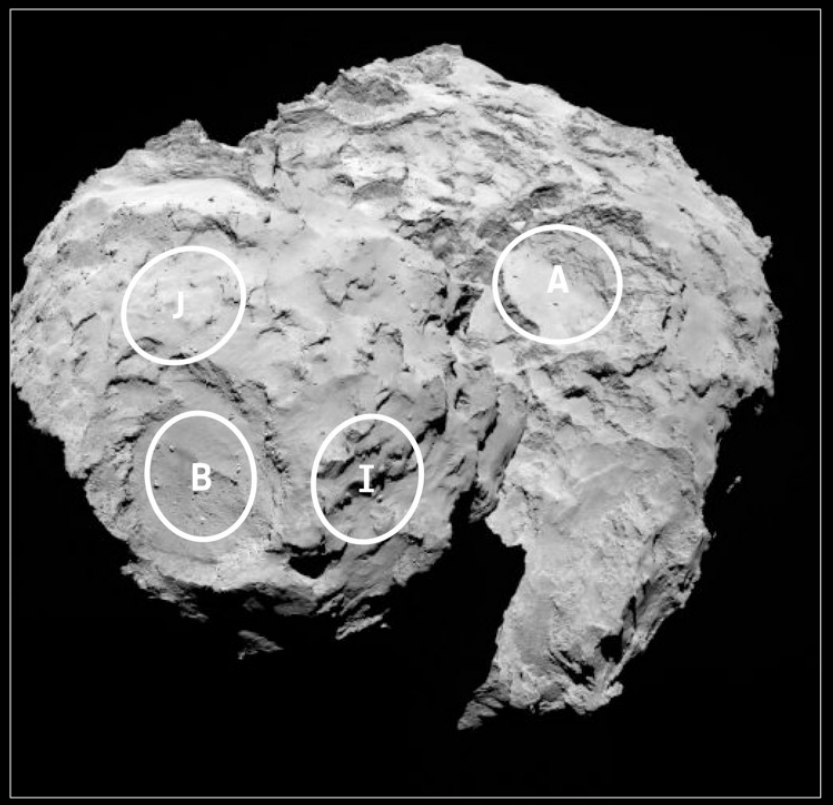


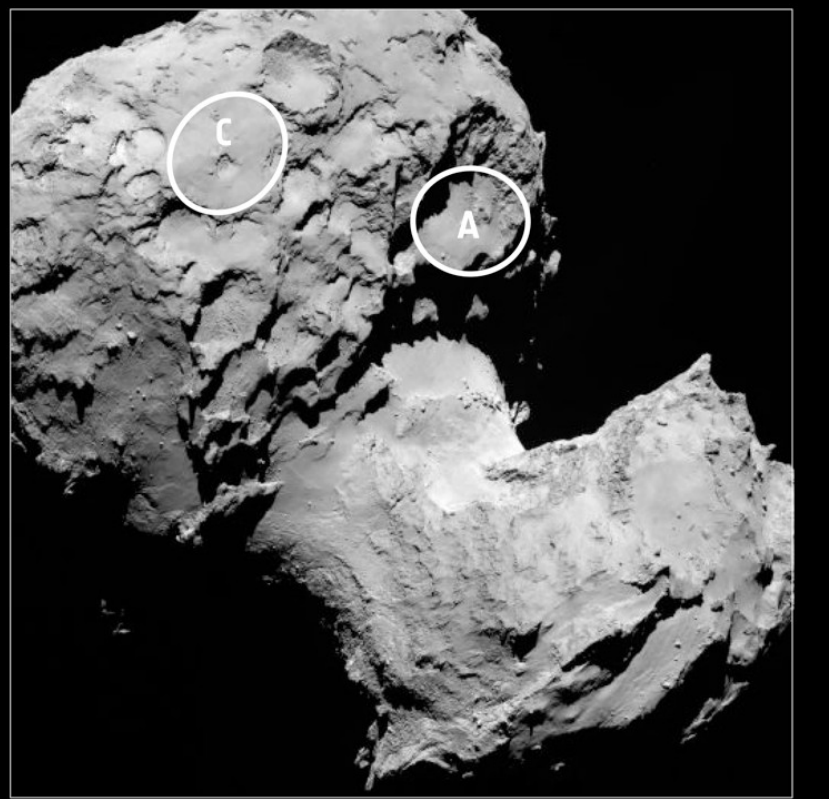


Carte d'identité de 67P

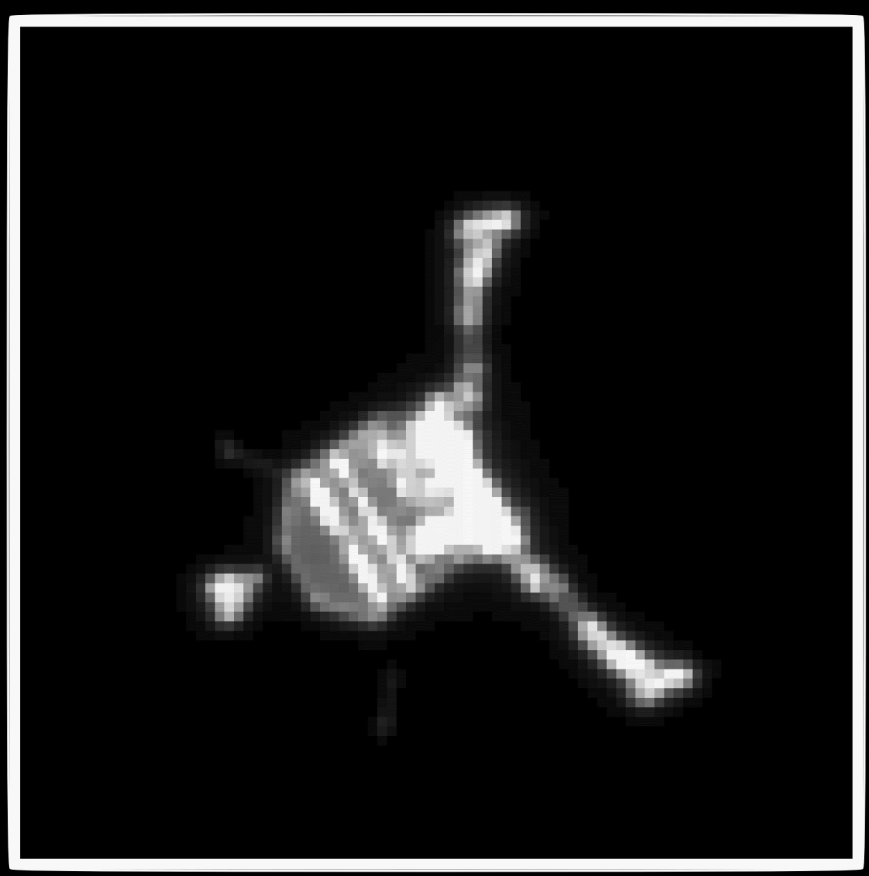
De 0.1 à 10 piscines olympiques par jour


