

**Pint of Science**

# **La mission Hayabusa 2 et l'astéroïde Ryugu**

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d'Astrophysique de Grenoble



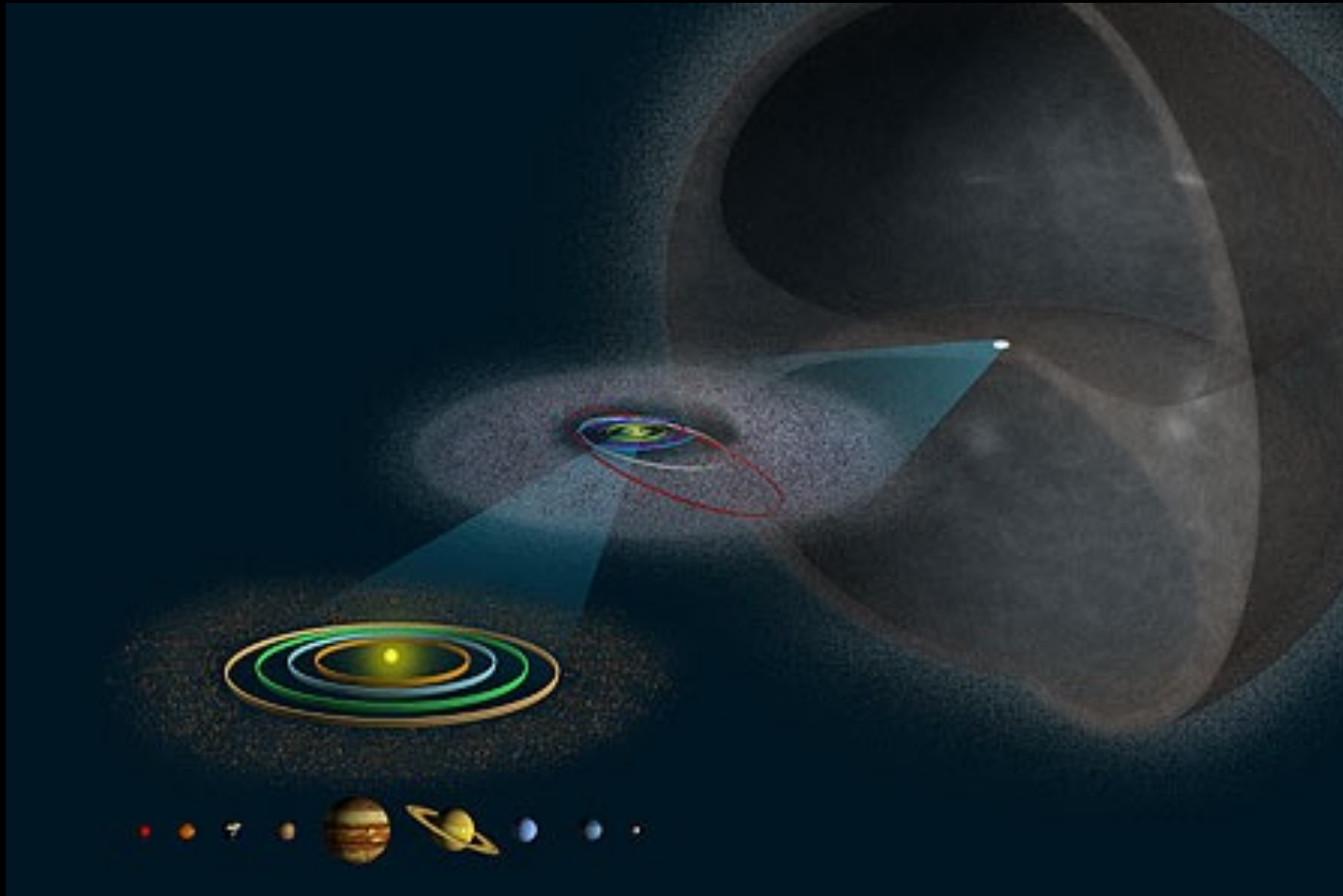
**UGA**  
Université  
Grenoble Alpes

## Petits corps: 3 réservoirs

Ceinture d'astéroïdes

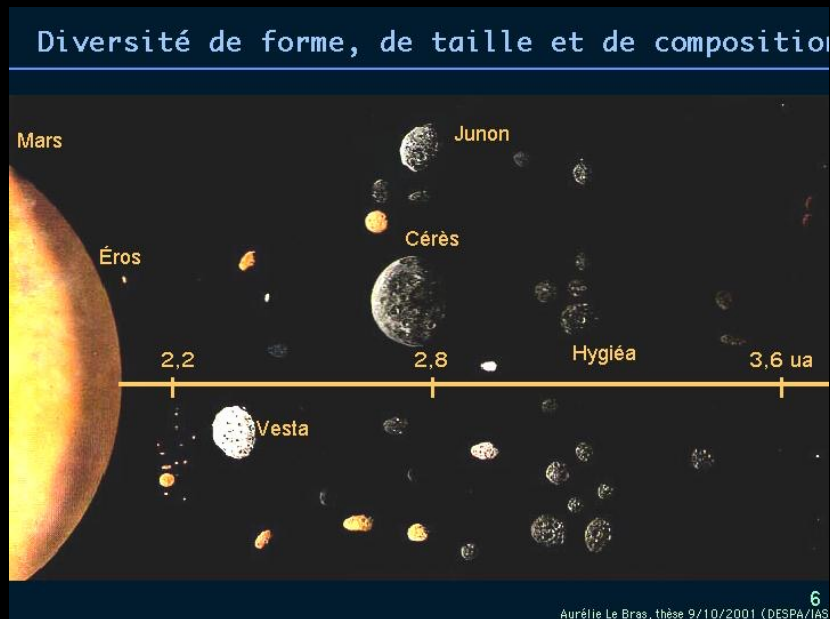
Ceinture de Kuiper

Nuage de Oort



# Les astéroïdes

## Petits corps < 500 km

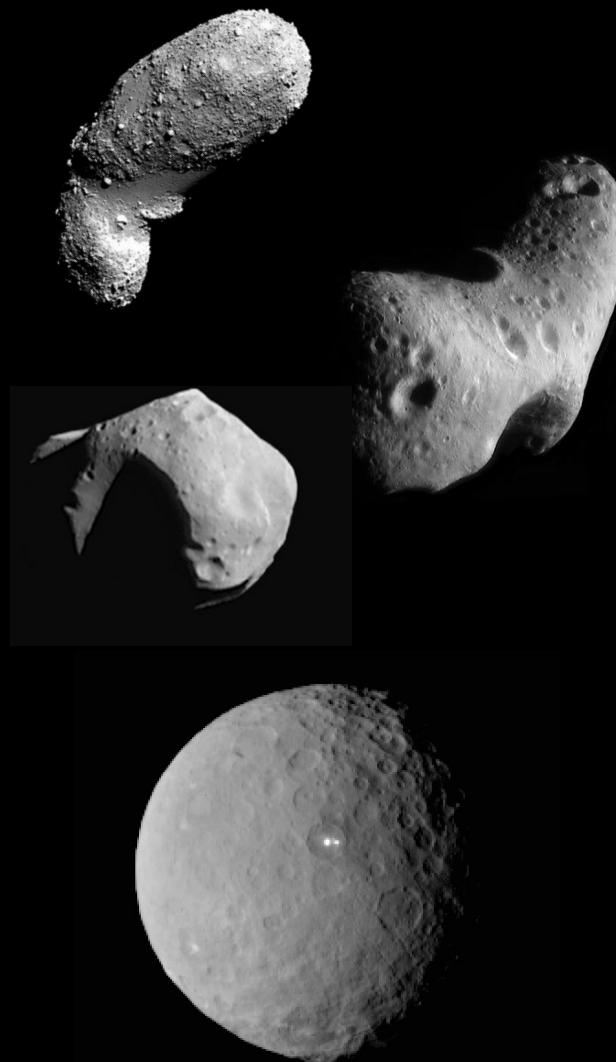
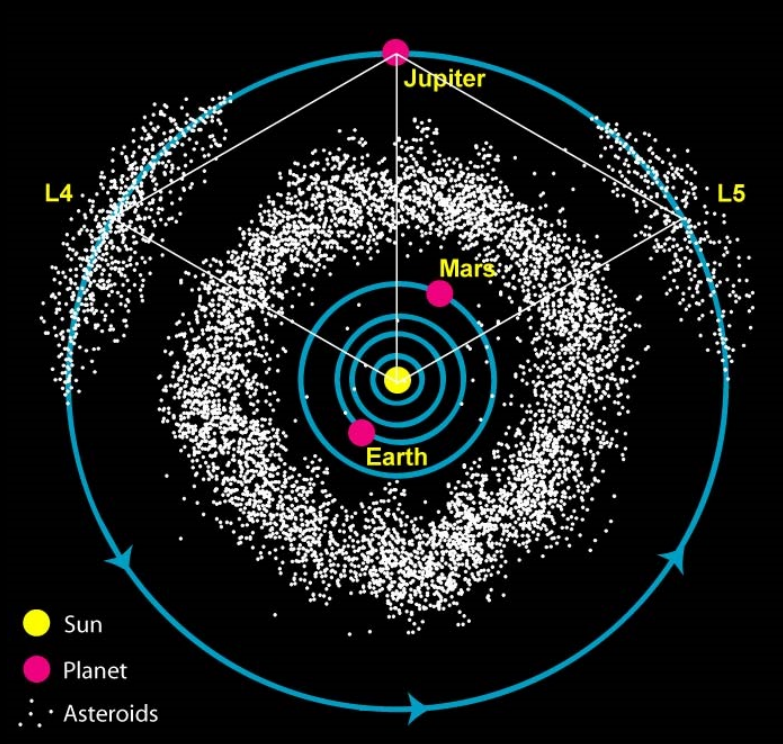


