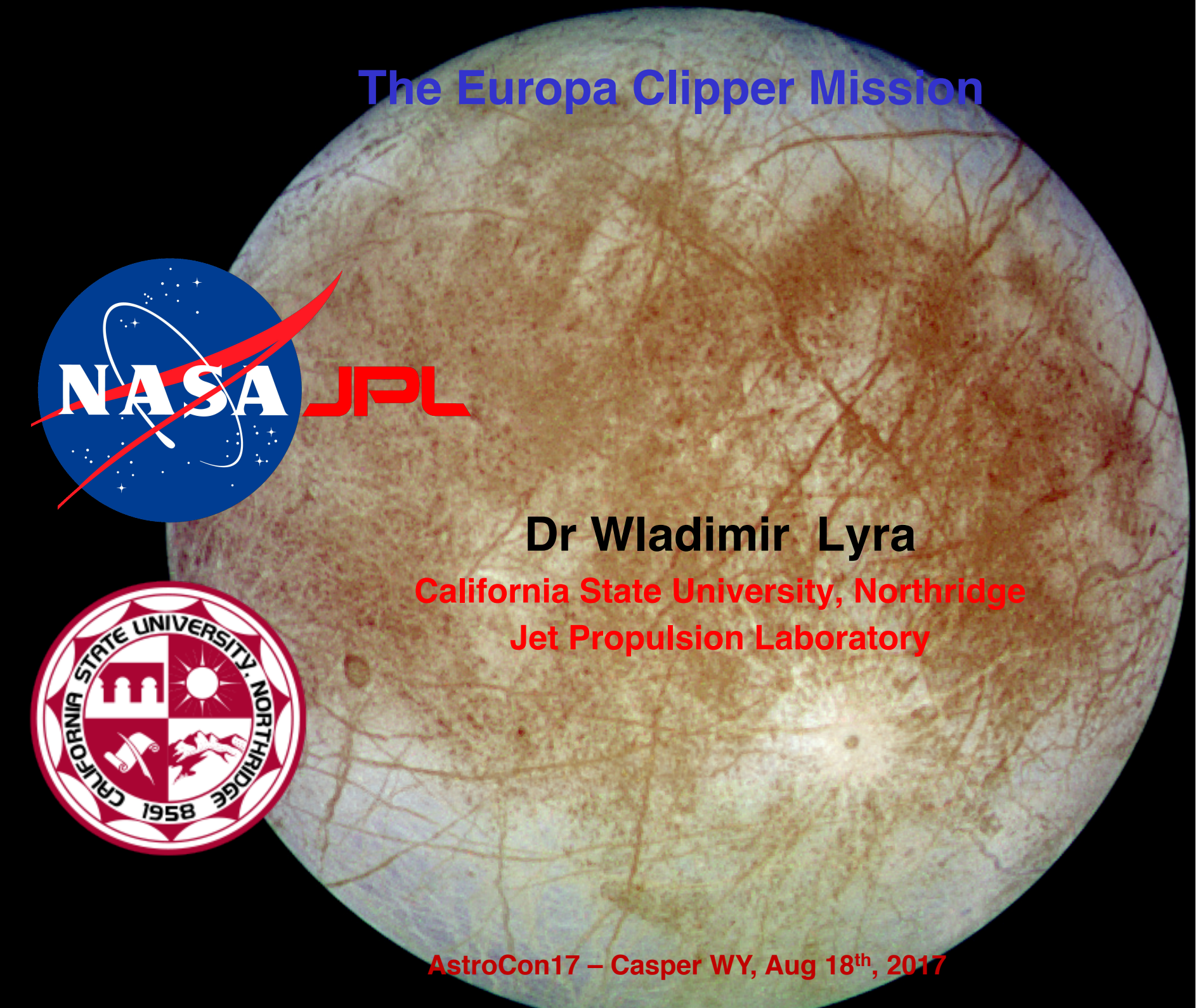
The Europa Clipper Mission



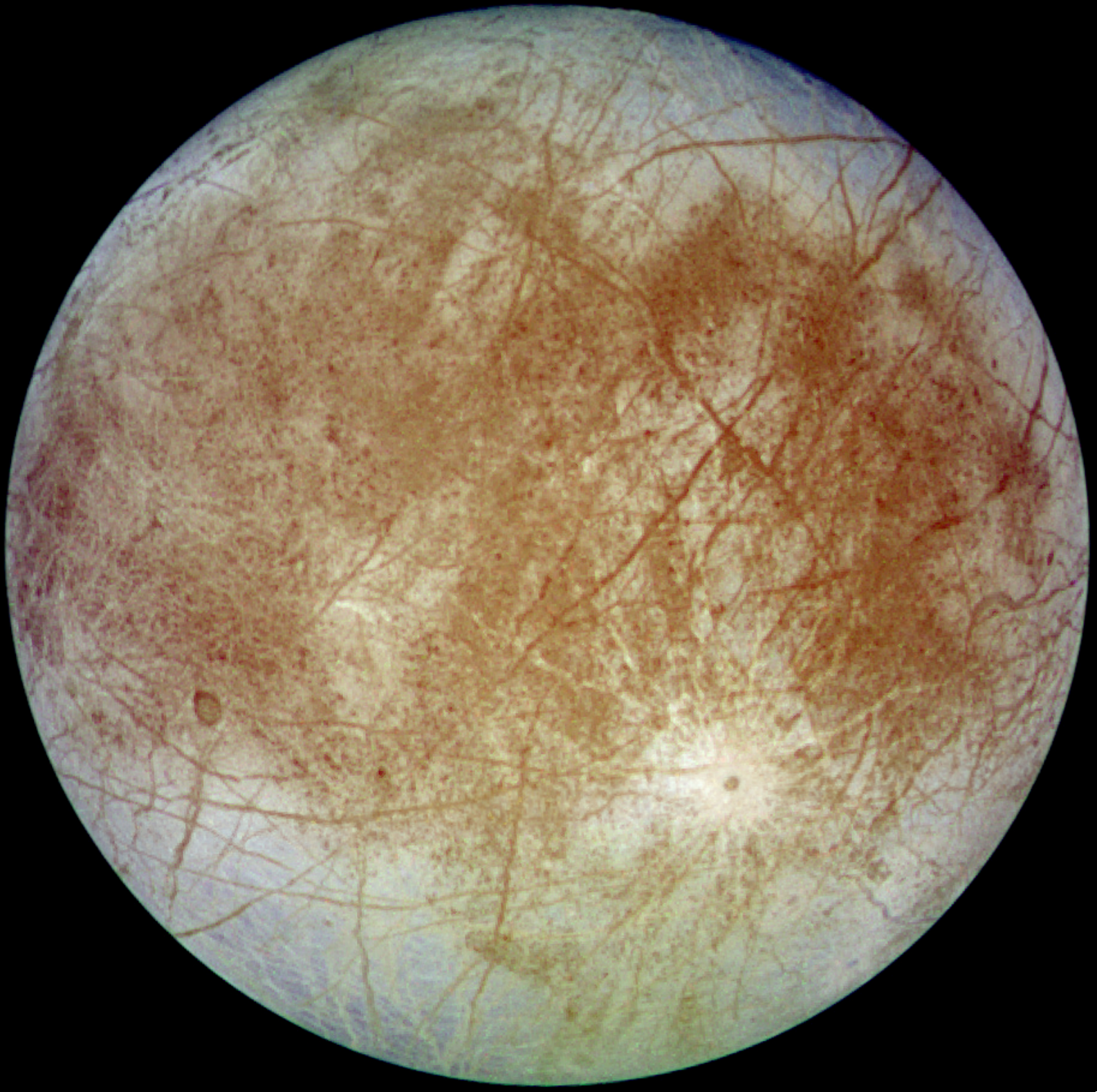
Dr Wladimir Lyra

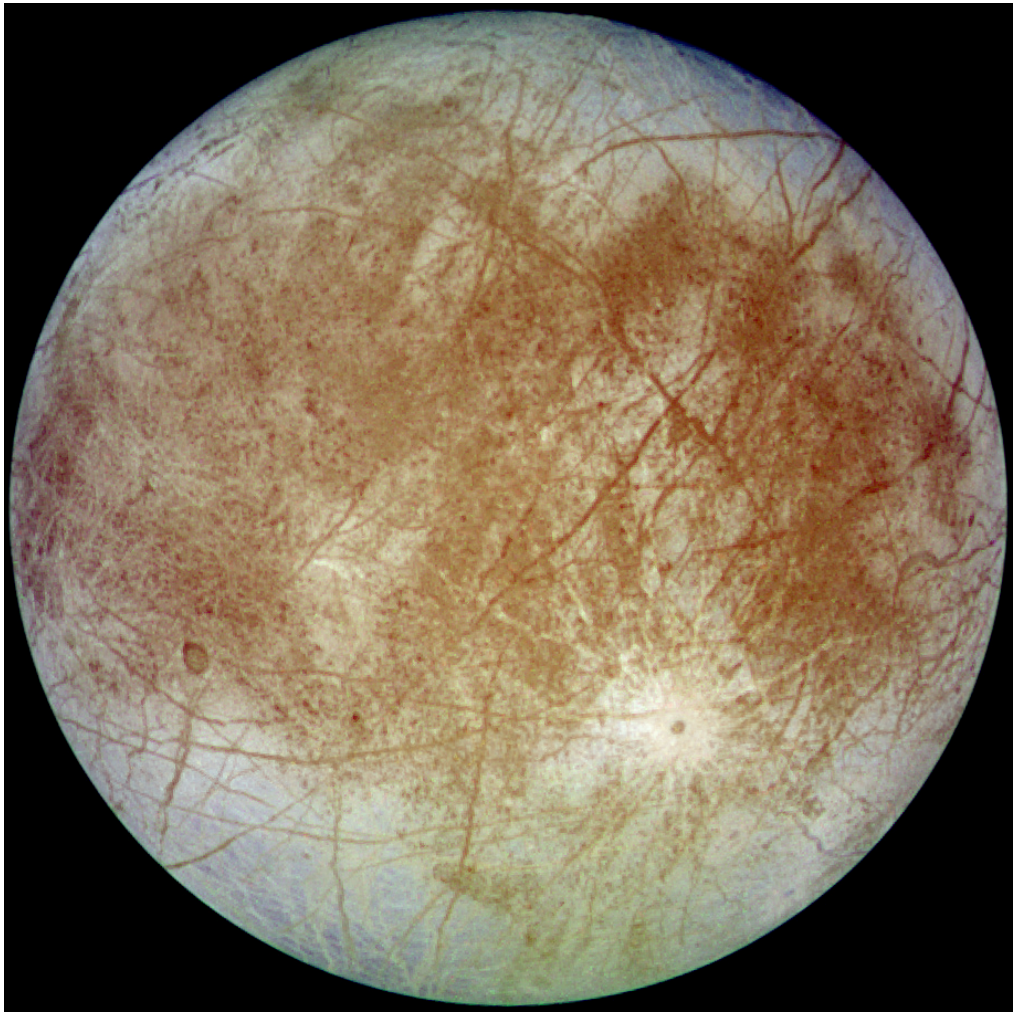
California State University, Northridge

Jet Propulsion Laboratory

AstroCon17 – Casper WY, Aug 18th, 2017


www.zerrenner.fot.br





Europa Fact Sheet

Diameter – 1900 miles
Earth's Moon: 2159 miles (88%)