B
I


J
A
B
I


C
A

10:18:55



67.4m

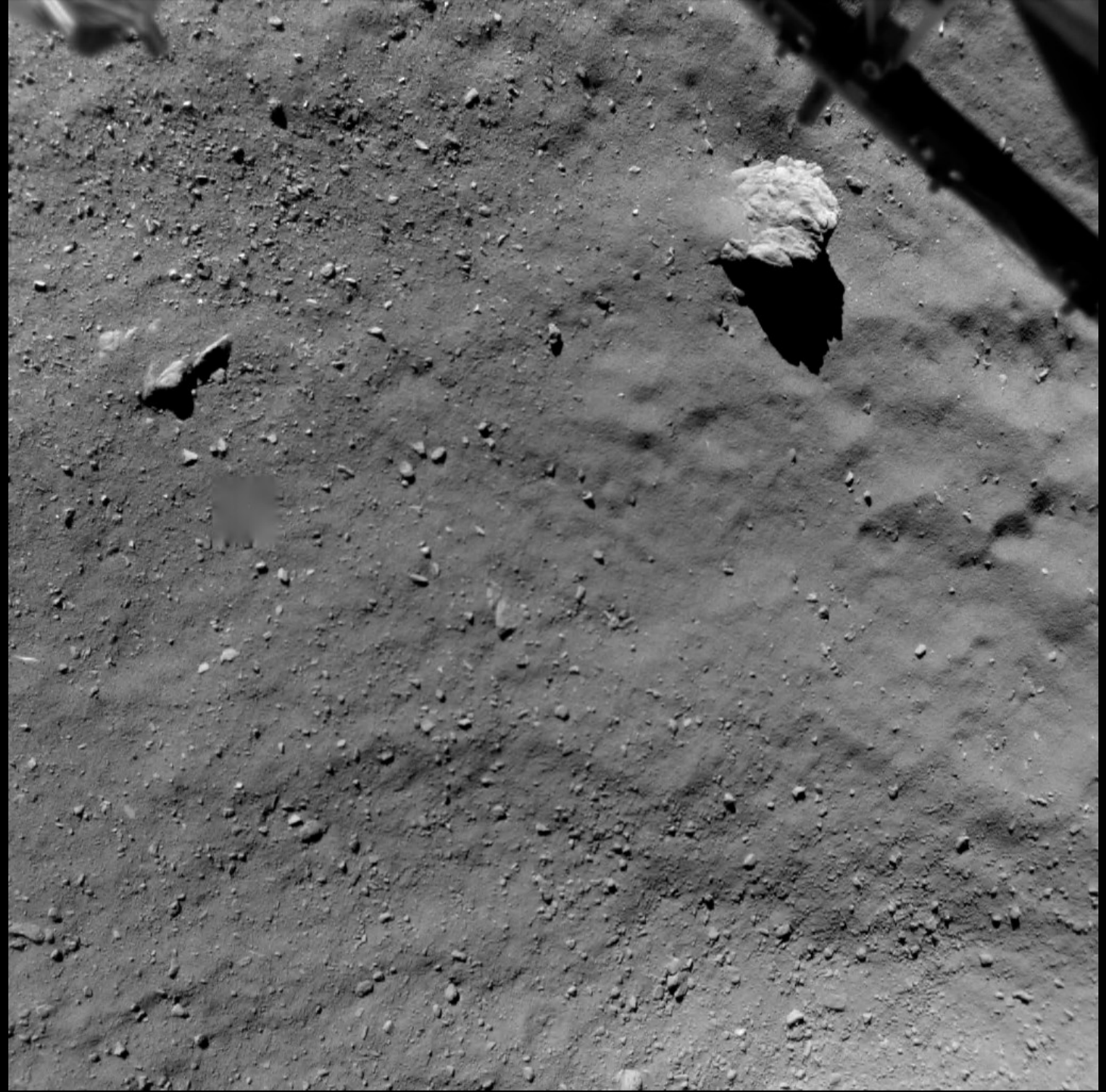
ESA/ROSETTA/PHILAE/ROLIS

57.9m

ESA/ROSETTA/PHILAE/ROLIS

48.5m

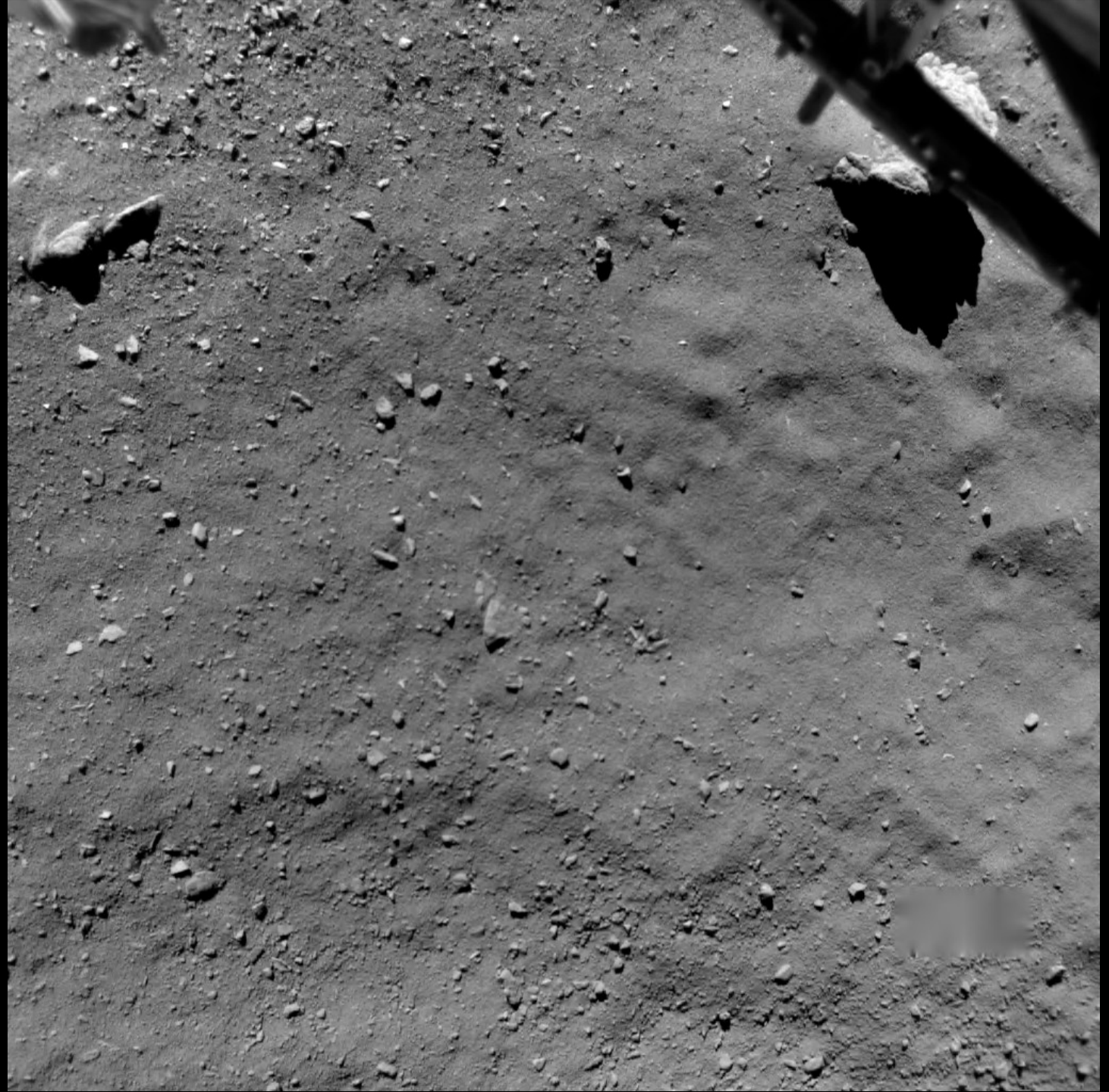
ESA/ROSETTA/PHILAE/ROLIS



38.6m

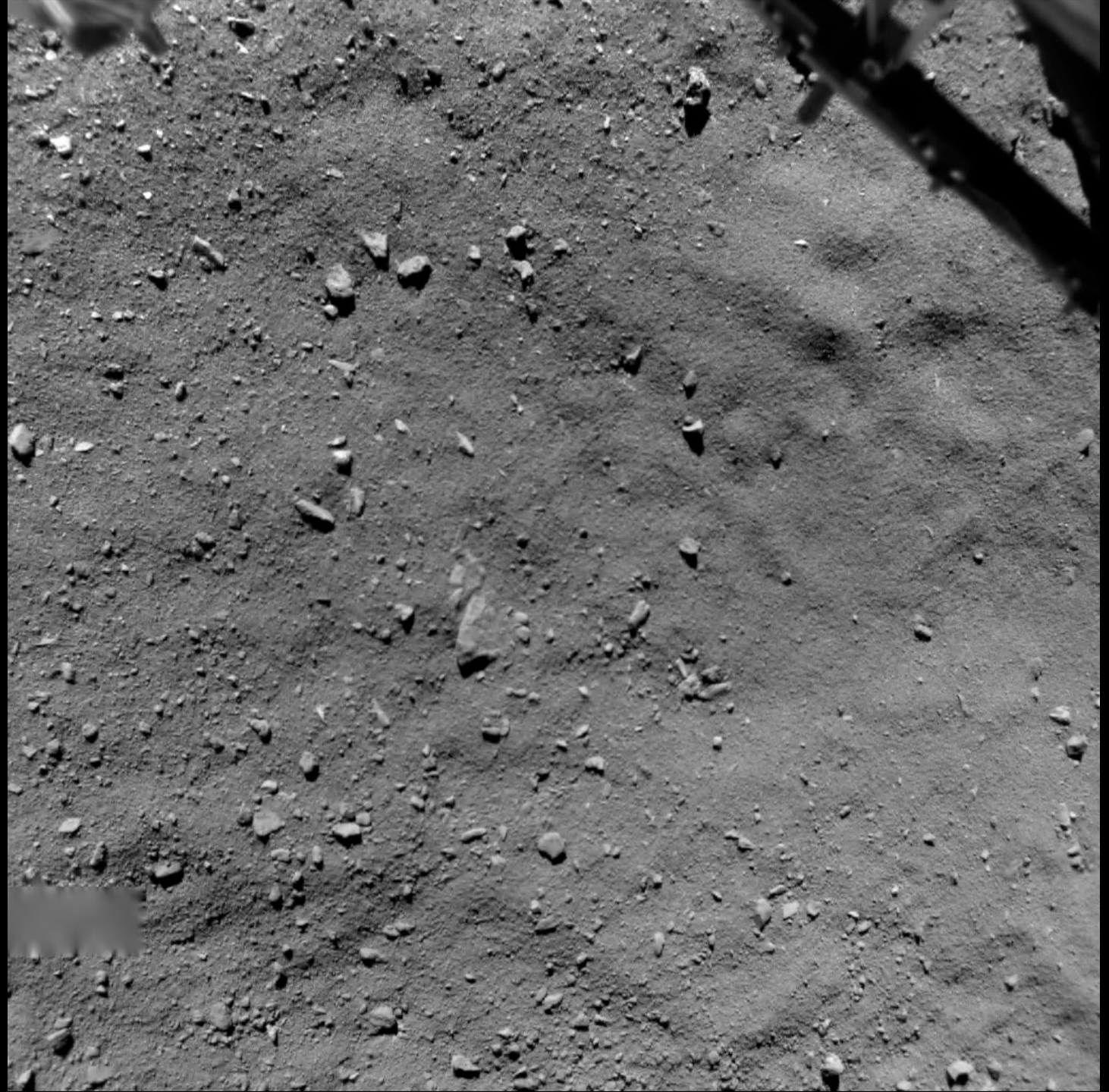
ESA/ROSETTA/PHILAE/ROLIS

28.9m



ESA/ROSETTA/PHILAE/ROLIS

18.8m

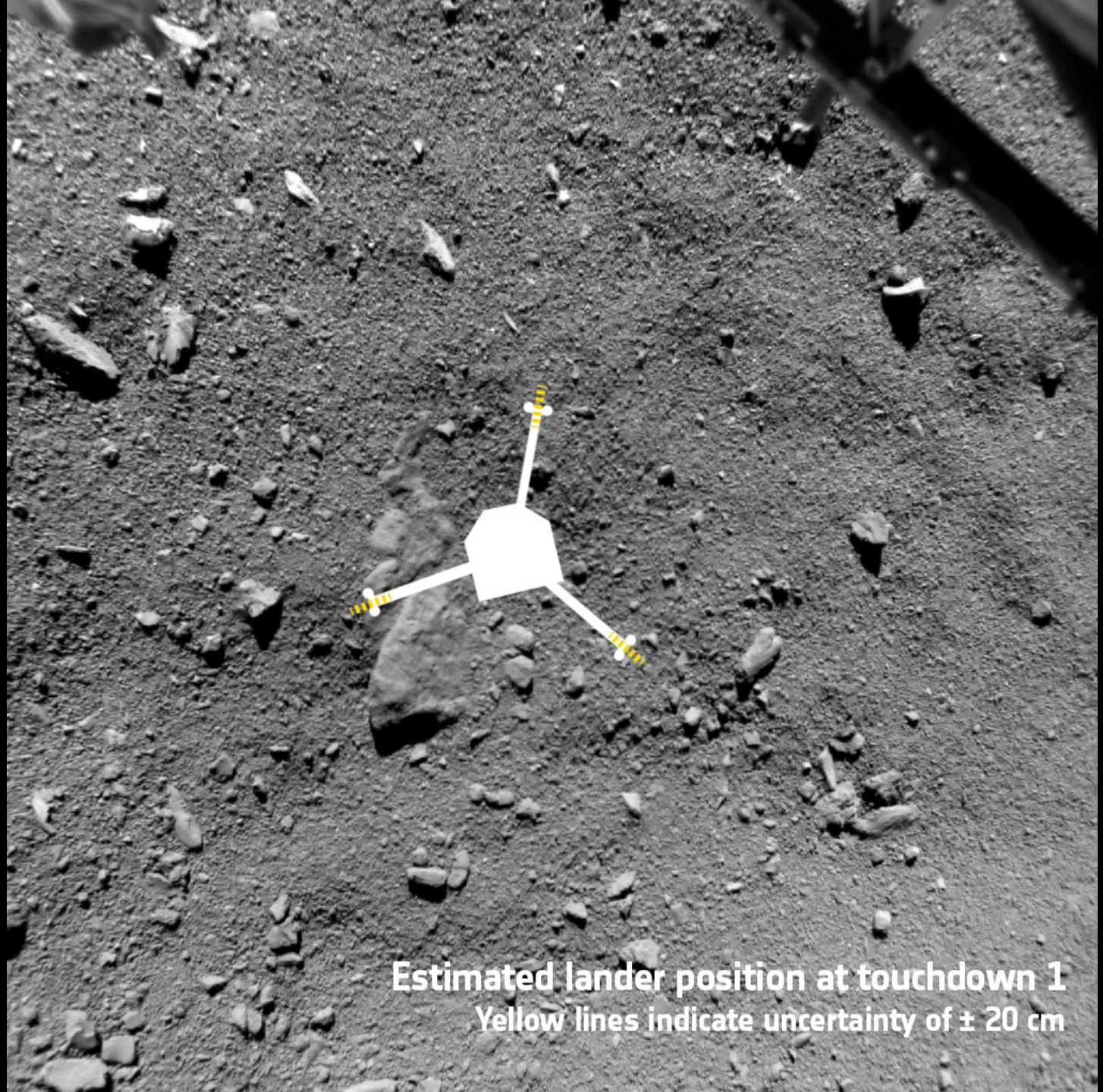


ESA/ROSETTA/PHILAE/ROLIS

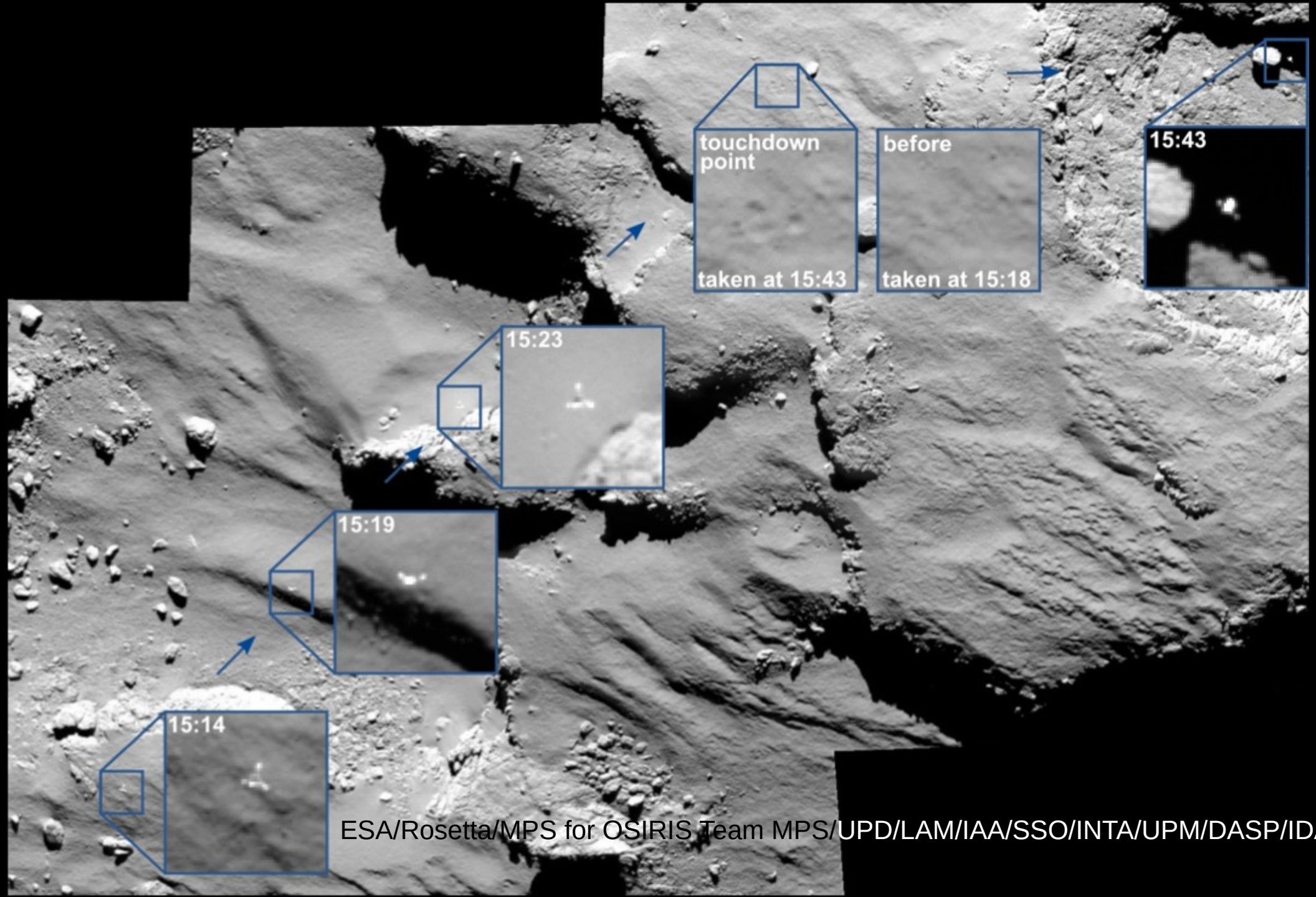
9m

ESA/ROSETTA/PHILAE/ROLIS