Entre Mars et Jupiter



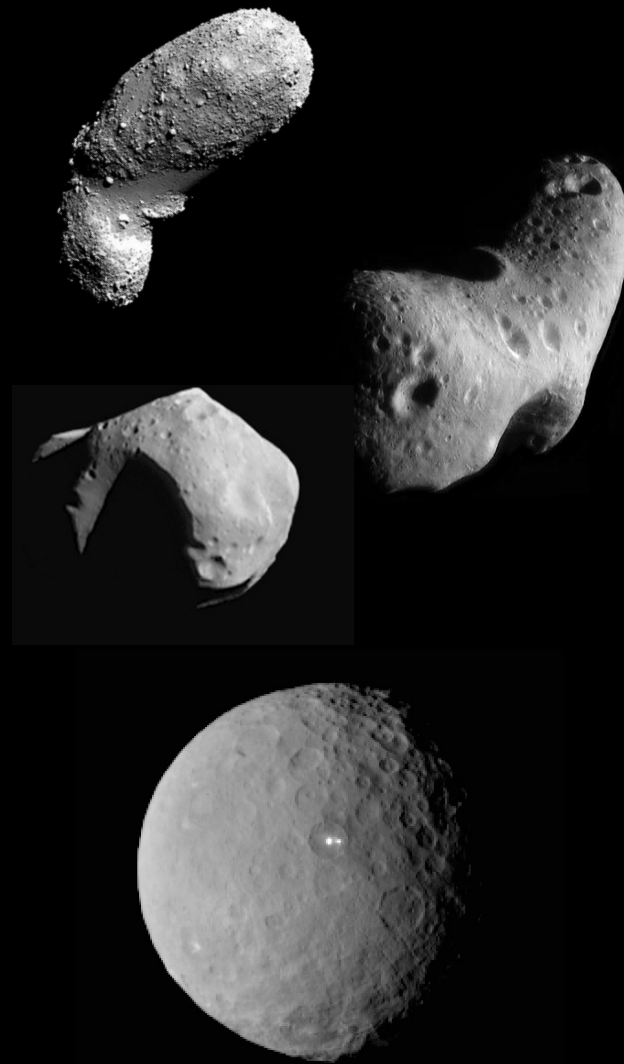
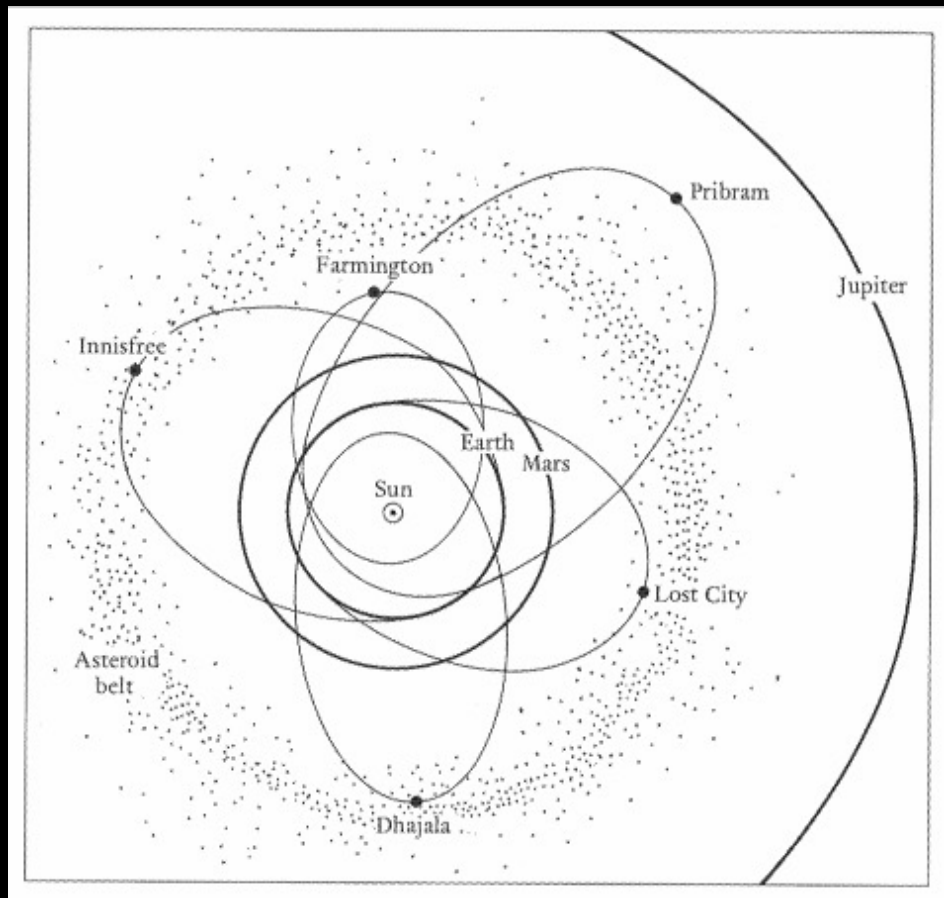
## 1. Qu'y a-t-il dans le système solaire

# Les astéroïdes

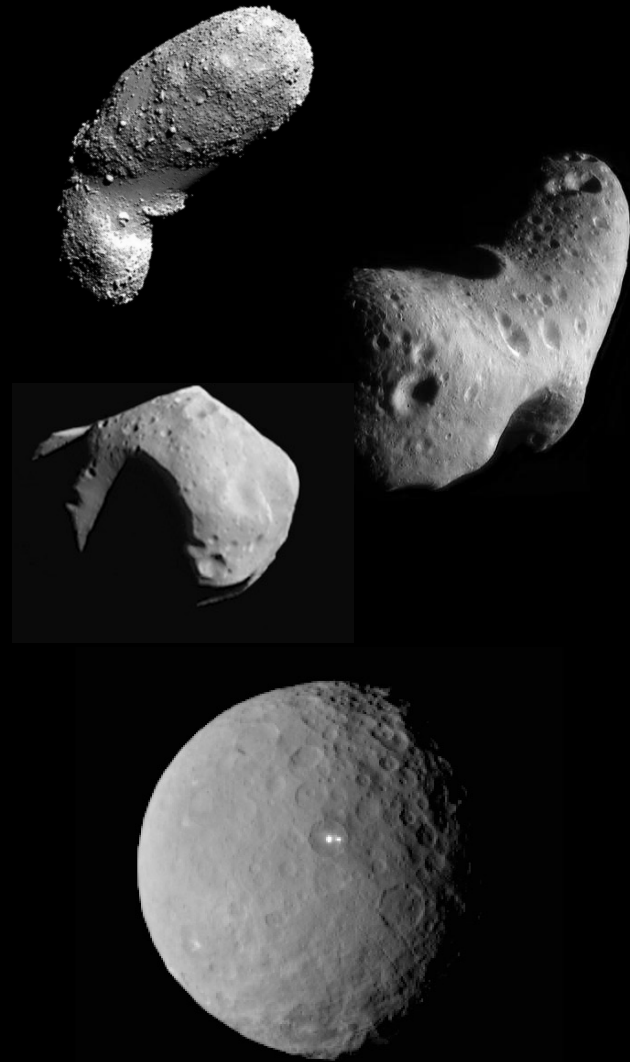
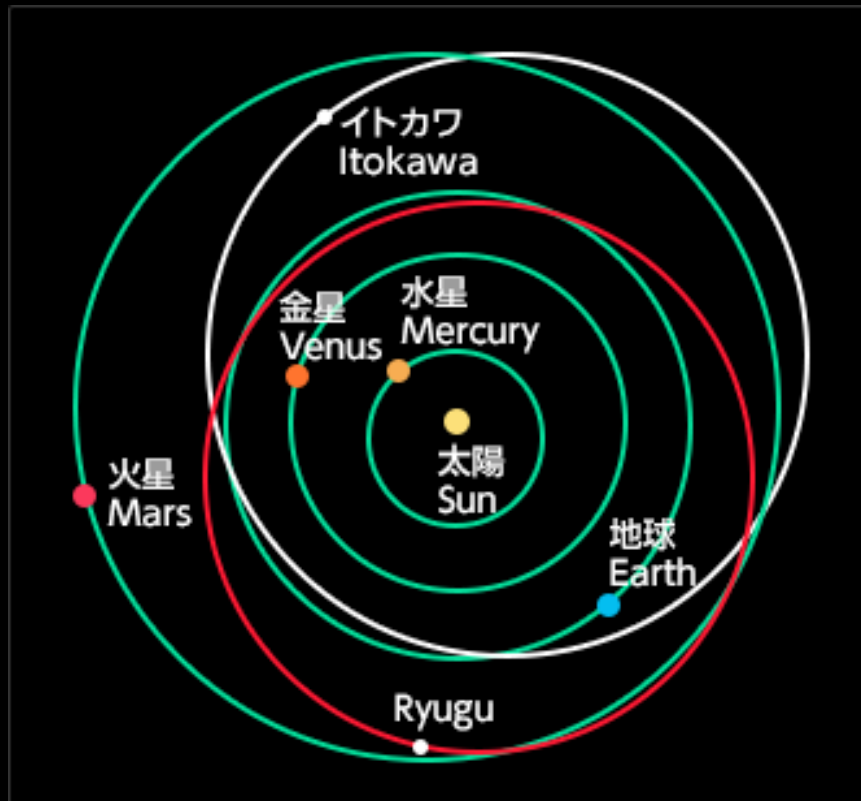