Mass – 65% of Earth's Moon

Distance from Jupiter
414,000 miles *(9.5 Jupiter radii)*

Orbital period: 3.5 days

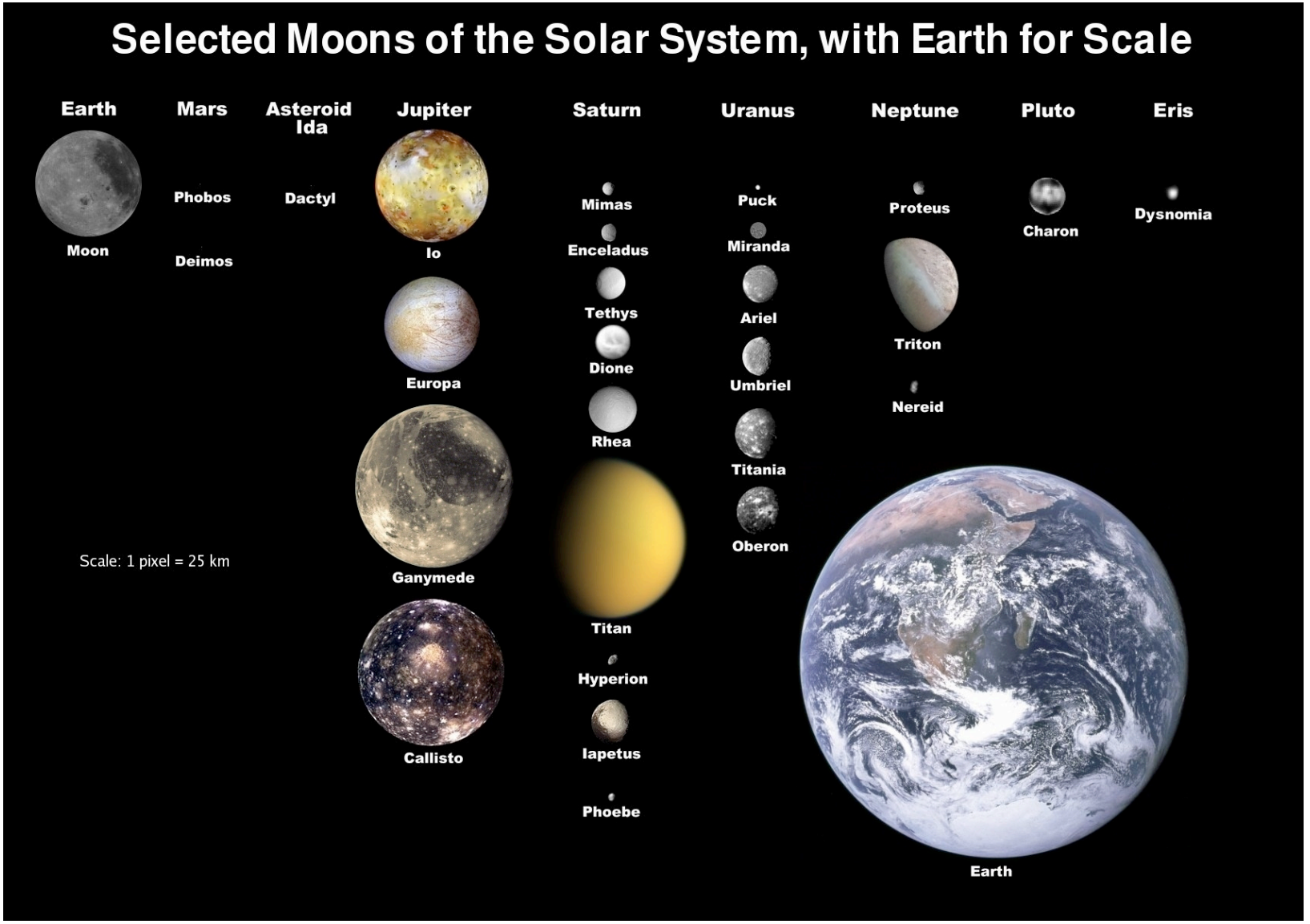
Temperature: -275^{o}F

Discovery: Jan 8th, 1610
Galileo Galilei

Jupiter's family portrait

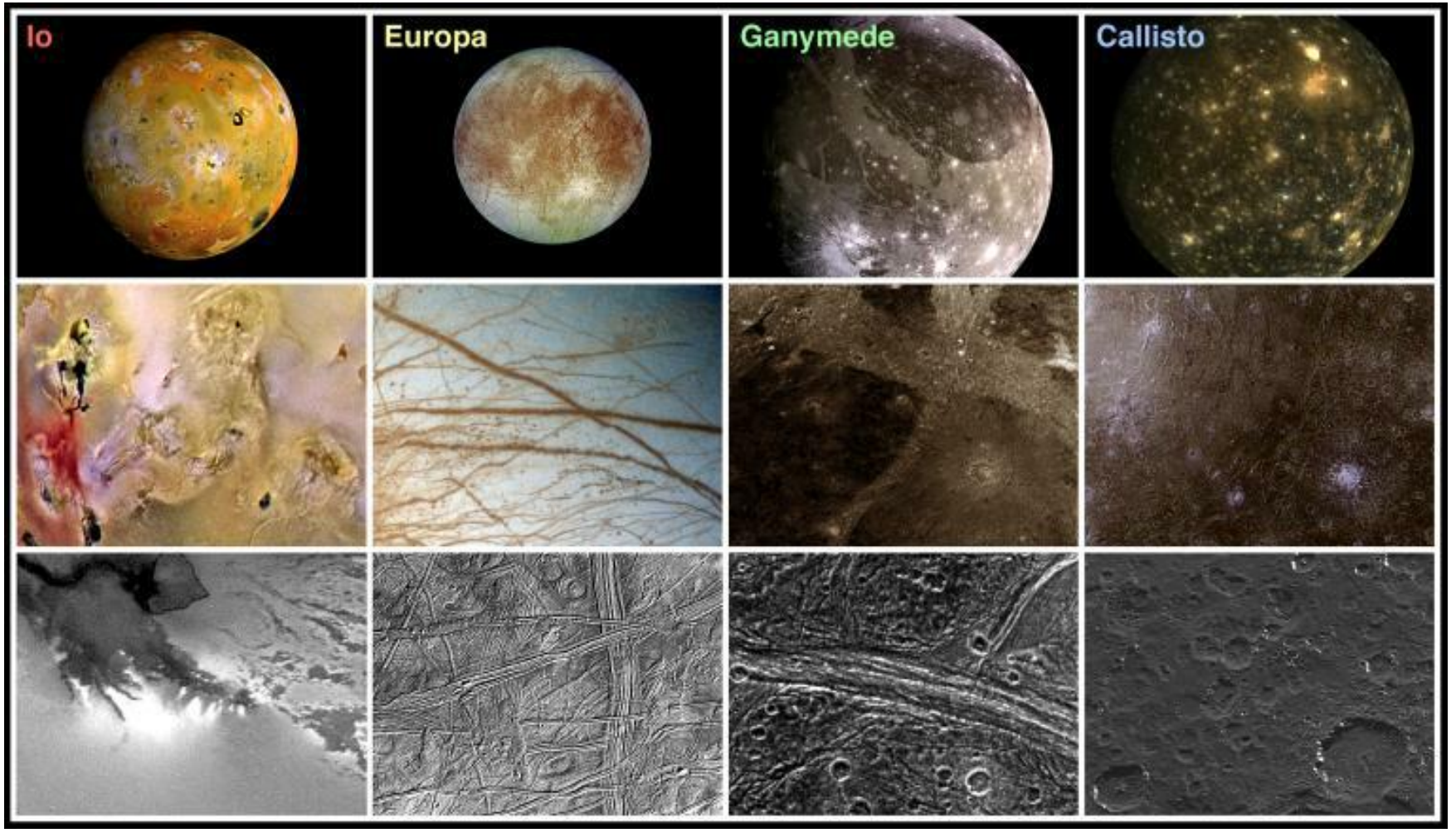
Io Europa Ganymede Callisto

Moons of the Solar System



Size Comparison

Surfaces of the Galilean Moons



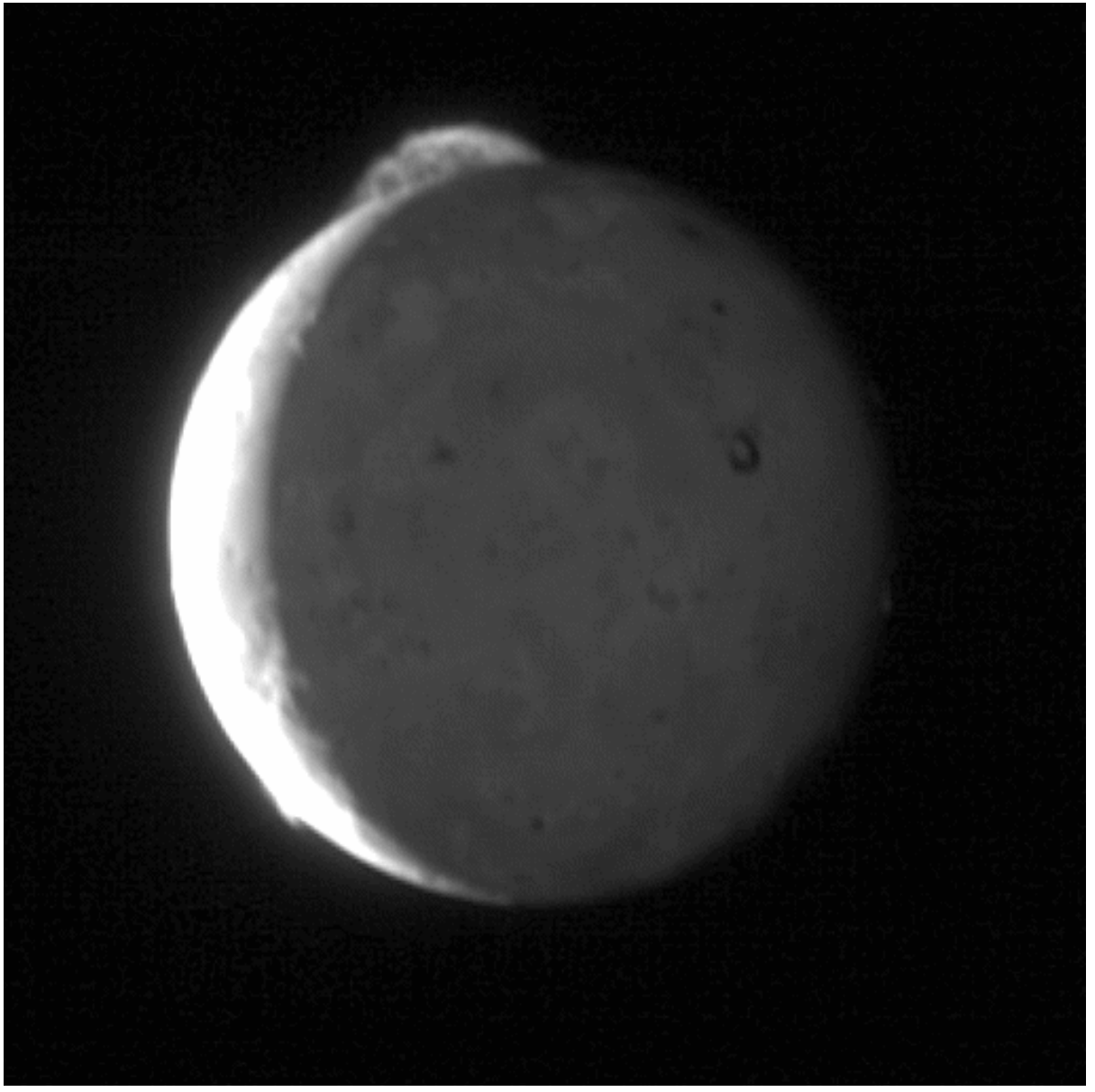
Young surfaces