ESA/Rosetta/Philae/ROLIS

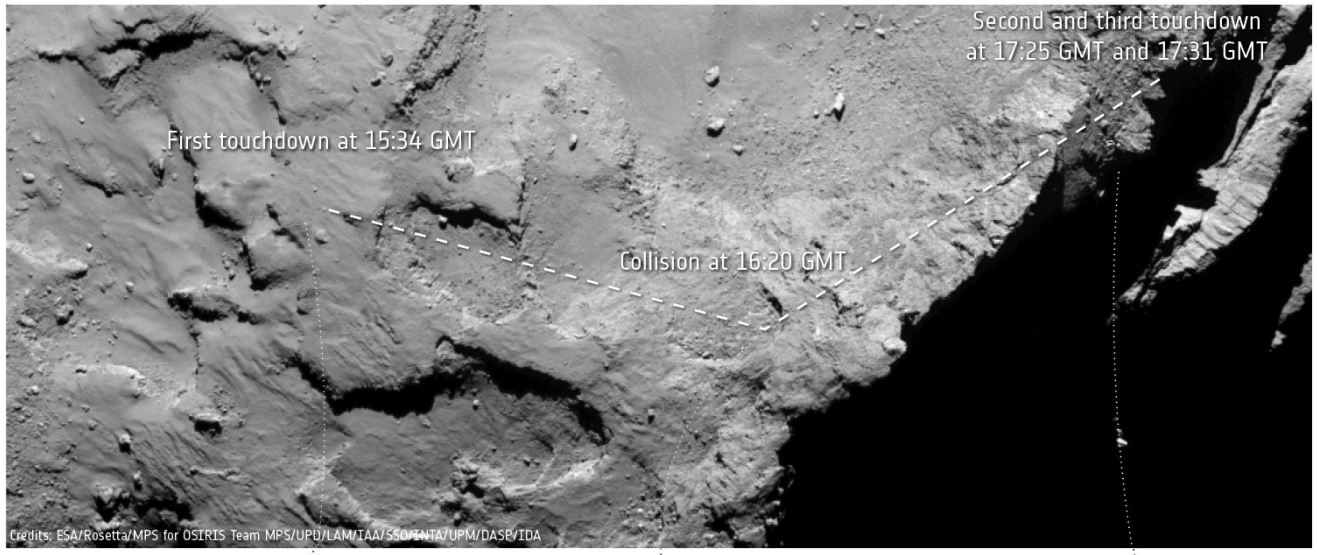


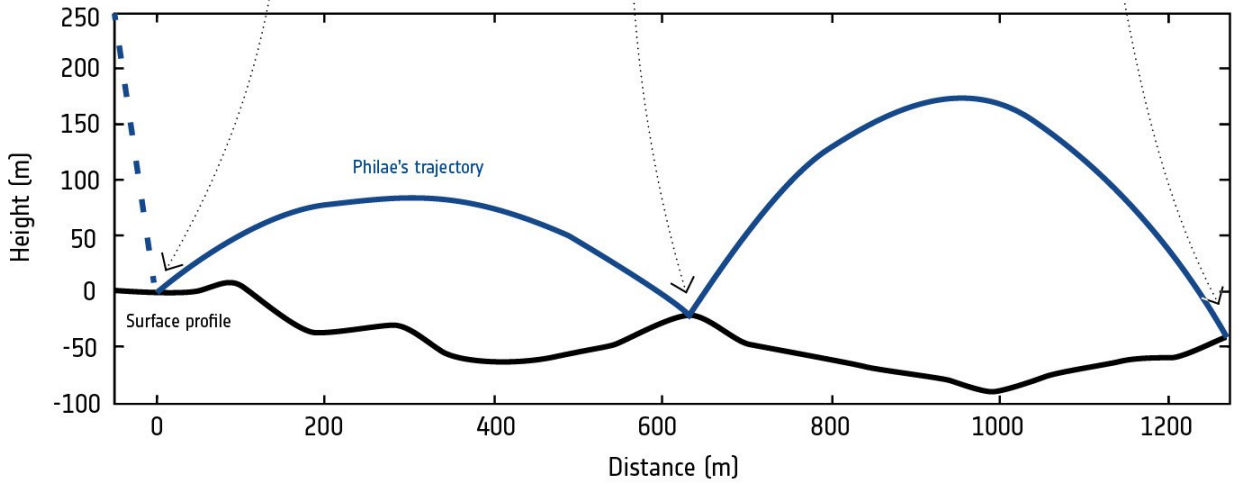
Mottola et al., 2015
Biele et al., 2015


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

Les aléas d’atterrir sur une comète

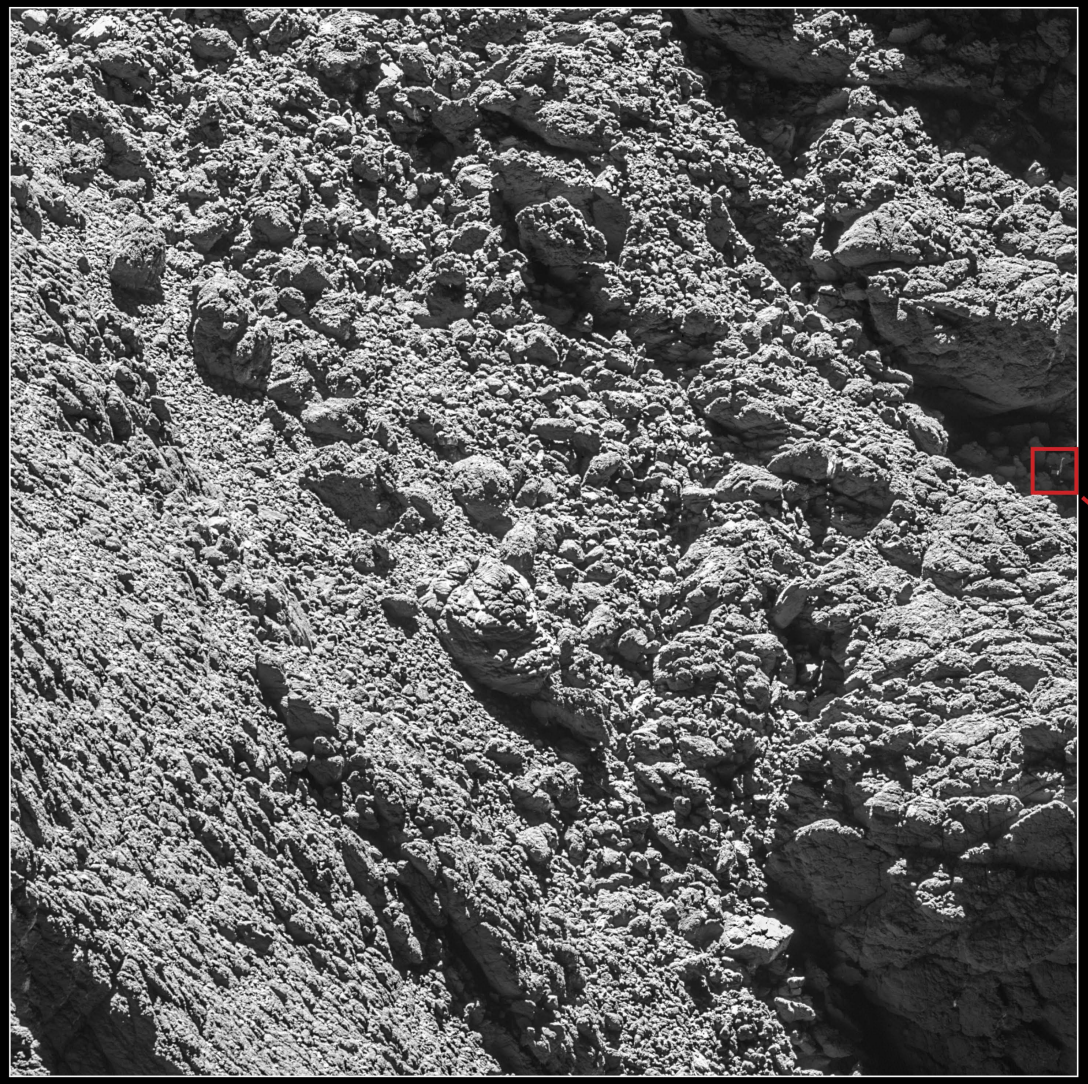
Les aléas d’atterrir sur une comète

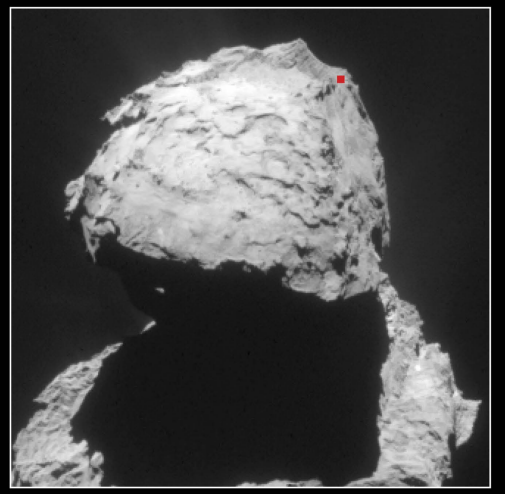




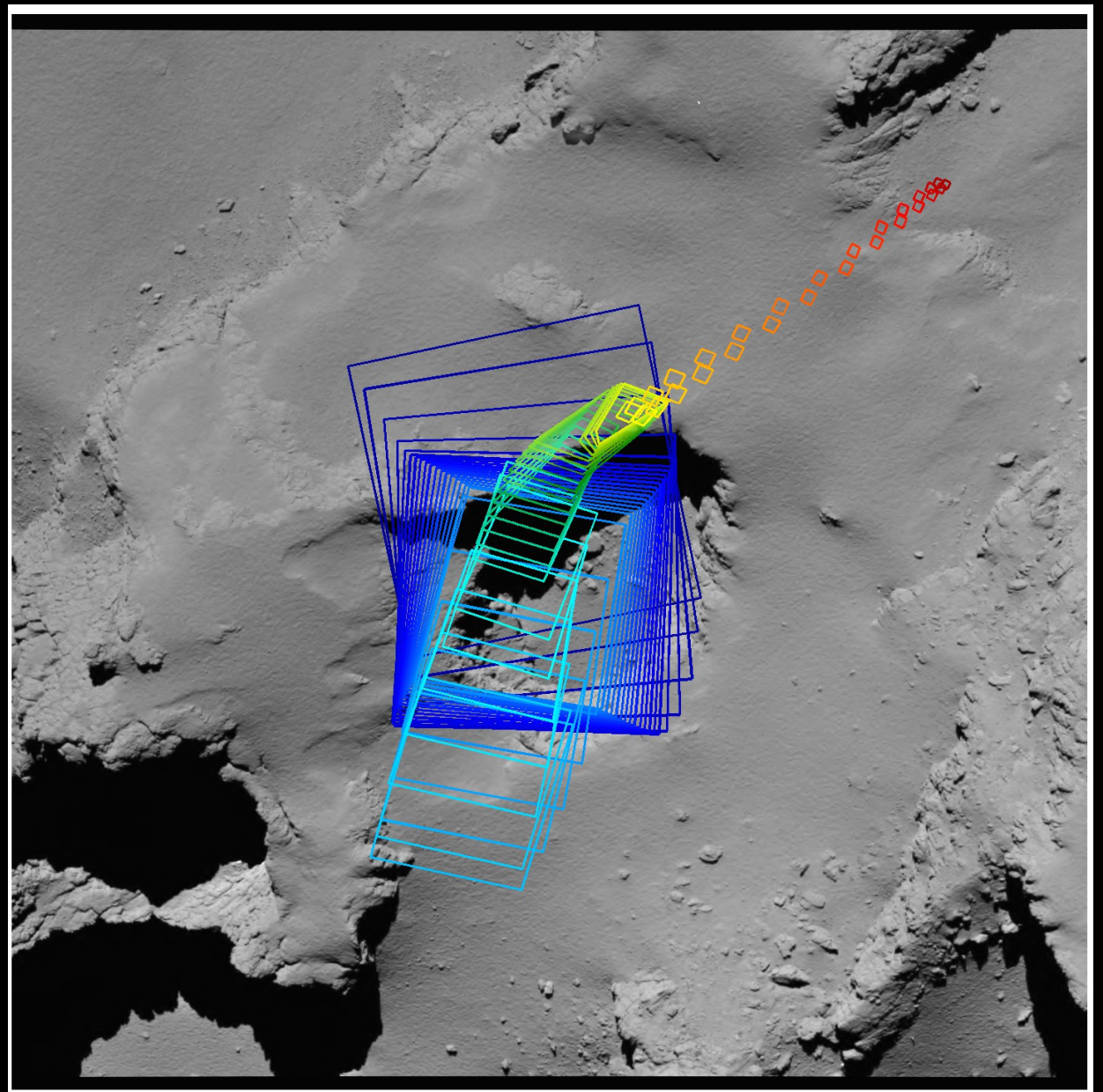
Data from Auster et al (2015)

Où est Philae?