# Les astéroïdes



# Les astéroïdes





Coût = 120 M€





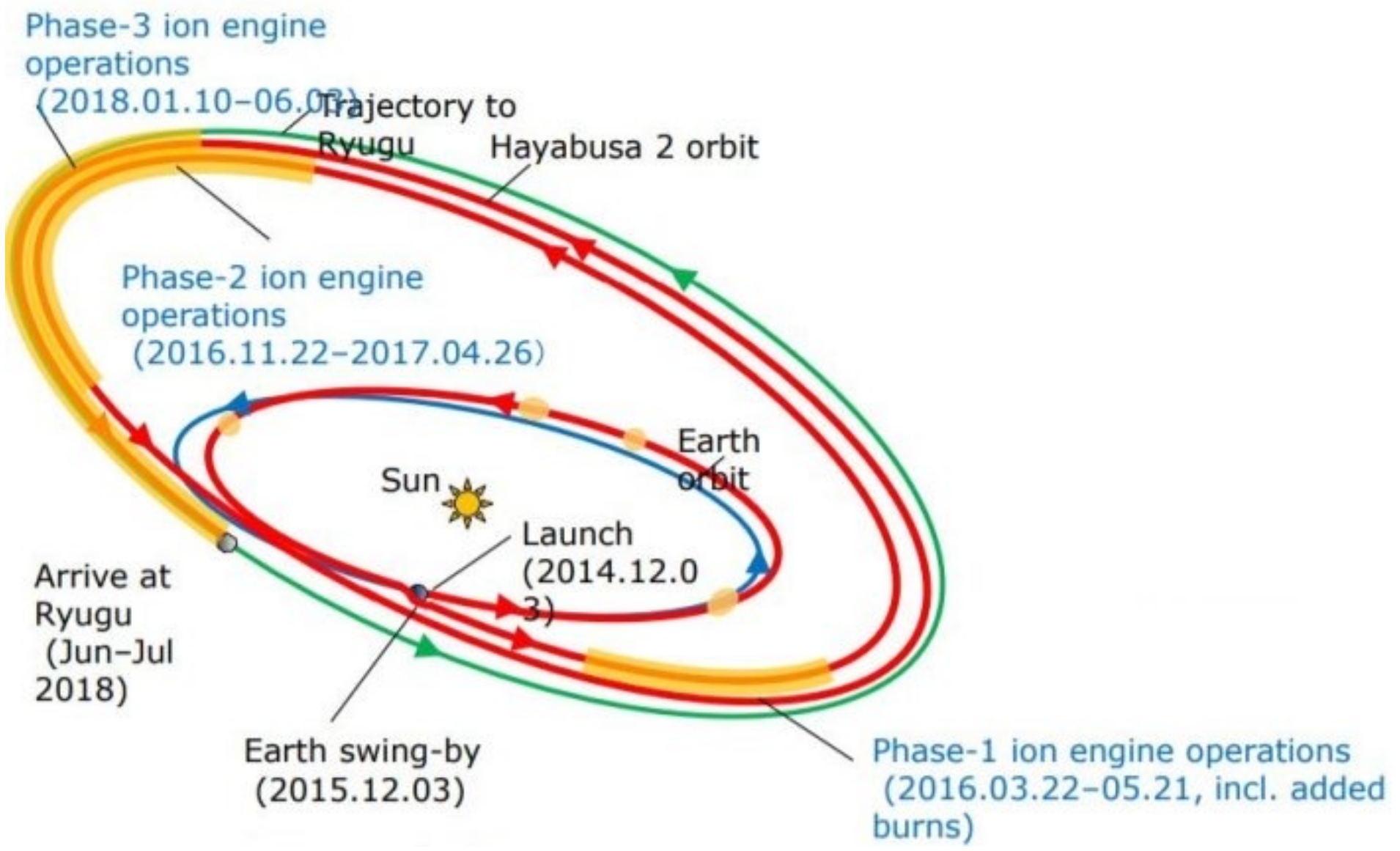
Budget 2022 Olympique Lyonnais = 250 M€



150 G\$  
=  
1000 missions Hayabusa



Amadea, yacht d'Oligarche Russe = 300 M\$





2nde opération moteur ionique  
(du 12 mai à sept 2020)

Trajet de Hayabusa 2

Orbite de  
l'astéroïde Ryugu

Orbite de  
la Terre

Soleil

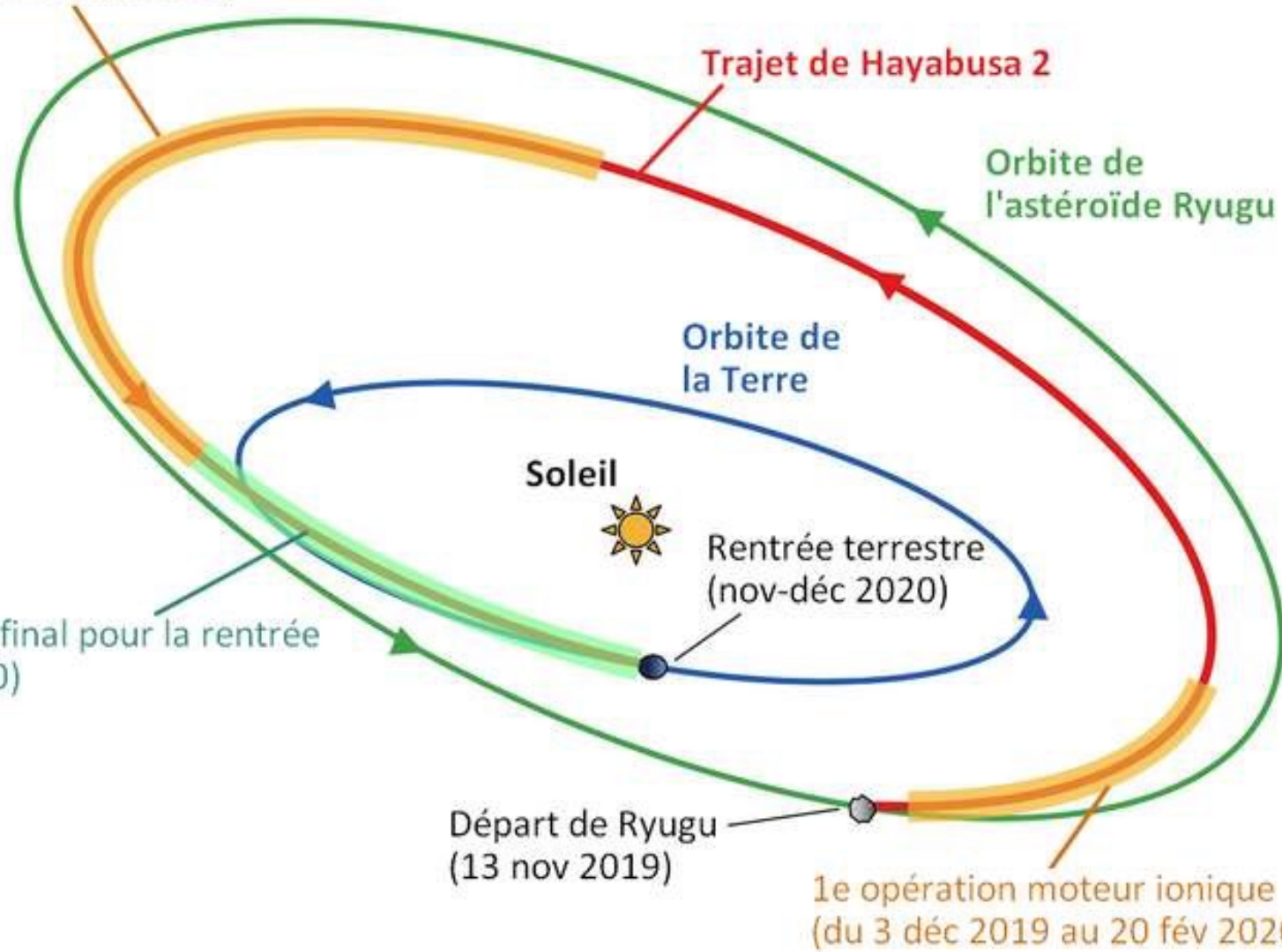


Rentrée terrestre  
(nov-déc 2020)

Guidage final pour la rentrée  
(oct 2020)

Départ de Ryugu  
(13 nov 2019)

1e opération moteur ionique  
(du 3 déc 2019 au 20 fév 2020)



Cost 150 M\$

**Launch: Dec 3, 2014**



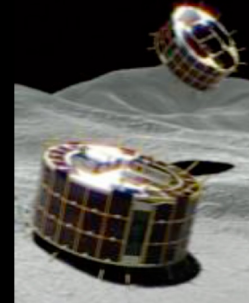
**Earth swing-by  
Dec 3, 2015**



**Ryugu arrival  
Jun 27, 2018**



**MINERVA-II1 separation  
Sep 21, 2018**



**MASCOT separation  
Oct 3, 2018**



**Target marker separation  
Oct 25, 2018**



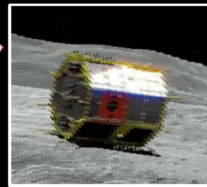
**Ryugu departure  
Nov 13, 2019**



**Earth return  
Dec 6, 2020**

(image credit: illustrations including spacecraft by Akihiro Ikeshita, others by JAXA)

**MINERVA-II2 separation  
Oct 3, 2019**



**Target marker separation  
Sep 17, 2019**



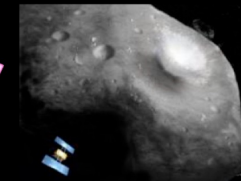
**Second touchdown  
Jul 11, 2019**



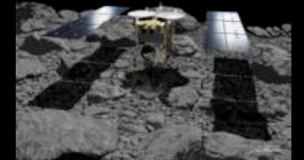
**Target marker separation  
May 30, 2019**



**Impactor (SCI)  
Apr 5, 2019**

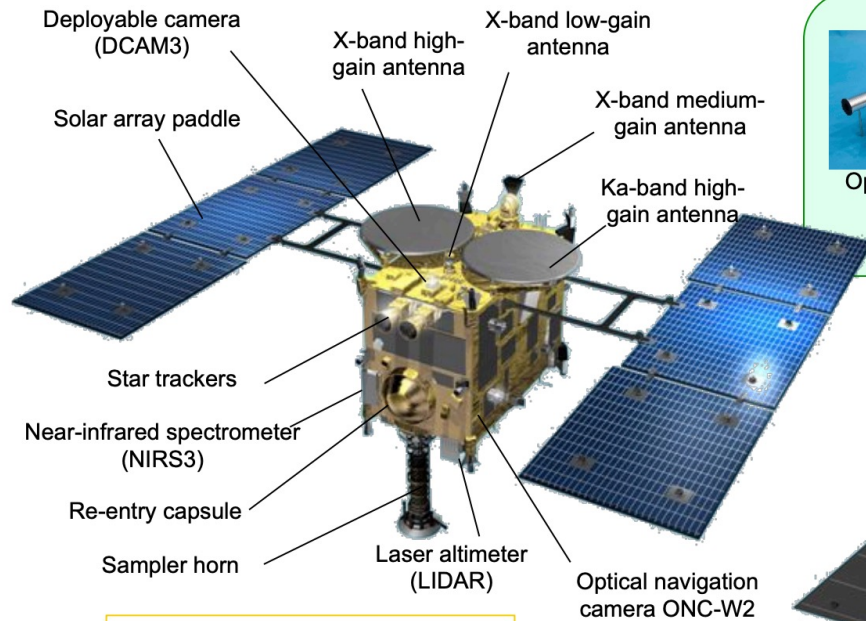
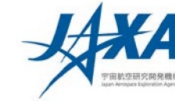



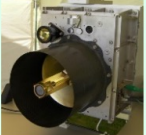
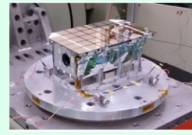
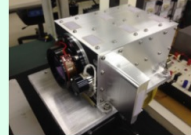
**First touchdown  
Feb 22, 2019**





# Primary spacecraft components









Optical navigation camera ONC-T    Laser altimeter LIDAR    Near-infrared spectrometer NIRS3    Thermal infrared camera TIR

**Scientific observation equipment**

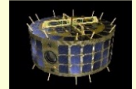
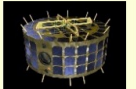
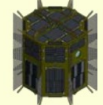
**Small lander & rover**

