

Cassini and its 'Grand' Tour of the Saturn System

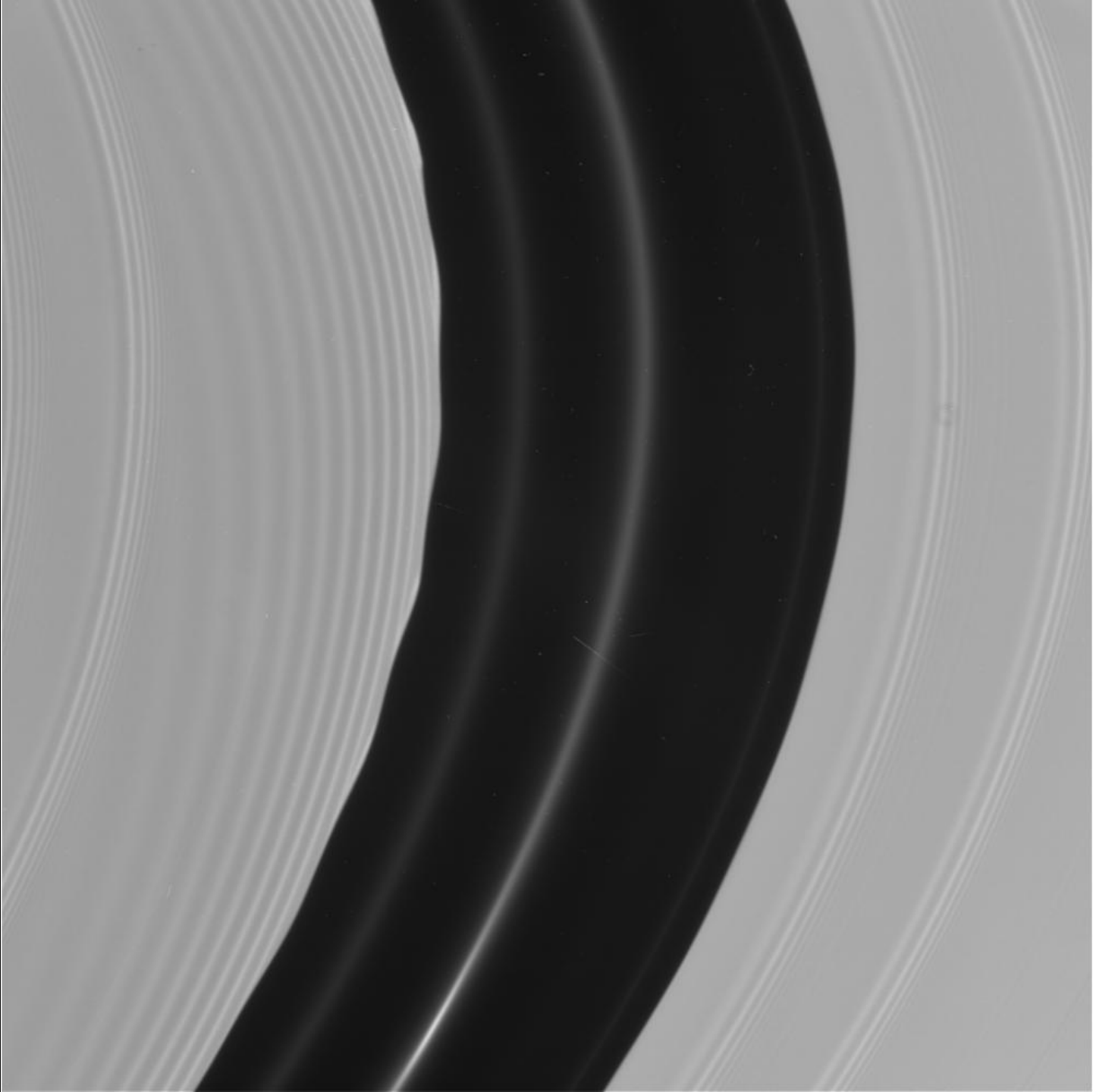
Emily Martin



Smithsonian Institution

National Air and Space Museum
Center for Earth and Planetary Studies

NASA/JPL/SSI/PIA06099



March 10th, 2006



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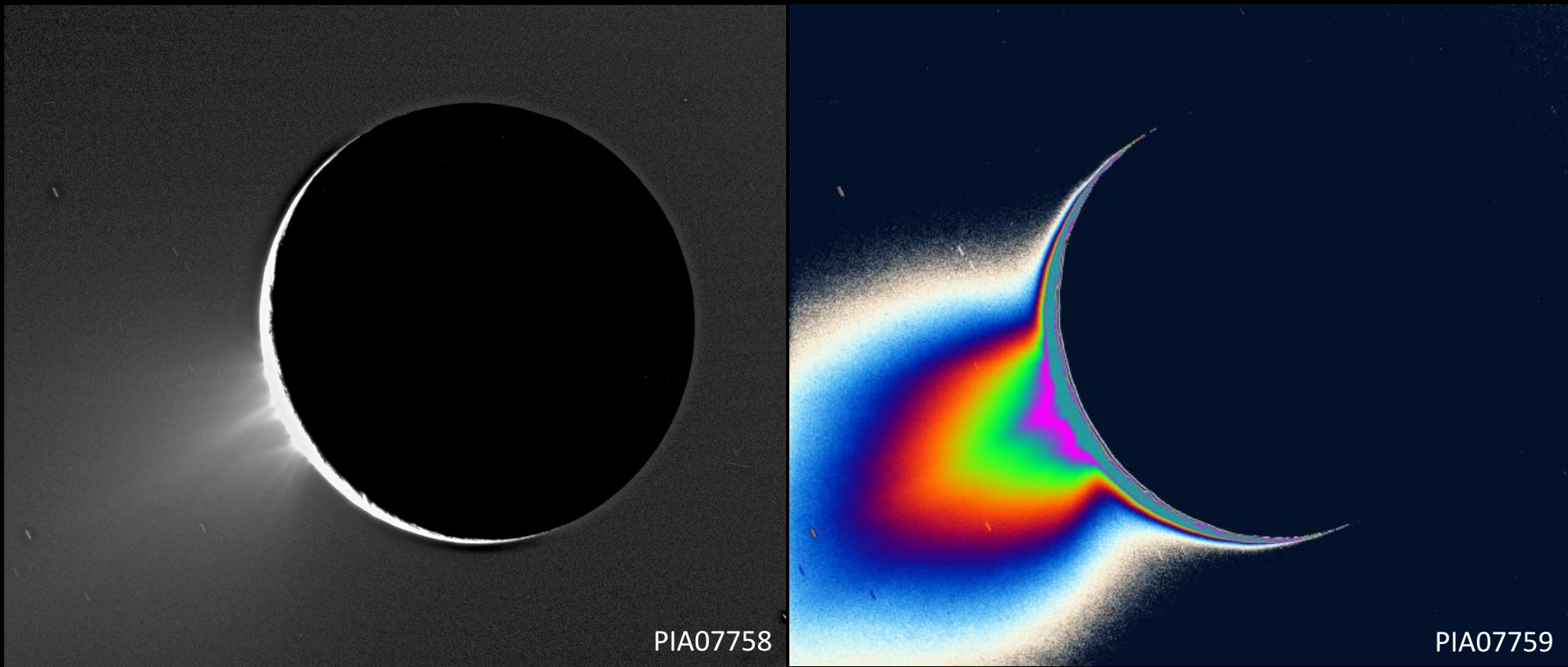
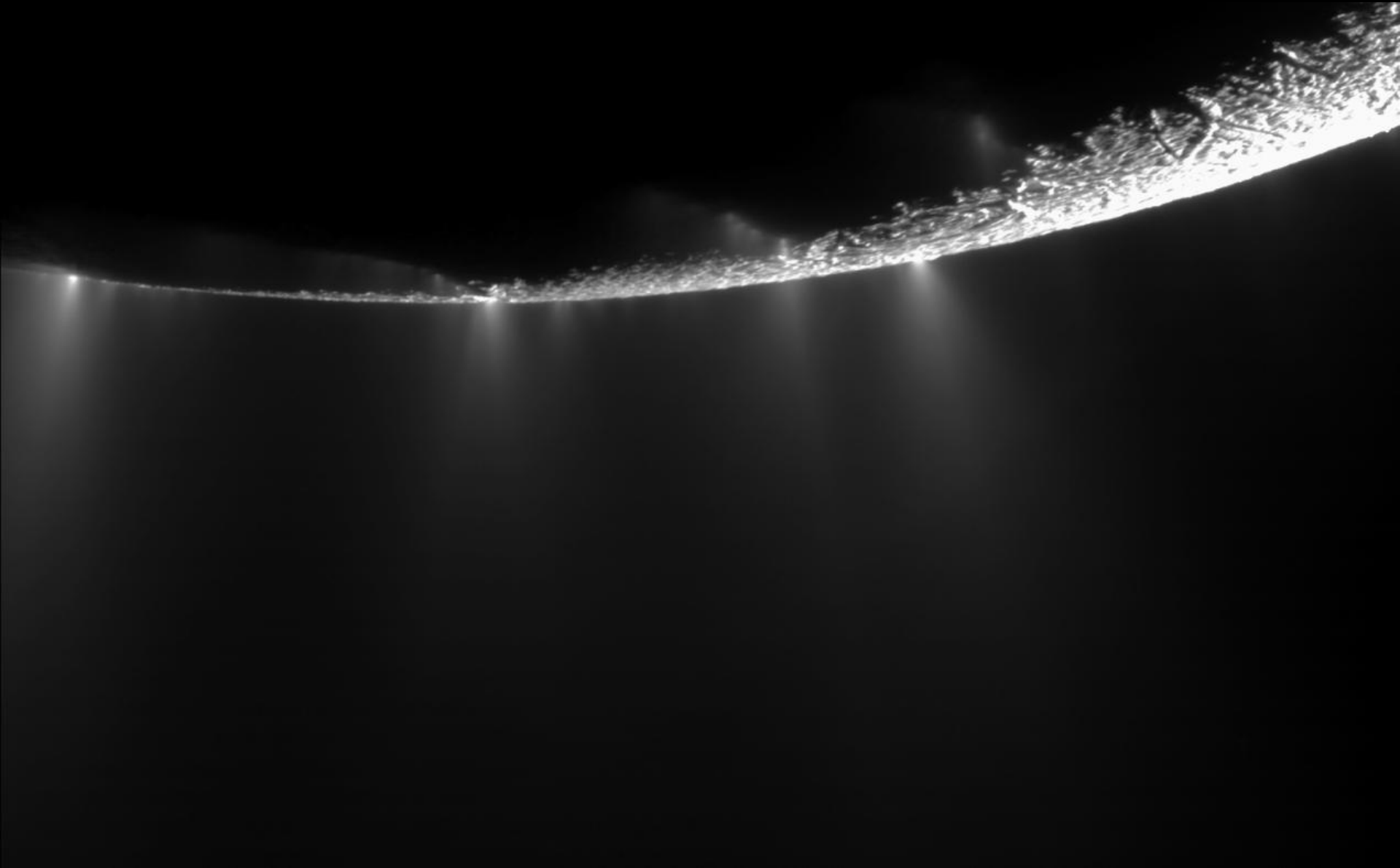


Fig. 6. (A) An ISS NAC clear-filter image (12) of Enceladus' near-surface plumes (which can be resolved into individual jets) taken on 27 November 2005 at a phase angle of 161.4° with an image scale of ~ 0.89 km/pixel. The subspacecraft latitude was $+0.9^\circ$; the view on this day was also

broadside to the tiger stripes (Fig. 1). The south pole is pointing toward the lower left. **(B)** A color-coded version of (A), in which faint light levels were assigned different colors to enhance visibility, shows the enormous extent of the fainter component above the south polar region.

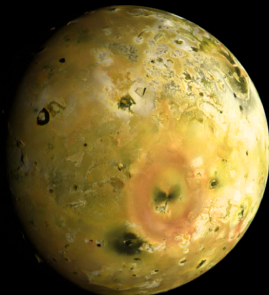


The Not-Planets

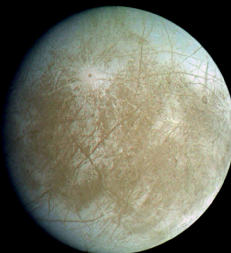
Many large round worlds are not currently classified as planets: the solar system's major moons, the largest asteroids, and large Kuiper belt objects. These are the ones spacecraft have visited.

Images from Galileo (Jupiter's moons), Cassini (Saturn's moons), Voyager 2 (Uranus and Neptune's moons), New Horizons (Pluto), Dawn (asteroids). Data from NASA/JPL/JHU/APL/SwRI/UCLA/MPS/DLR/IDA processed by Ted Stryk, Gordan Ugarkovic, Emily Lakdawalla, and Jason Perry. Earth's Moon photo by Gari Arrillaga. Montage by Emily Lakdawalla, The Planetary Society, blog@planetary.org.

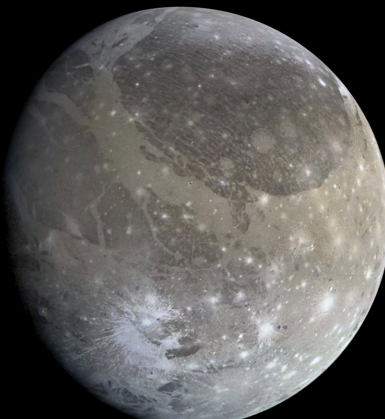
Jupiter satellites:



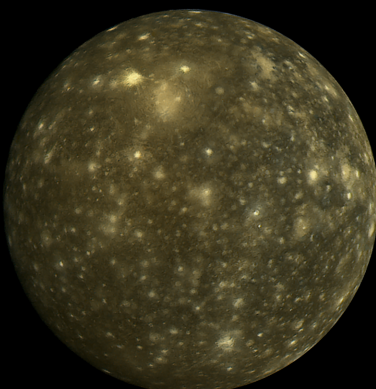
Io



Europa



Ganymede

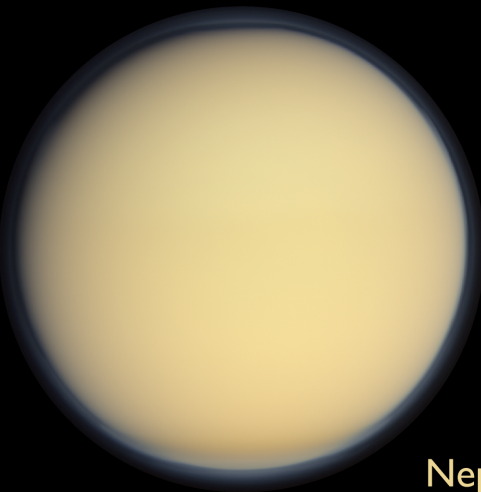


Callisto

Earth's Moon:



The Moon



Titan

Pluto system:



Pluto



Charon

Saturn satellites:

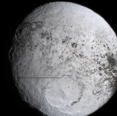


Mimas Enceladus

Tethys

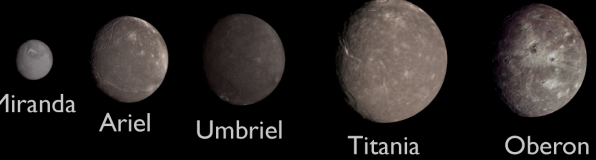
Dione

Rhea



Iapetus

Uranus satellites:



Miranda

Ariel

Umbriel

Titania

Oberon

Neptune satellites:



Triton



Proteus

Asteroids:



Vesta

Ceres

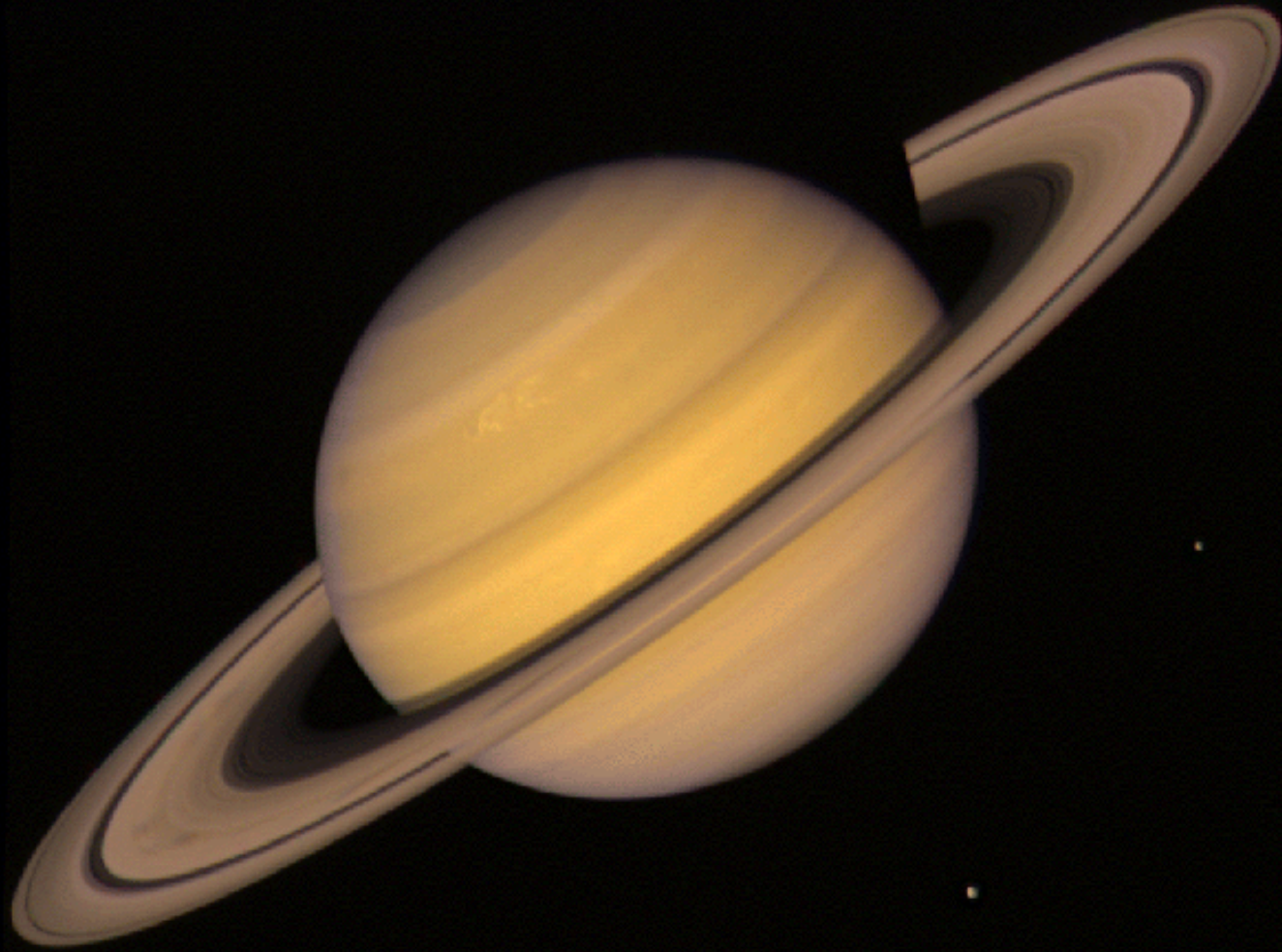


A Look at the Saturn System Before Cassini



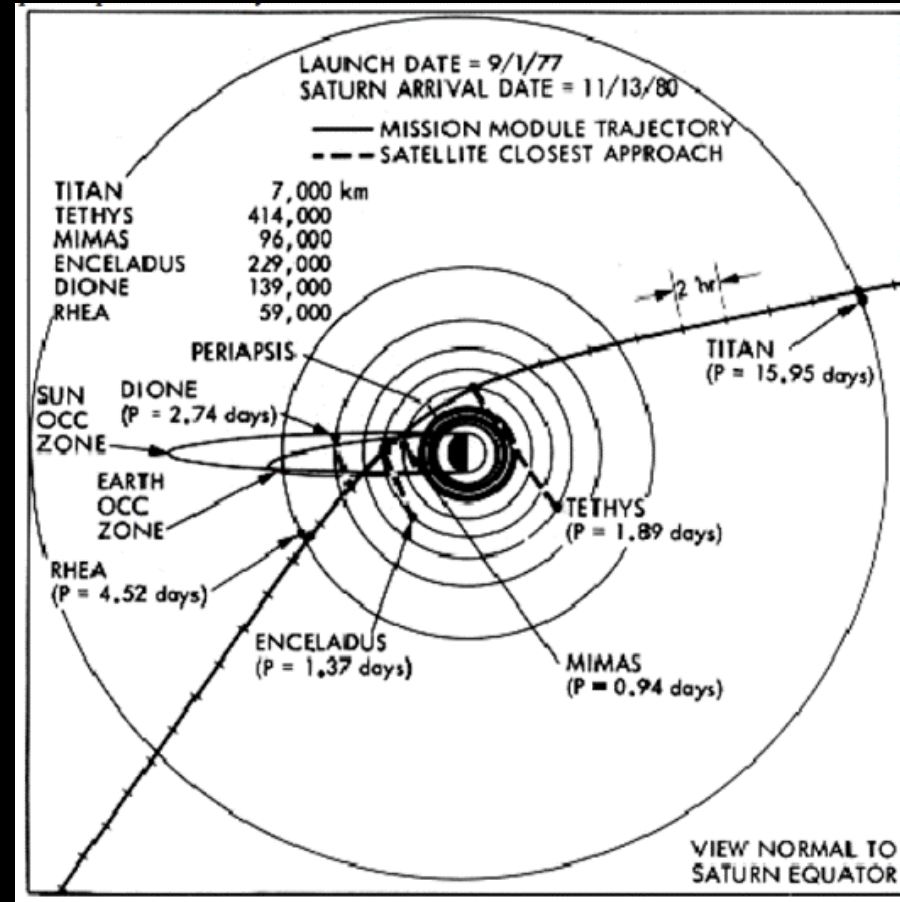
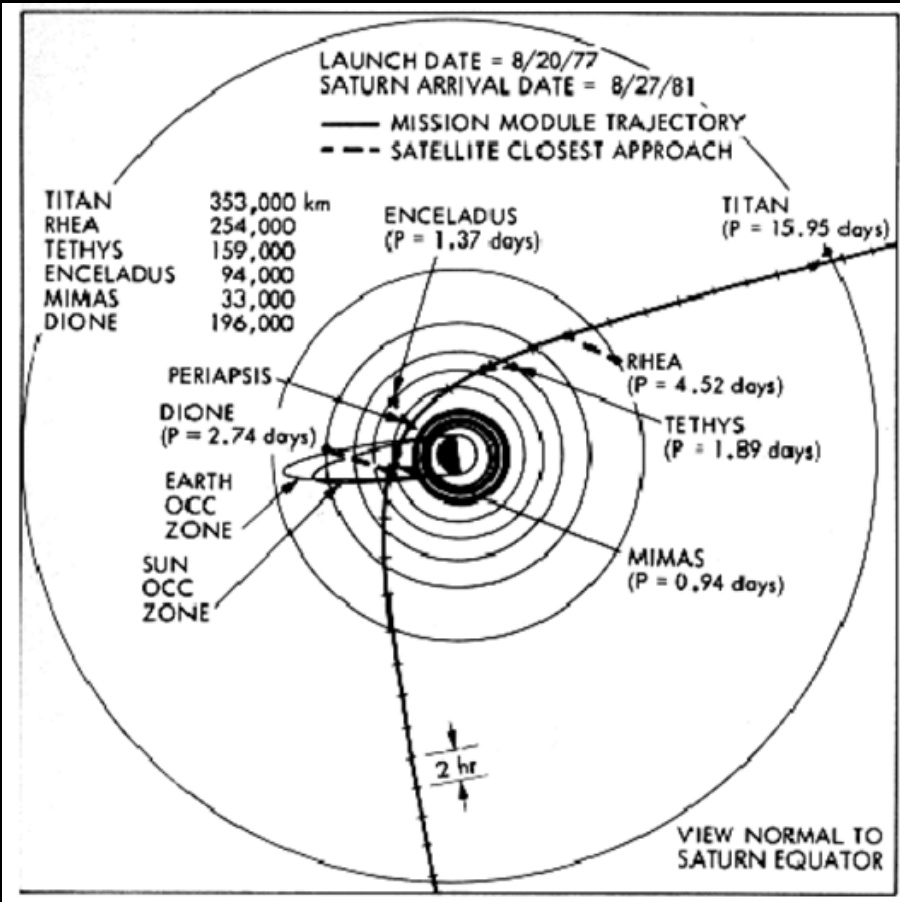
Saturn and Titan from Pioneer 11

A Look at the Saturn System Before Cassini



Saturn and Titan from Voyager

Saturn Flybys from Voyager 1 & 2



Voyager 1 & 2 Saturn flybys in 1980 & 1981

A VERY Brief History of Cassini



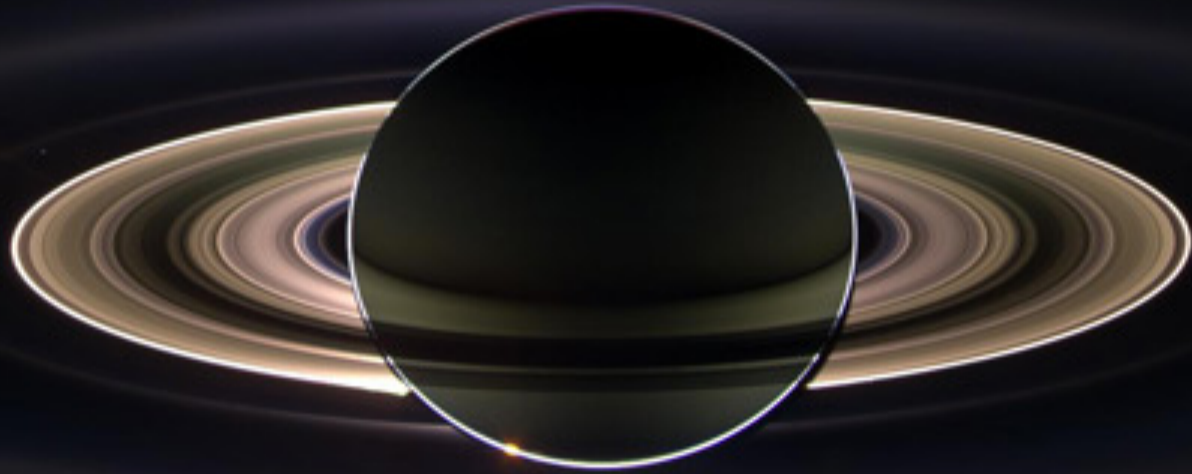
1982: Origins of Cassini mission concept

1983: NASA explores a Saturn orbiter and Titan probe

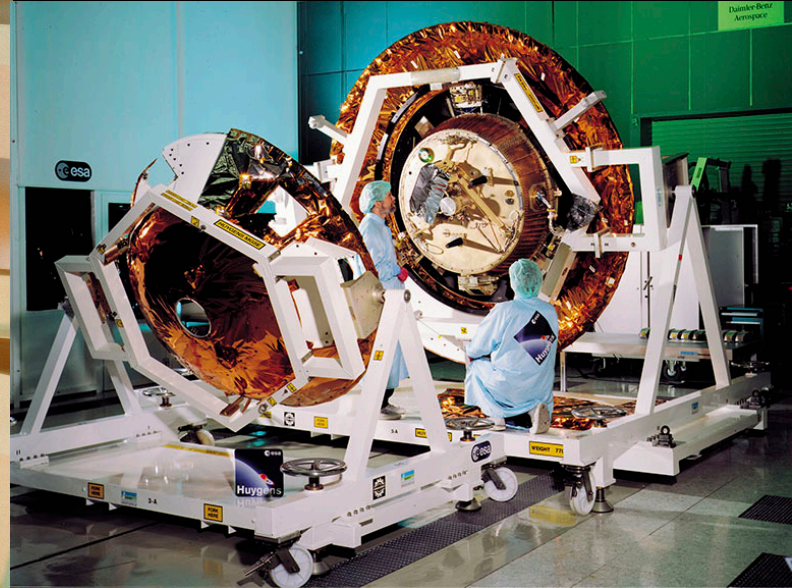
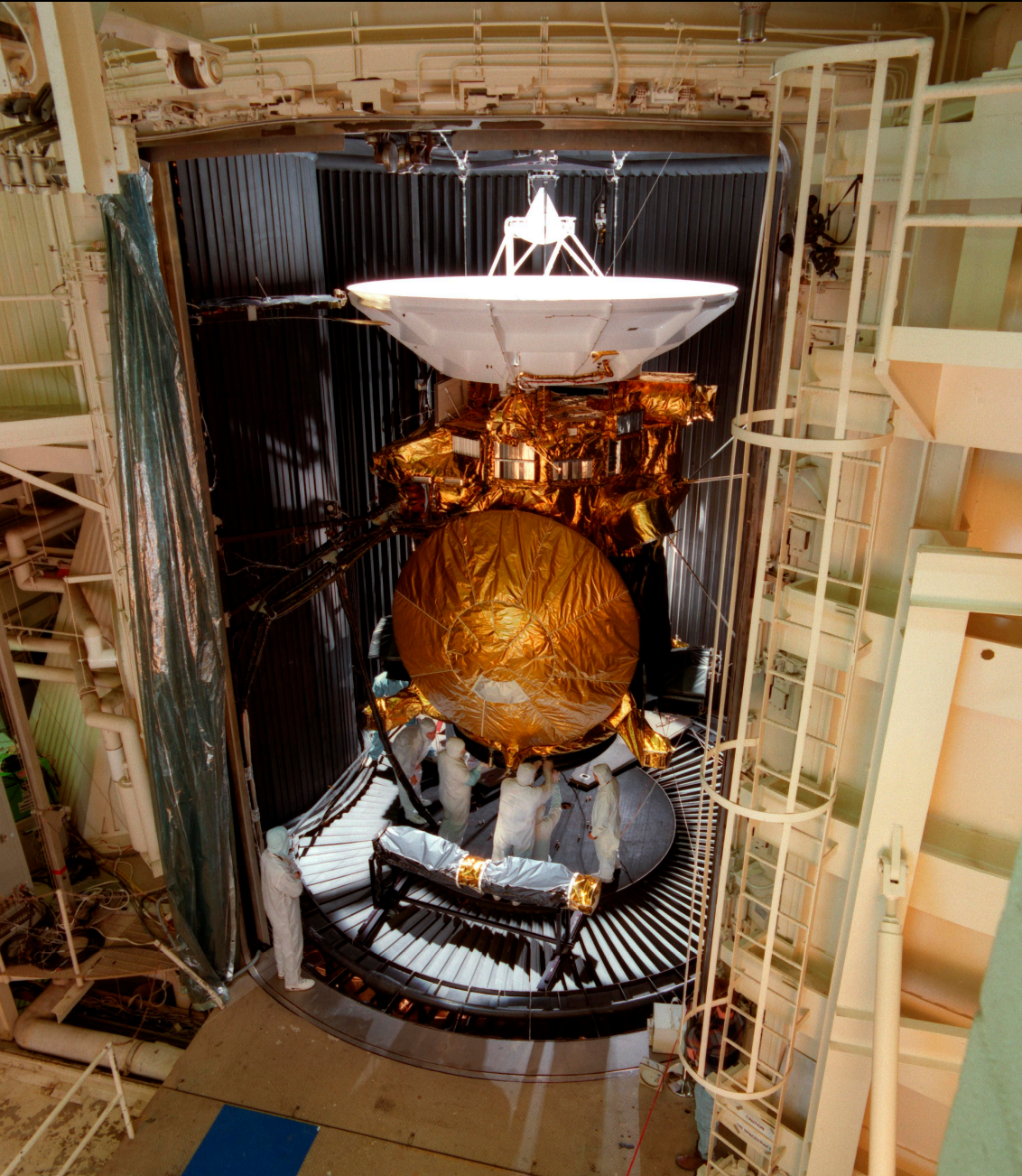
1984-85: NASA/ESA joint mission study

~1992-1994: Cassini is moving forward

#WorthIt



The Cassini-Huygens Mission NASA/ESA

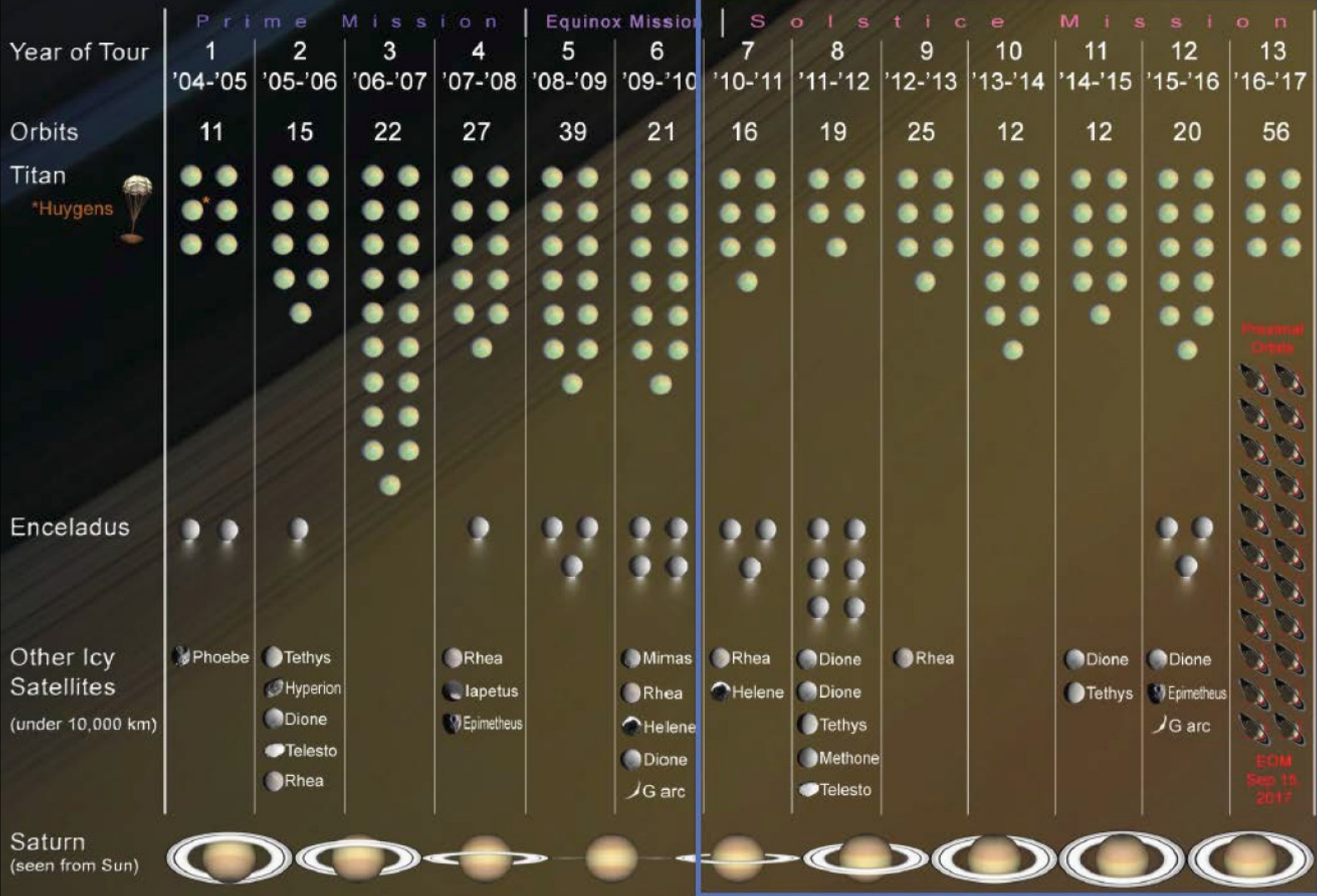


Cassini Launched October 15th 1997



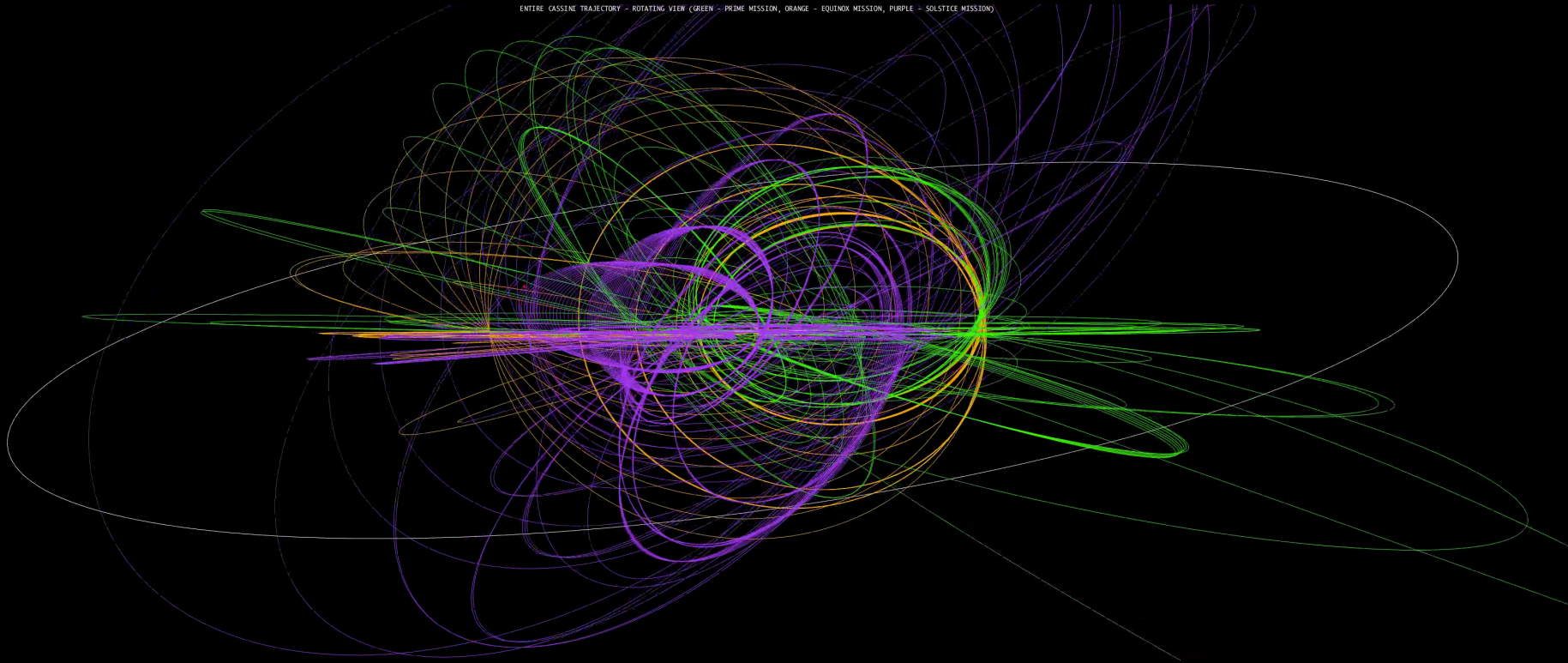
Cassini Mission Overview

Four-Year Prime Tour, Equinox Mission, and Solstice Mission (Proposed), May 2004 - September 2017