Les dernières images de Rosetta



Simulation de l’atterrissage

→ THE COMETARY ZOO: GASES DETECTED BY ROSETTA

esa

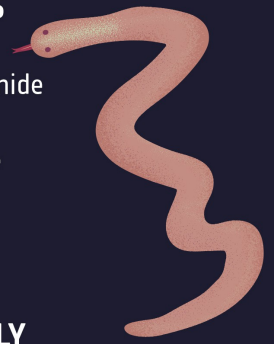
THE LONG CARBON CHAINS
Methane
Ethane
Propane
Butane
Pentane
Hexane
Heptane

THE AROMATIC RING COMPOUNDS
Benzene
Toluene
Xylene
Benzoic acid
Naphtalene

THE KING OF THE ZOO
Glycine (amino acid)

THE "MANURE SMELL" MOLECULES
Ammonia
Methylamine
Ethylamine

THE "POISONOUS" MOLECULES
Acetylene
Hydrogen cyanide
Acetonitrile
Formaldehyde

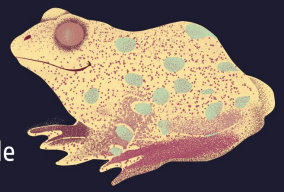


THE ALCOHOLS
Methanol
Ethanol
Propanol
Butanol
Pentanol

THE VOLATILES
Nitrogen
Oxygen
Hydrogen peroxide
Carbon monoxide
Carbon dioxide

THE "SMELLY" MOLECULES
Hydrogensulphide
Carbonylsulphide
Sulphur monoxide
Sulphur dioxide
Carbon disulphide

THE "SMELLY AND COLOURFUL"
Sulphur
Disulphur
Trisulphur
Tetrasulphur
Methanethiole
Ethanethiol
Thioformaldehyde



THE TREASURES WITH A HARD CRUST
Sodium
Potassium
Silicon
Magnesium

THE "SALTY" BEASTS
Hydrogen fluoride
Hydrogen chloride
Hydrogen bromide
Phosphorus
Chloromethane

THE BEAUTIFUL AND SOLITARY
Argon
Krypton
Xenon

THE "EXOTIC" MOLECULES
Formic acid
Acetic acid
Acetaldehyde
Ethylenglycol
Propylenglycol
Butanamide

THE MOLECULE IN DISGUISE
Cyanogen

www.esa.int

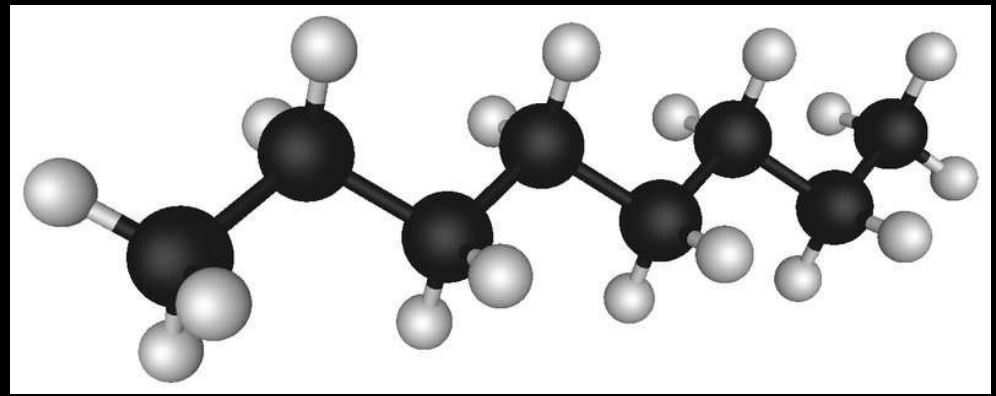
Credits: Based on data from ROSINA

European Space Agency

Hydrocarbure (saturés)

Longue molécule formé de Carbone et d’Hydrogène.

Se trouvent sur Terre sous diverses formes: pétrole, émission naturelle de l’élevage bovin, gaz de ville



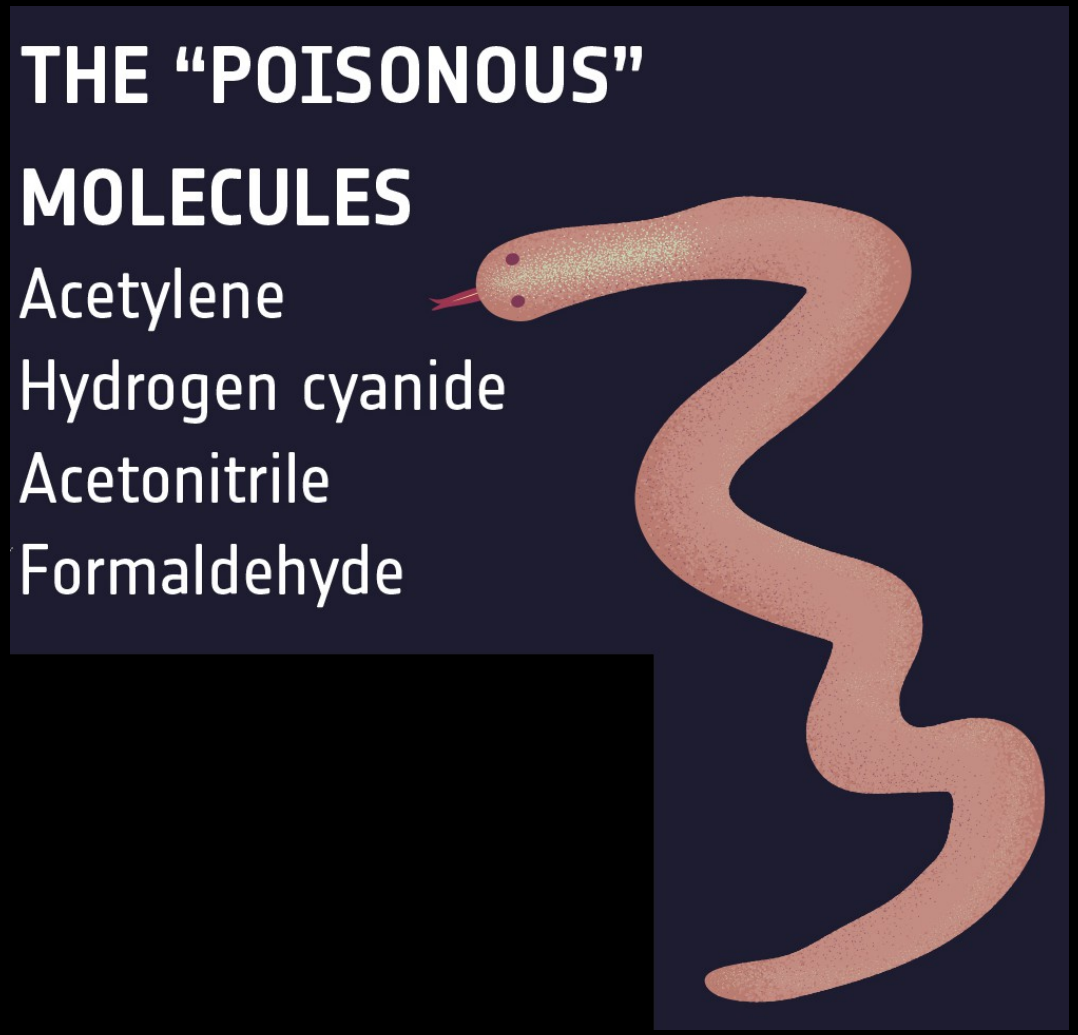
Alcools

Se trouvent sur Terre sous diverses formes mais surtout dans les bars

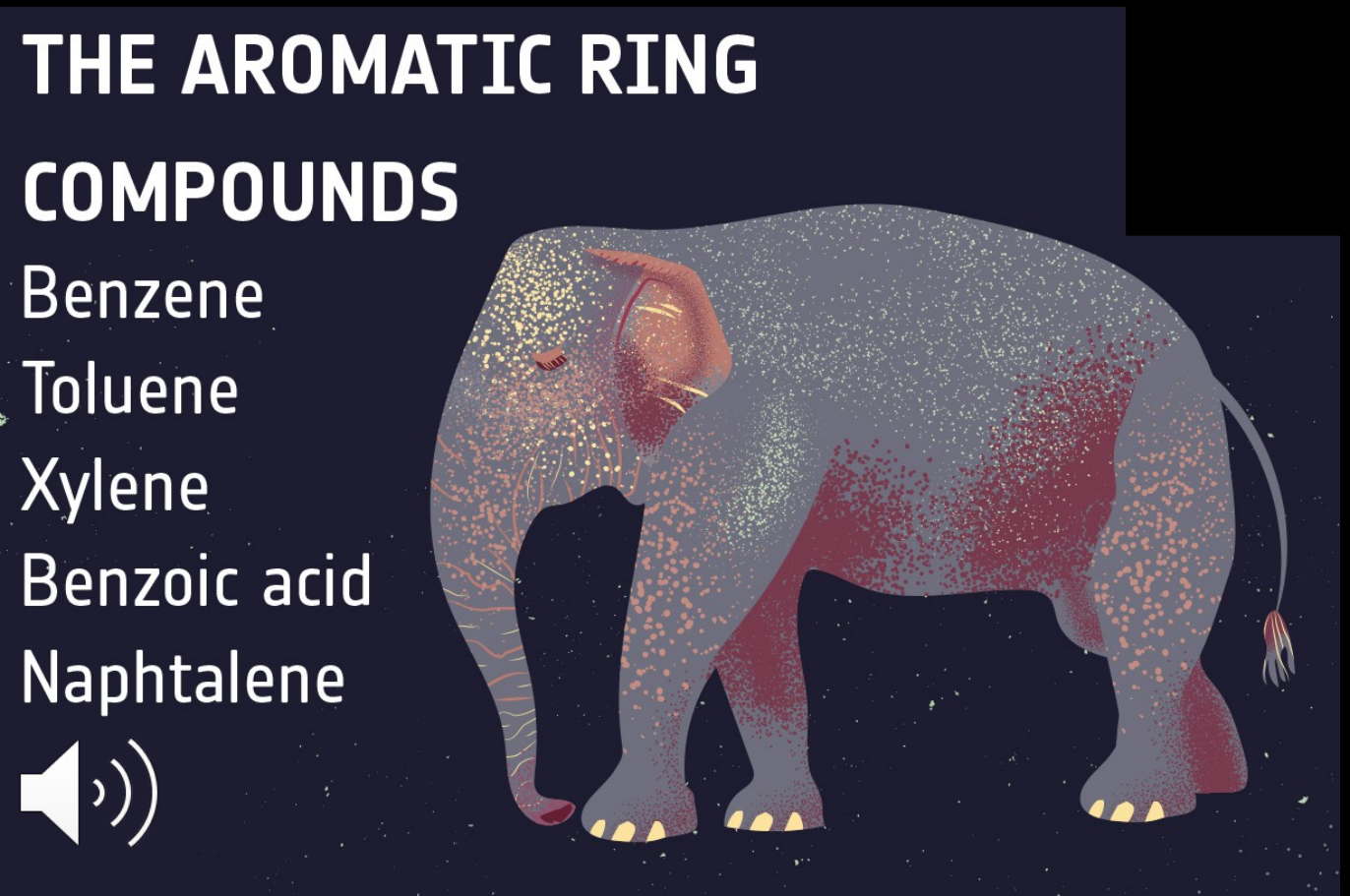
Les molécules toxiques

Inflammable
Corrosif
Toxique

Fumée de tabac par exemple…



Les grosses molécules (hydrocarbures aromatiques)



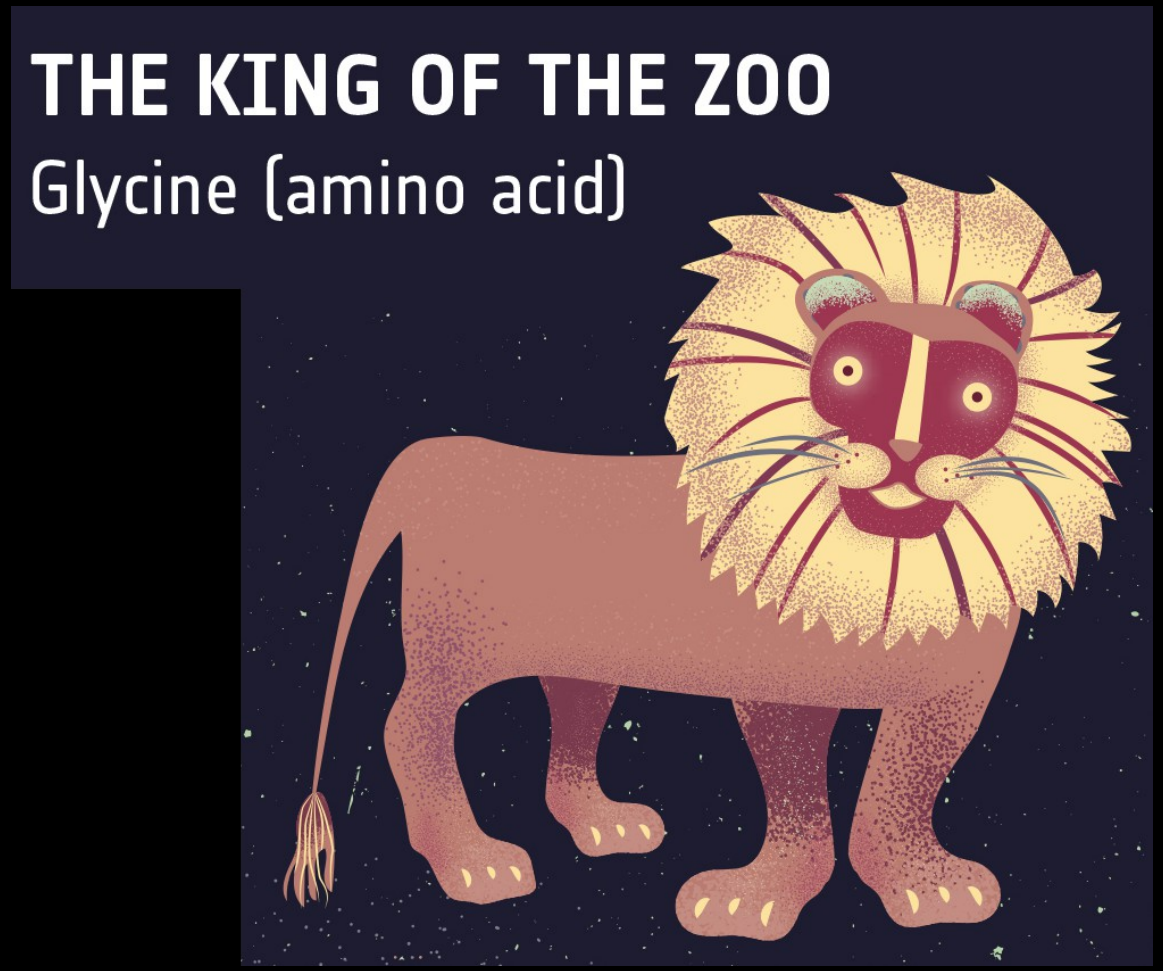
Rentre dans la synthèse de: matières plastiques, caoutchoucs, solvants, plastifiants, détergents, parfums, colorants, additifs alimentaires, médicaments, pesticides, explosifs, ….