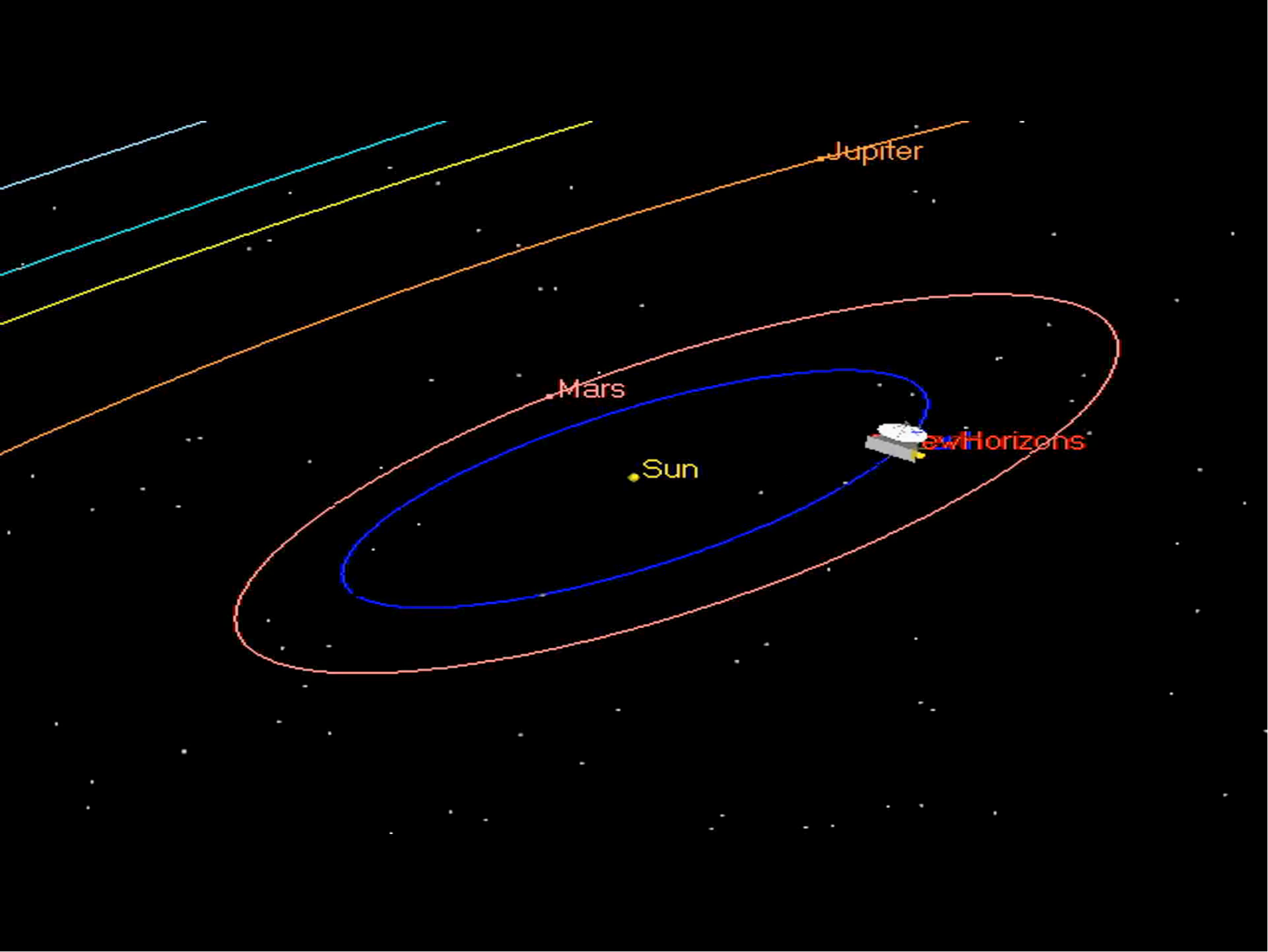
Old surface

(Geologically Active)

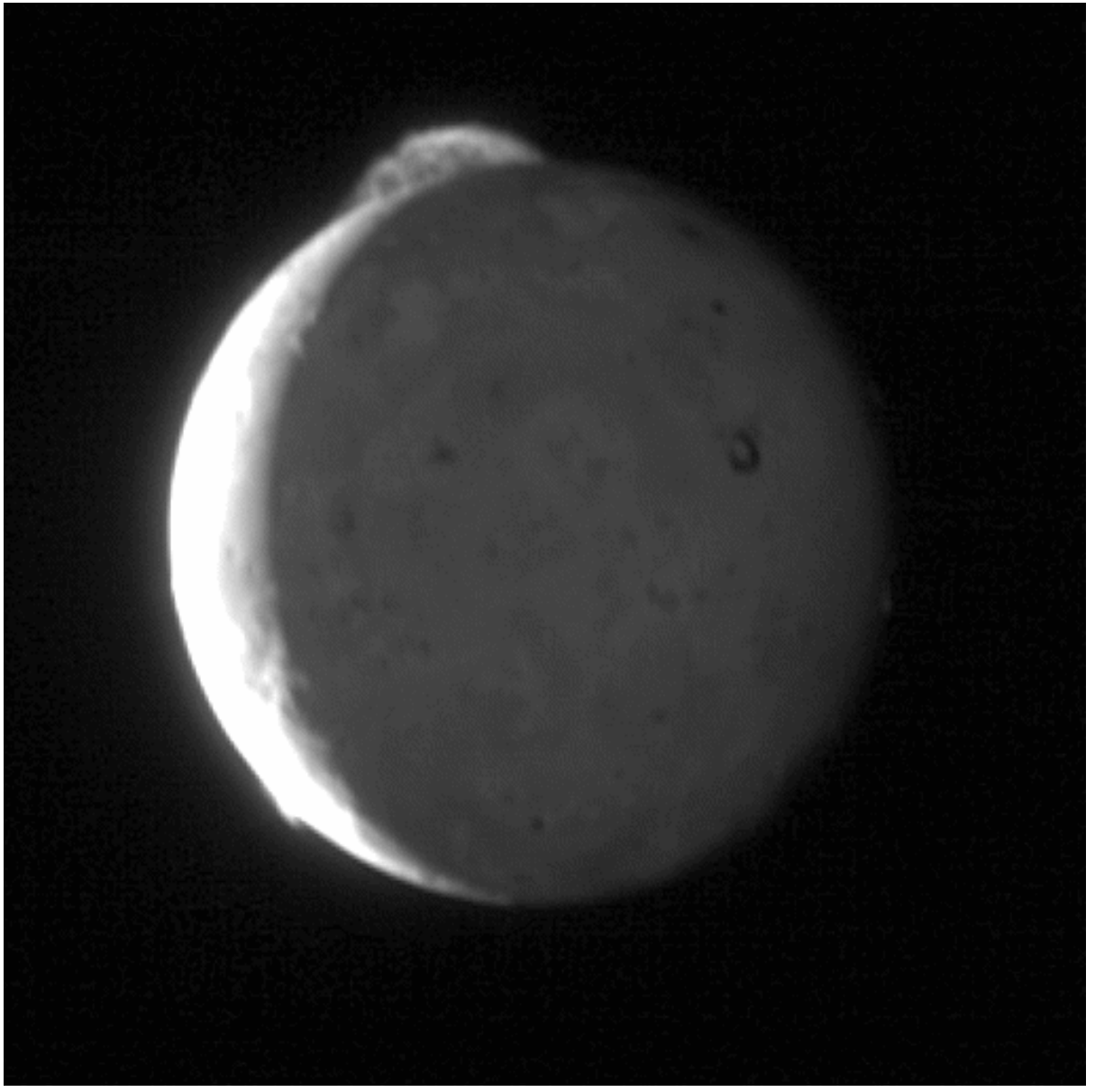
Volcanic Moons

Io in action



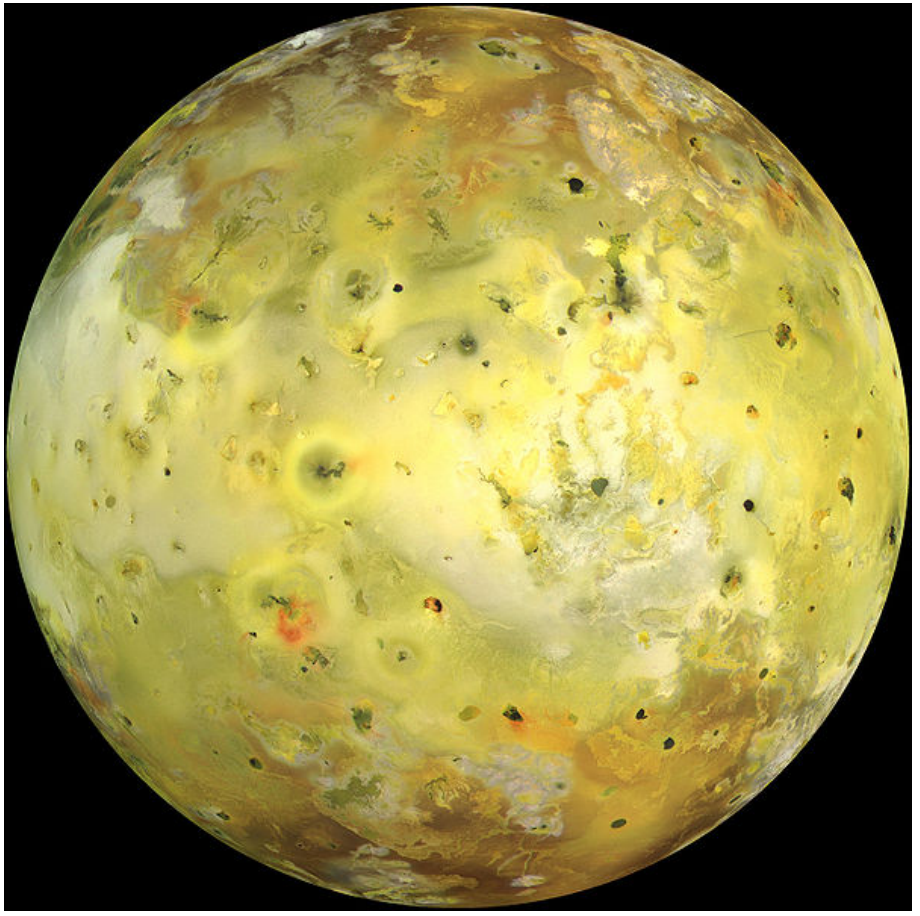

Jupiter
Mars
Sun
New Horizons

Io in action



Io – Jupiter's Volcanic Moon

"Nowhere else in the Solar System
do **volcanic processes**
so **dominate** everything we see as on **Io**"
Carl Sagan



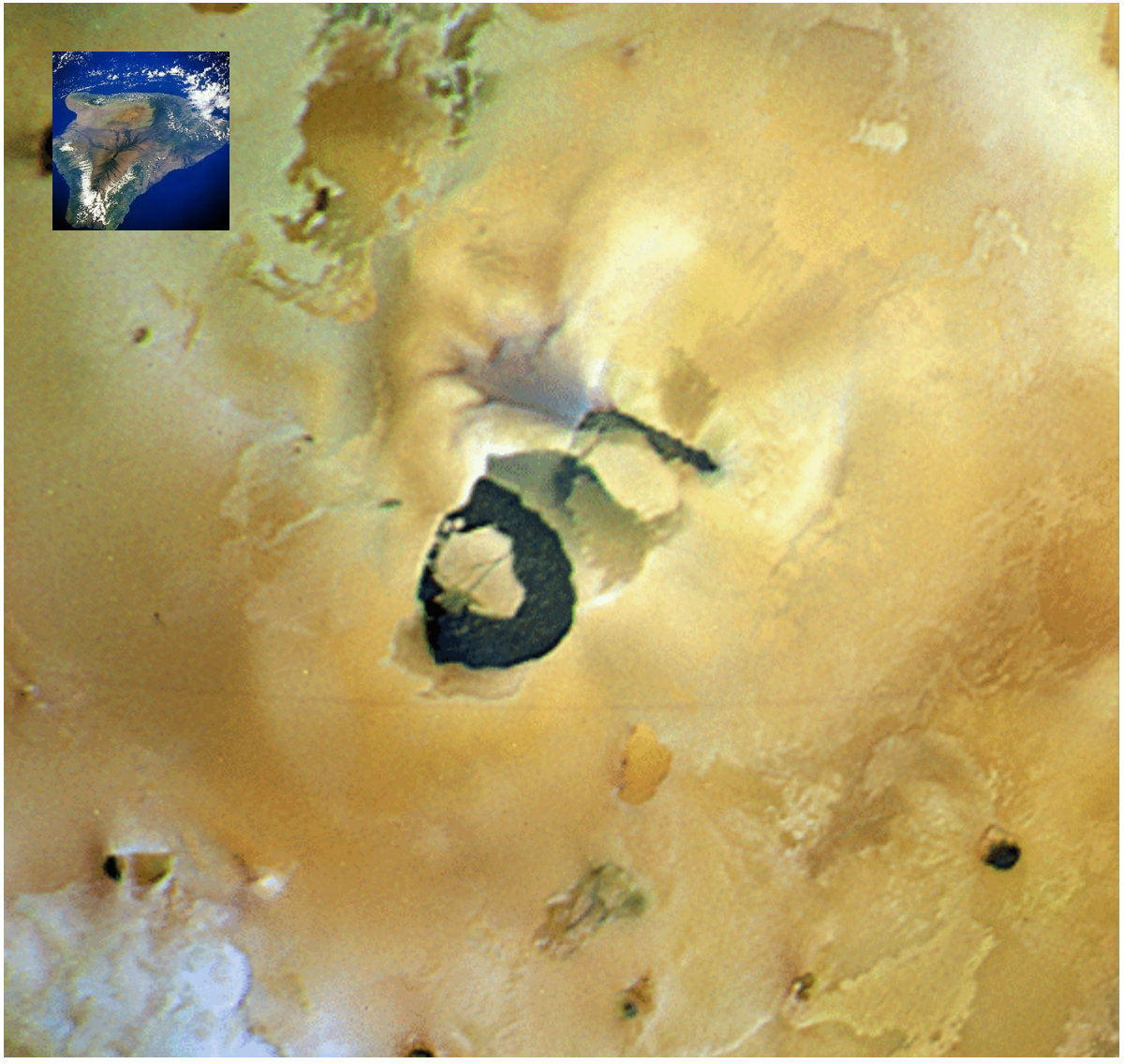
100 times more volcanic than Earth!!