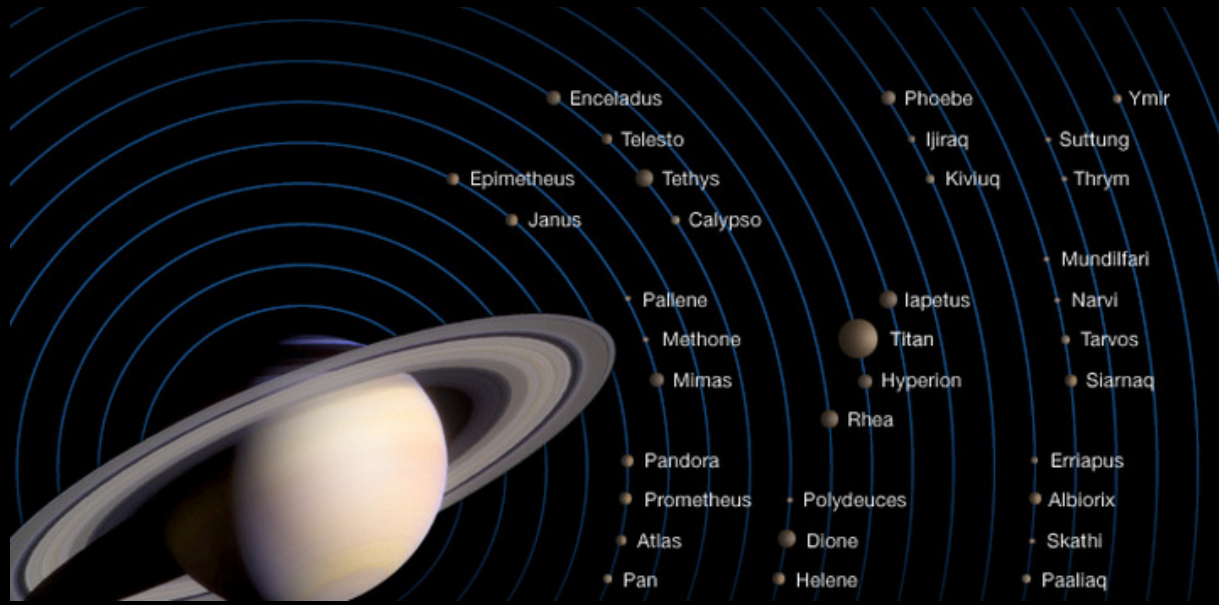


The Ball of Yarn

ENTIRE CASSINI TRAJECTORY - ROTATING VIEW (GREEN - PRIME MISSION, ORANGE - EQUINOX MISSION, PURPLE - SOLSTICE MISSION)

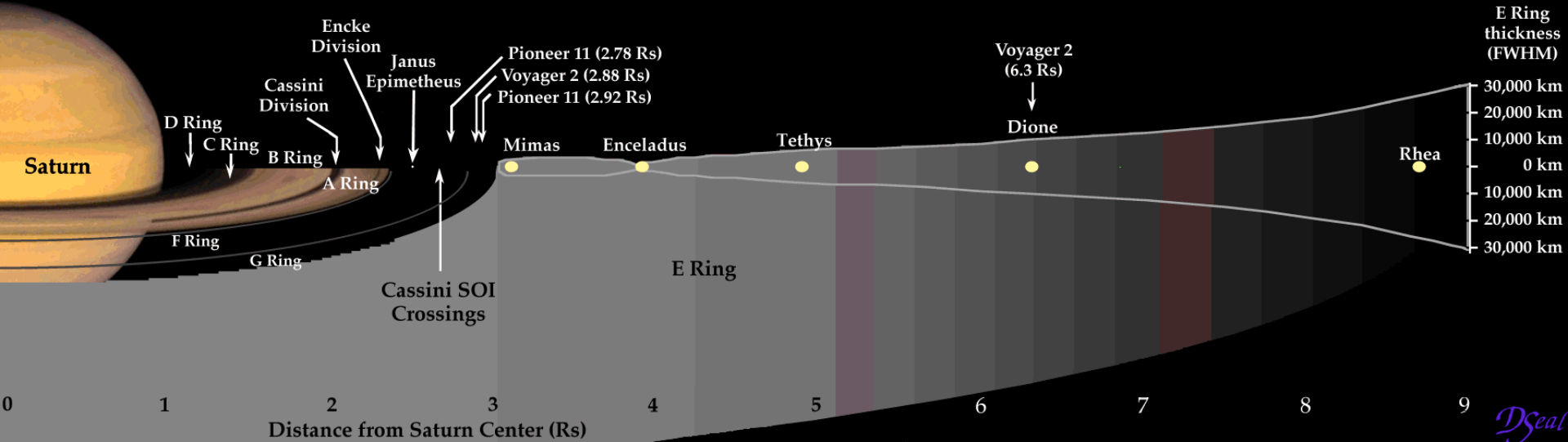


Roadmaps to the Saturn System

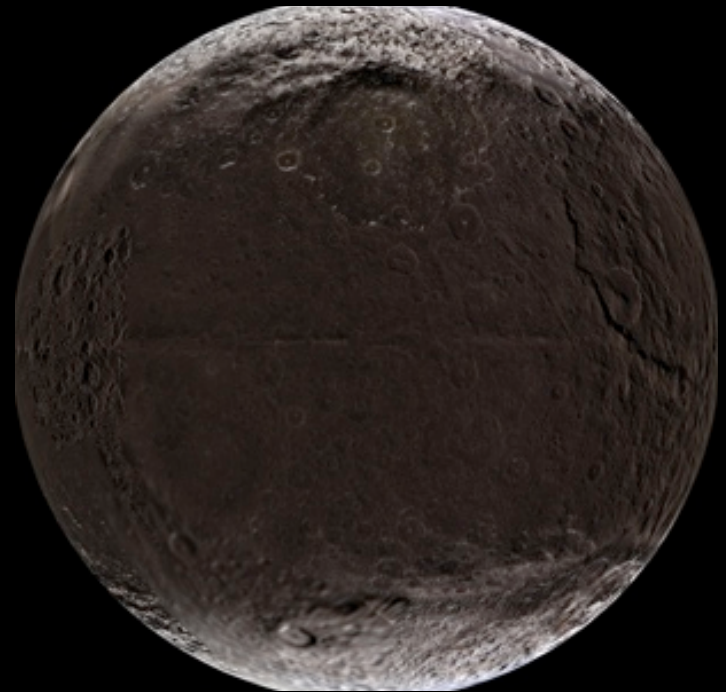
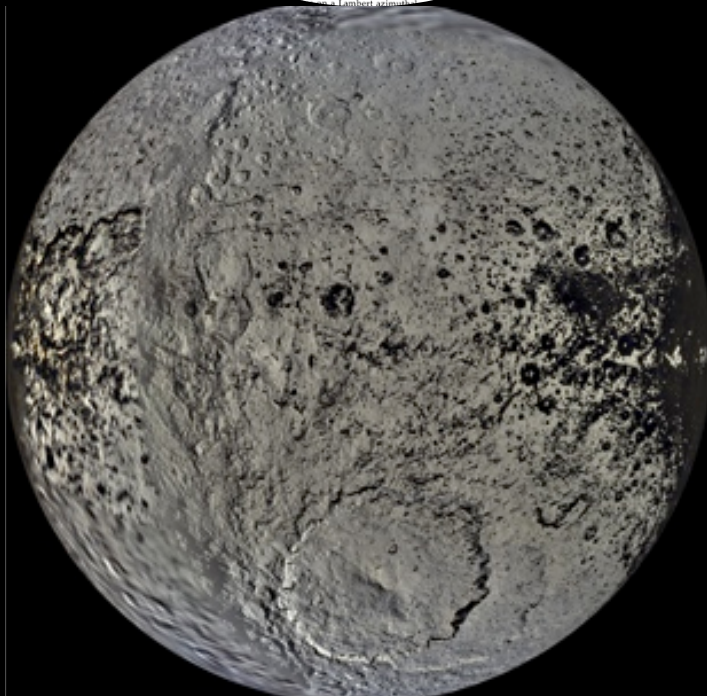
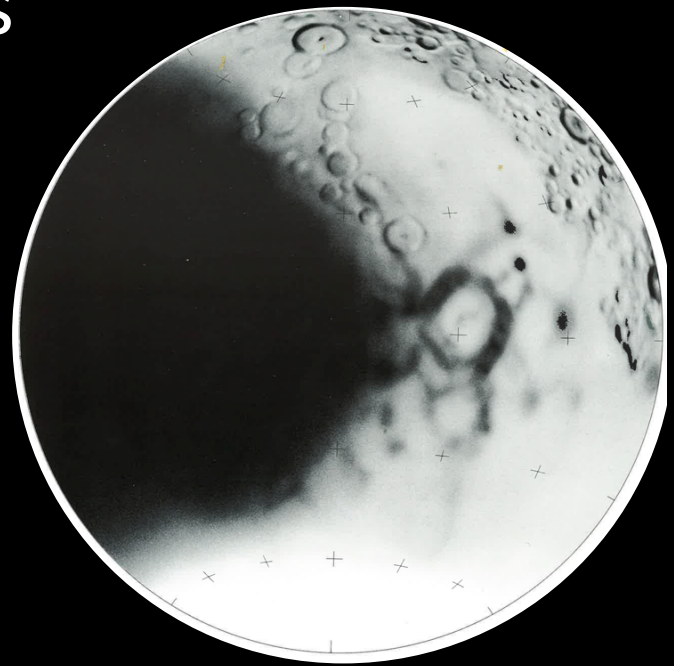
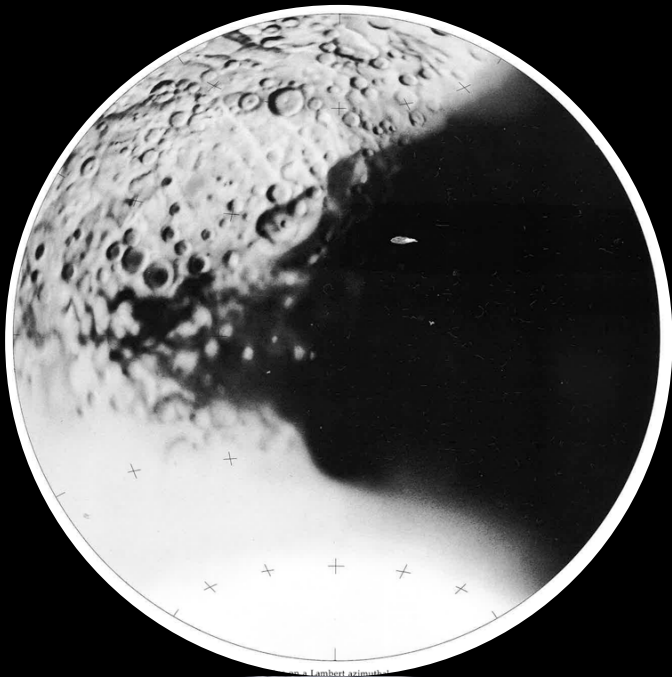


Not shown:

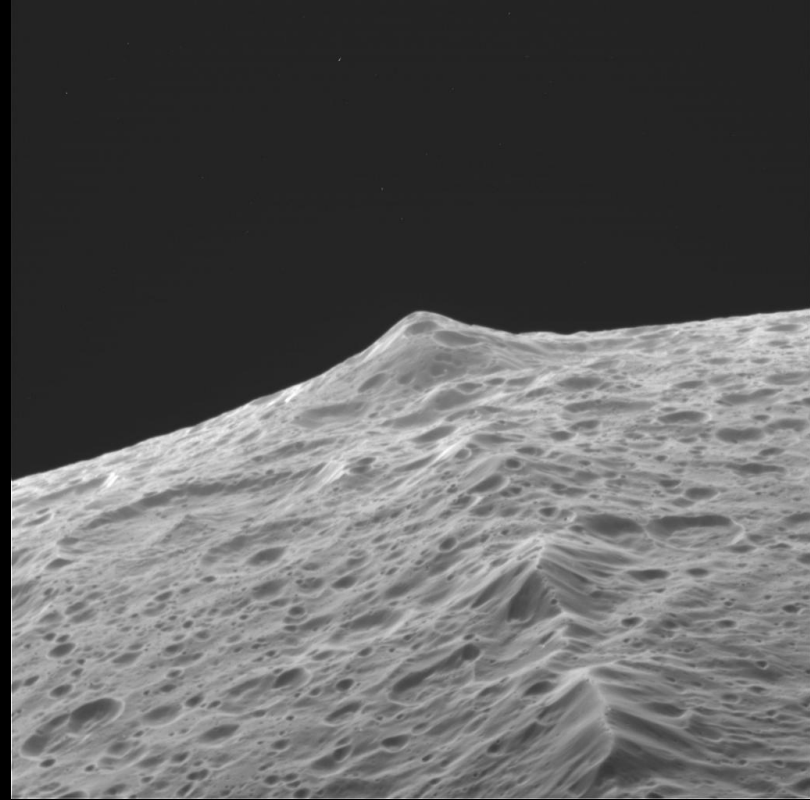
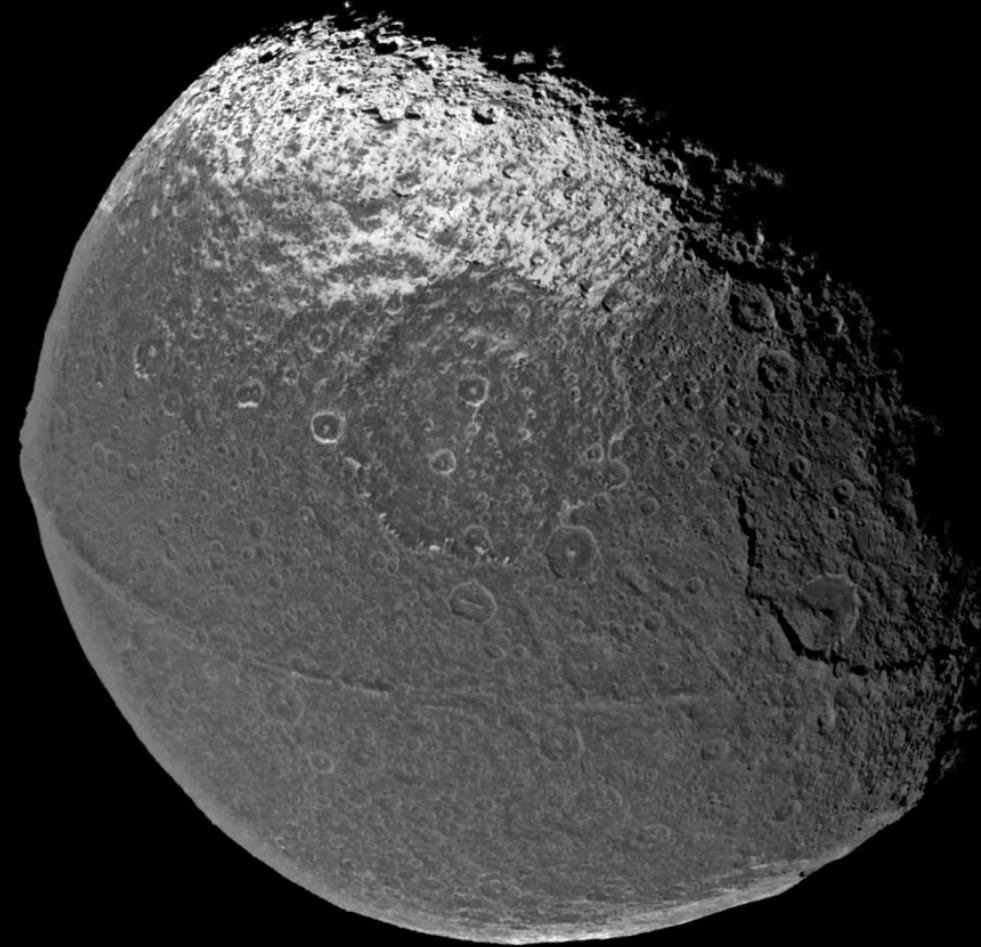
Pan	2.22 Rs	Titan	20.3 Rs
Atlas	2.28 Rs	Hyperion	24.6 Rs
Prometheus	2.31 Rs	Iapetus	59.1 Rs
Pandora	2.35 Rs	Phoebe	214.9 Rs