**MASCOT**

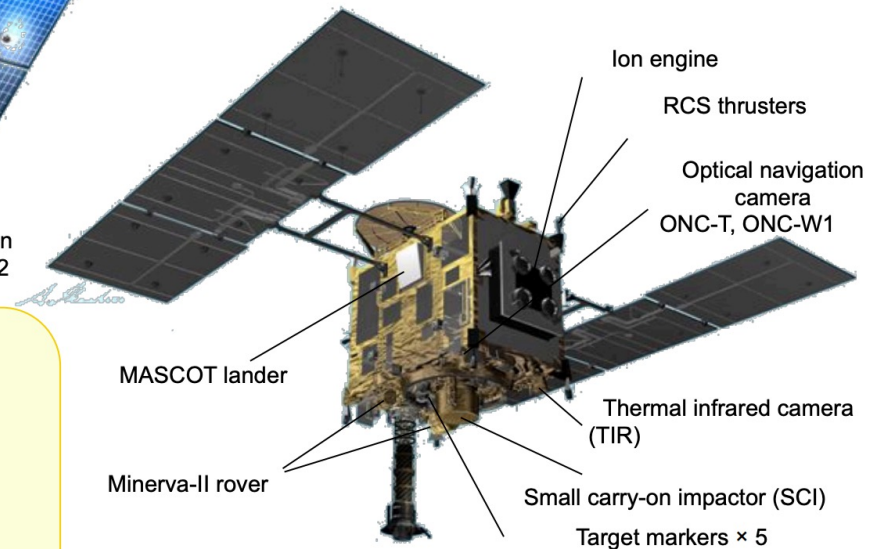


Created by DLR and CNES

**Minerva 2**

II-1: By the JAXA Minerva-II team  
II-2: By Tohoku Univ. & the Minerva-II Consortium



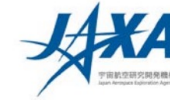
Size: 1 × 1.6 × 1.25 m (main body)  
Solar paddle deployed width 6 m  
Mass : 609 kg (incl. fuel)

(© JAXA)



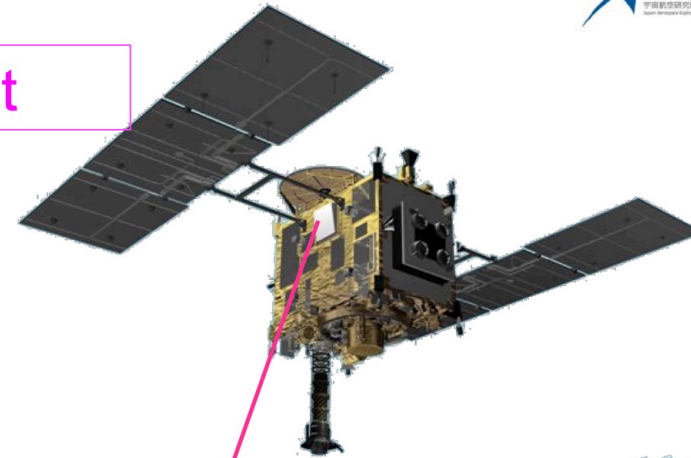


# MASCOT



## Mobile Asteroid Surface Scout

- Created by DLR (German Aerospace Center) and CNES (French National Centre for Space Studies)
- Small lander with mass approx. 10 kg
- Carries four scientific instruments
- Can move only once, by jumping



### Scientific instruments aboard MASCOT

Device	Function
Wide-angle camera (CAM)	Imaging at multiple wavelengths
Spectroscopic microscope (MicrOmega)	Investigation of mineral composition and characteristics
Thermal radiometer (MARA)	Surface temperature measurements
Magnetometer (MAG)	Magnetic field measurements



Flight model (© DLR)





UTC  
2018-06-18 03:50



UTC  
2018-06-18 04:15



UTC  
2018-06-18 04:40



UTC  
2018-06-18 06:30



UTC  
2018-06-18 23:00



UTC  
2018-06-18 23:25



UTC  
2018-06-18 23:50



UTC  
2018-06-19 04:30



UTC  
2018-06-19 04:55



UTC  
2018-06-19 05:20



UTC  
2018-06-19 22:40



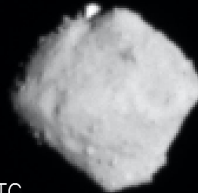
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2018-06-19 23:05



UTC  
2018-06-19 23:30



UTC  
2018-06-20 09:00



UTC  
2018-06-20 09:25

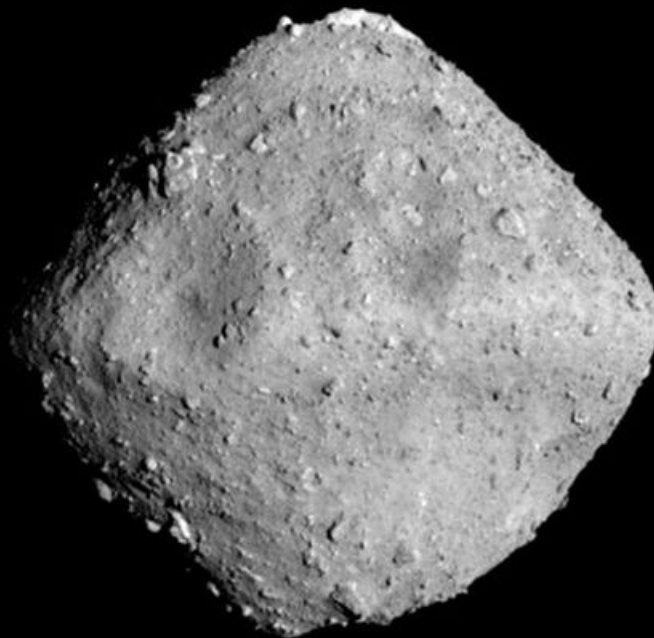


UTC  
2018-06-20 09:50





25143 Itokawa  
Hayabusa  
2005



162173 Ryugu  
Hayabusa 2  
2018

# Ryugu

Taille comparée  
de l'astéroïde



**Taipei  
101**  
*Taipei*  
Taïwan  
508 m

**Tour  
Eiffel**  
*Paris*  
France  
324 m

**Ryugu**  
*à 300 millions de km  
de la terre*  
**Approx. 900 m**

**Burj  
Khalifa**  
*Dubai*  
EAU  
830 m

**Sky  
Tree**  
*Tokyo*  
Japon  
634 m

Source : Jaxa

© AFP

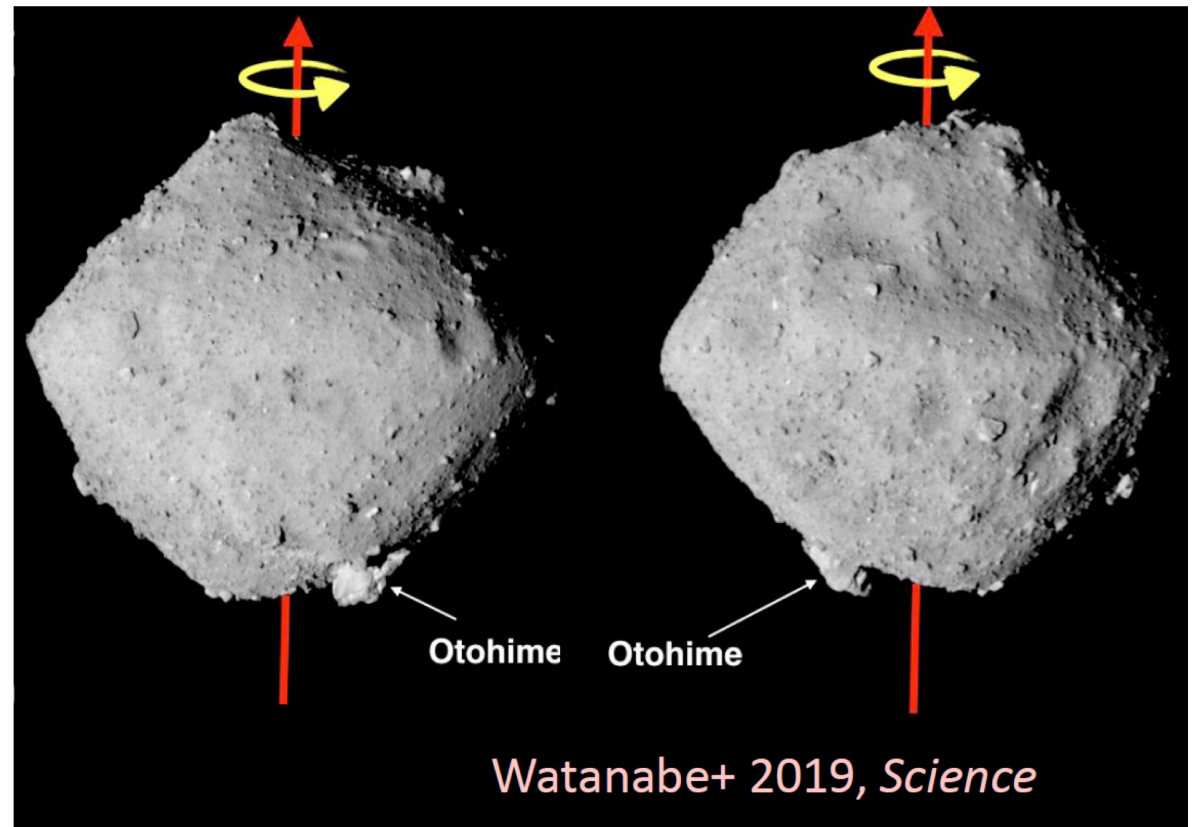
Obliquité: 172°. période: 7.63h  
Rayon équatorial = 502 +/- 2 m  
Densité: 1.19 g/cm<sup>3</sup>  
(porosité: > 50 %)