Ground temperature: -260°F

Bright areas: Fresh sulfur frost

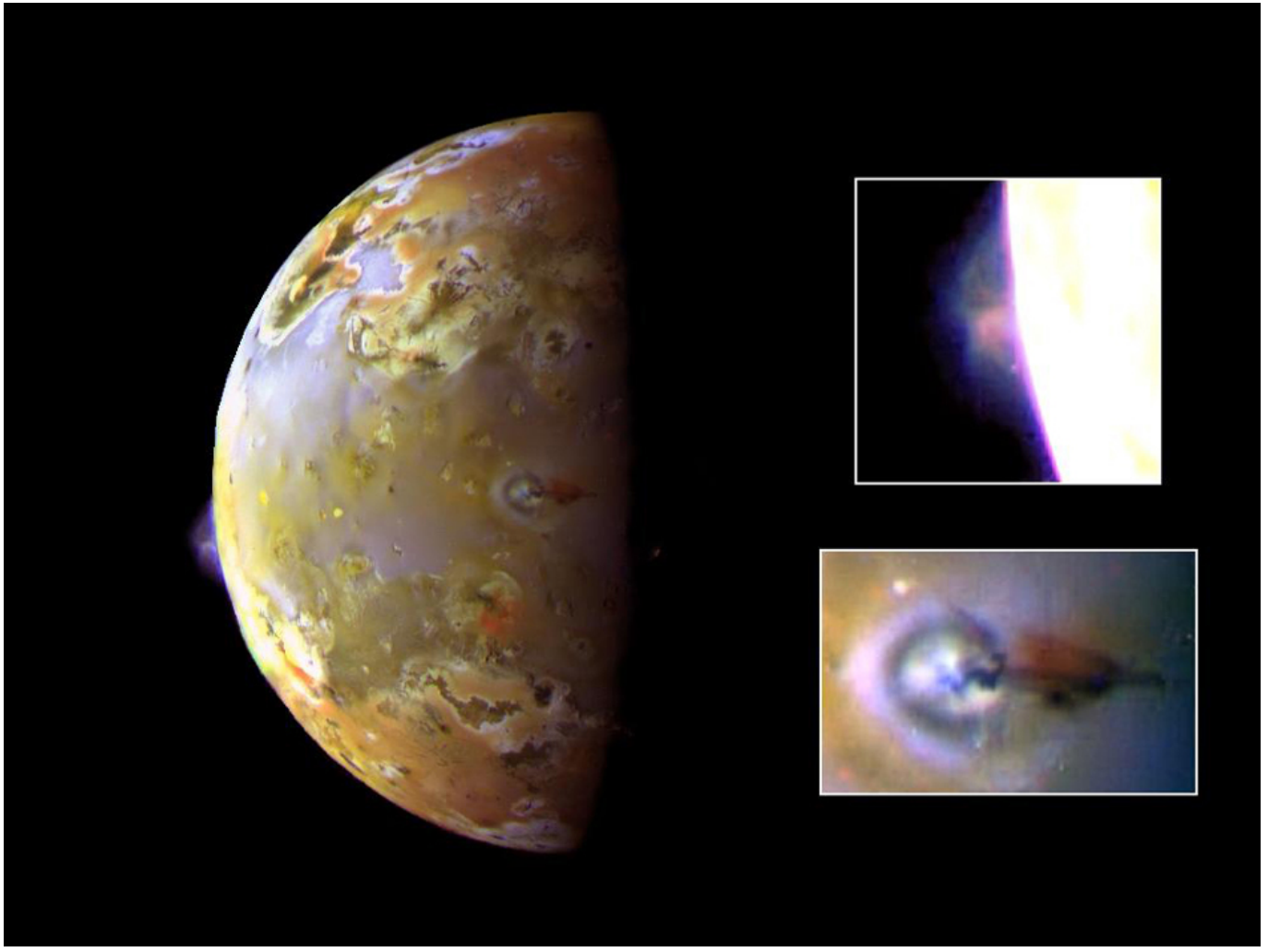
Yellow-Brown areas: older sulfur compounds

Io's Volcanoes

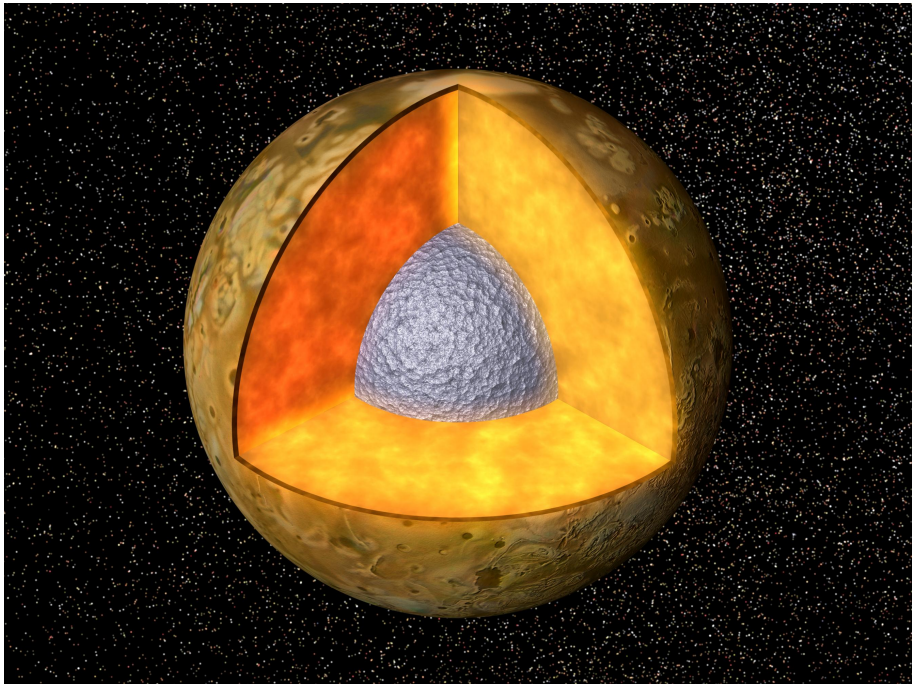


Loki

Active volcanoes



Io's interior



Thin silicate crust

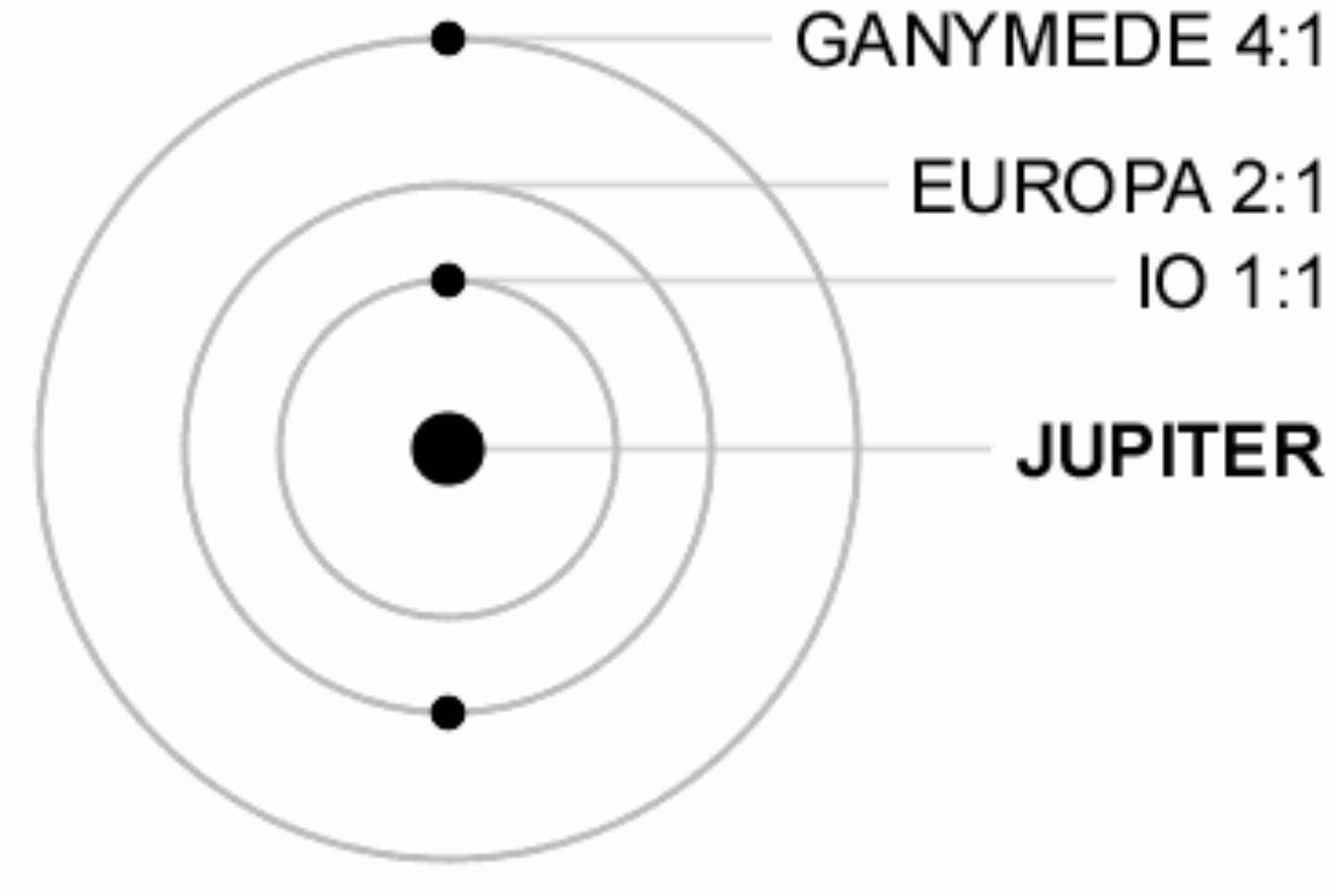
Molten silicate interior

Iron rich core

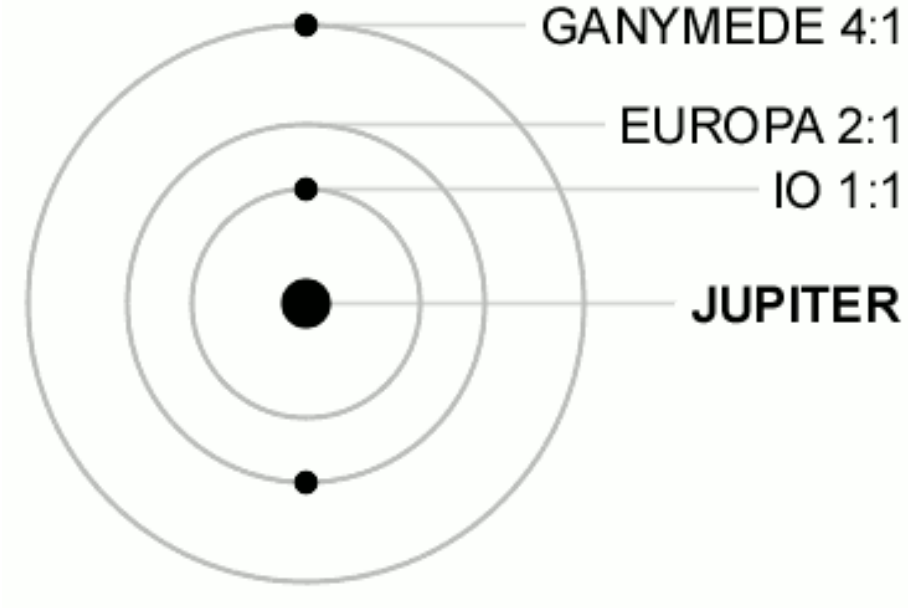
Io is roughly the size of the Moon.
How does such a small body retain such a hot interior?