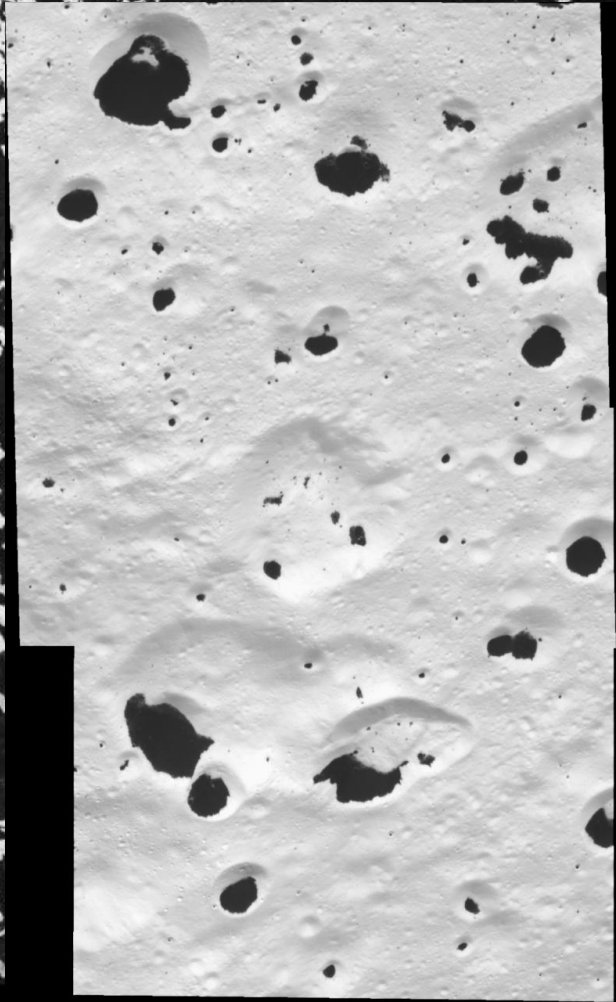
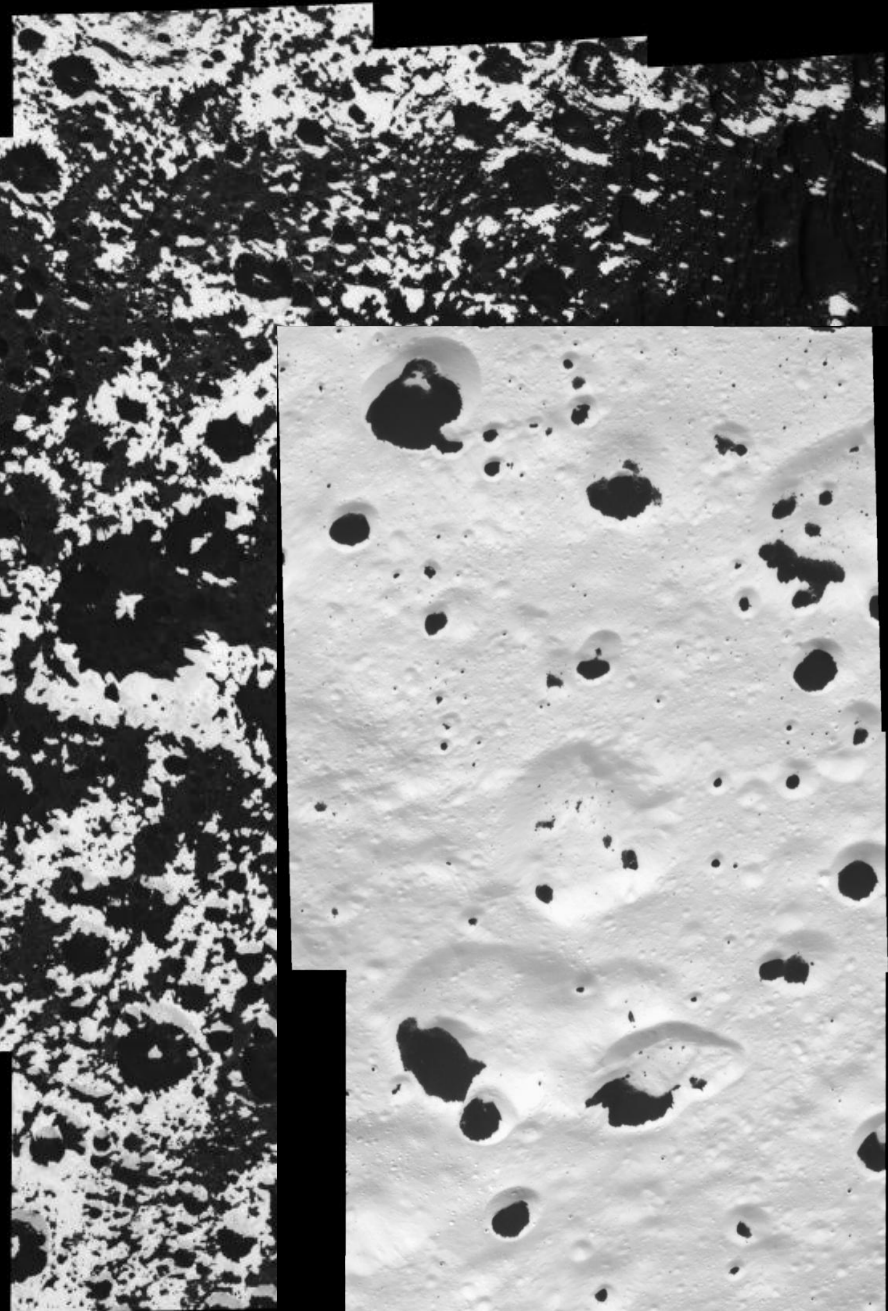
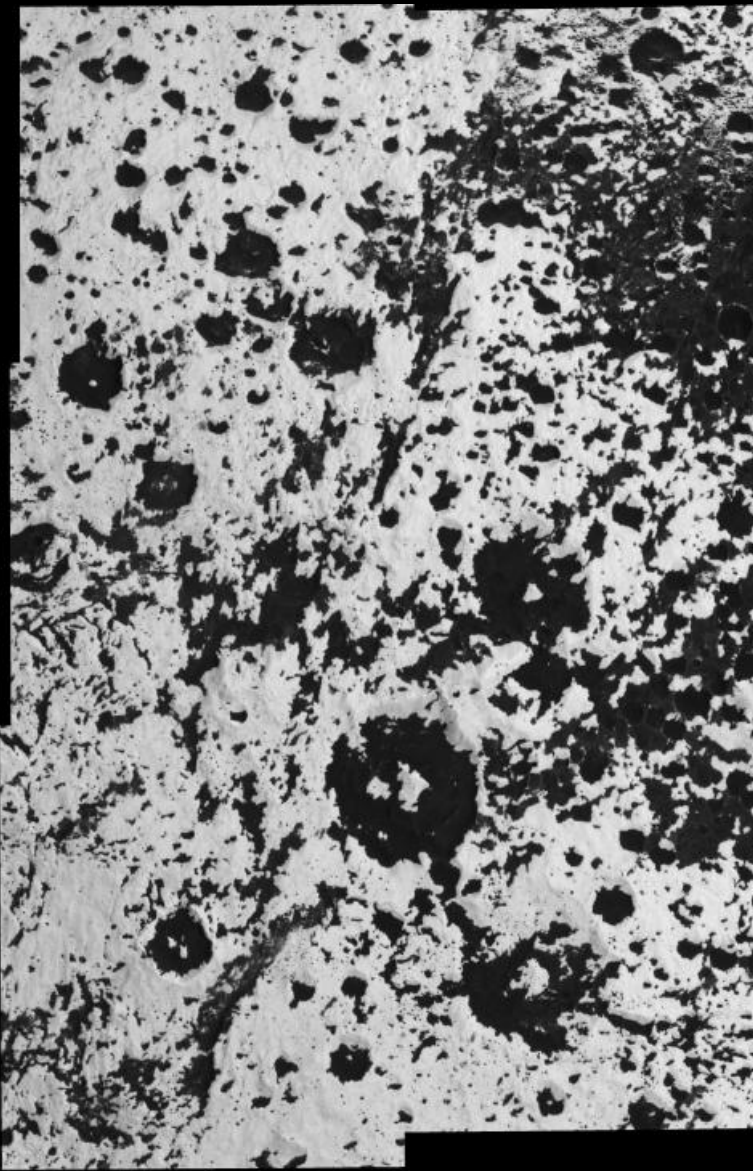
Iapetus



Iapetus



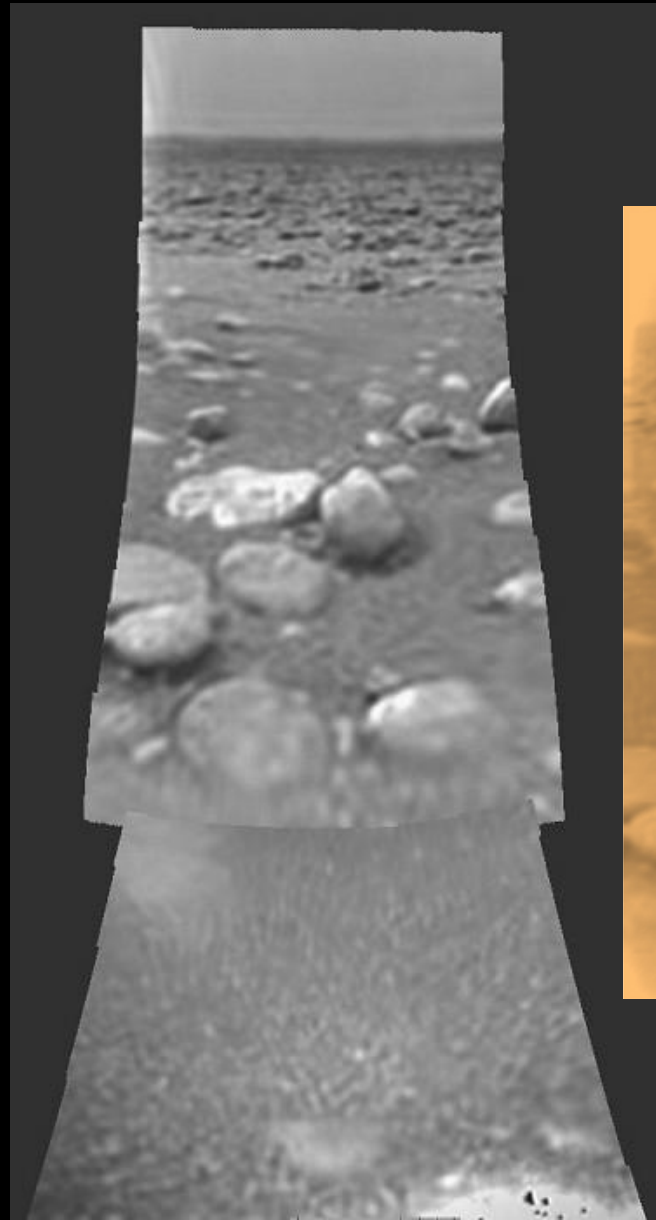
Iapetus



Titan



Joint NASA/ESA Huygens probe



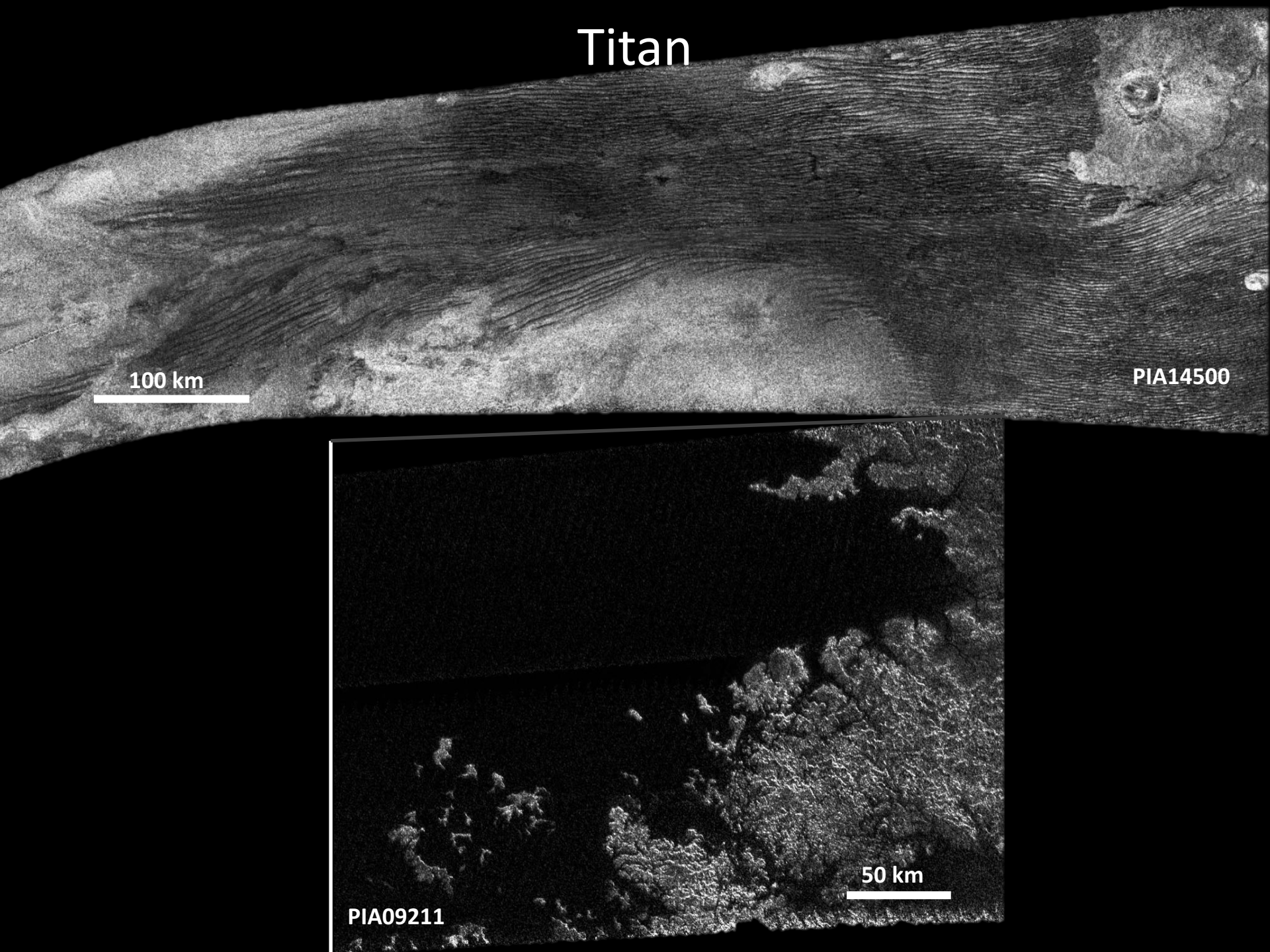
Titan

100 km

PIA14500

PIA09211

50 km

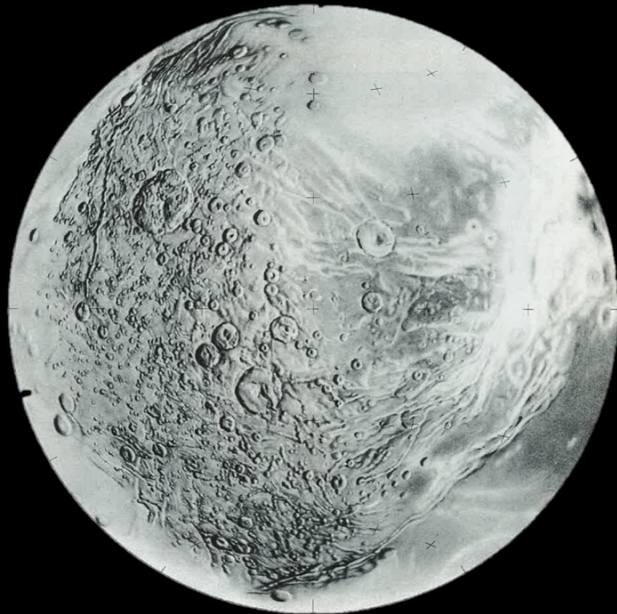
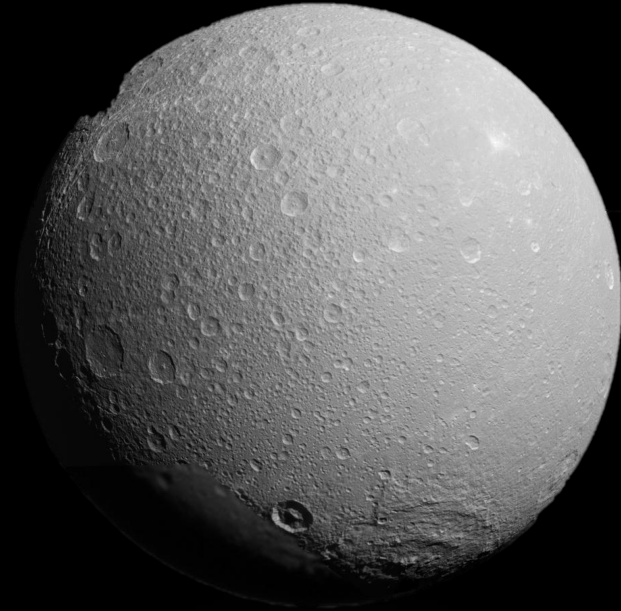
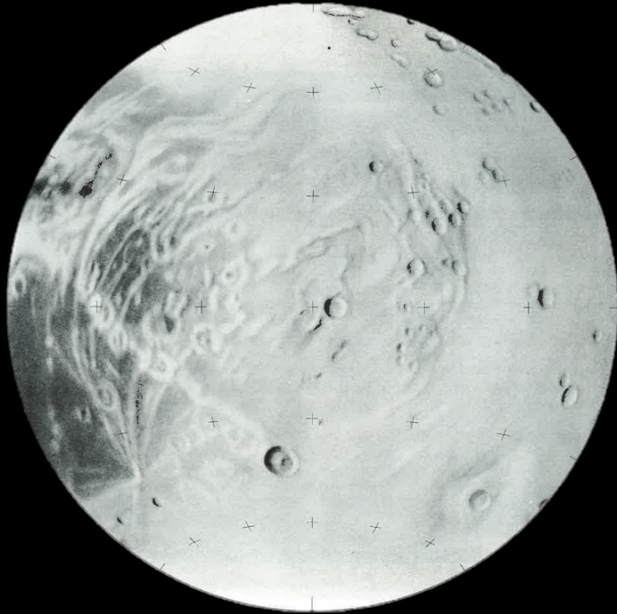