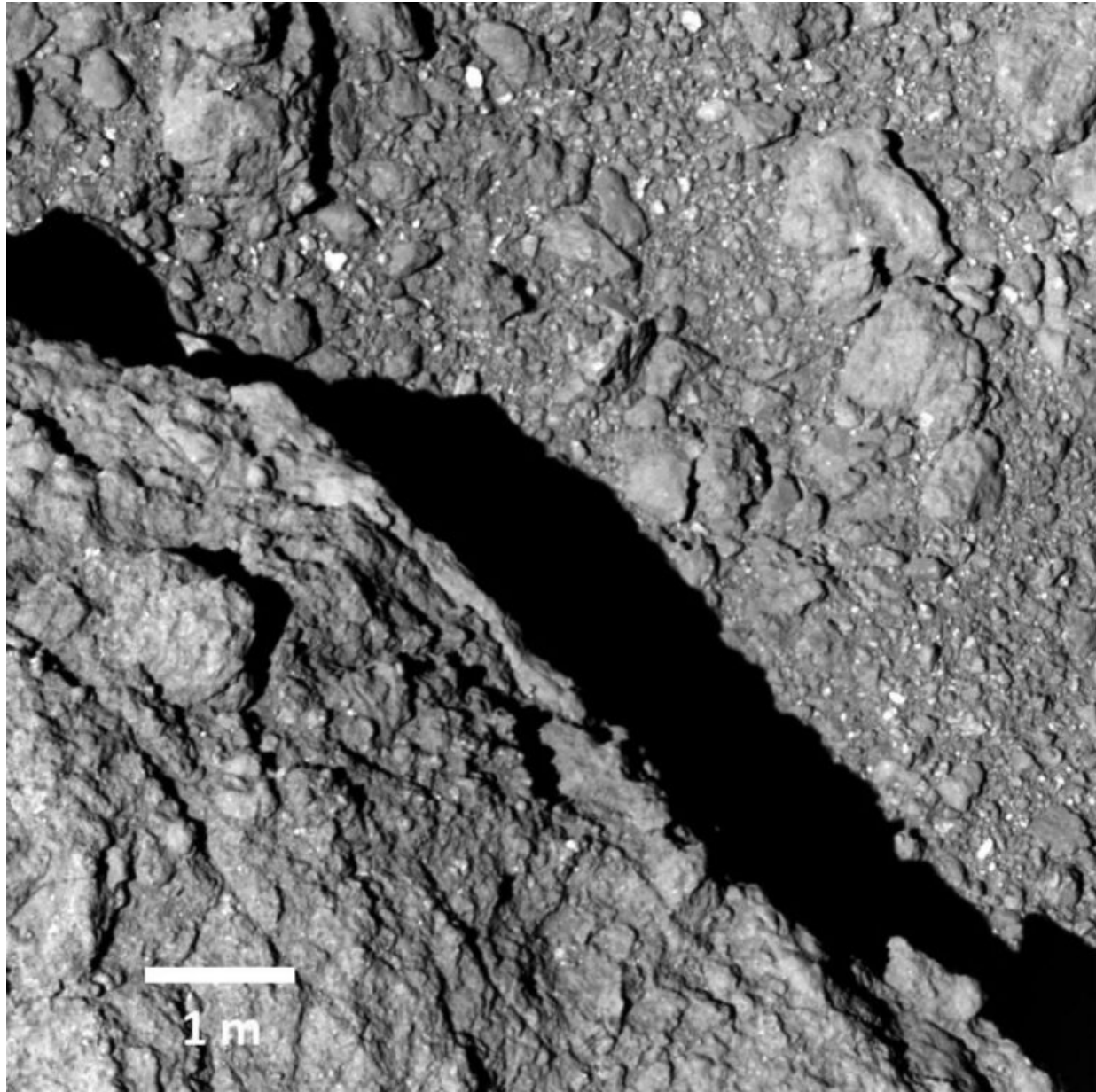
Albédo (moyen): 4.5 %

**Renversé !**

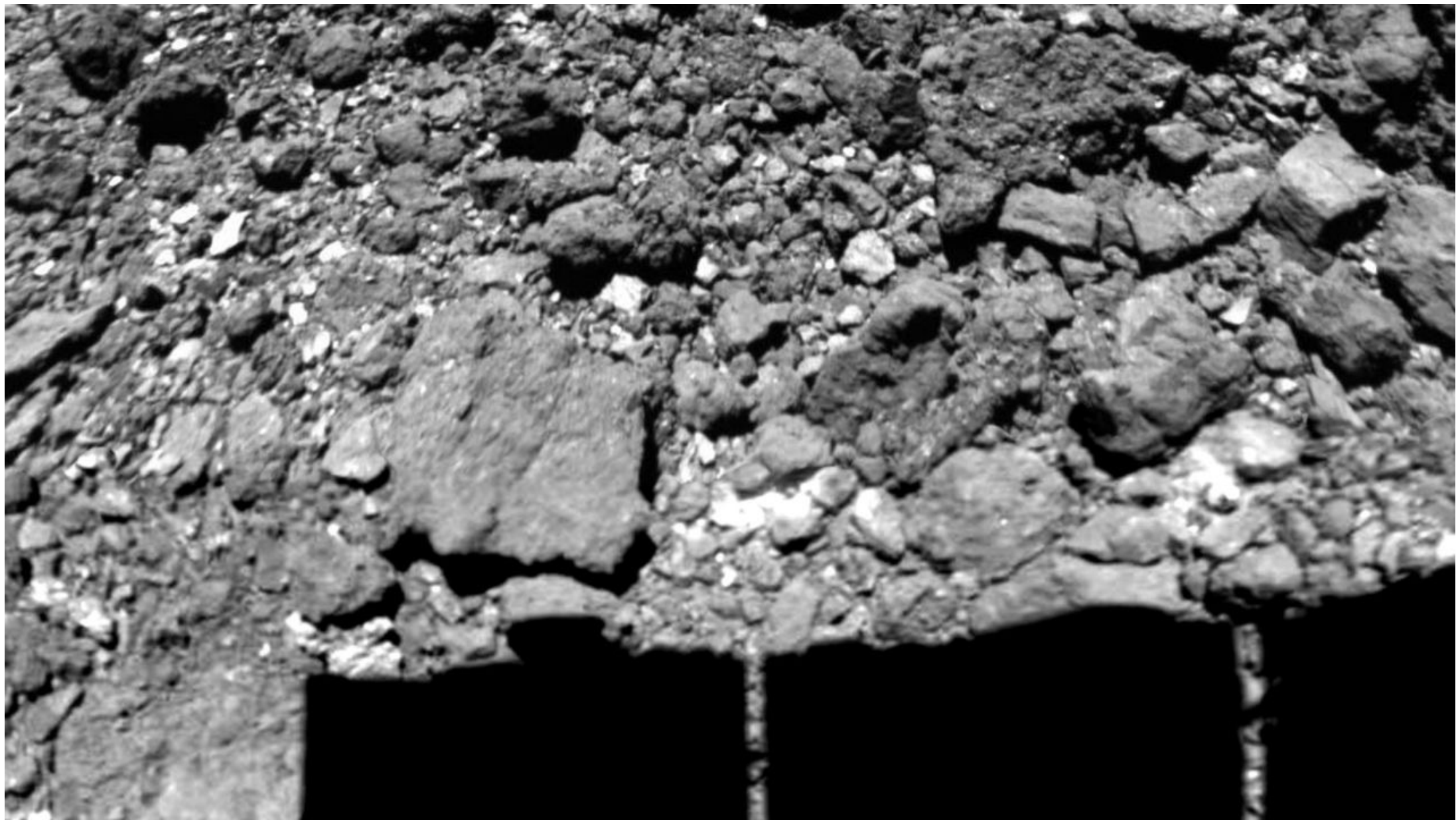
**Très vide !**

**Très sombre !**





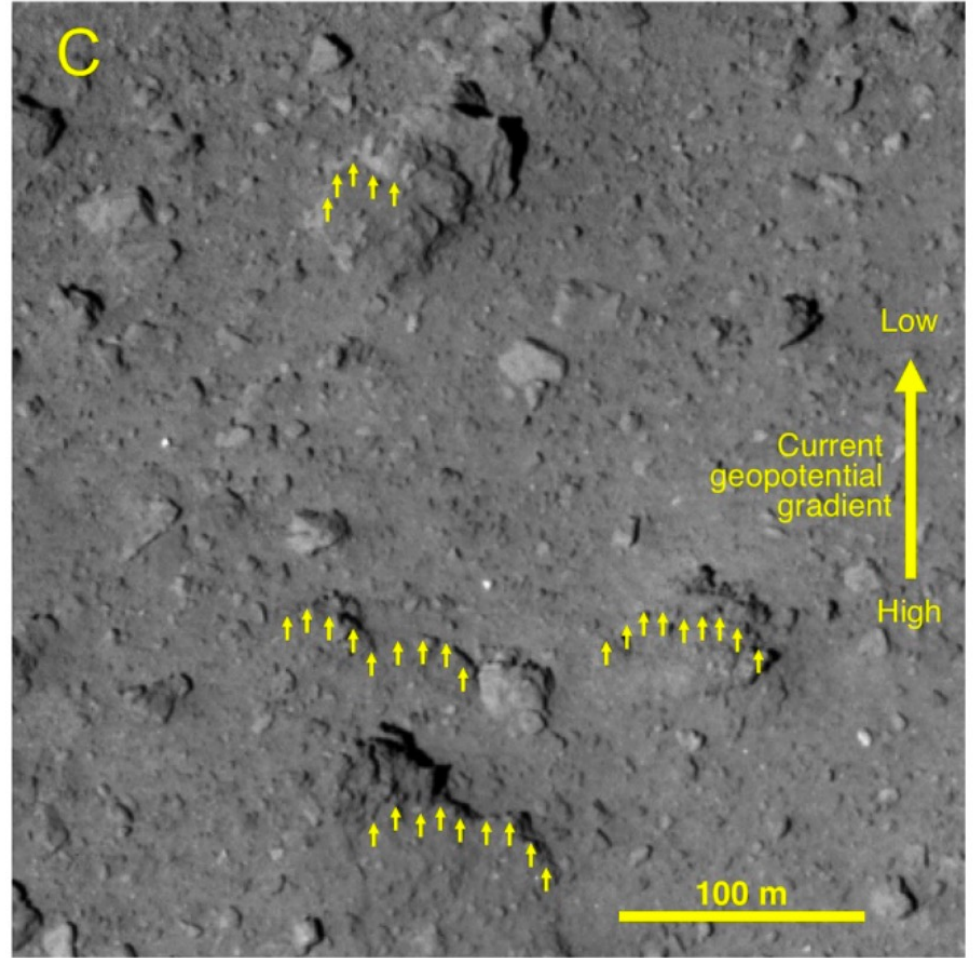
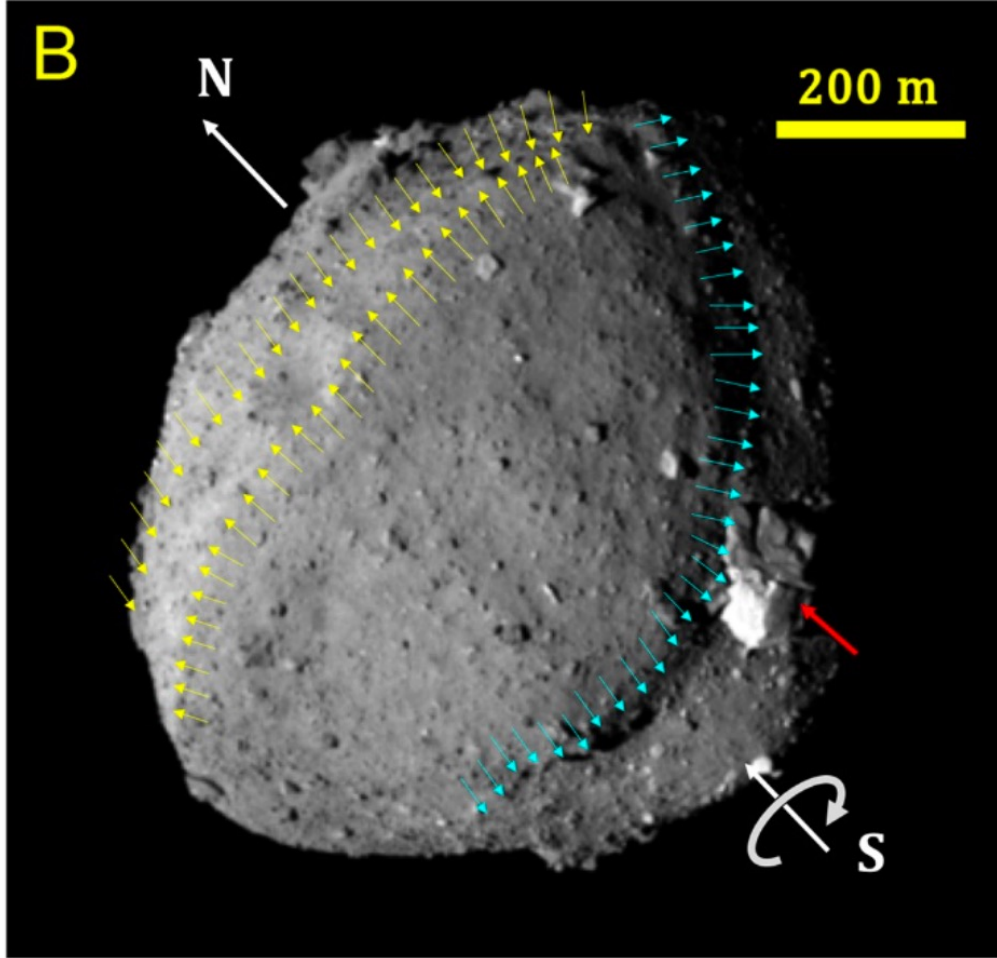