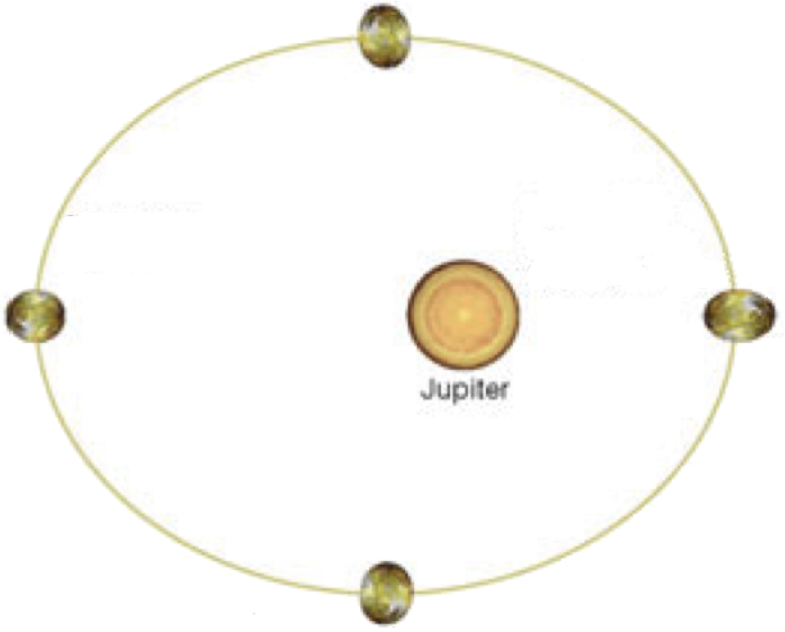
Tides

Orbital Clockwork



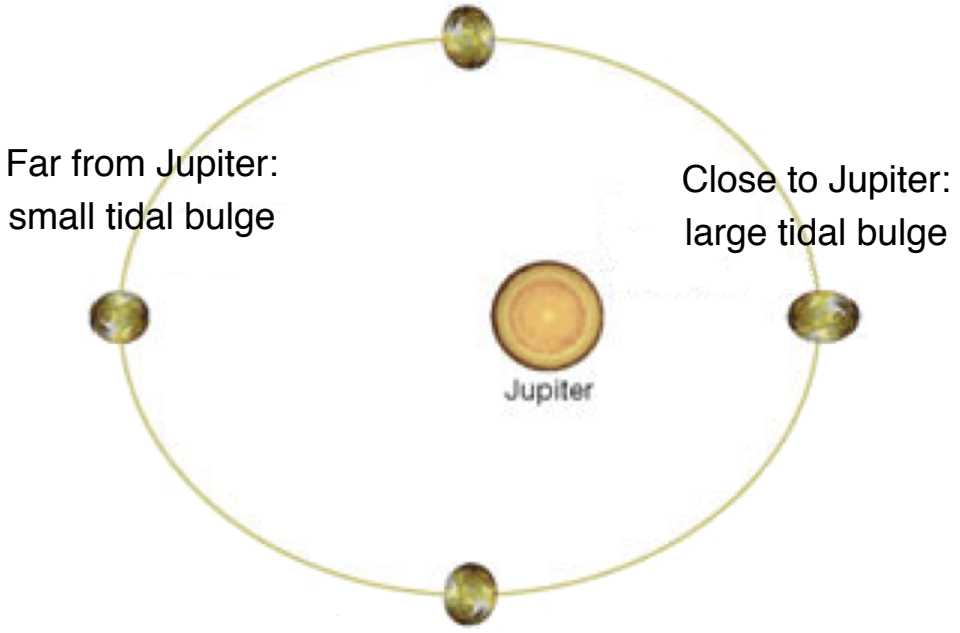
Swinging Moons





Periodic tug of Europa makes
Io's orbit slightly elliptic

Tidal Heating



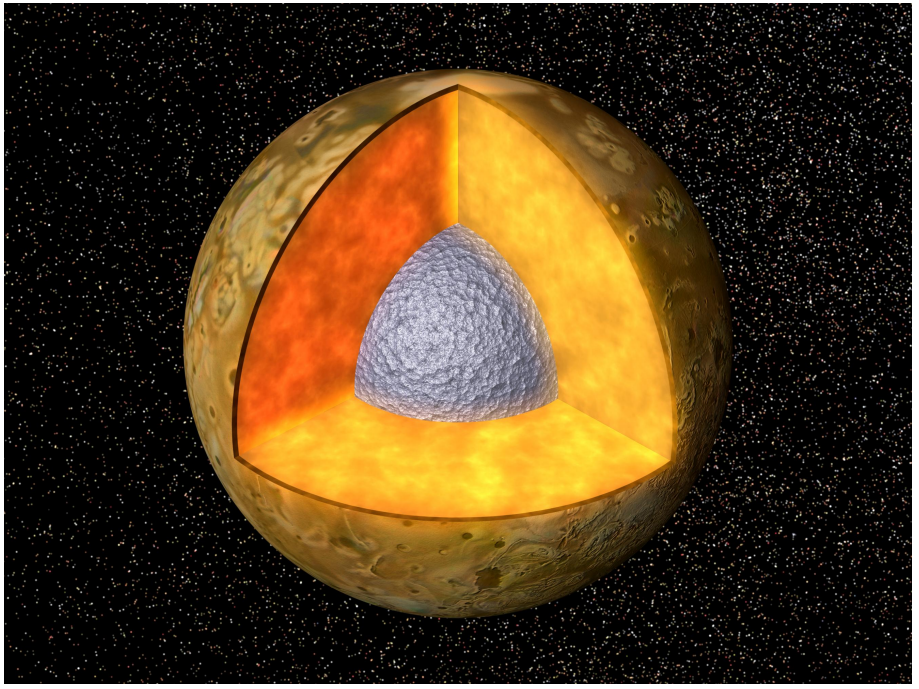
Difference in tidal bulge
from closest to farthest from Jupiter:
100 m (~300 ft)

MASSIVE FRICTION!!!