Titan

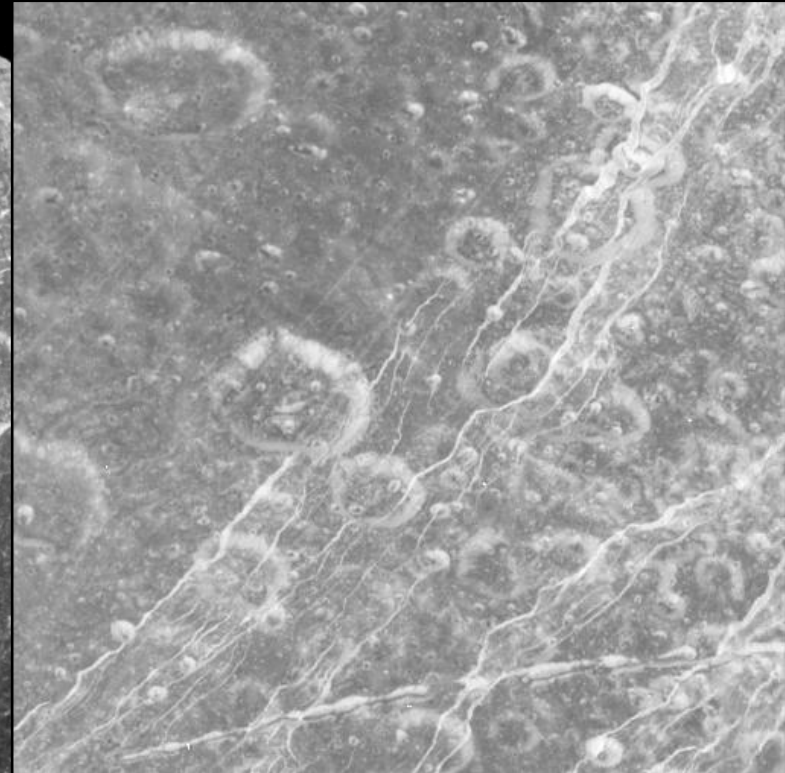
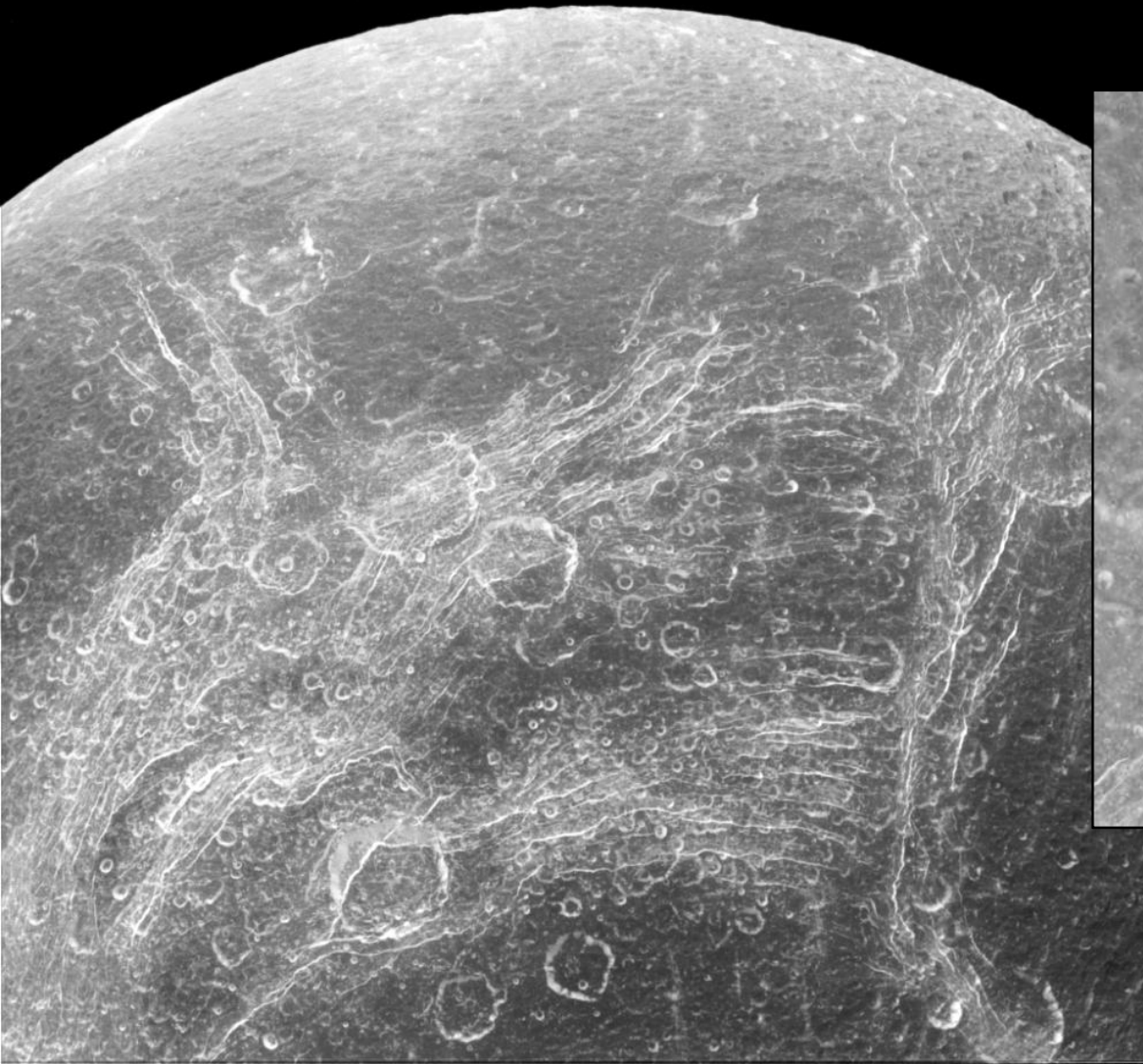


Seasonal Changes in Titan's lakes

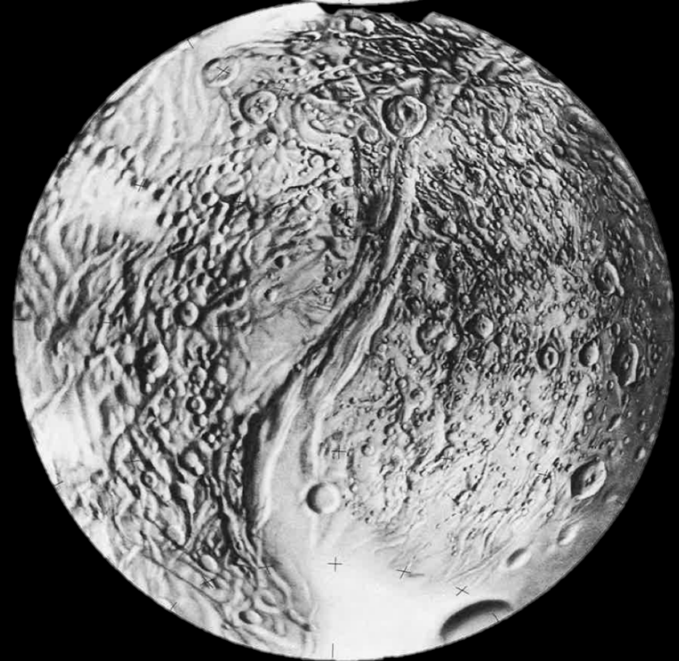
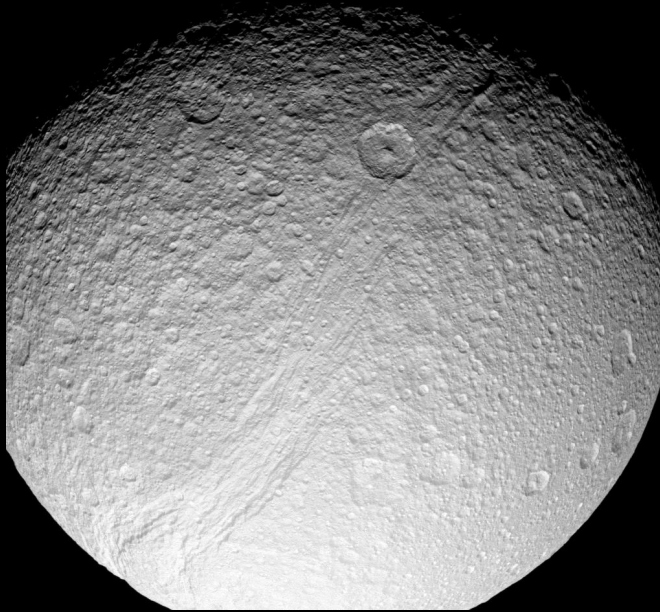
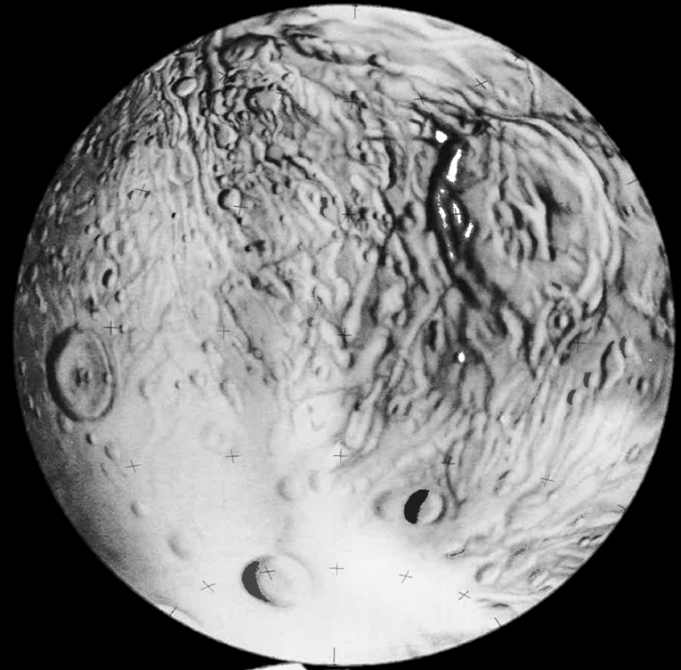
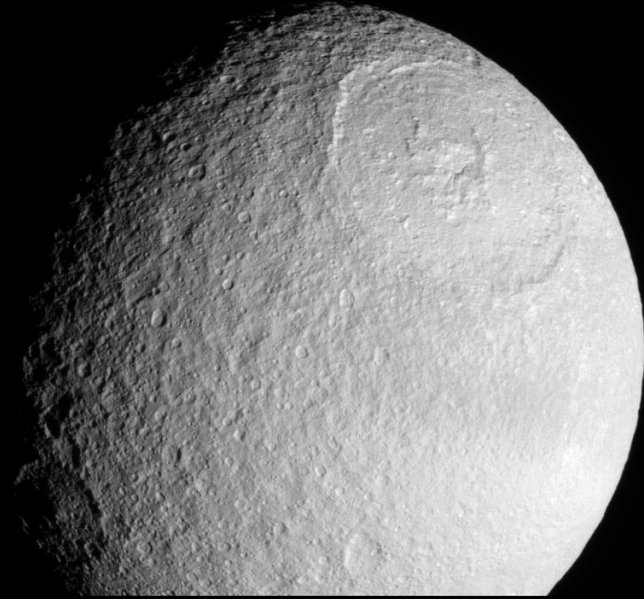
Dione



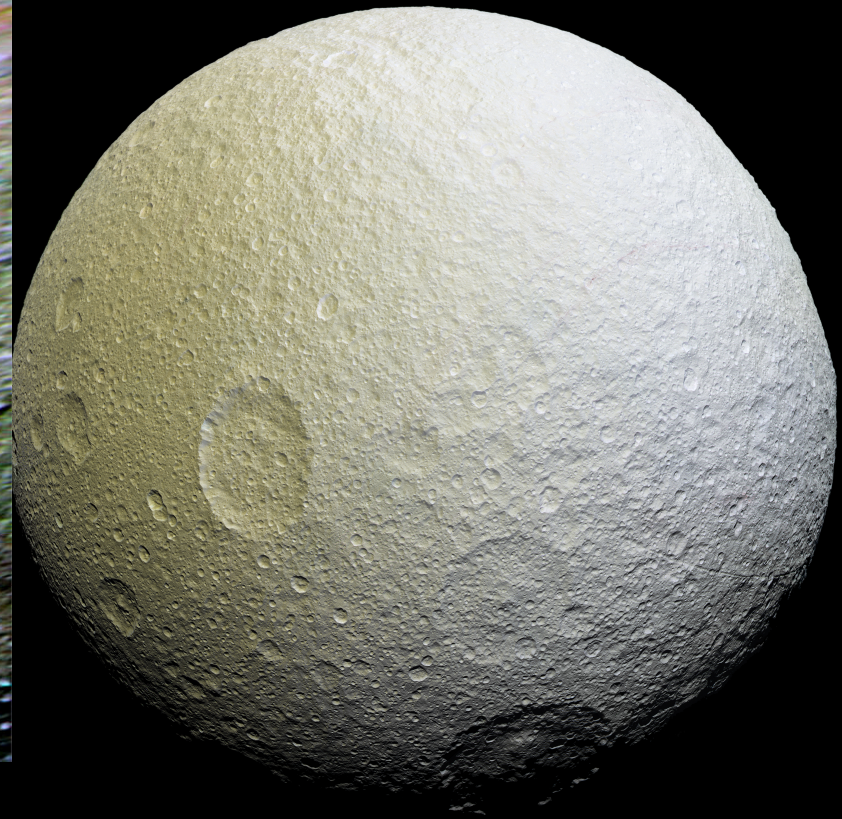
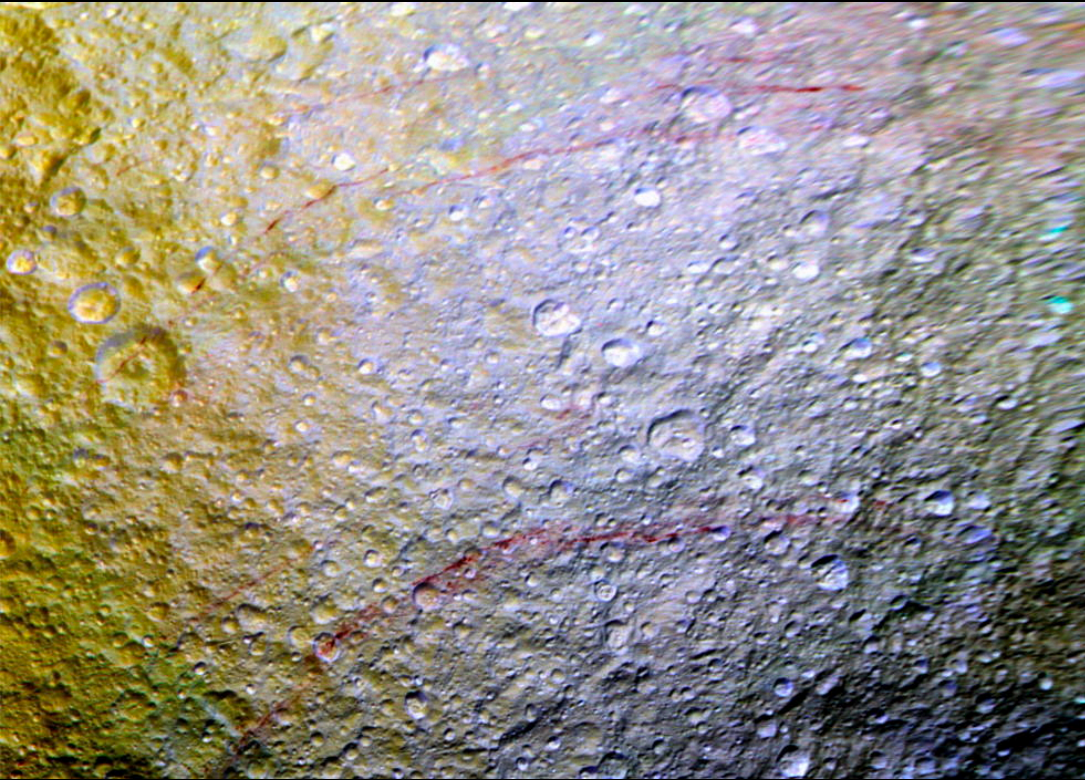
Dione



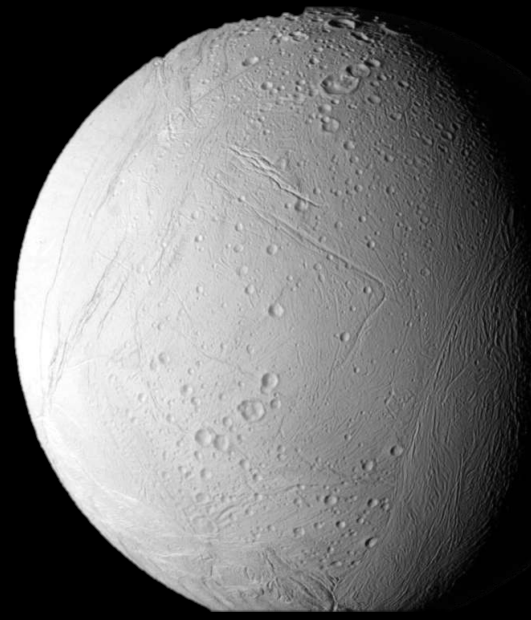
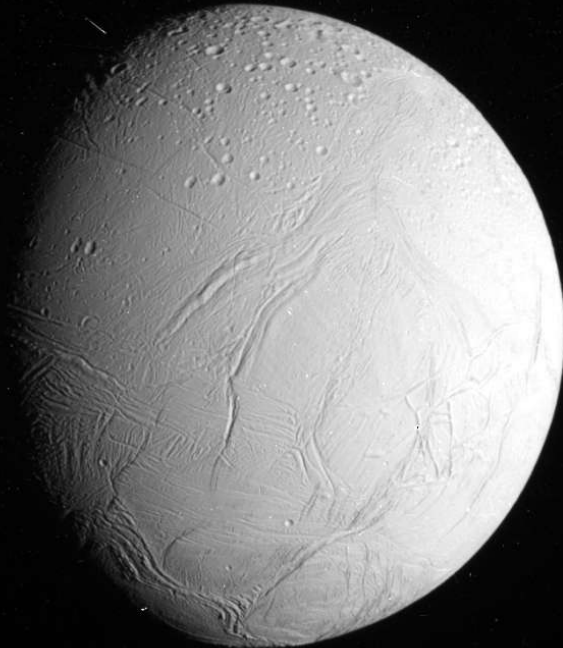
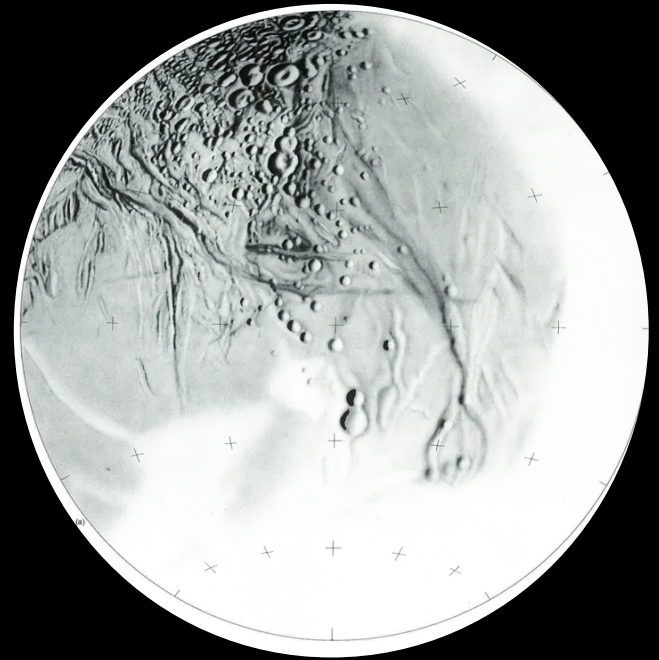
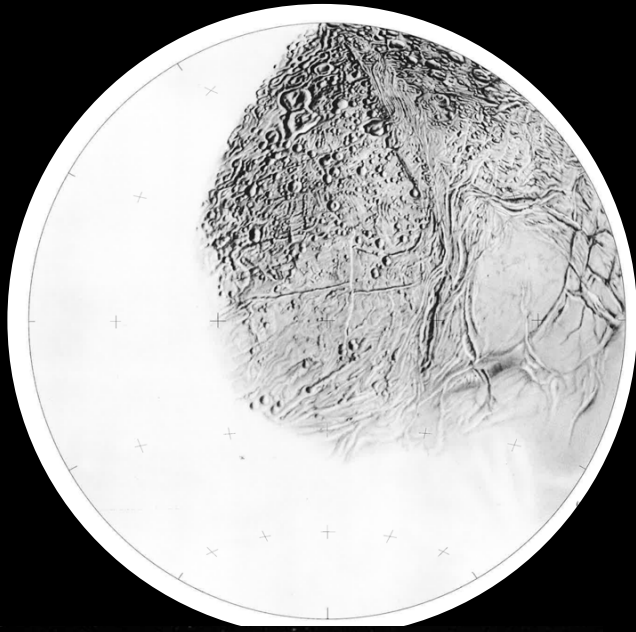
Tethys