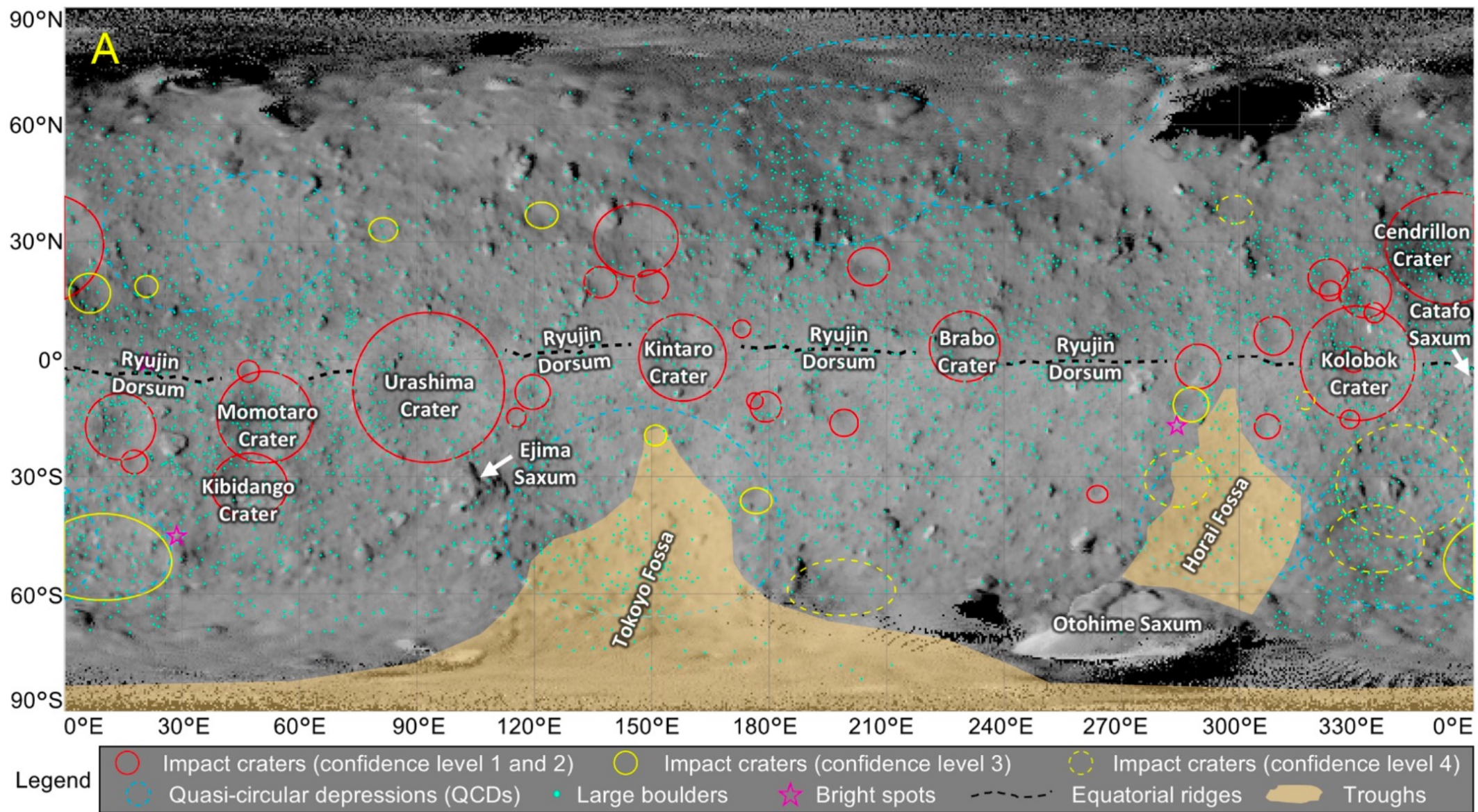


**MASCOT:**  
Surface illuminée par des diodes  
MASCOT a fonctionné pendant 17h à la surface de Ryugu avant la fin des batteries  
—> présence non flagrante de poussière fine

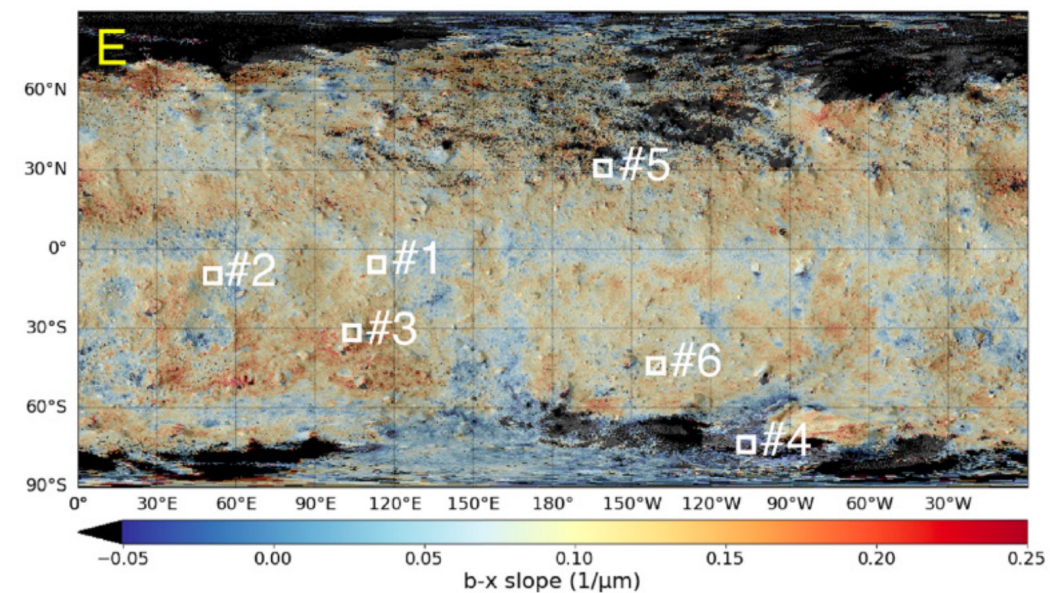
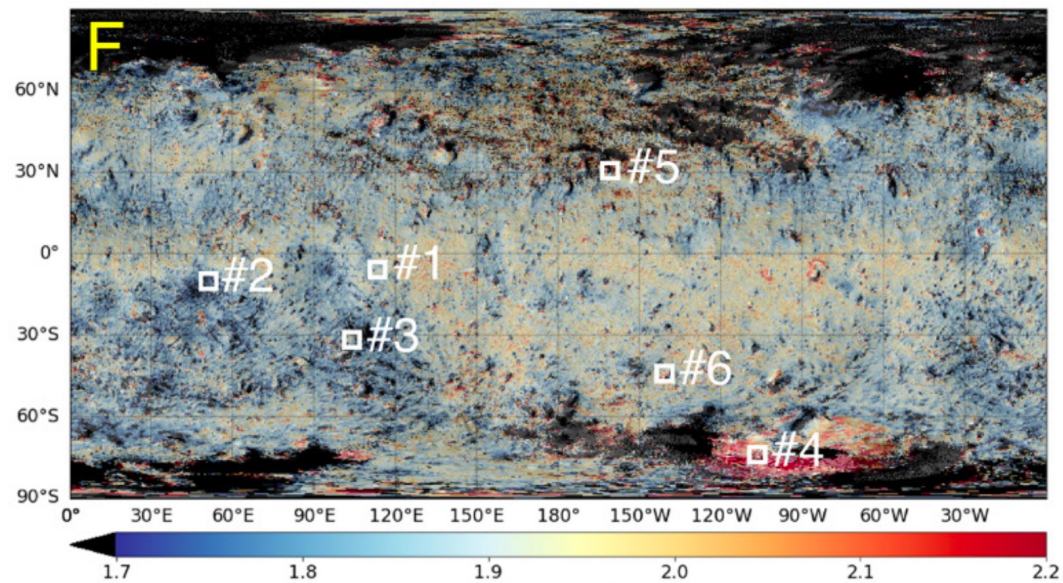
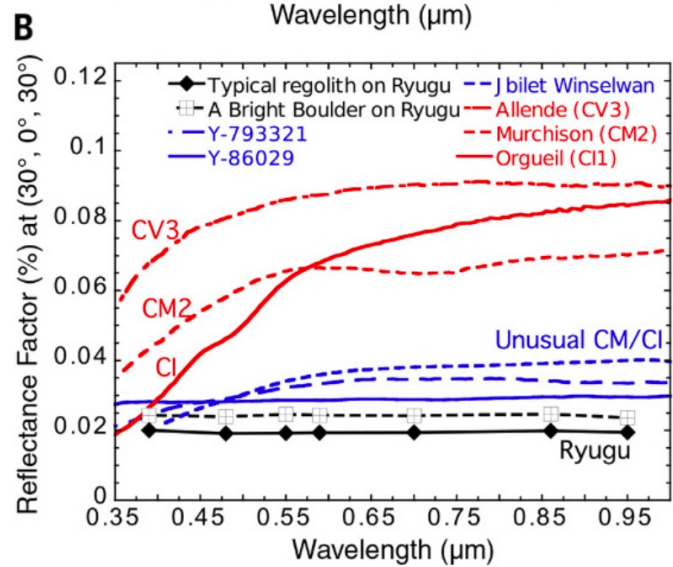
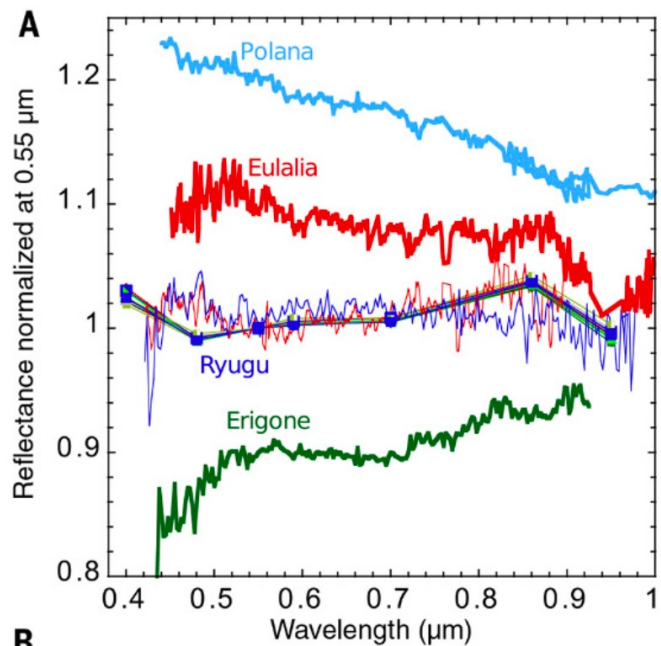