Jupiter
Io

Tidal heating

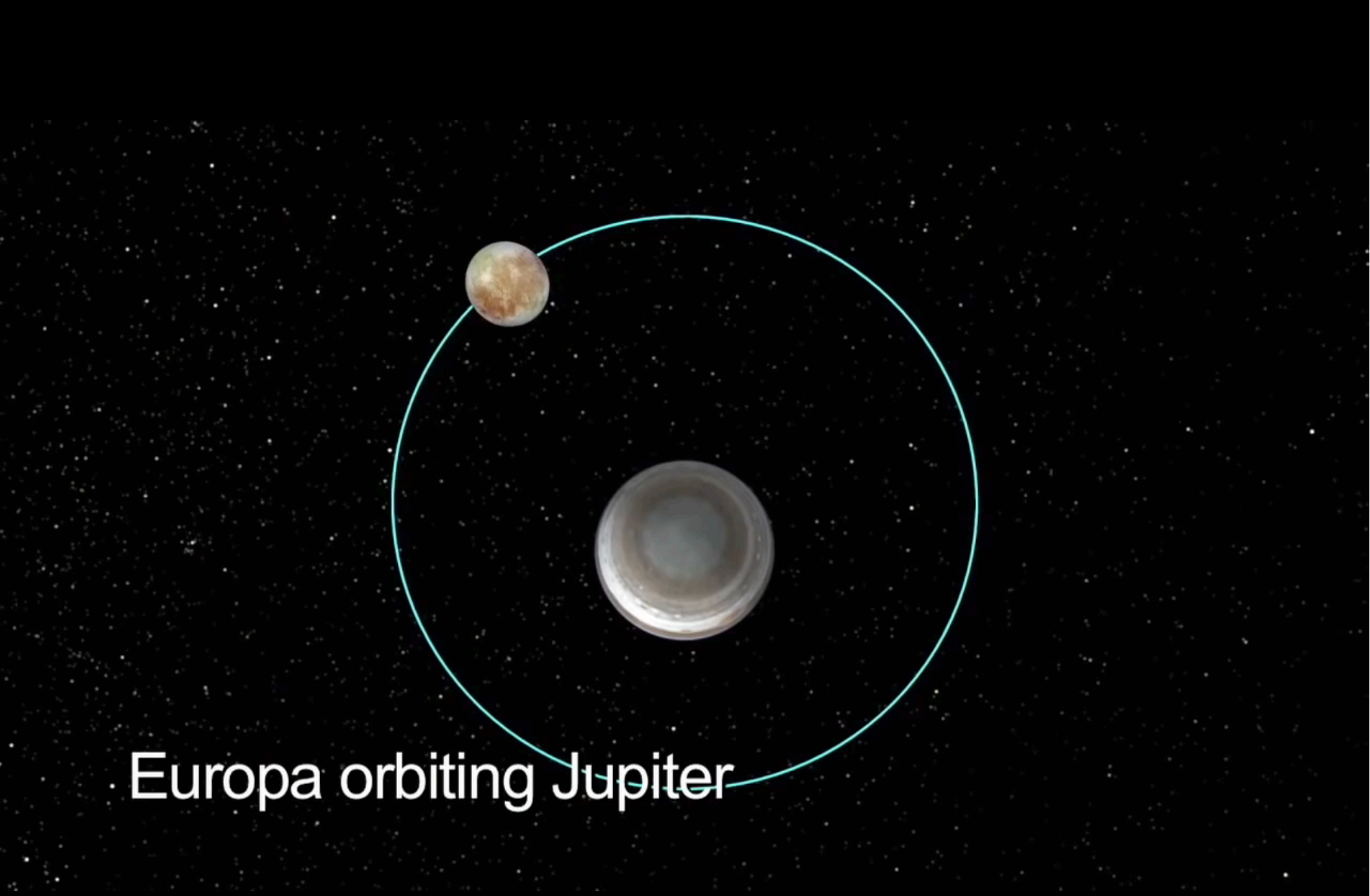
keeps Io's interior molten

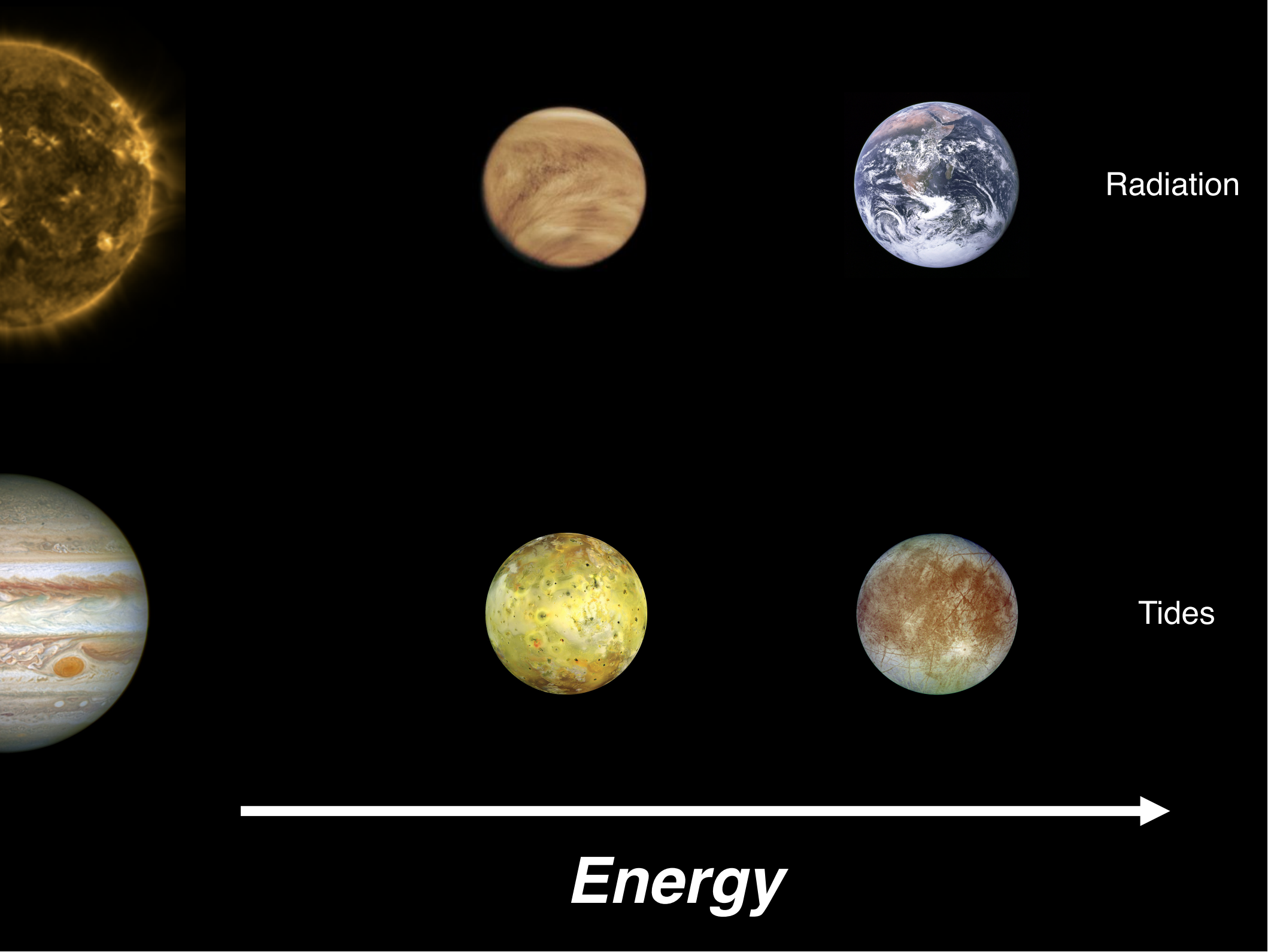


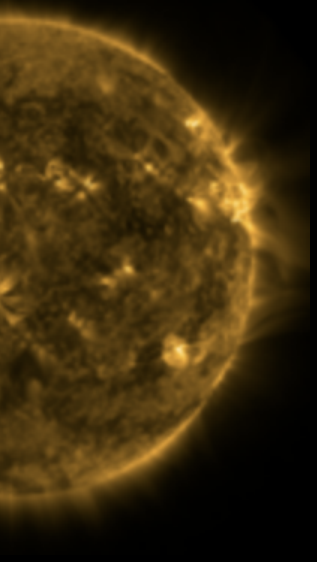
Thin silicate crust

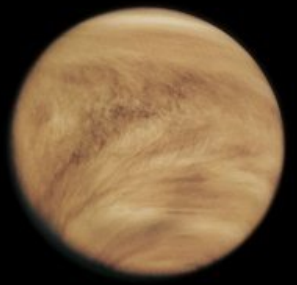
Molten silicate interior

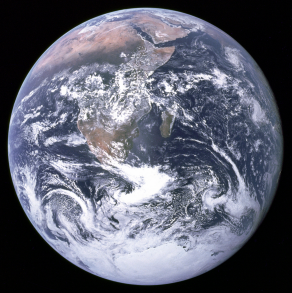
Iron rich core


Europa orbiting Jupiter


Radiation
Tides
Energy

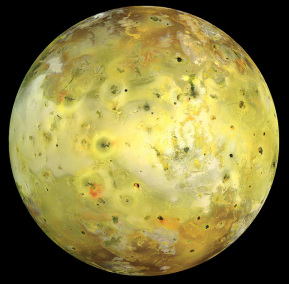


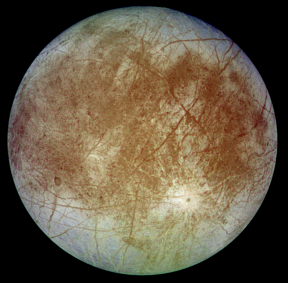




Too much!