Le roi des animaux: la glycine

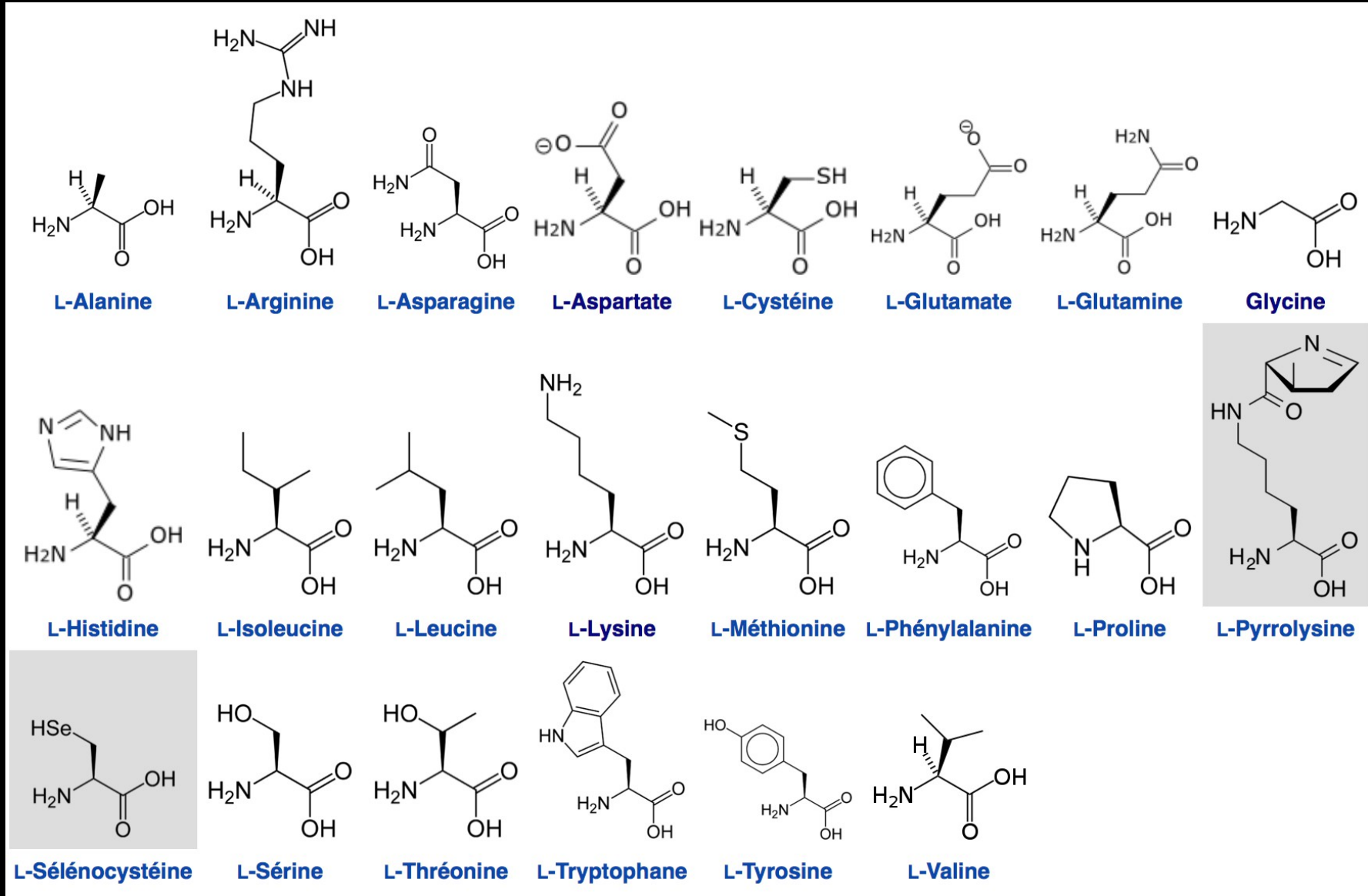
Le plus simple des acides aminés, une seule forme (pas de chiralité)

Additif dans les produits alimentaires

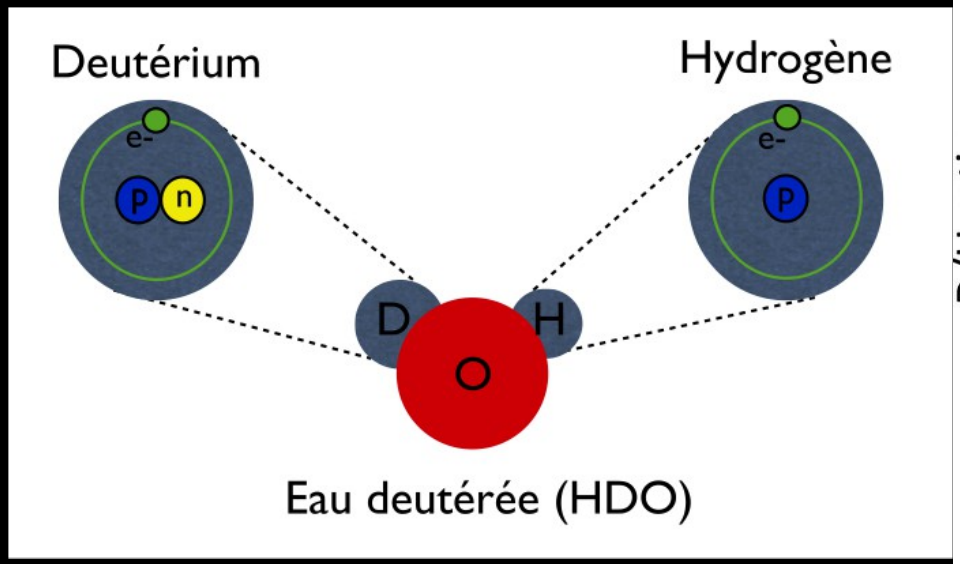
Élément de base à la synthèse des protéines

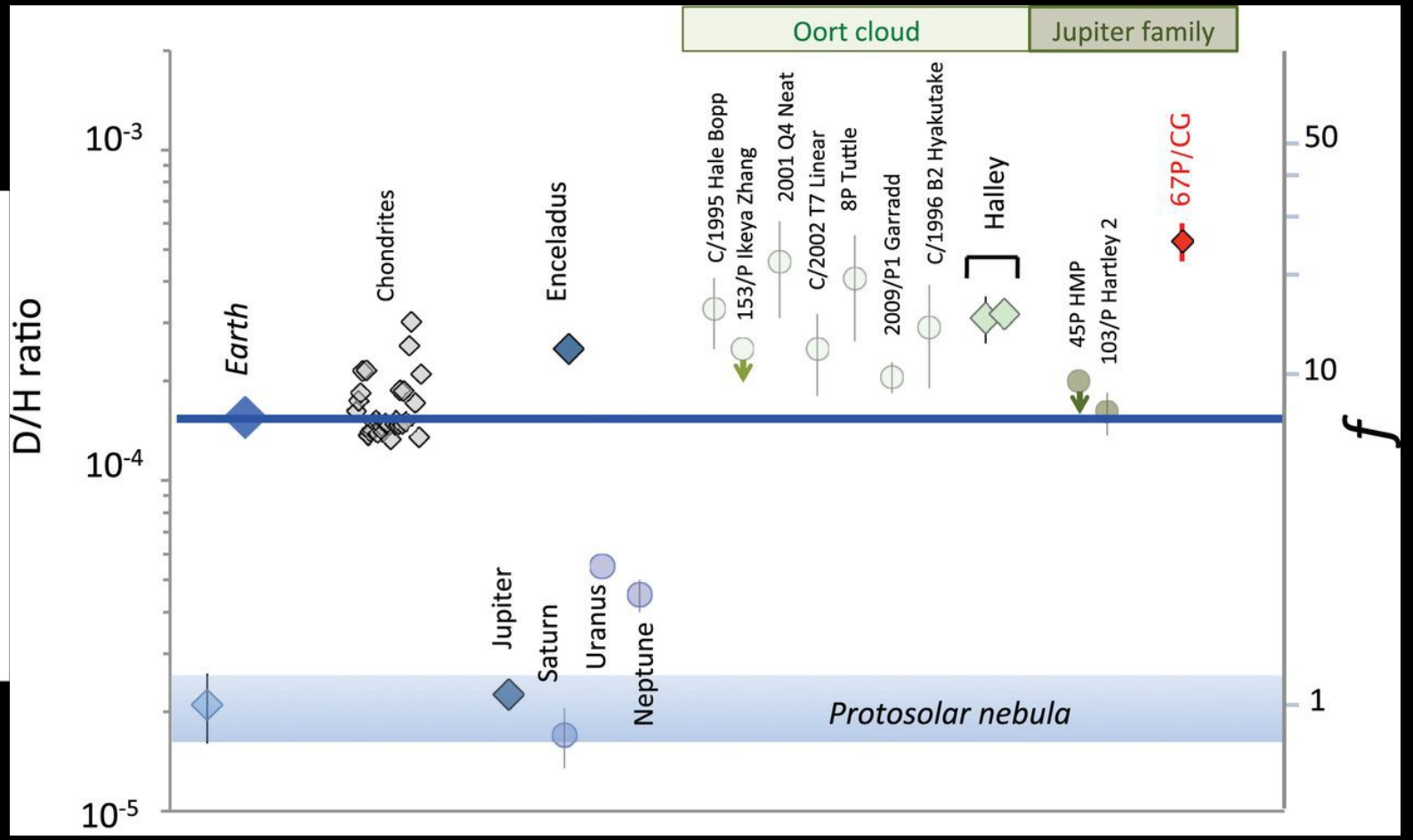


Liste des acides aminés (22 au total)