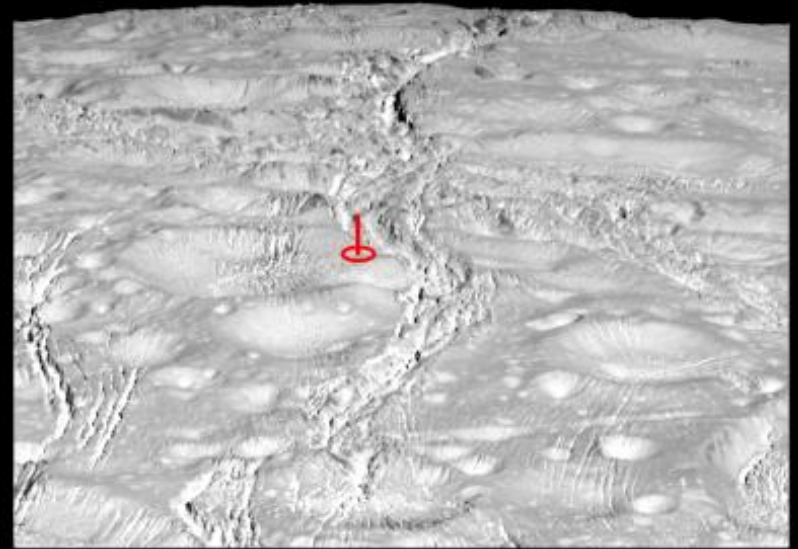
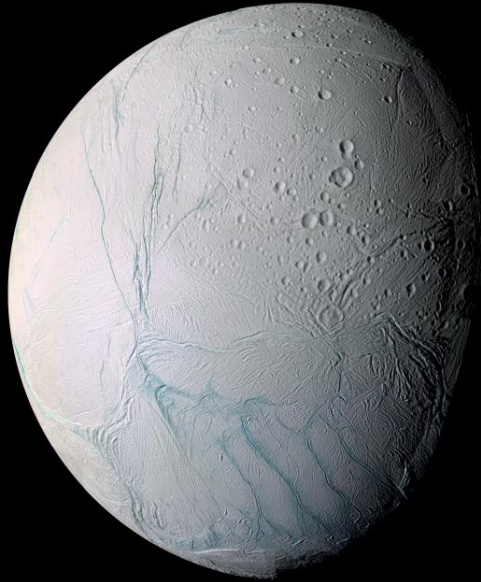
Tethys



Enceladus



Enceladus



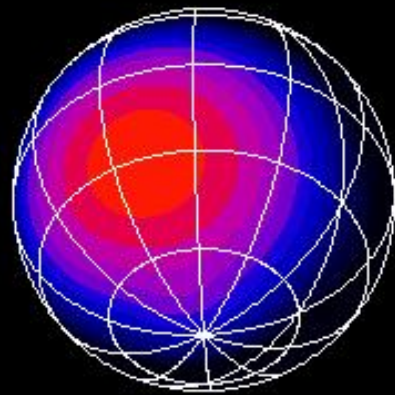
10 kilometers



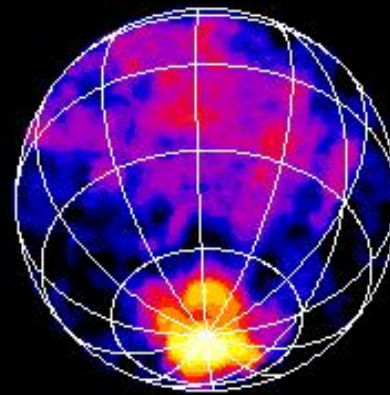
100 kilometers



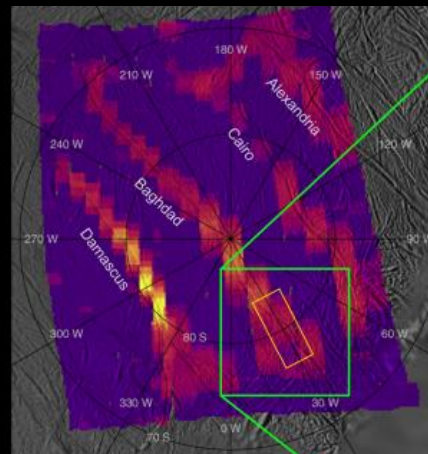
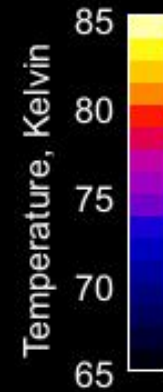
Enceladus Temperature Map



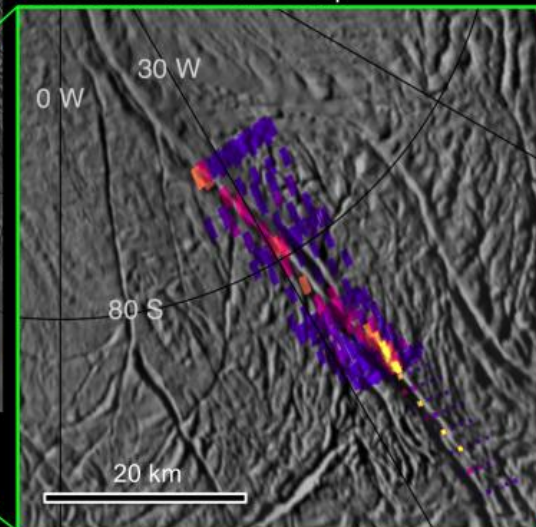
Predicted
Temperatures



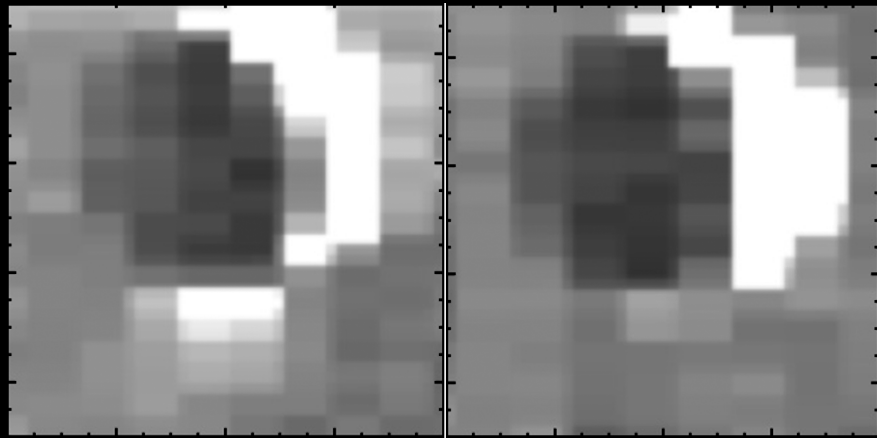
Observed
Temperatures



November 2009 CIRS map

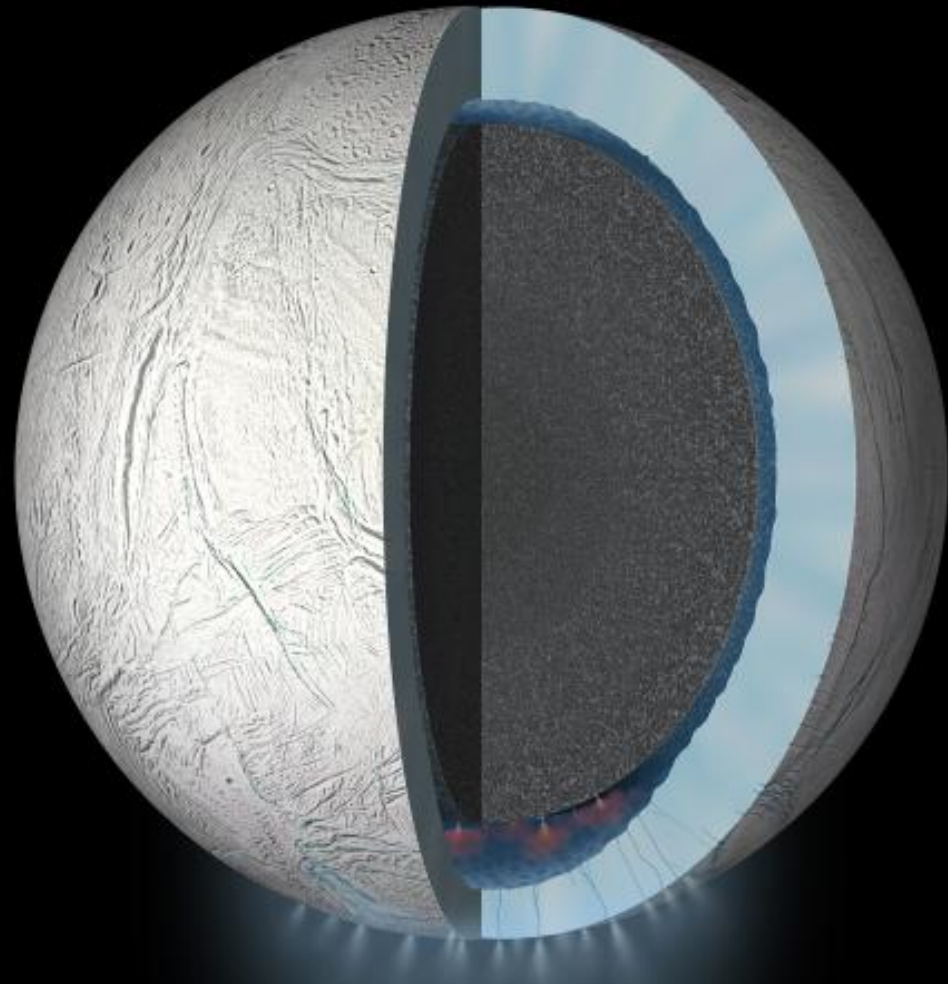


Enceladus's Tidally Controlled Plume

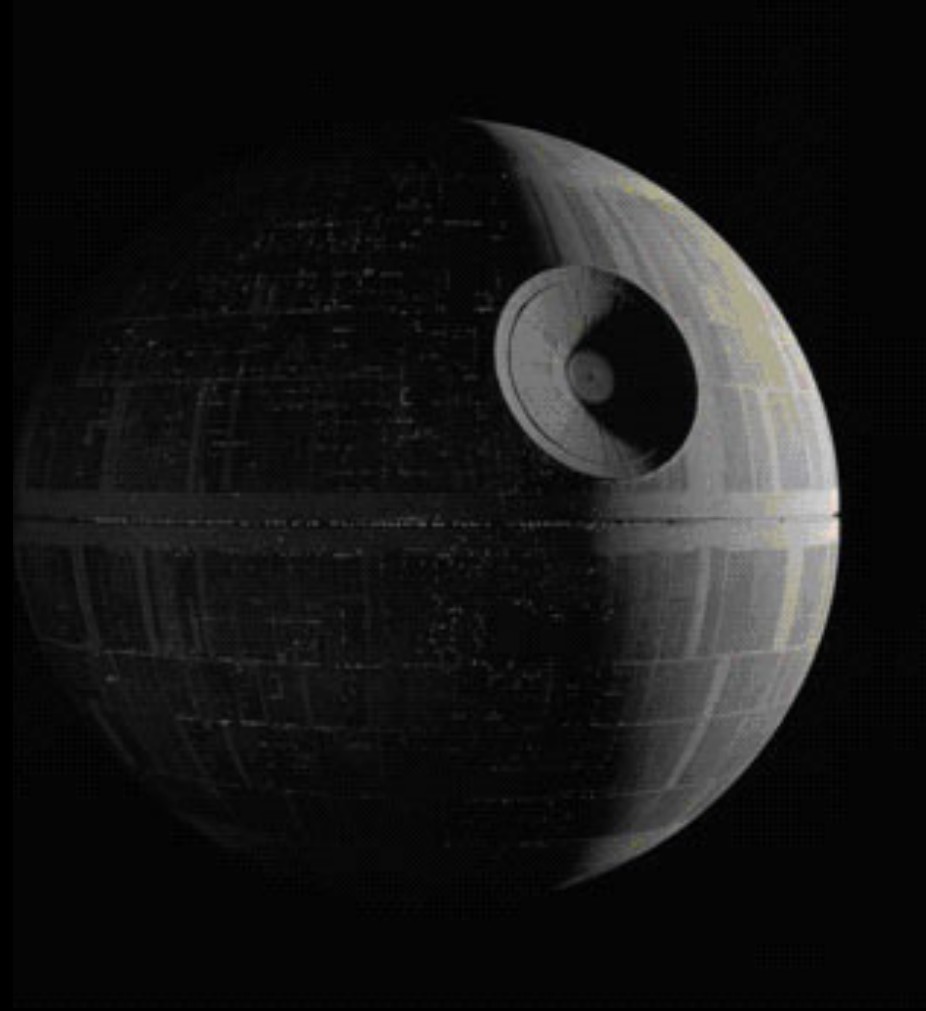
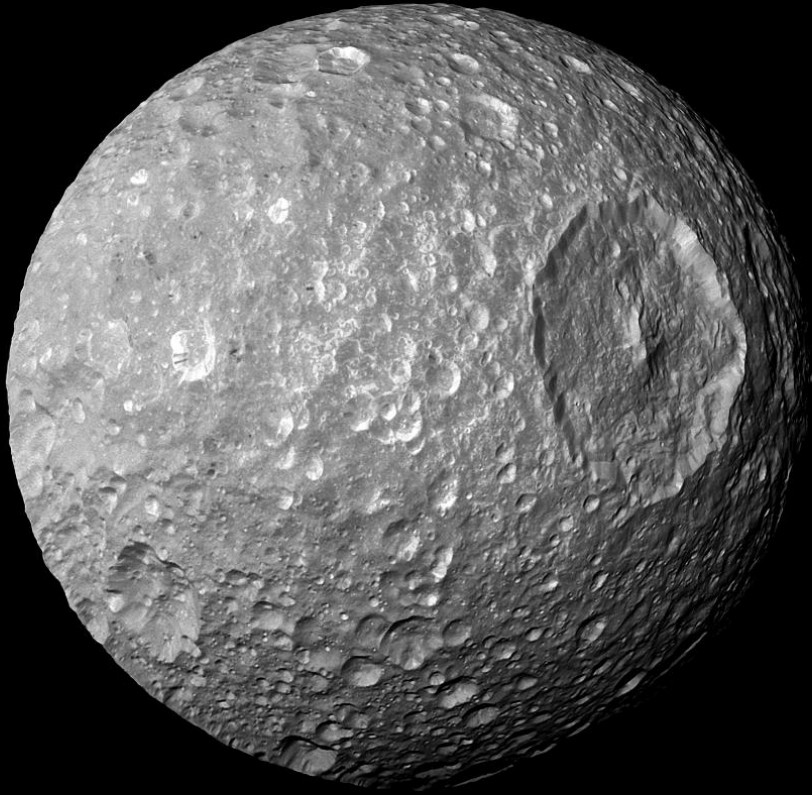