Just right



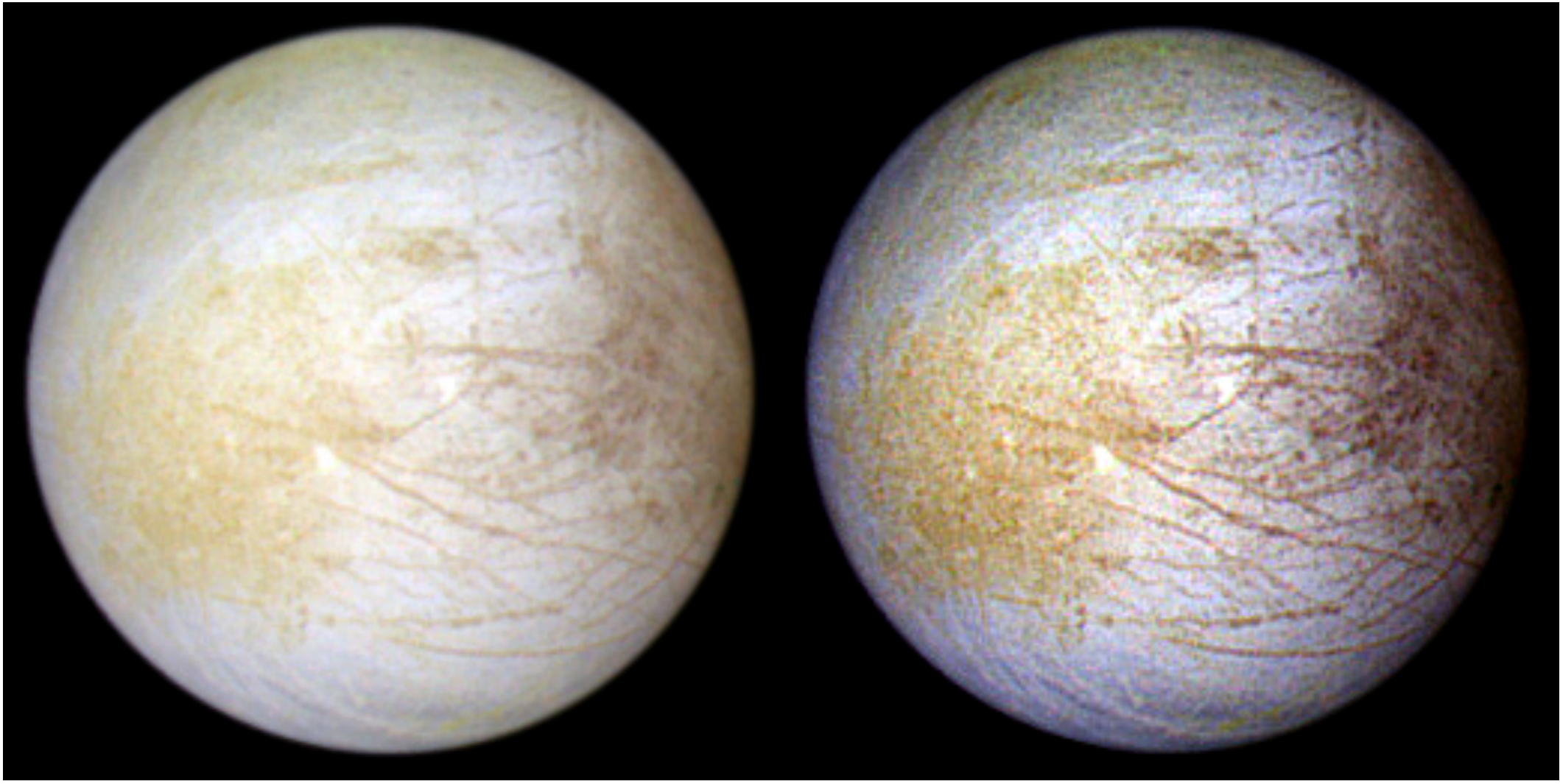


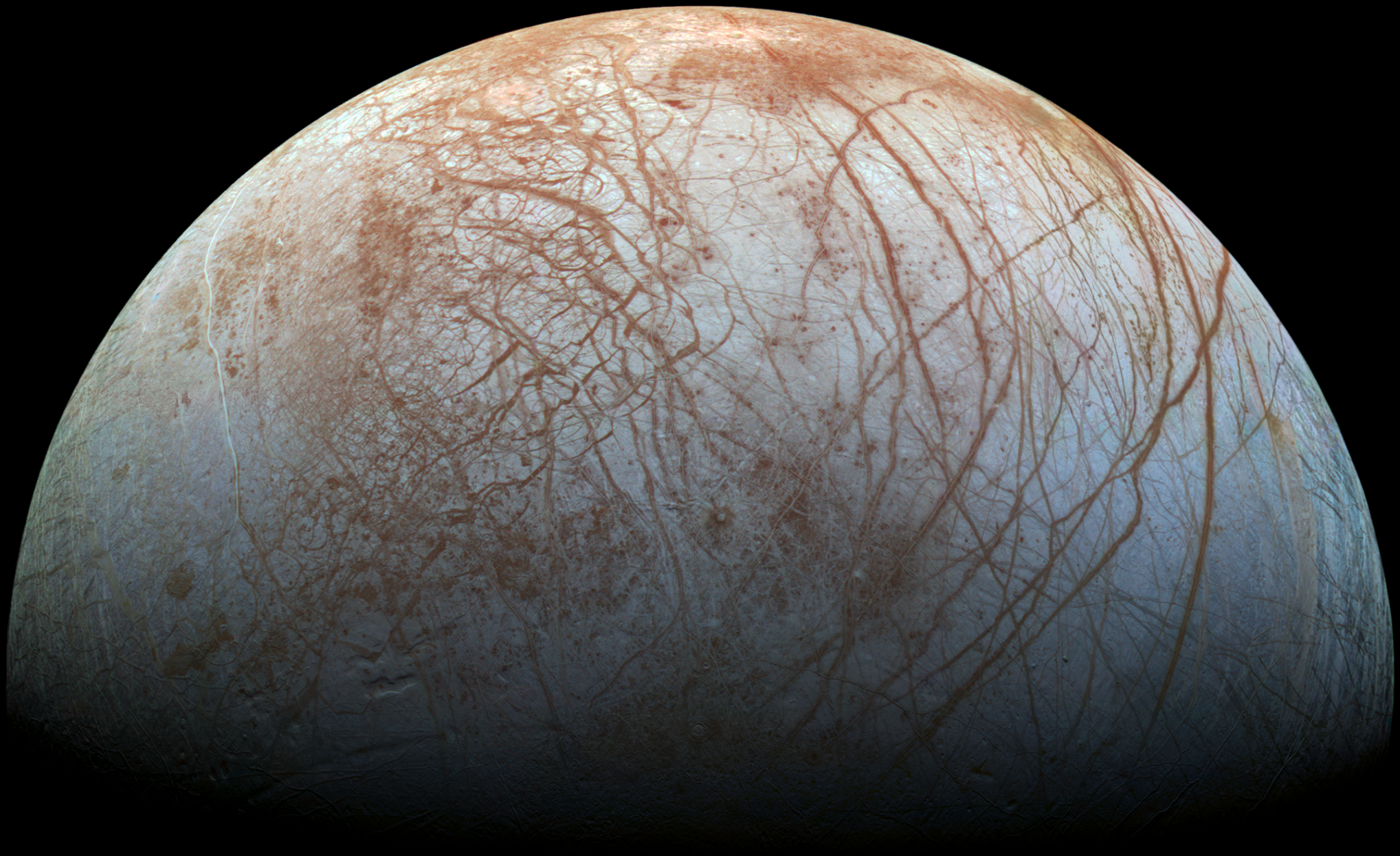
Radiation

Tides

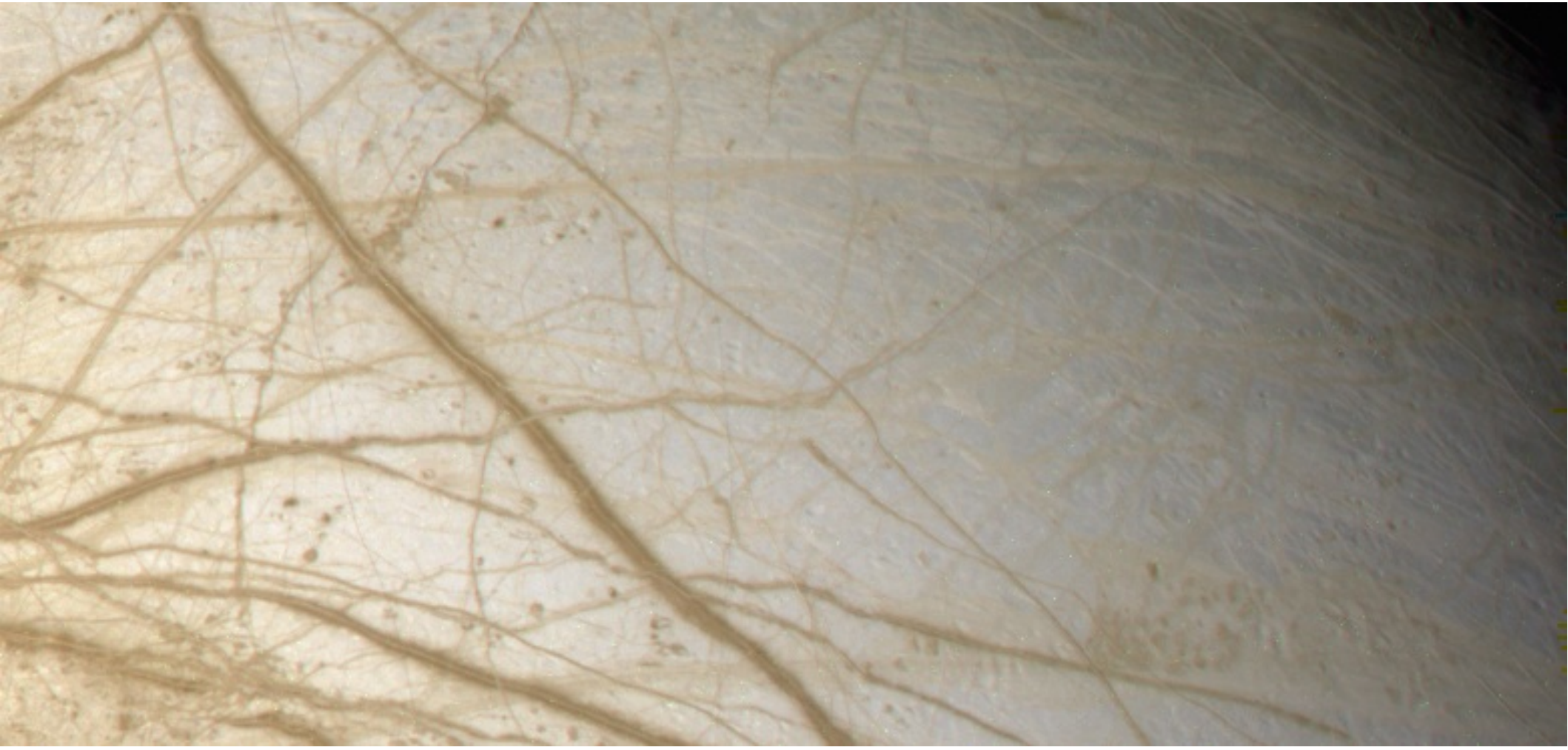
Energy

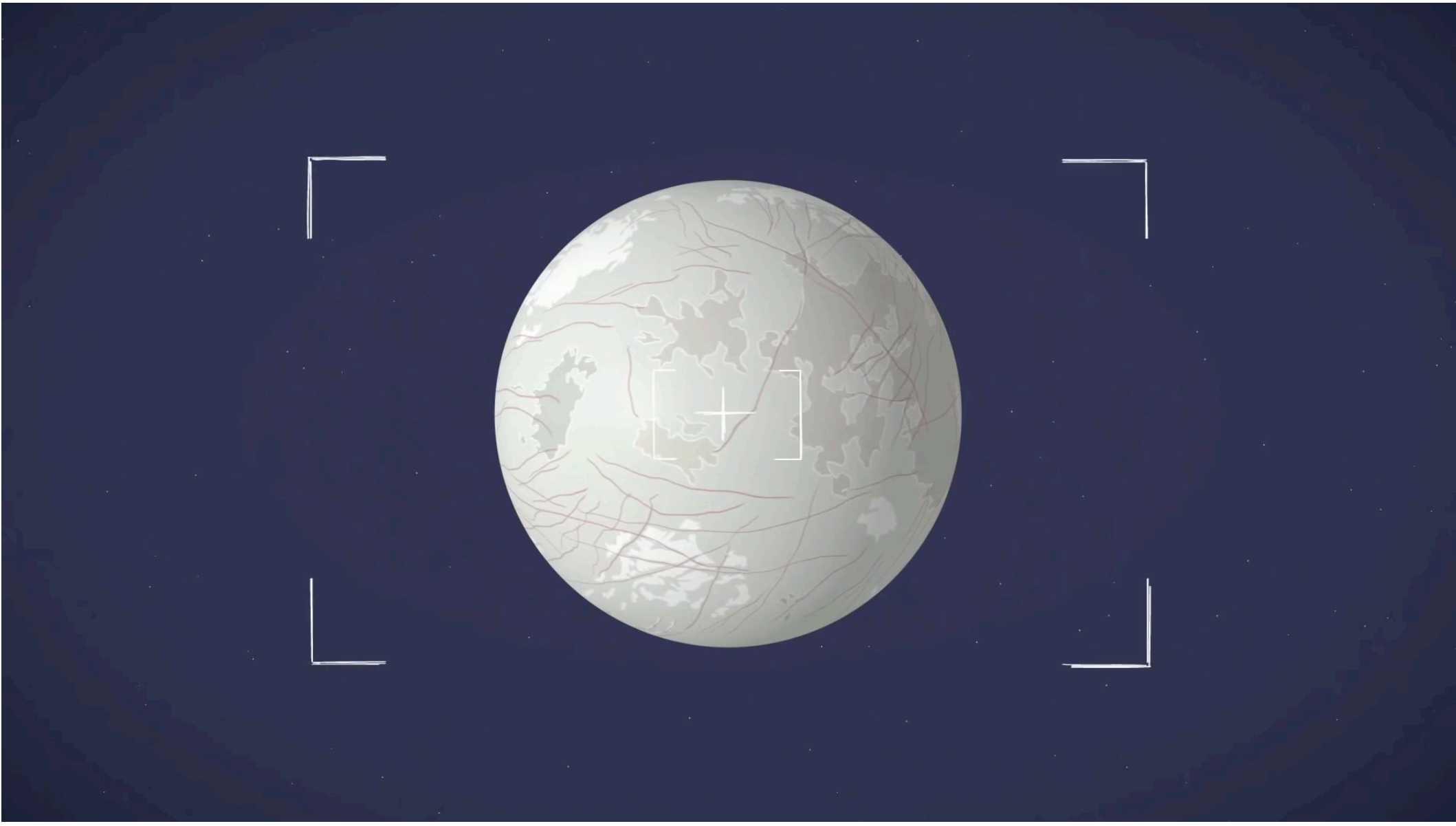
Europa



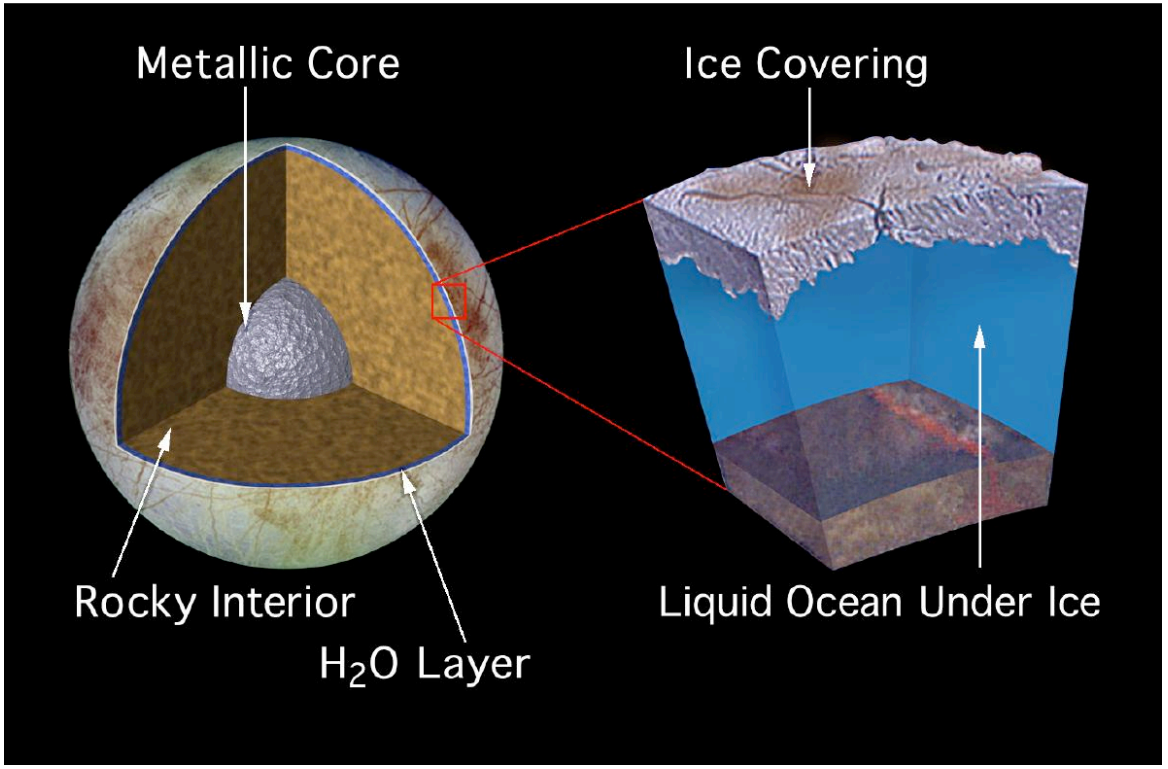


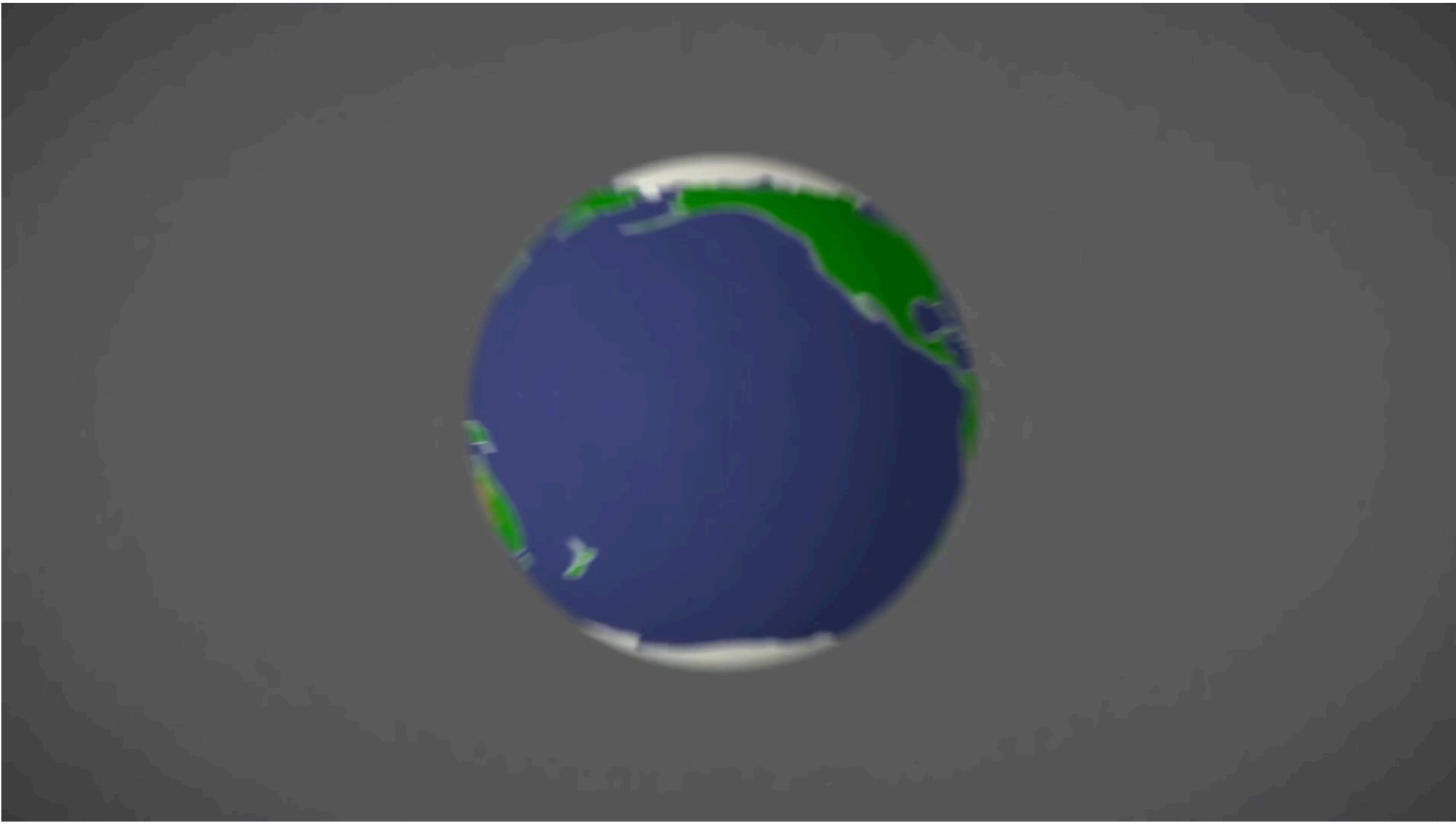
Ice Tectonics