L’origine de l’eau sur Terre: le rapport D/H

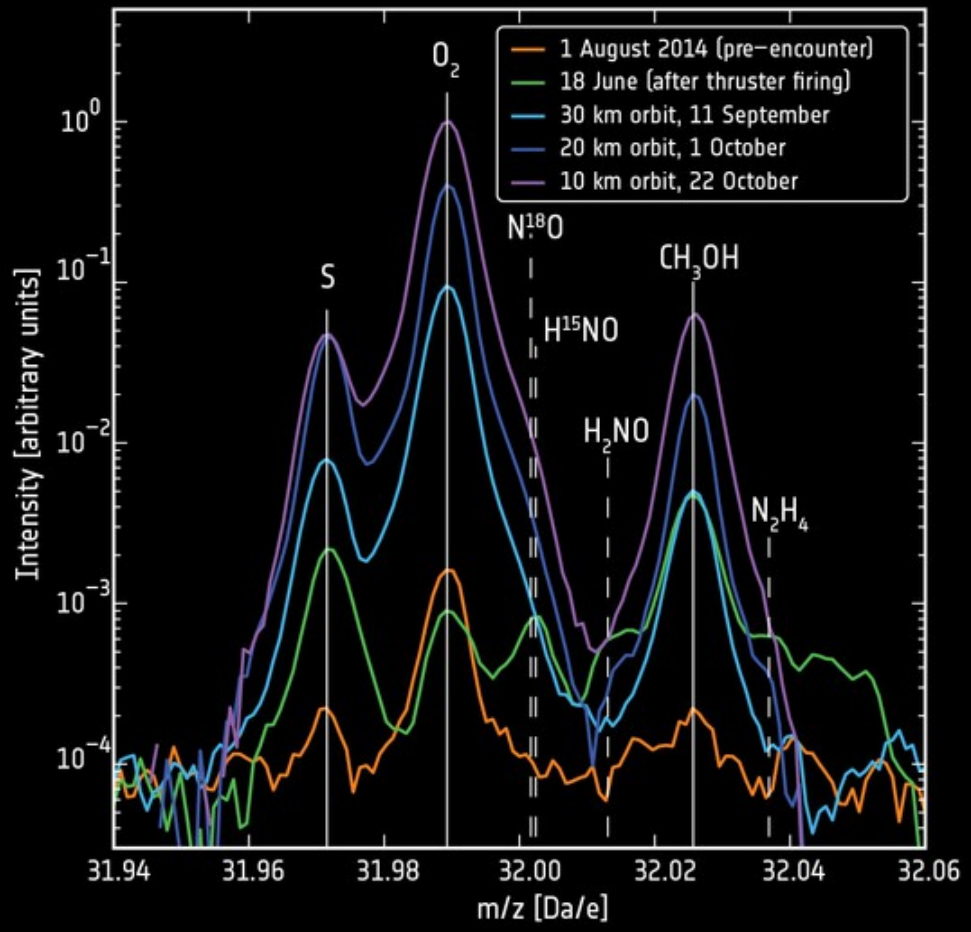




K. Altwegg et al. Science 2015;347:1261952

K. Altwegg et al. Science 2015;347:1261952

De l'oxygène sur 67P

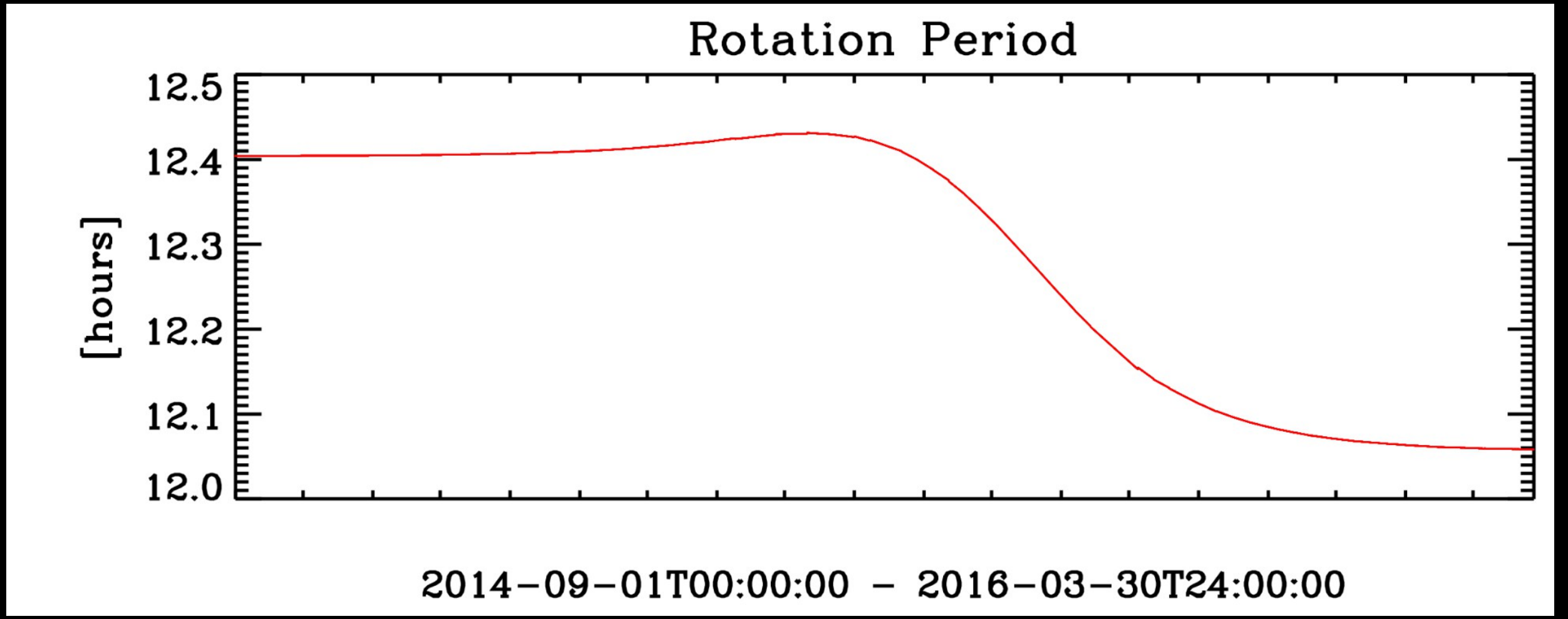


Incorporation de du dioxygnène dans le noyau lors de de sa formation

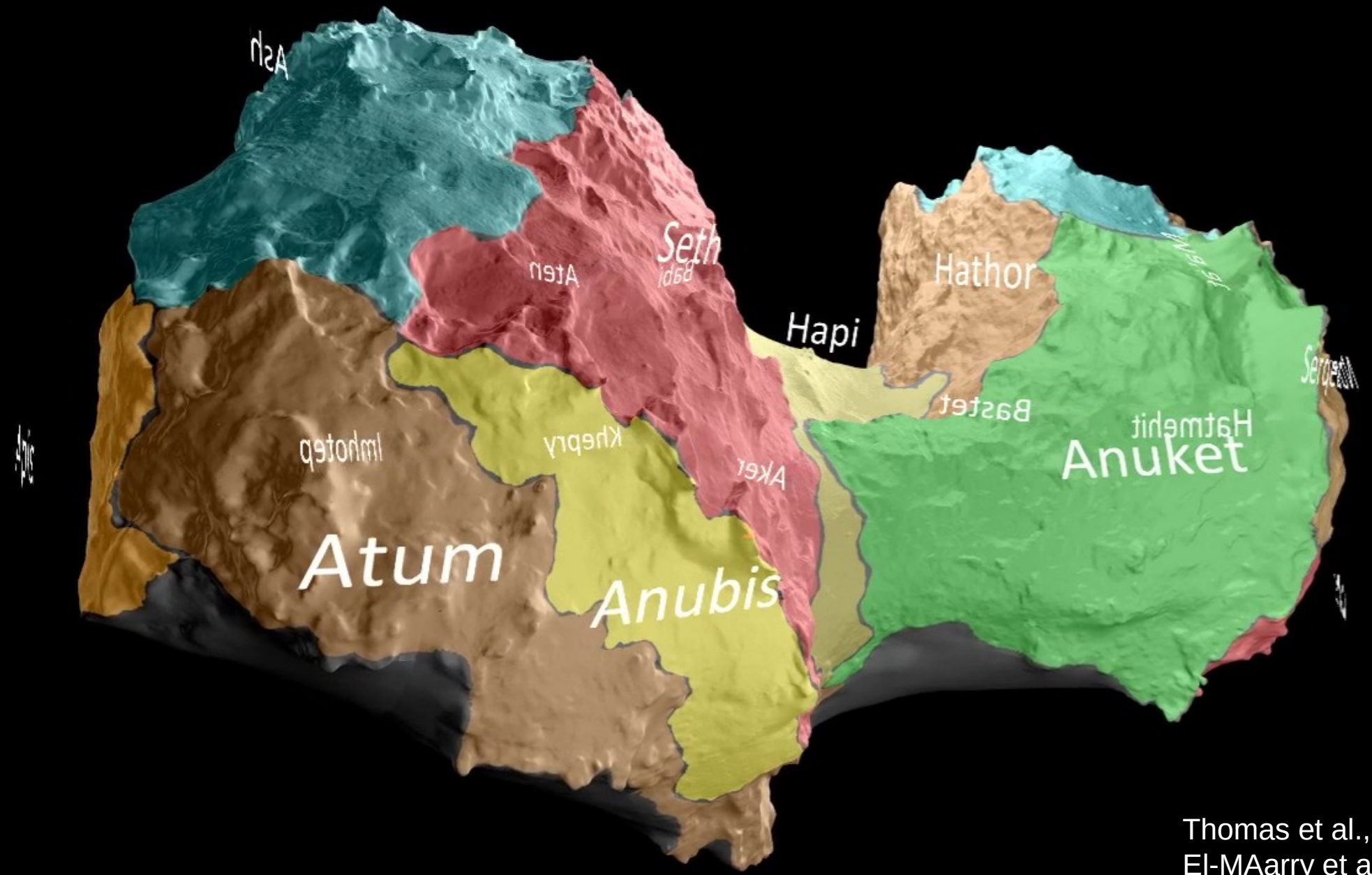
-> ne colle pas avec les modèles

A Bieler *et al. Nature* **526**, 678-681 (2015) doi:10.1038/nature15707

Une comète tournant de plus en plus vite

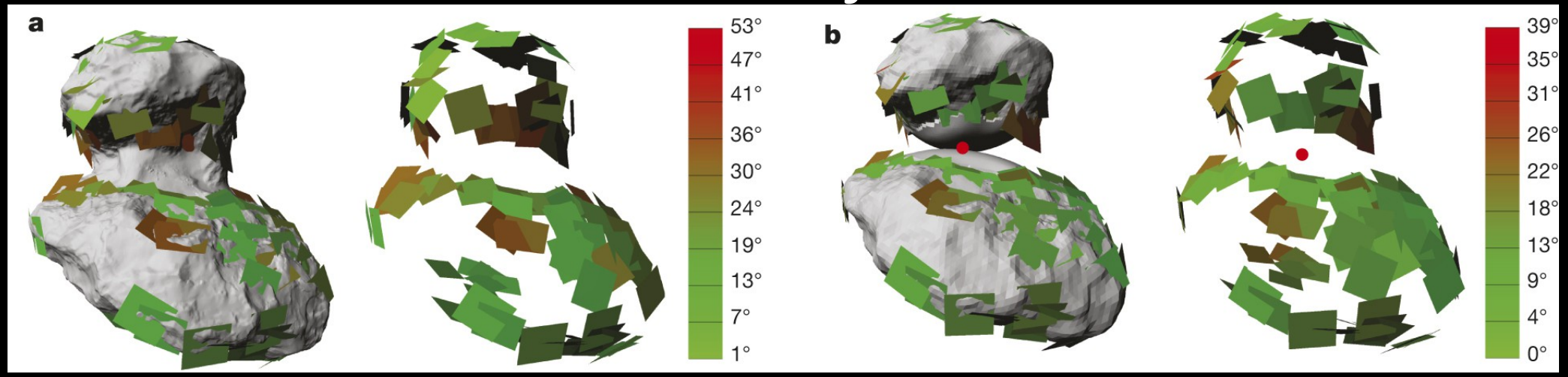


Surface inhomogène

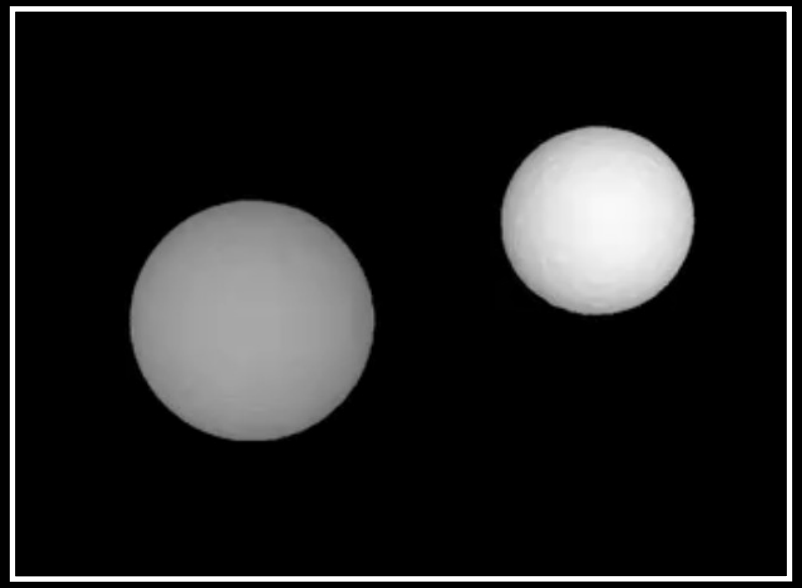


Thomas et al., A+A, 2015
El-MAarry et al., A+A, 2015

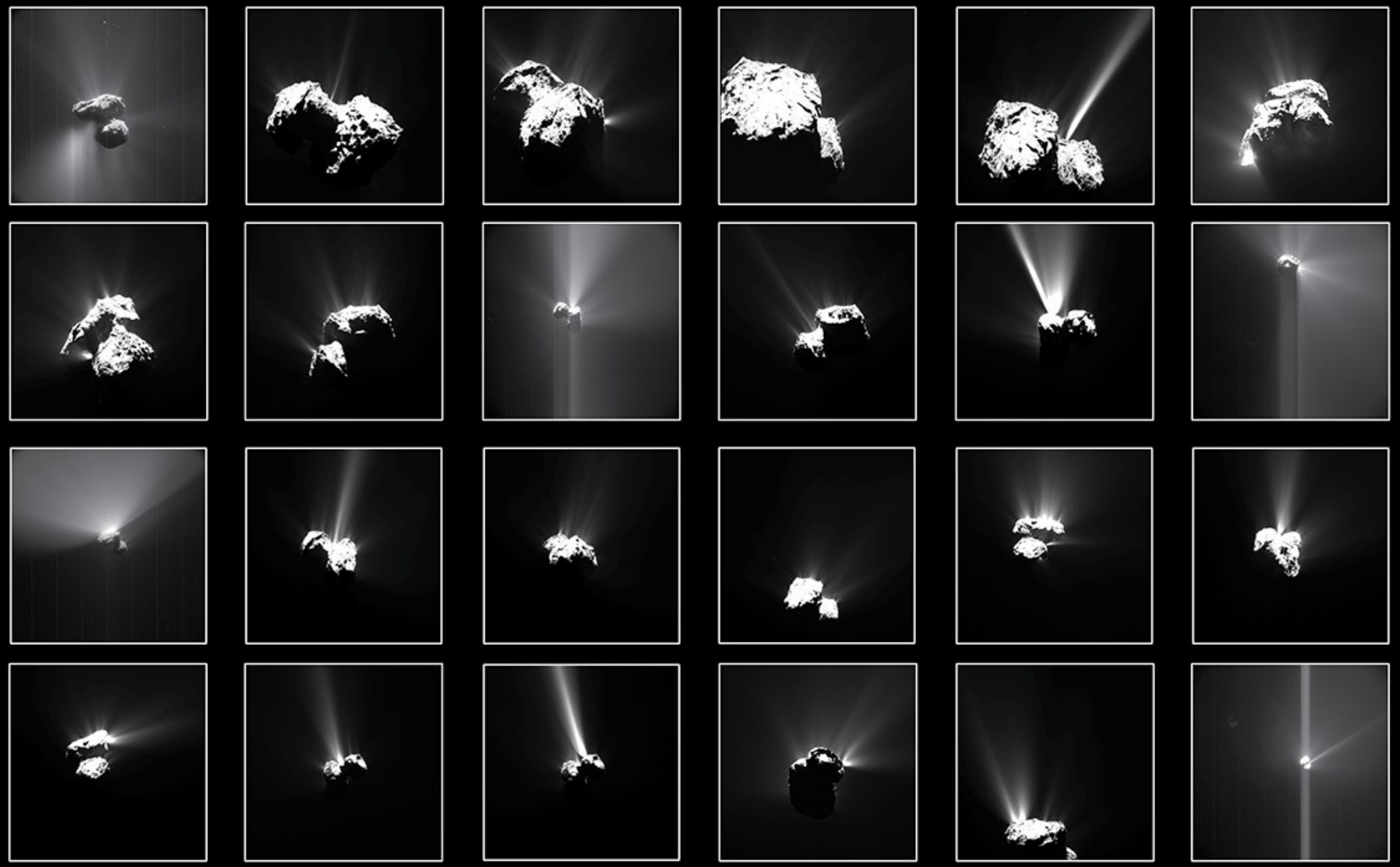
Accrétion de 2 objets à très faible vitesse