Periapse

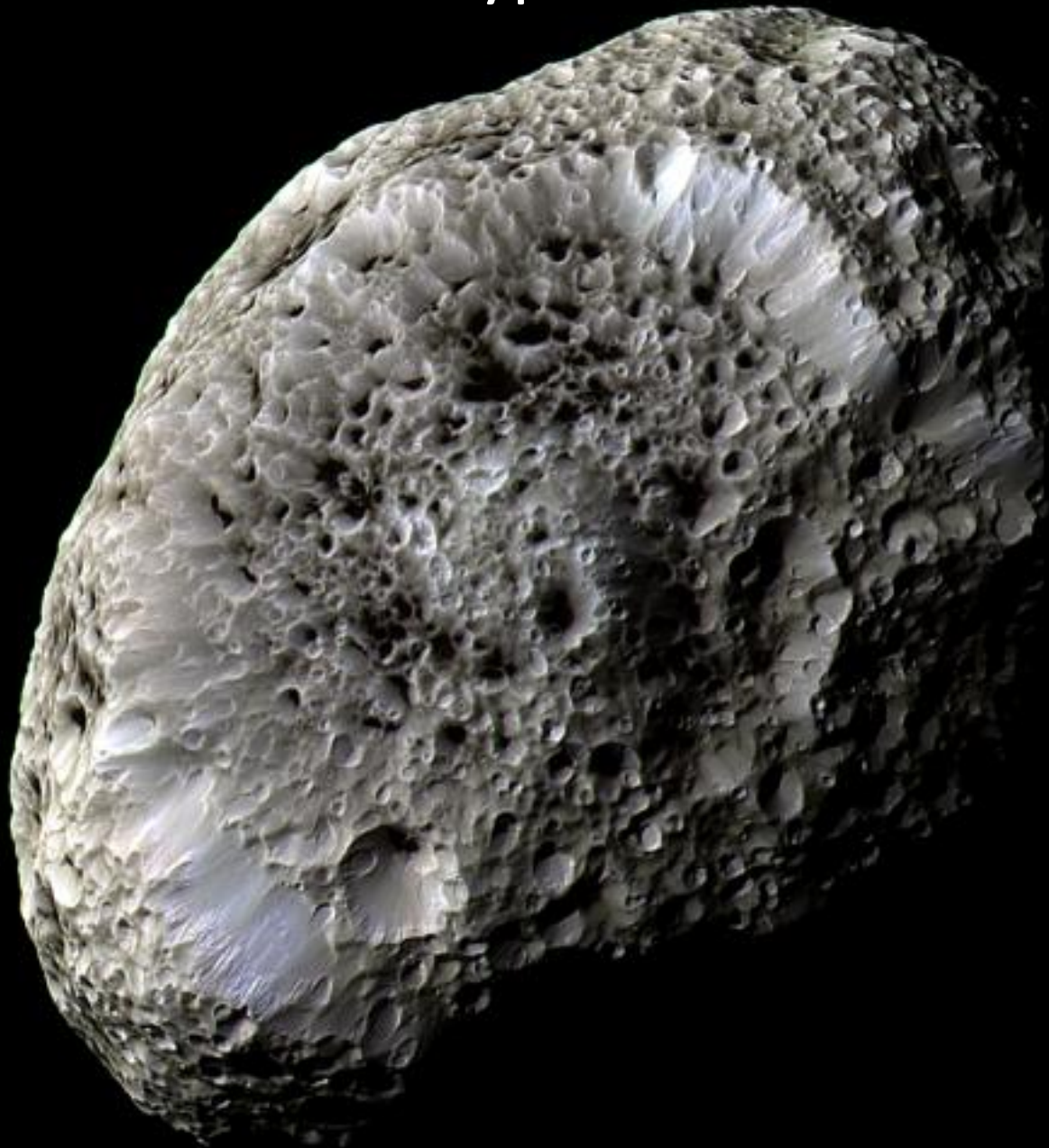
Apoapsis



Mimas



Hyperion



Aegaeon
1.4 × 0.5 × 0.4 km



Methone
3.88 × 2.58 × 2.42 km



Anthe
2 × 2 × 2 km



Pallene
5.76 × 4.16 × 3.6 km



Telesto
32.6 × 23.6 × 19.6 km



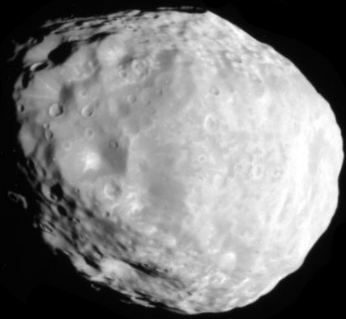
Calypso
30.6 × 18.6 × 12.6 km



Polydeuces
3.0 × 2.4 × 2.0 km



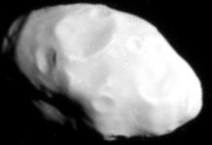
Helene
45.0 × 39.2 × 26.6 km



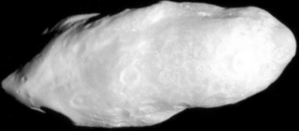
Phoebe
218.8 × 217.0 × 203.6 km



Daphnis
9.2 × 9.0 × 5.6 km



Pan
34.4 × 30.8 × 20.8 km



Atlas
41.0 × 35.6 × 18.8 km



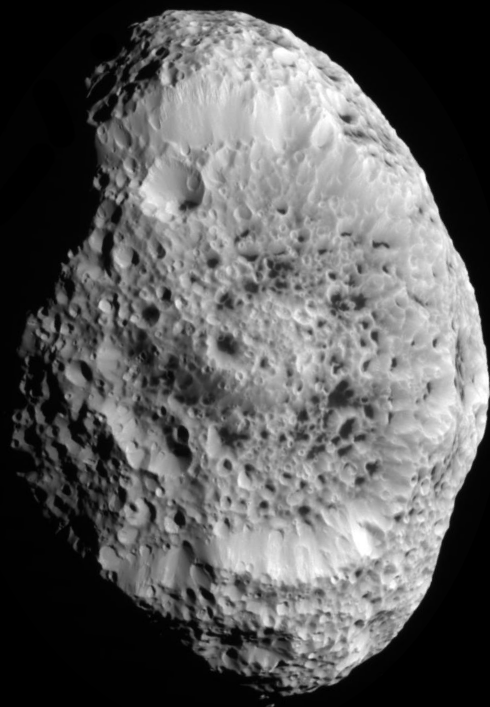
Pandora
104.4 × 81.6 × 63.0 km

Prometheus
136.4 × 83.2 × 56.4 km

Janus
203.4 × 186.0 × 152.6 km

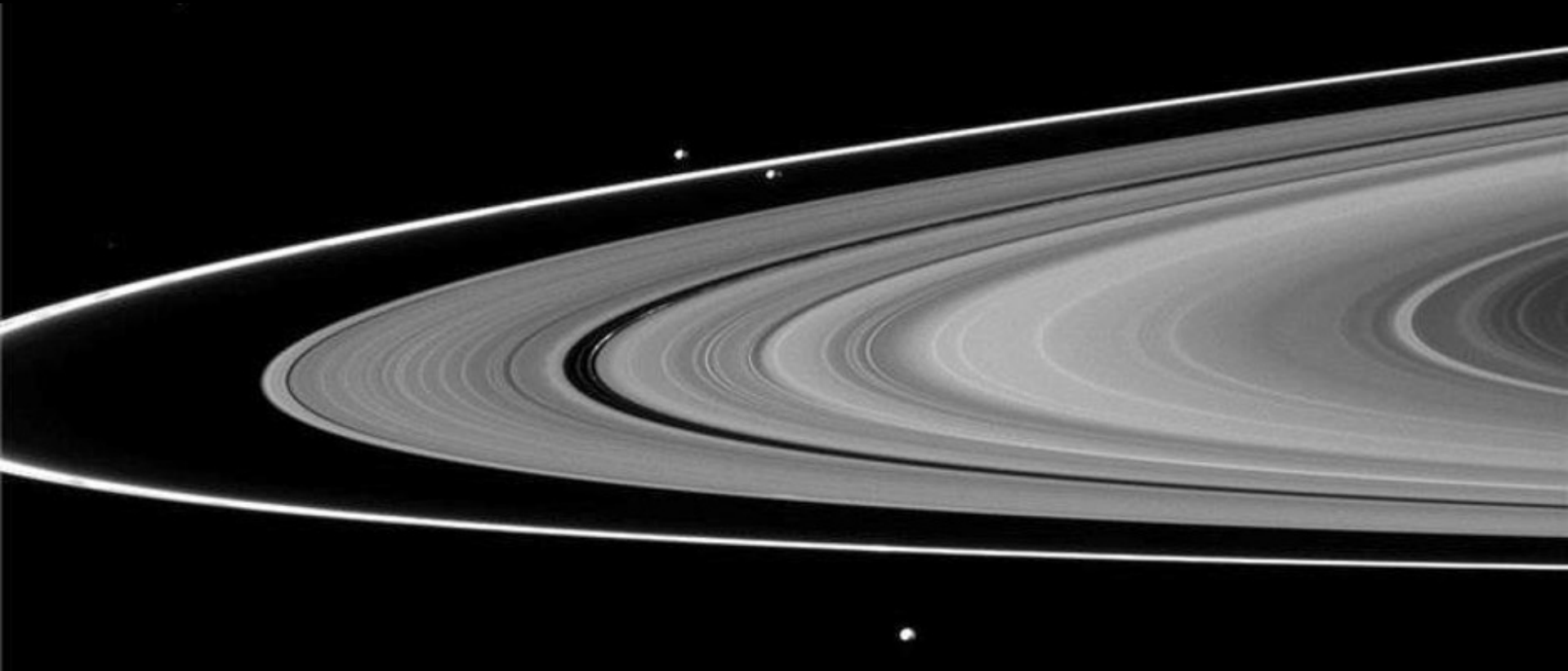
Epimetheus
129.8 × 114.6 × 106 km

Hyperion
360.2 × 266.0 × 205.4 km

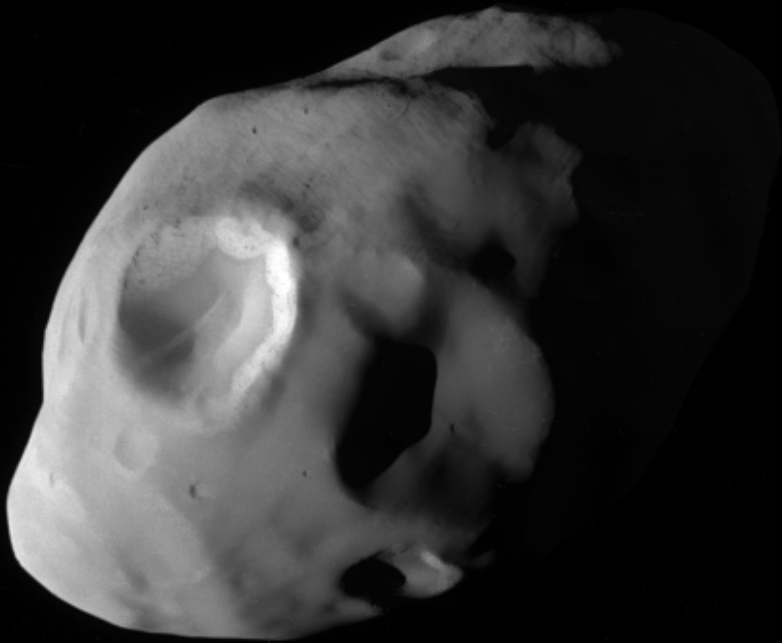


Produced by Emily Lakdawalla for The Planetary Society from Cassini data (NASA/JPL-Caltech/SSI). Satellite dimensions from Thomas et al. (2013)

The Shepard Moons




The Shepard Moons



Pandora



Prometheus



Aegaeon
 $1.4 \times 0.5 \times 0.4$ km



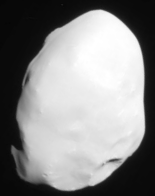
Methone
 $3.88 \times 2.58 \times 2.42$ km



Anthe
 $2 \times 2 \times 2$ km




Pallene
 $5.76 \times 4.16 \times 3.6$ km



Telesto
 $32.6 \times 23.6 \times 19.6$ km



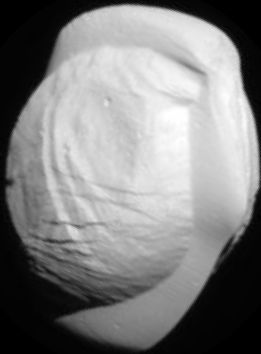
Calypso
 $30.6 \times 18.6 \times 12.6$ km



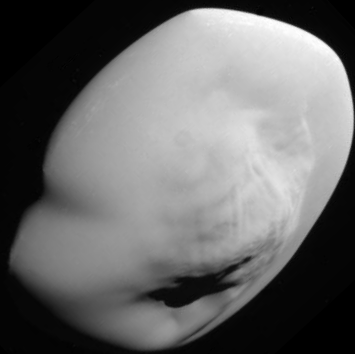
Polydeuces
 $3.0 \times 2.4 \times 2.0$ km