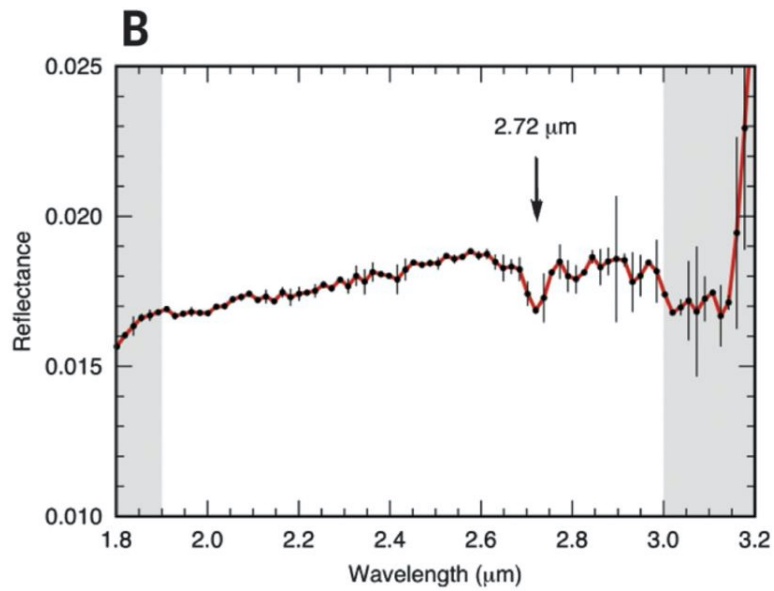
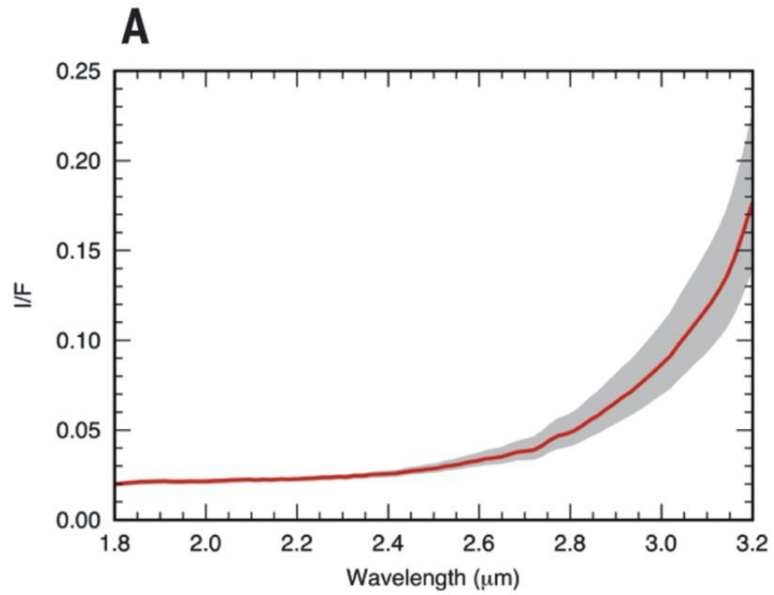




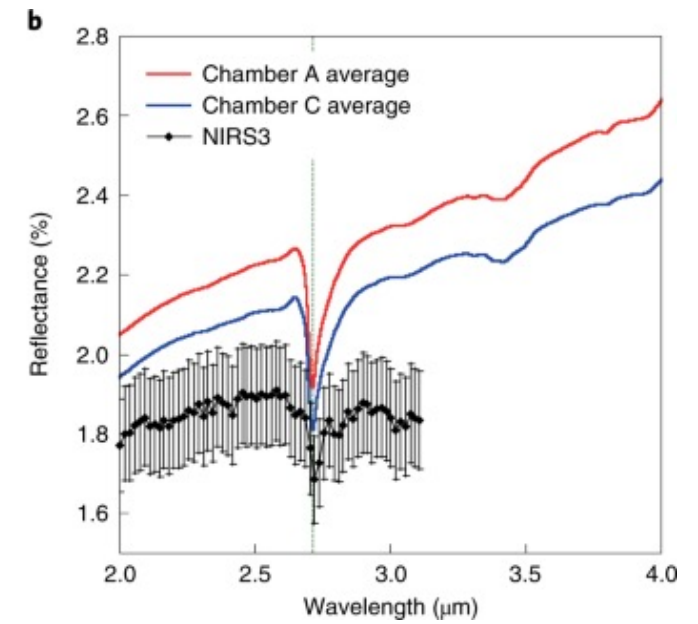
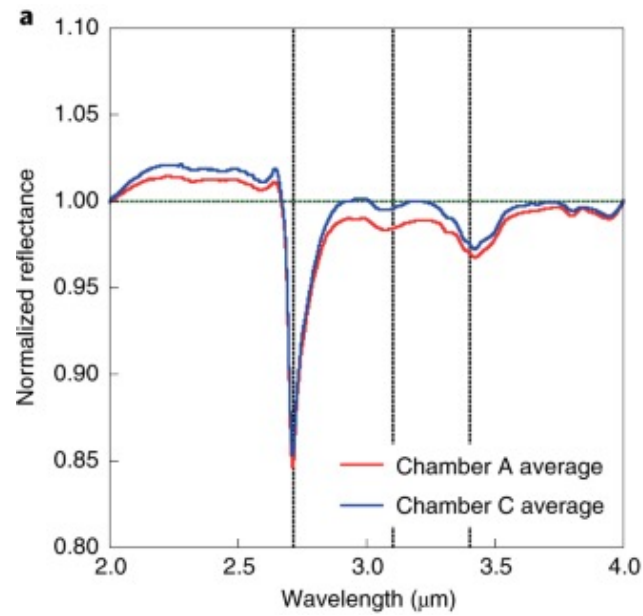








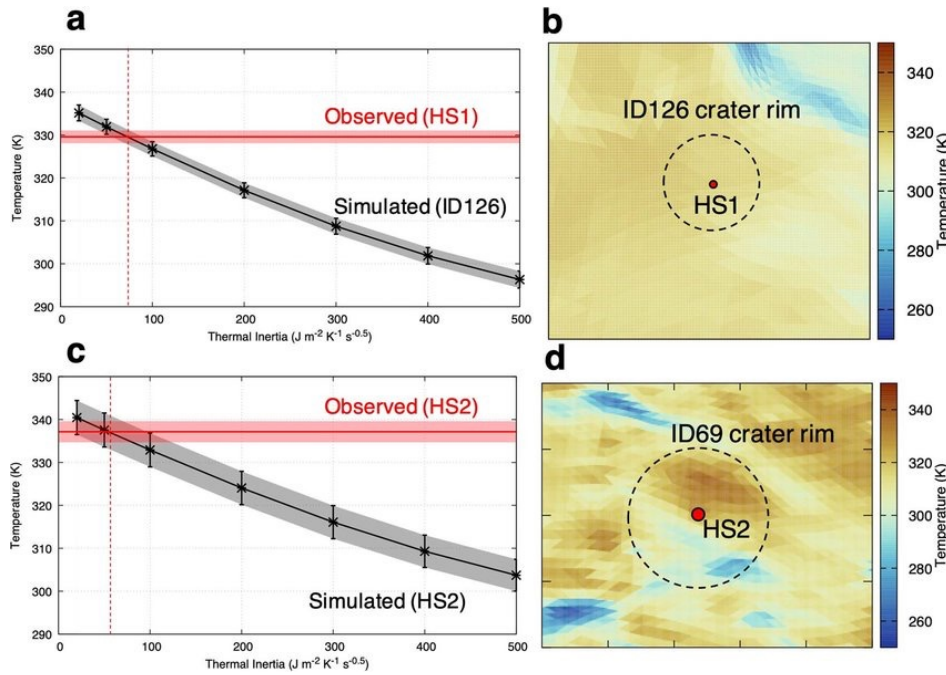
**De l'eau sur Ryugu !... Sous forme de -OH  
Minéraux argileux riches en magnésium**



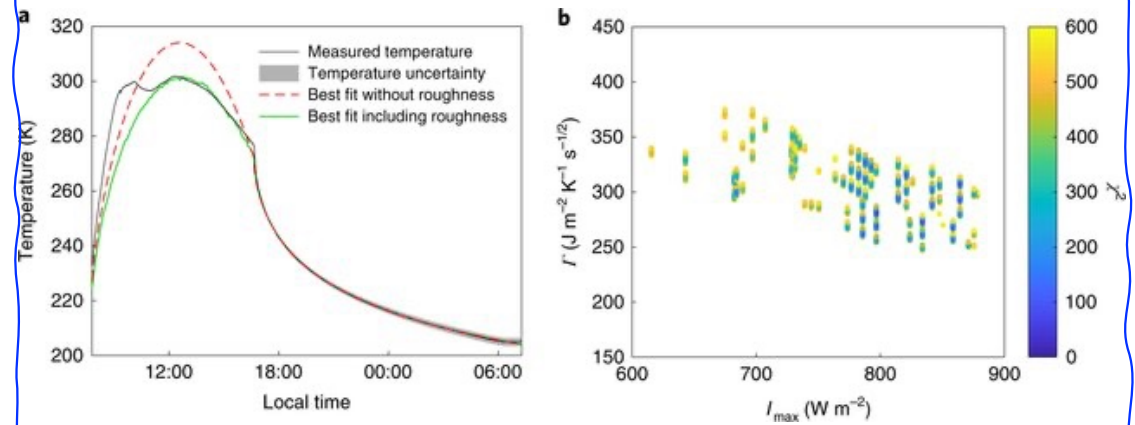
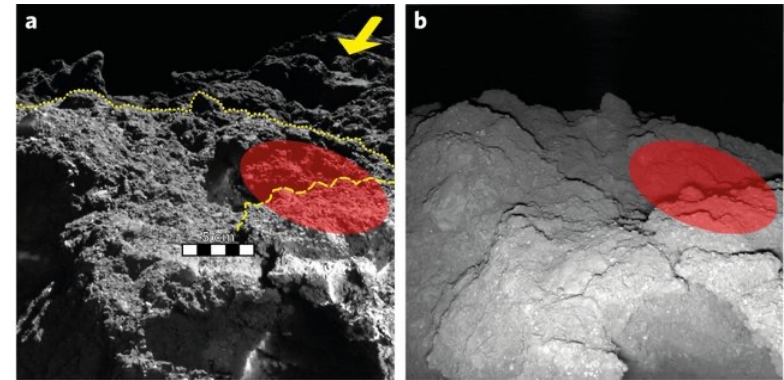