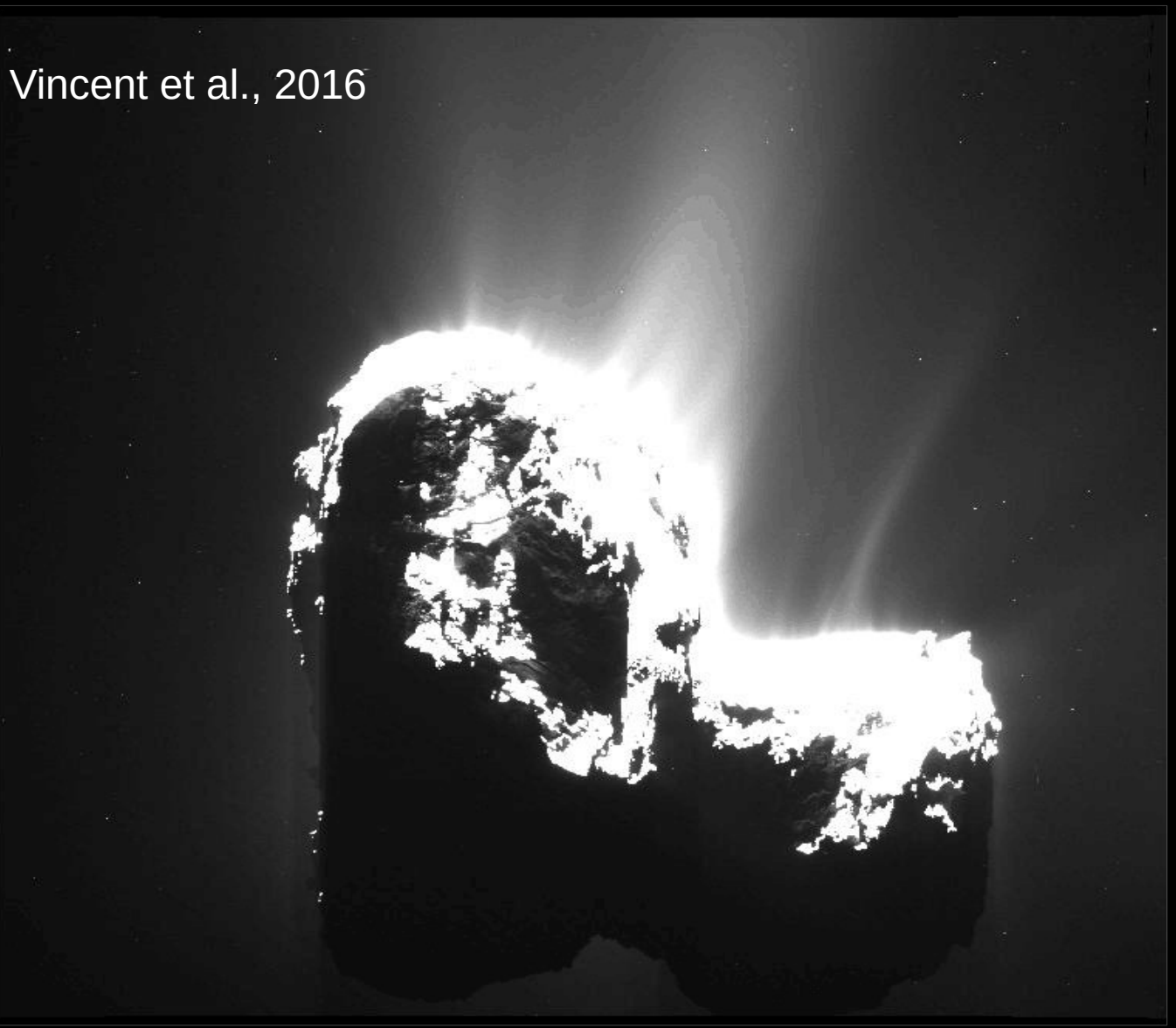
M Massironi *et al. Nature* **000**, 1-4 (2015)
doi:10.1038/nature15511