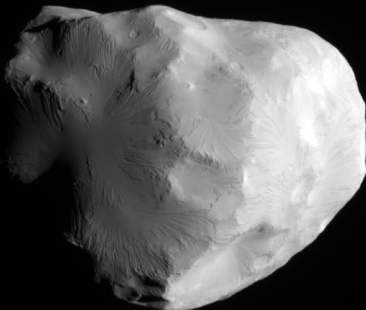
Daphnis
 $9.2 \times 9.0 \times 5.6$ km



Pan
 $34.4 \times 30.8 \times 20.8$ km



Atlas
 $41.0 \times 35.6 \times 18.8$ km



Helene
 $45.0 \times 39.2 \times 26.6$ km

Pan: The Space Ravioli



Pan: The Space Empanada



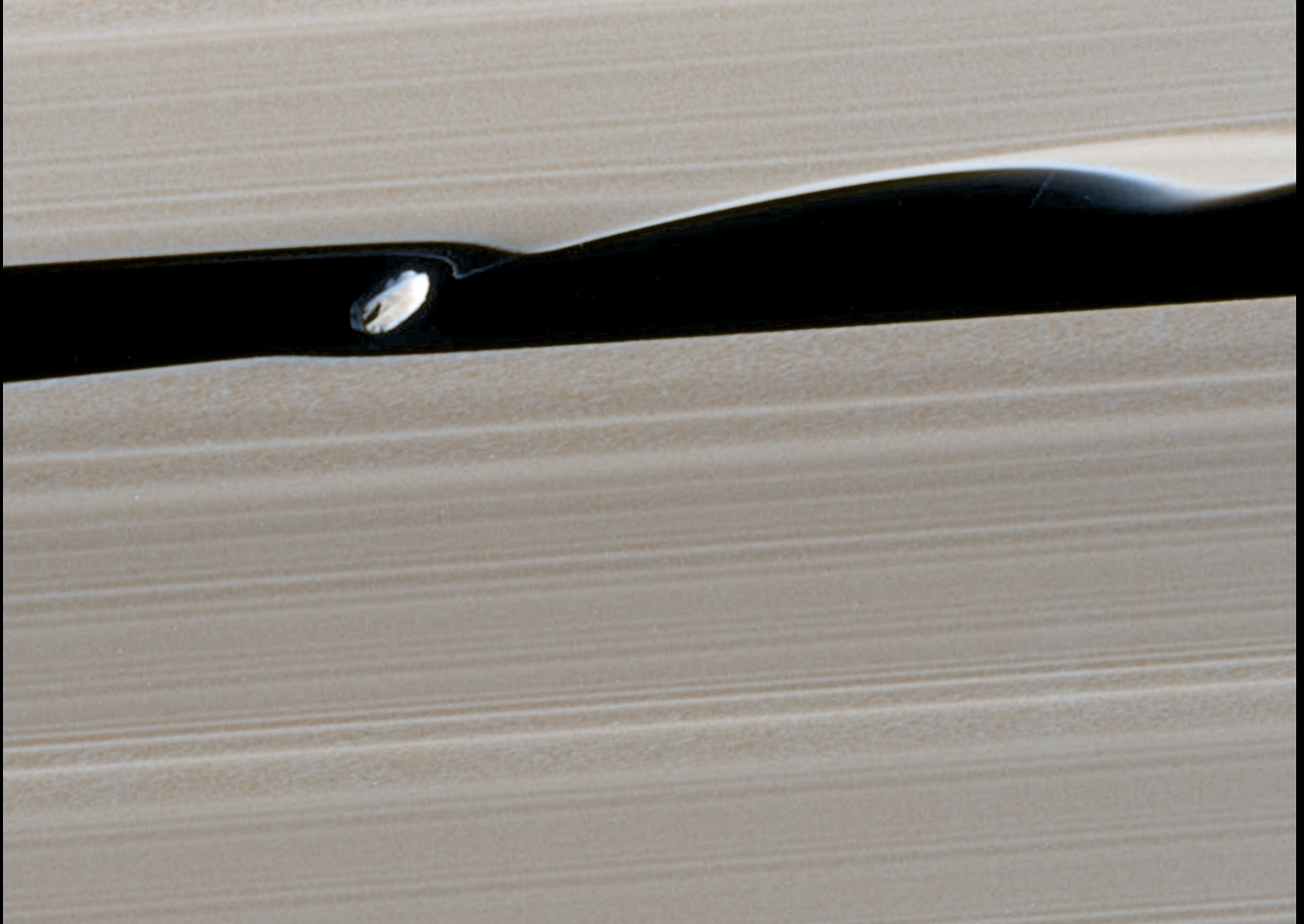
Pan: The Space Perogi



Pan: The Cosmic Dumpling

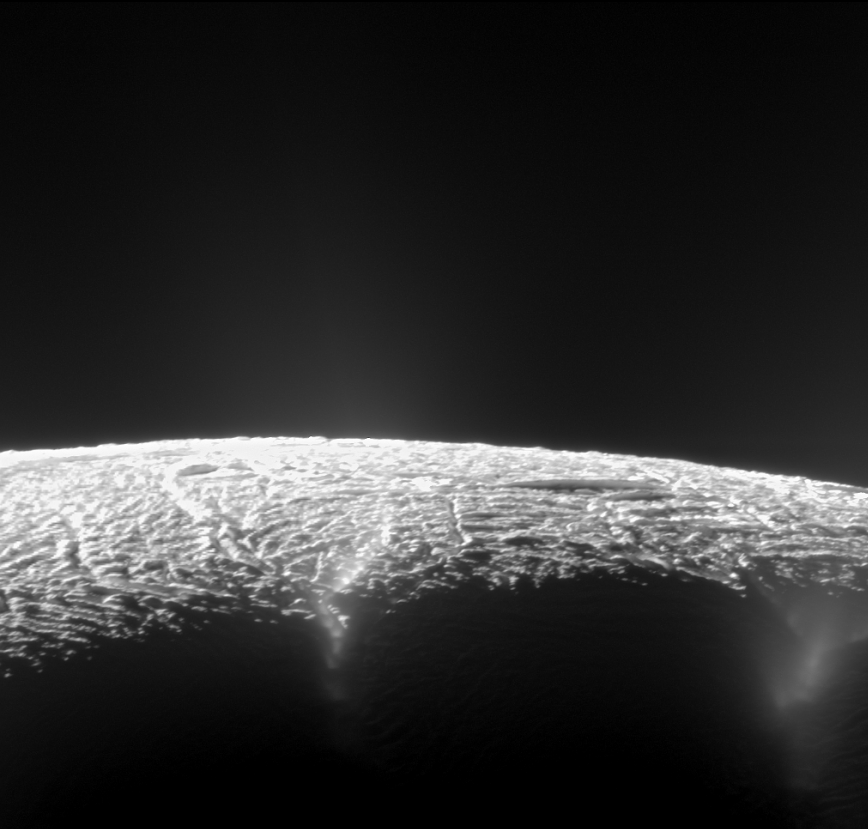


Daphnis Making Waves

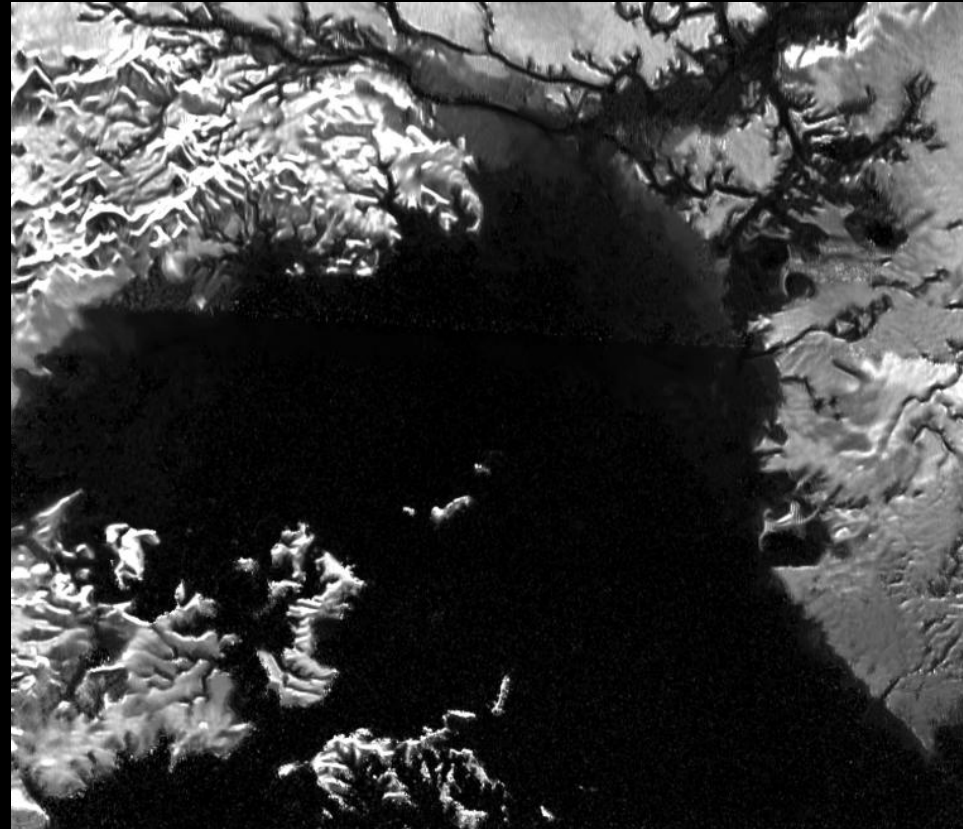


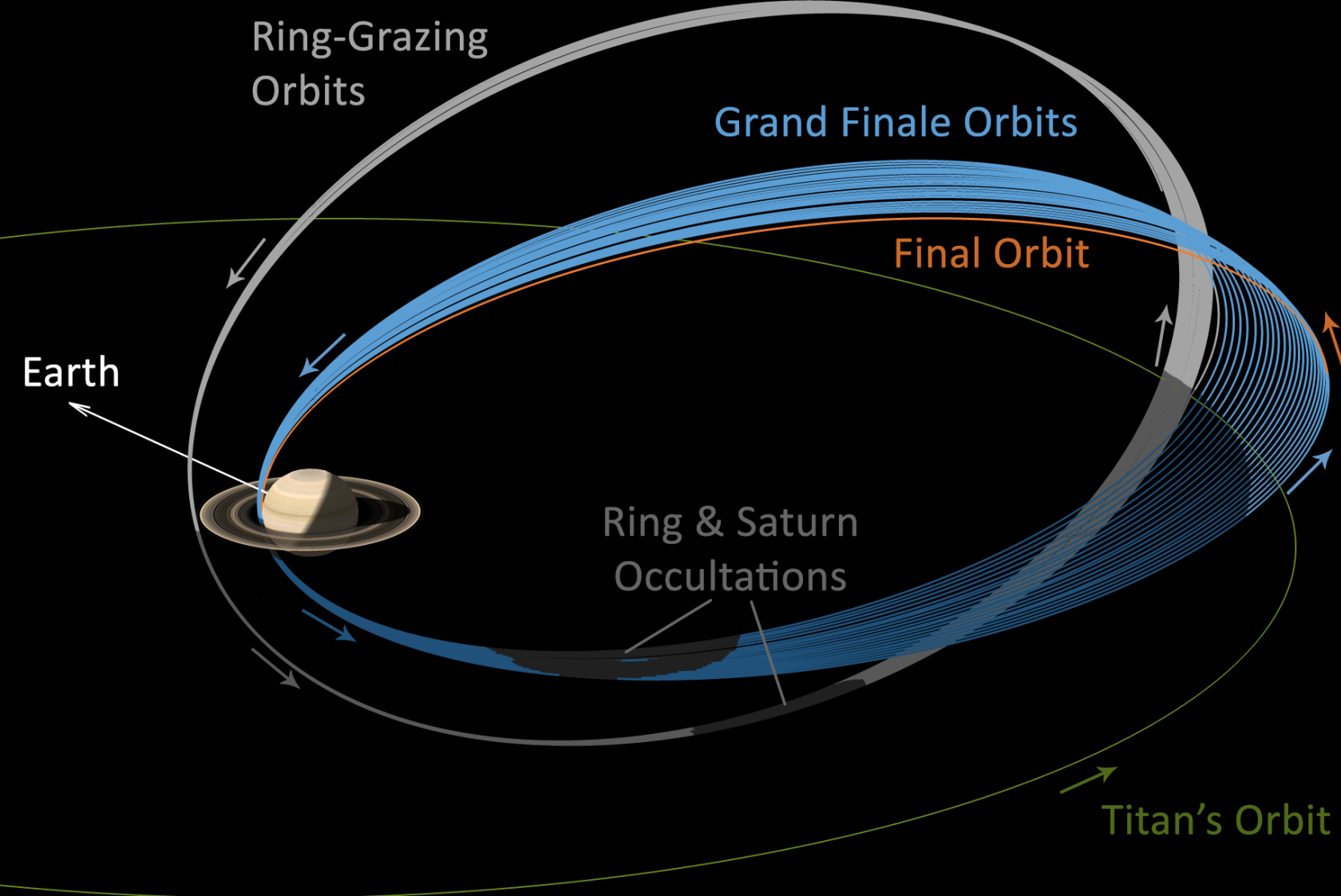
So Why End Such a Productive Mission?

Enceladus



Titan



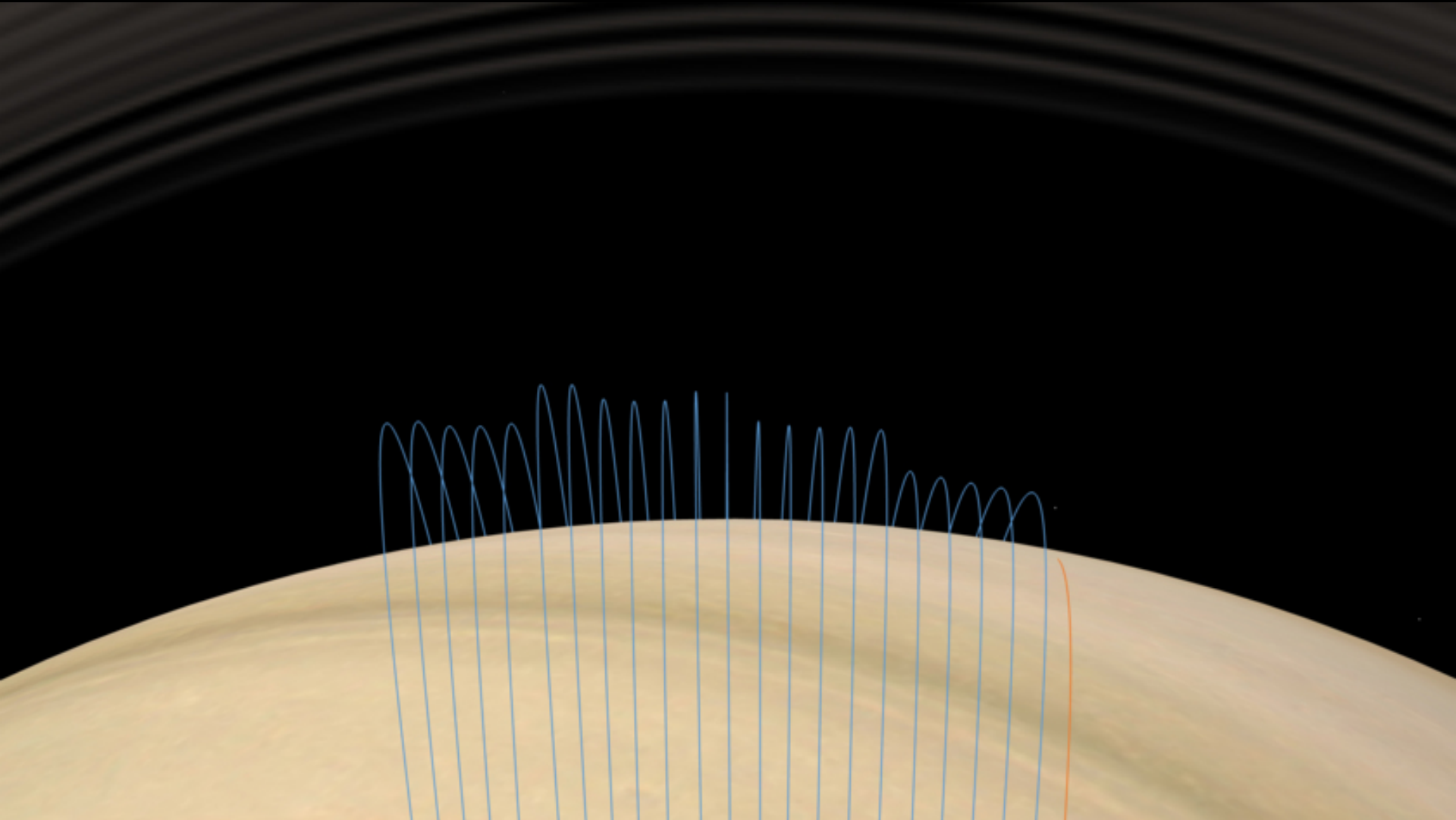


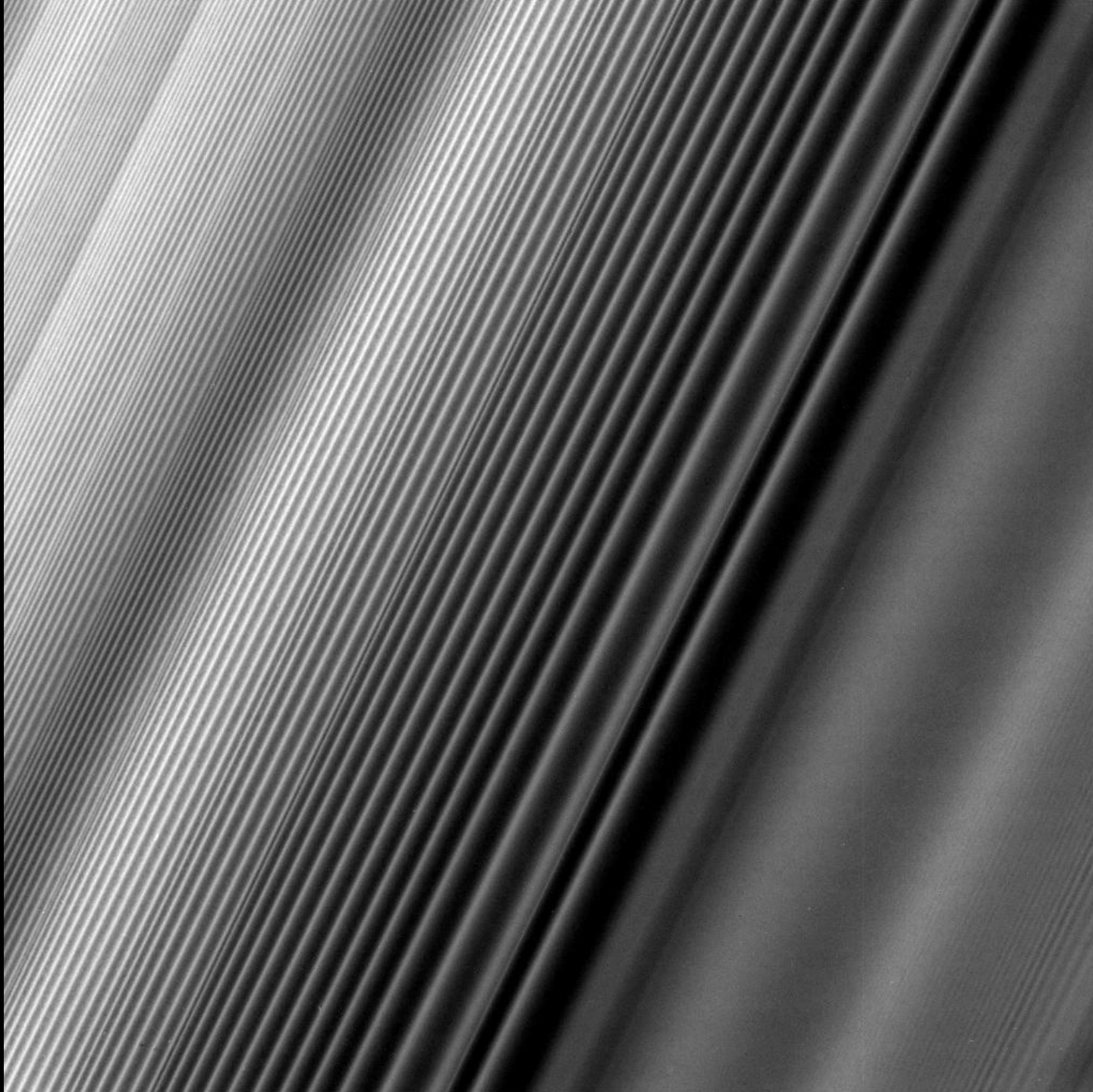
Saturn's gravity, magnetic fields, internal structure, and rotation rate.

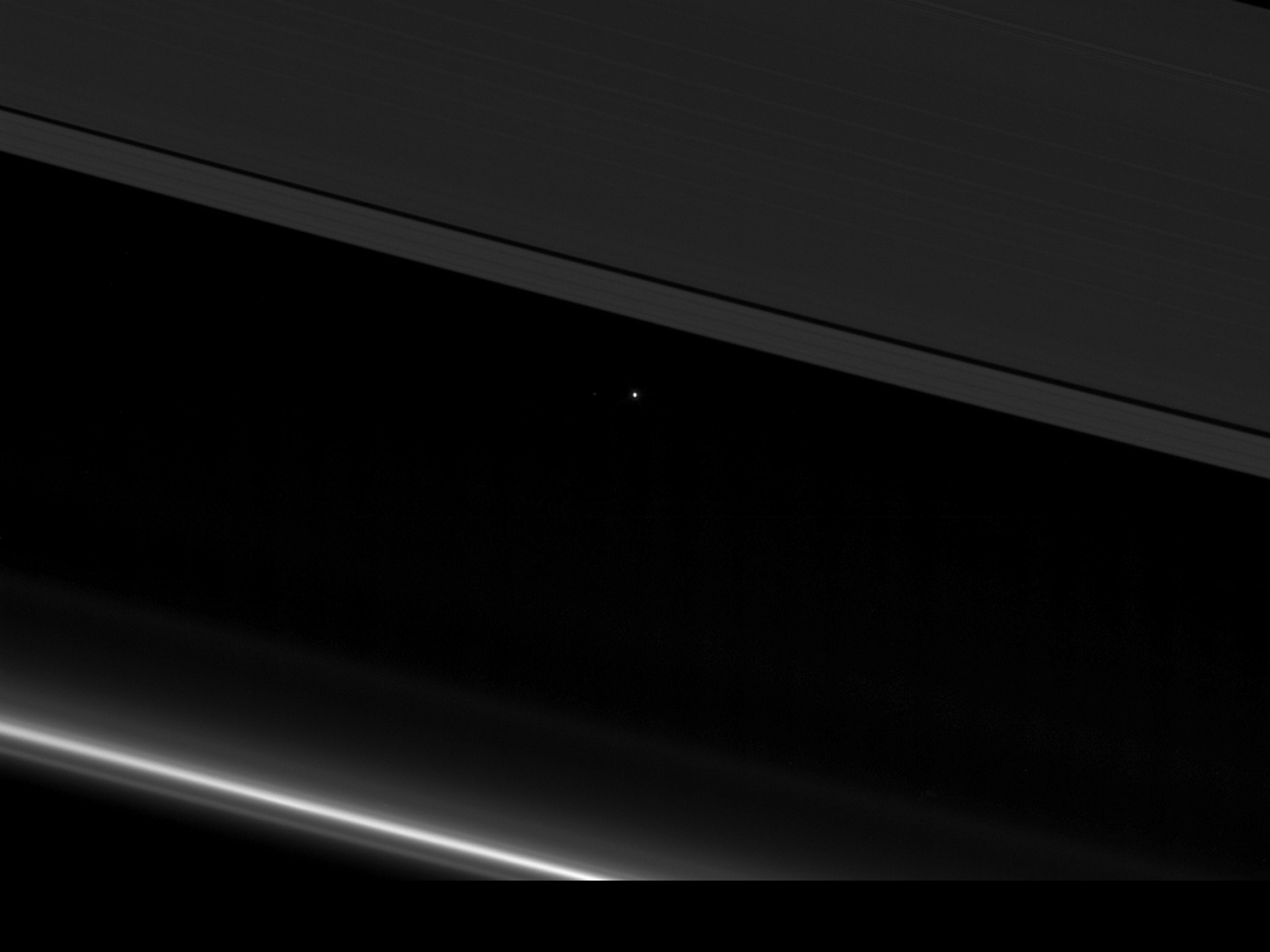
How much material is in the rings, and more about their formation?

Sample ring particles falling into Saturn's atmosphere.

22 Orbits Crossing the Ring Plane



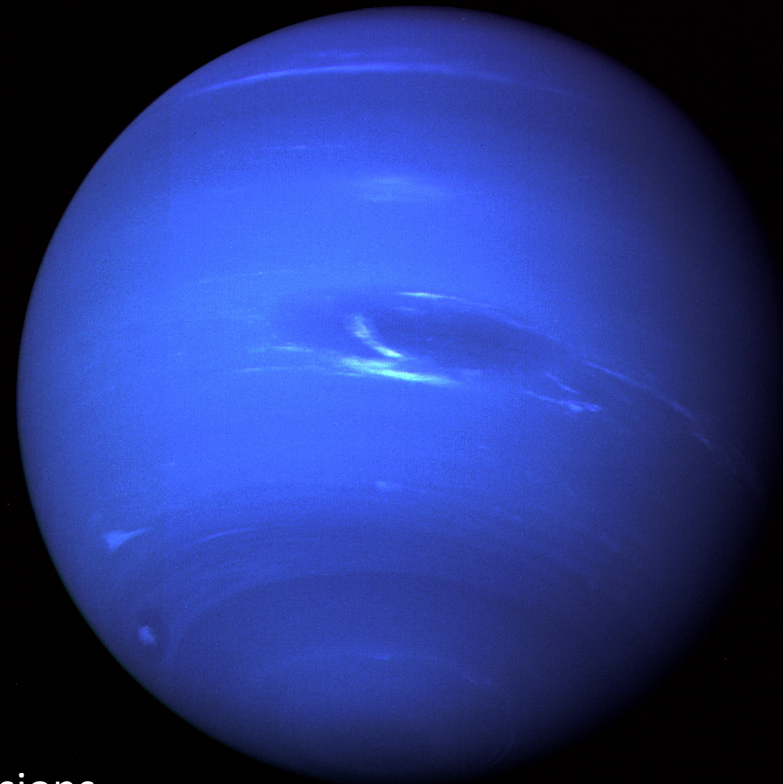
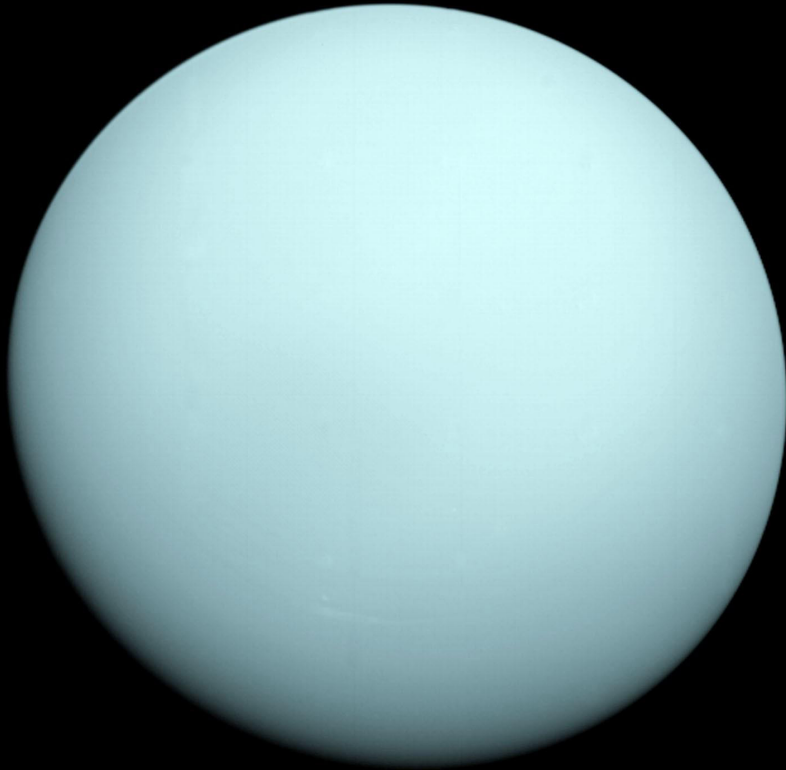




But There is Still Hope!



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Ice Giant Missions
2020's-2030's