Thermal inertia: $I$ [ $J^{-2} s^{-0.5} K^{-1}$ ]	Surface physical state	Example
~10	Very fluffy, high porosity (~80 %)	Ceres, Martian soils
~50	Fine sand ( $d < 100 \mu m$ )	Lunar regolith
100~200	Sandy regolith ( $d \sim mm$ )	Eros soil
200~400	Pebbles ( $d \sim cm$ )	Itokawa flat terrain (Muses-C Regio)
400~1000	Boulders, rock fragments ( $d < m$ )	Itokawa rough terrain
1000~2000	Rocks with high porosity	
2000~	Monolithic rocks	

### Mesure à large échelle (TIR/orbiteur)



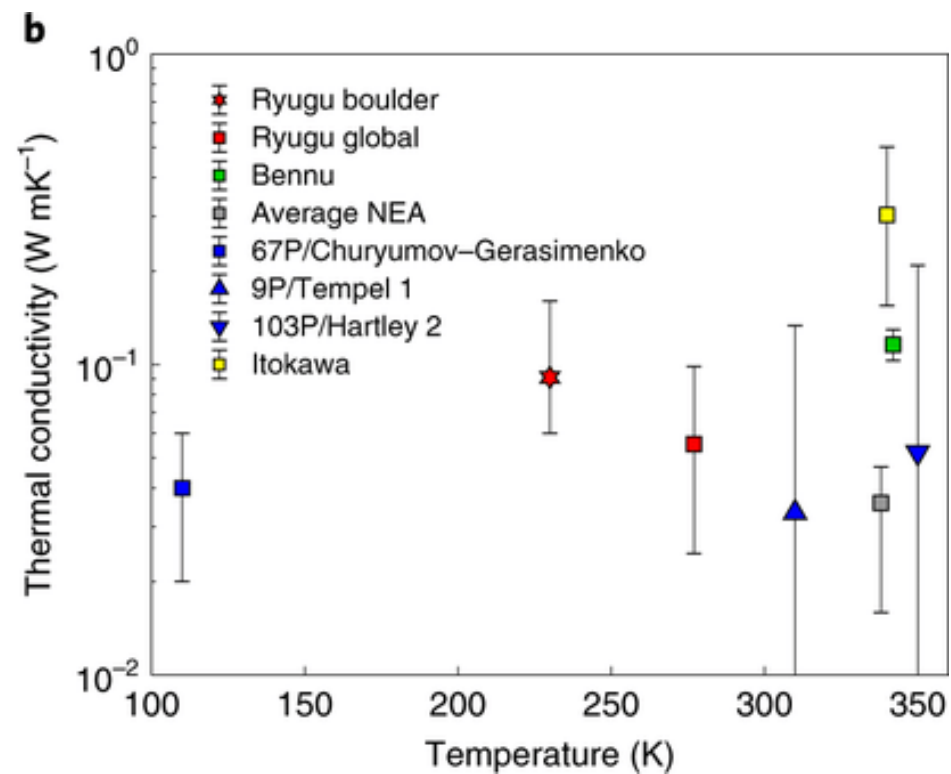
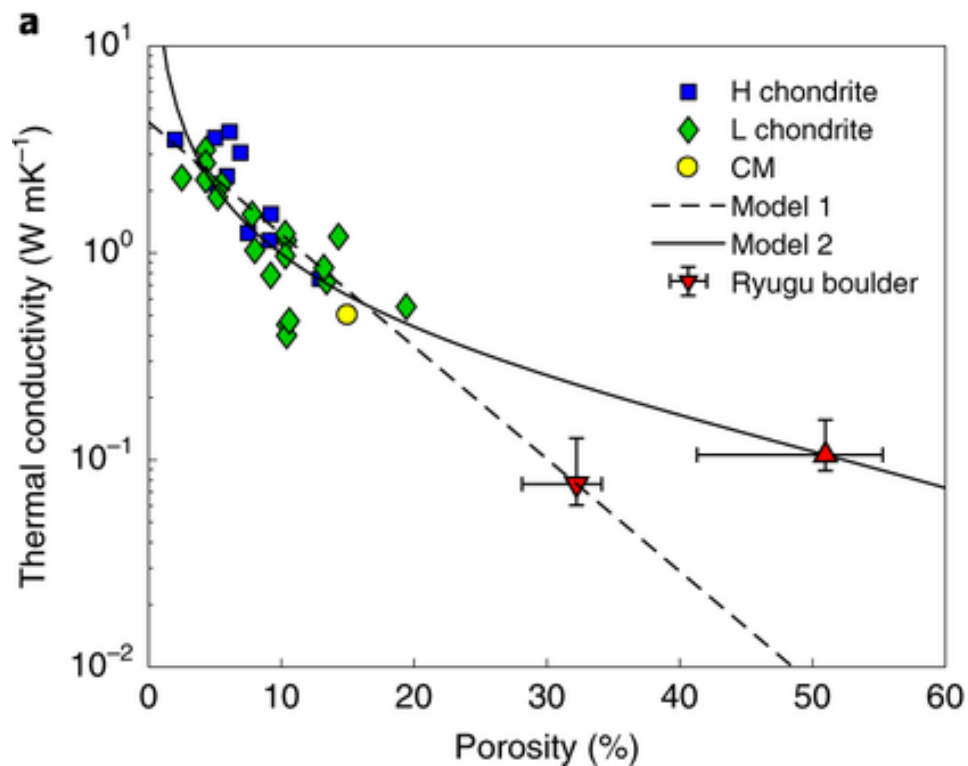
### Mesure sur un boulder (MARA/MASCOT)

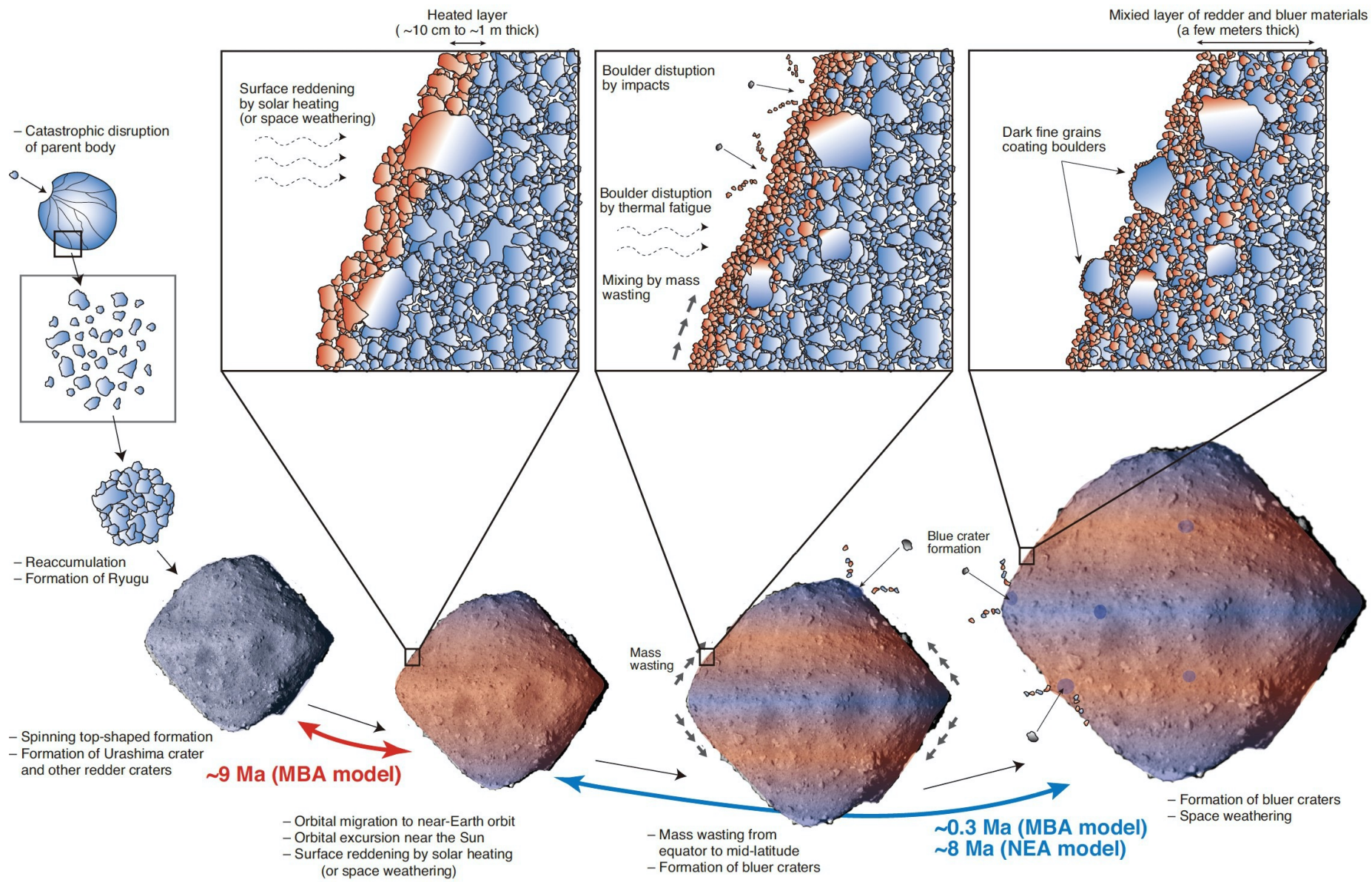


Porosité >> aux météorites

Matériau fragile, mal représenté dans les collections

Bulk density de Ryugu = 1.19 (50% porosité)







**Et la vérité terrain à présent ....**