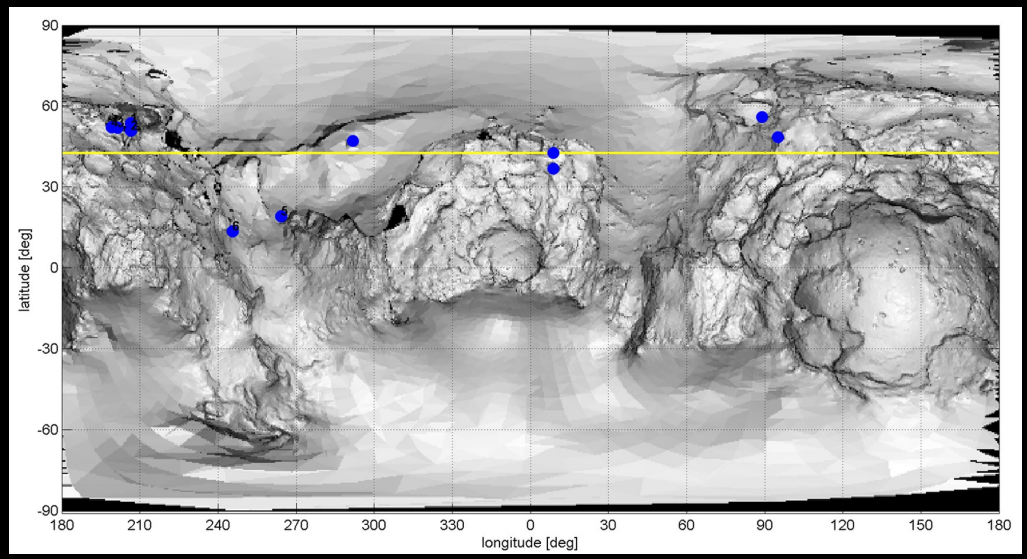


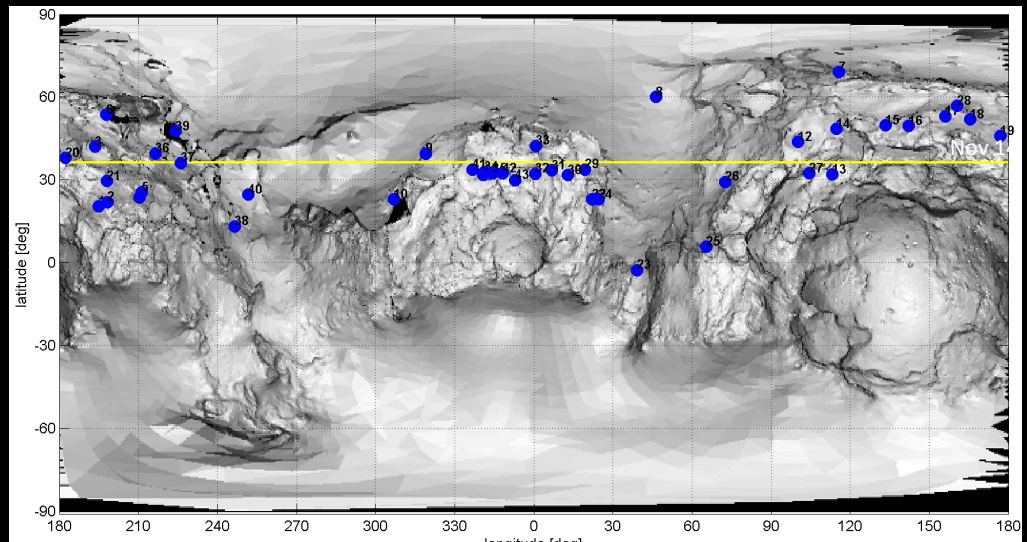
Jutzi and Asphaug, 2015 Science



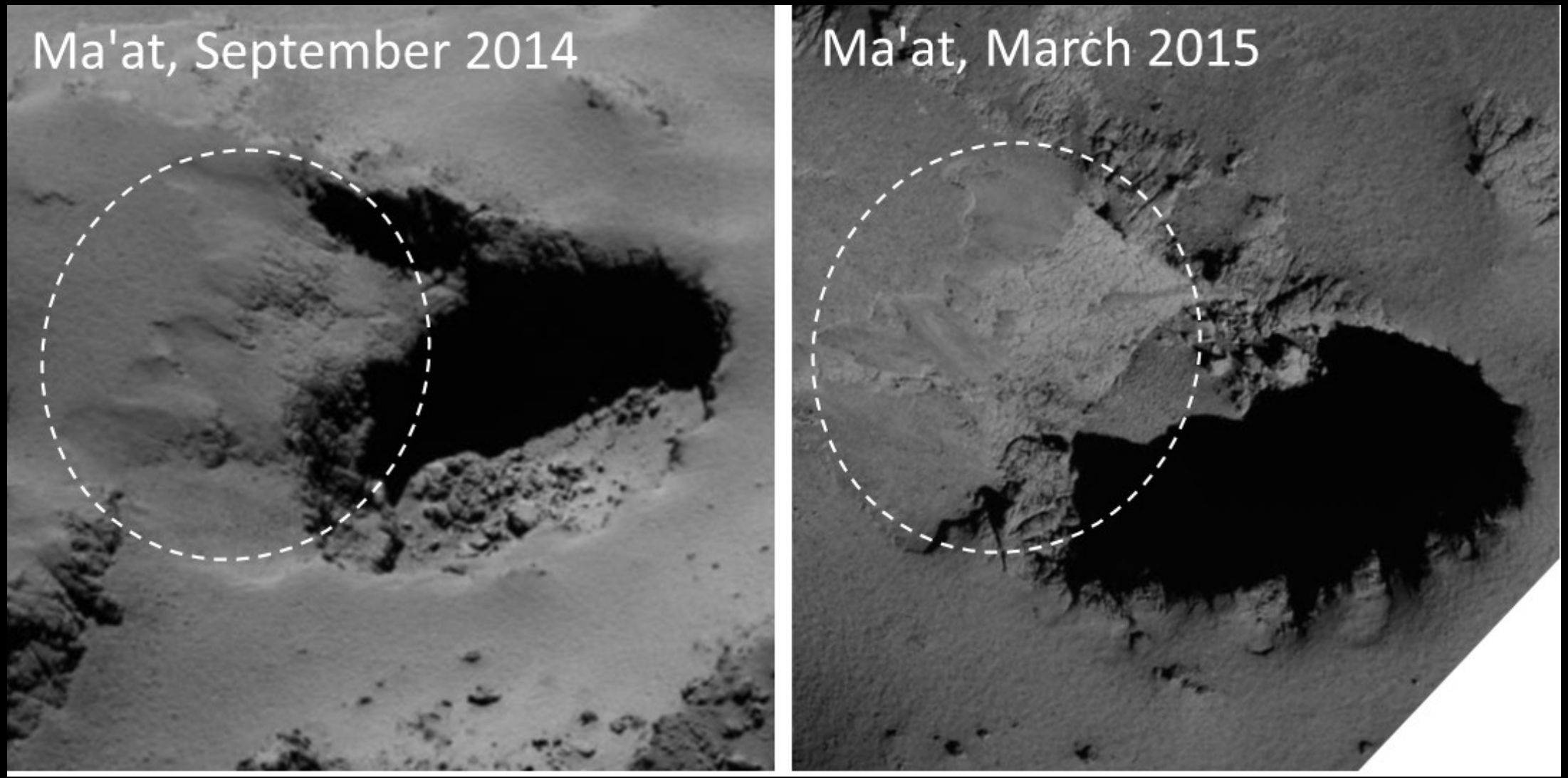
Évolution de la surface



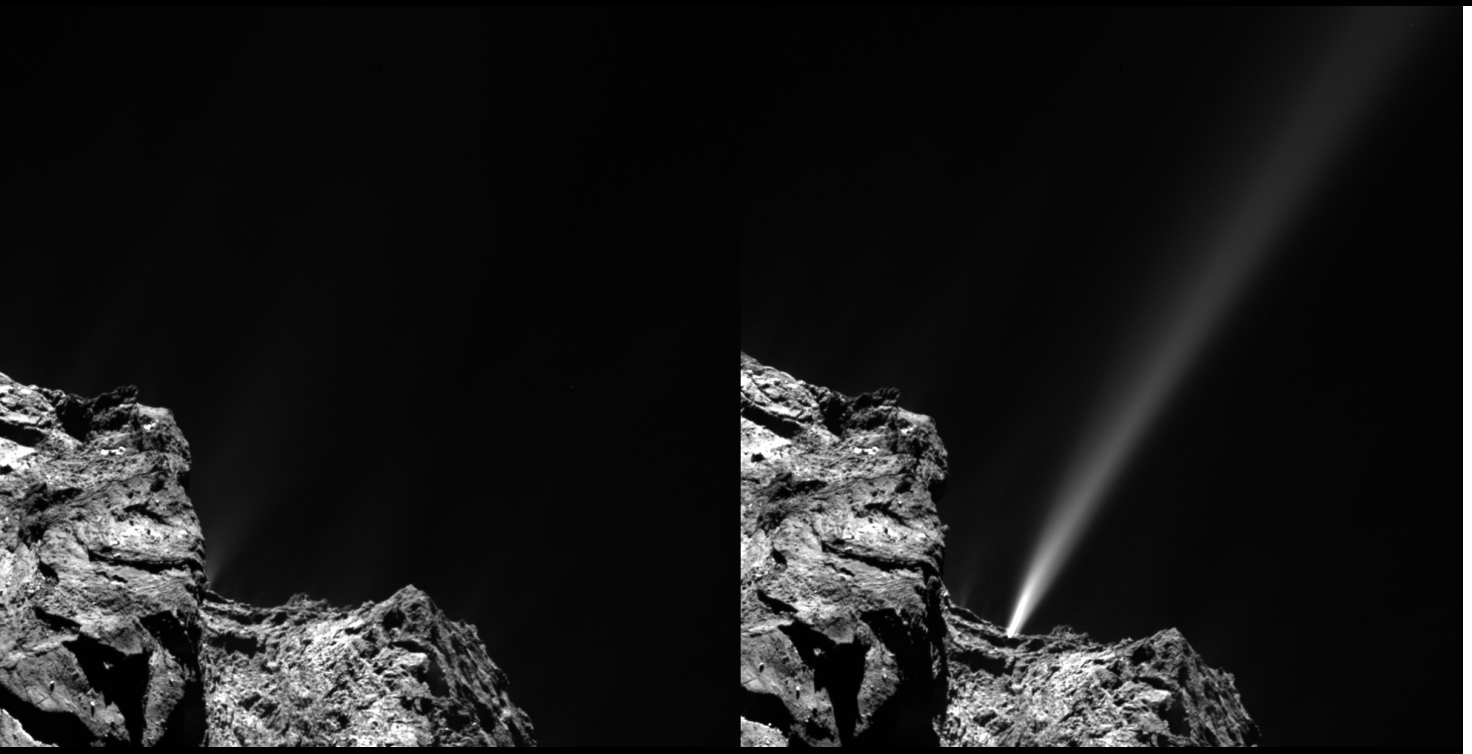


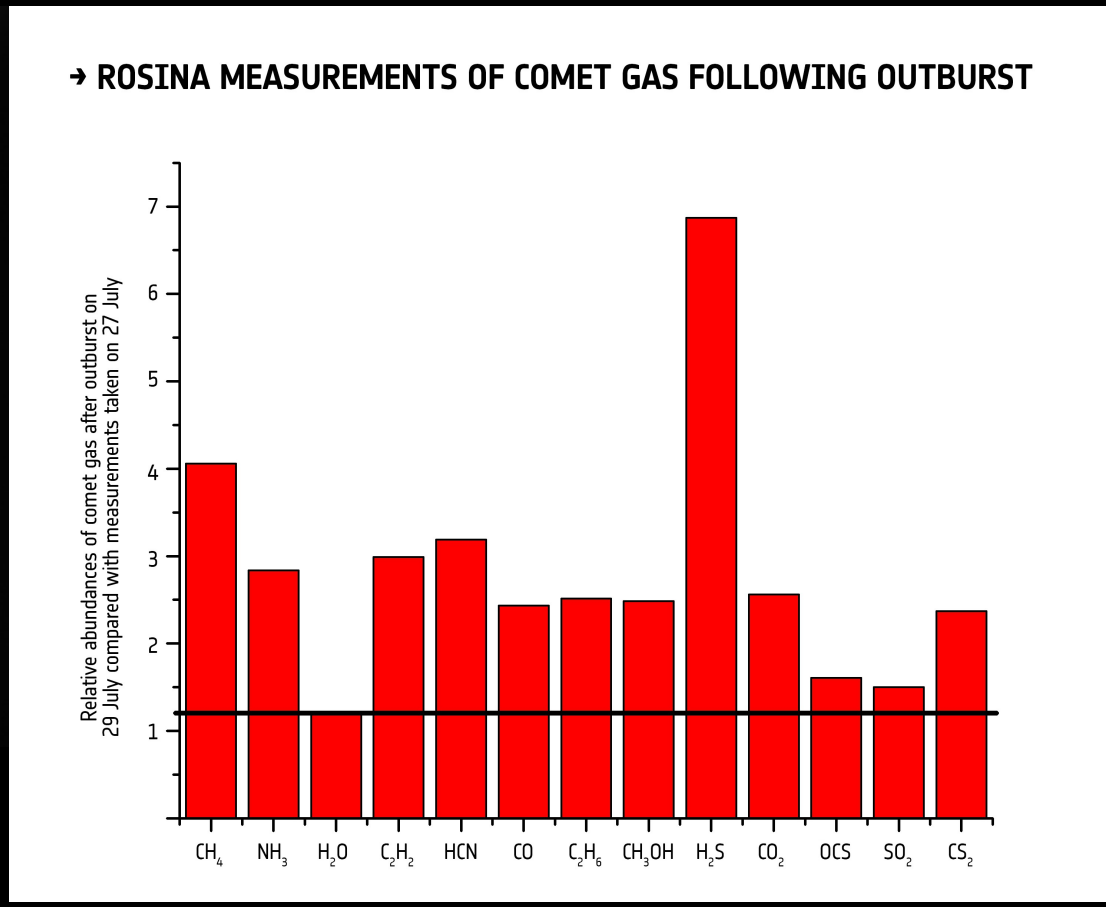


Évolution de la surface

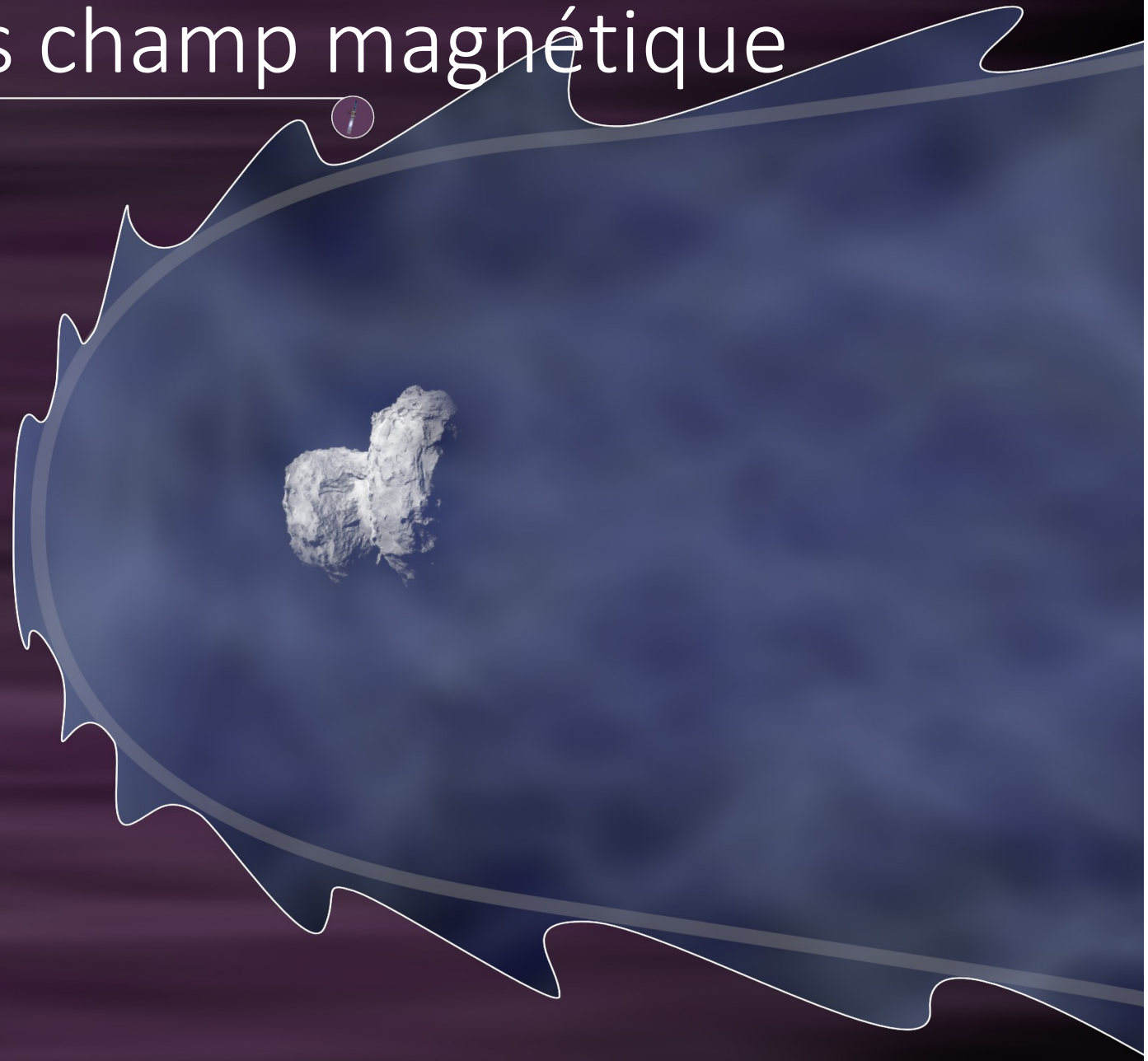


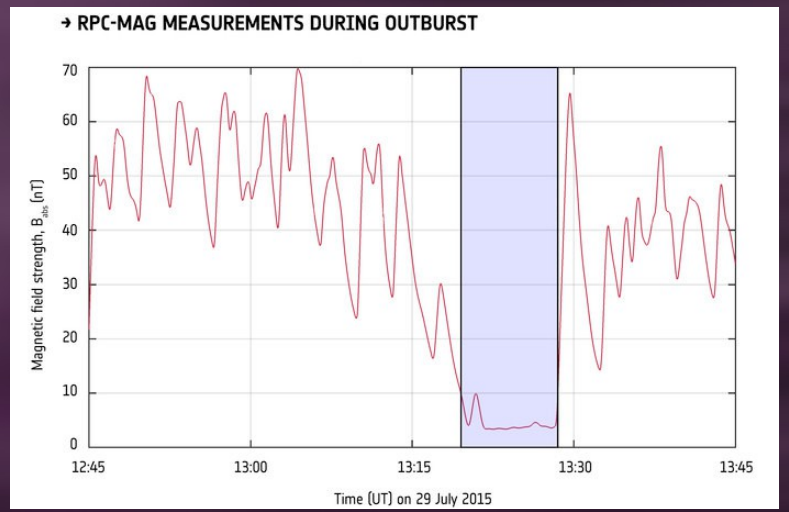
Évolution de la surface et de la coma





Une région sans champ magnétique





Les quelques résultats de Philae

Quelques molécules organiques détectées en surface, les moins volatiles

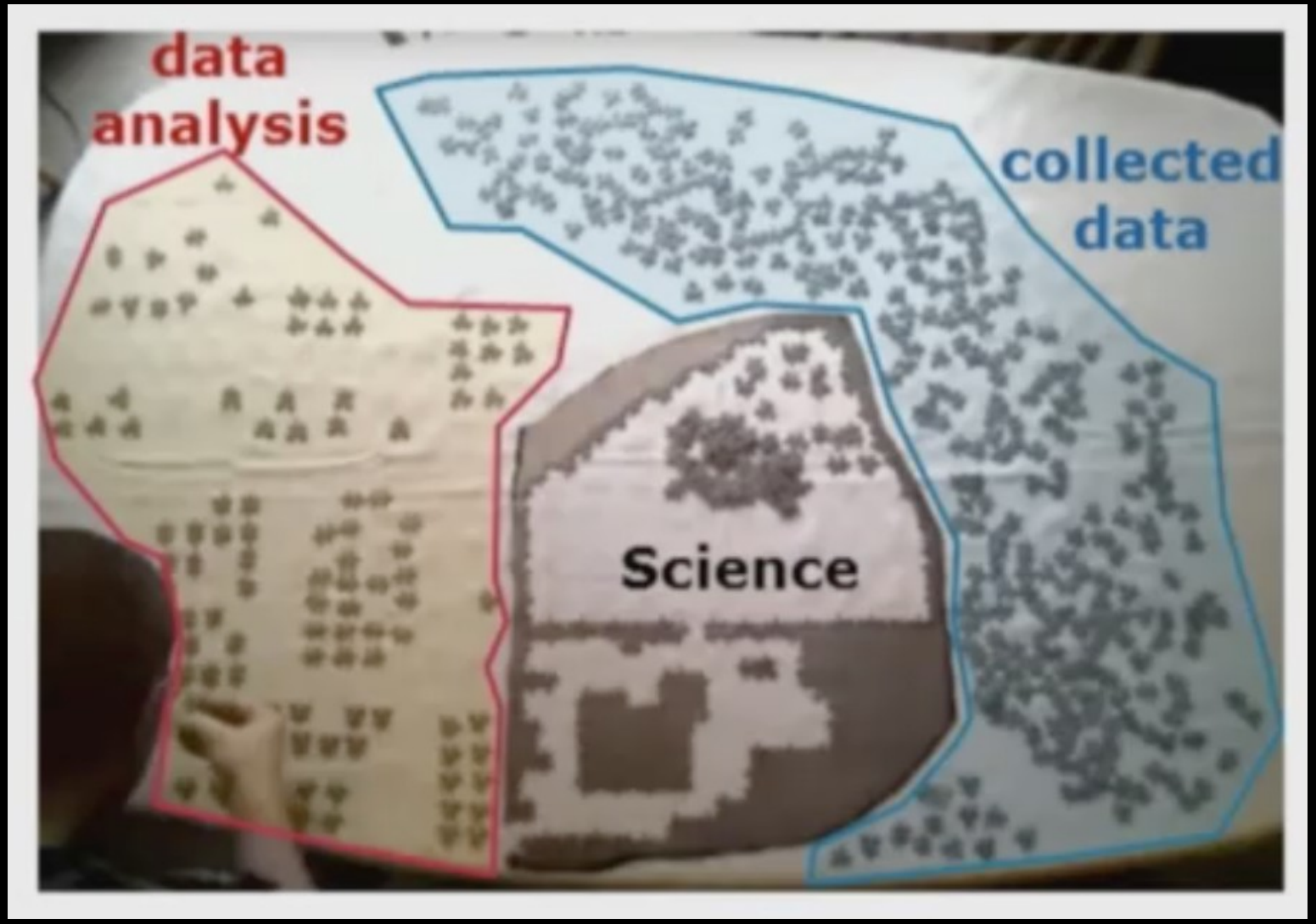
Pas de champ magnétique propre
-> contraintes sur les modèles

Couche fine de poussière

Température allant de -180 à -145 degrés

Porosité de 80%: comme une éponge

Et on fait quoi maintenant?



Penser à la prochaine mission:

- Retour d'échantillon
- Traiter un gros paquet de données
- De nouvelles découvertes dans les 10 prochaines années