Surface floating on liquid

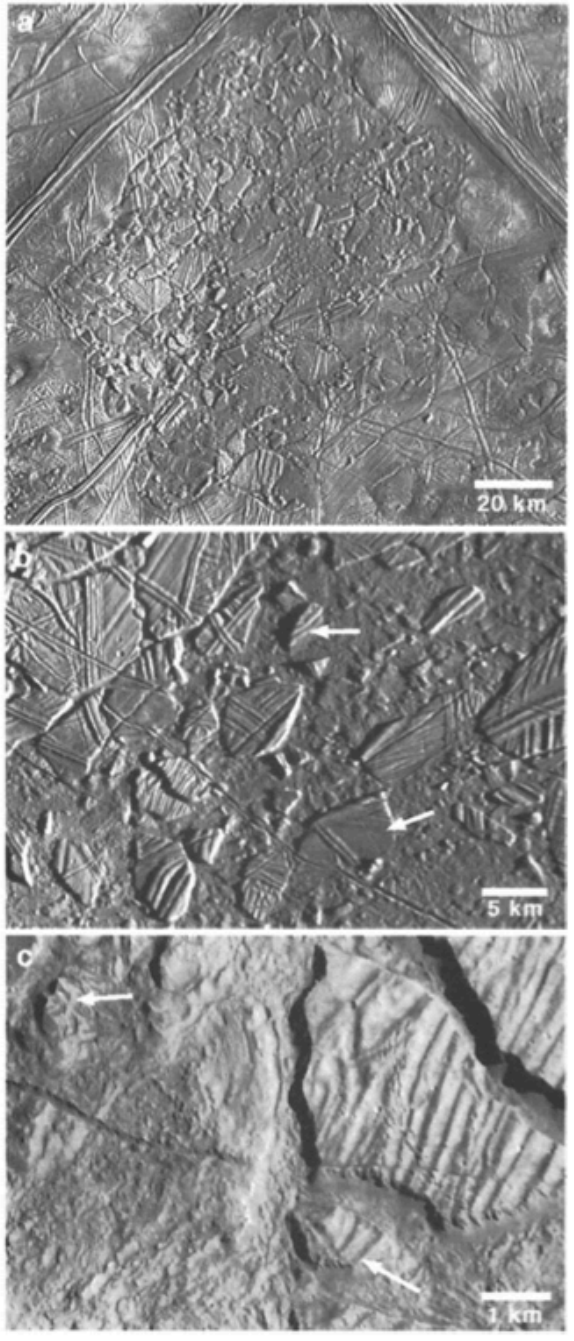


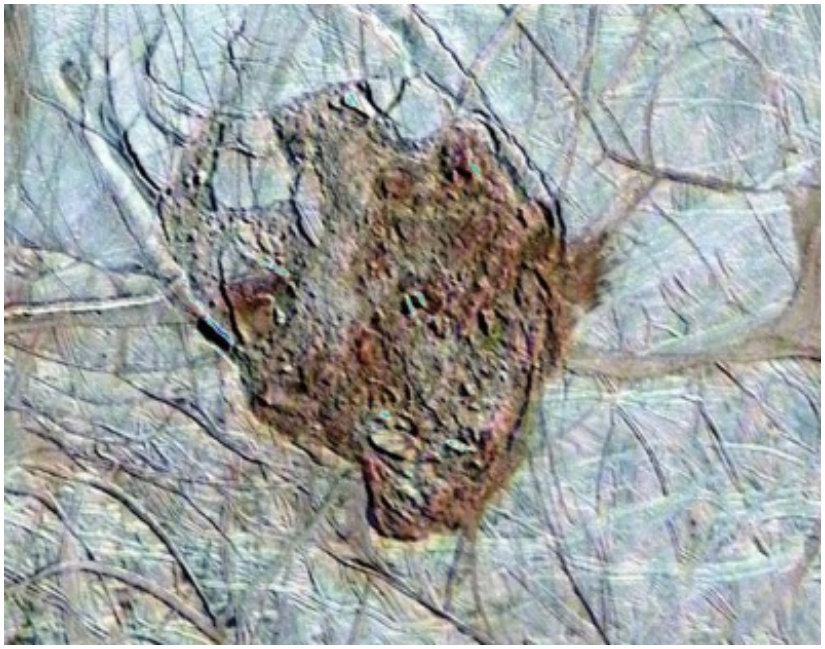


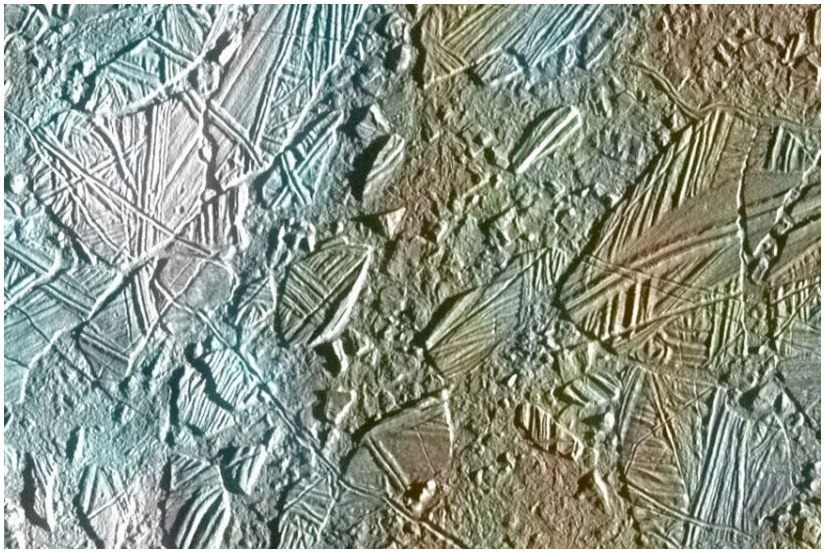
“Pull-apart” bands

Domes and Pits (“freckles”)

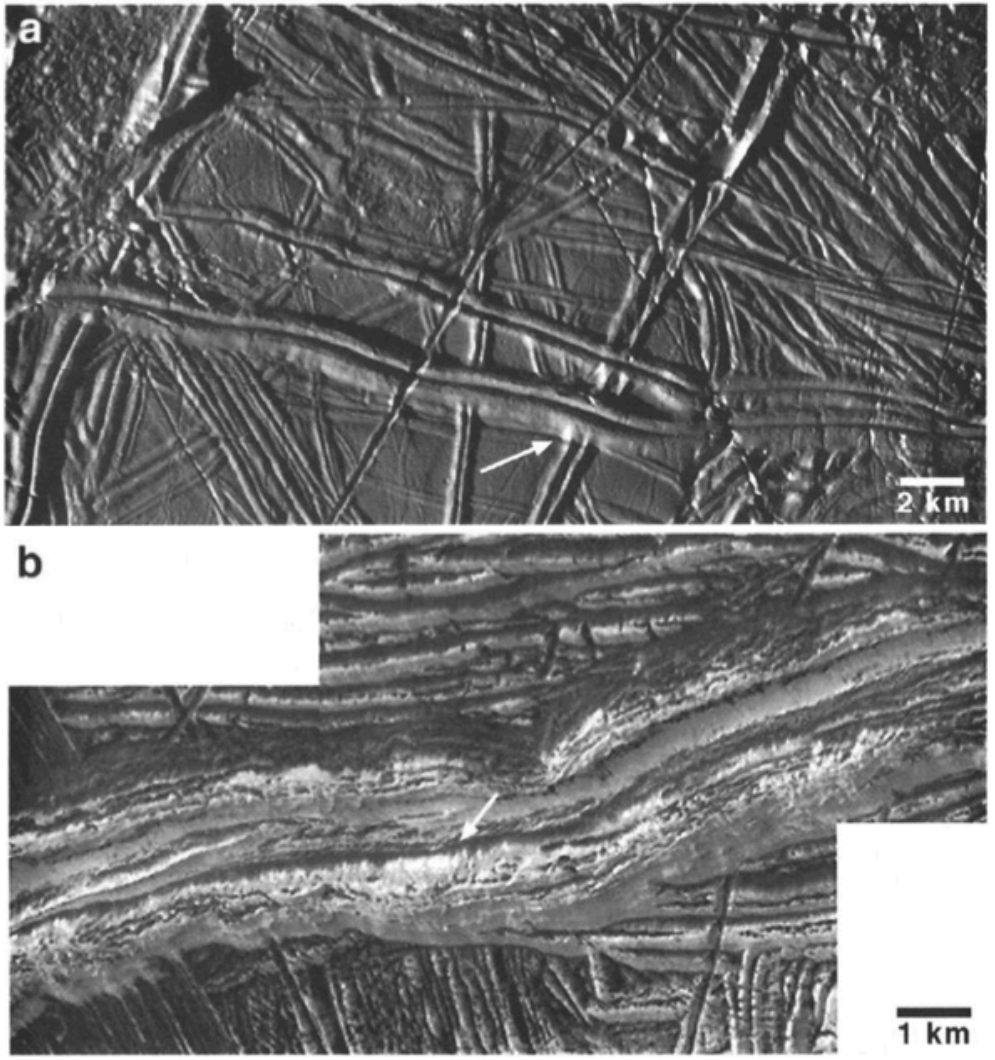
“Chaos” features

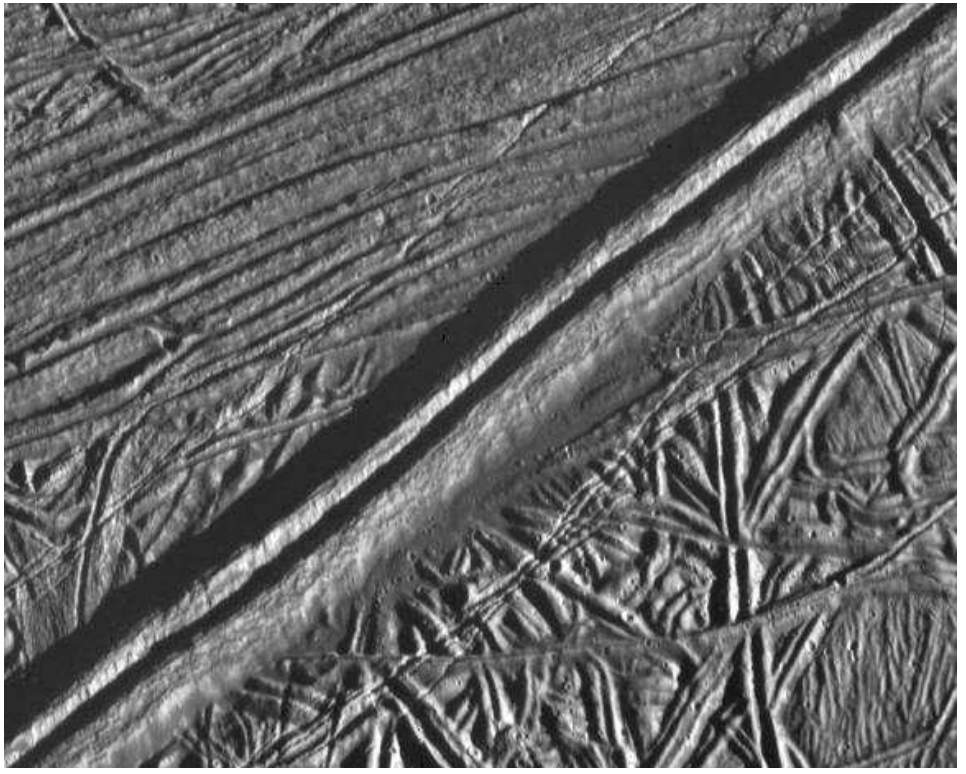




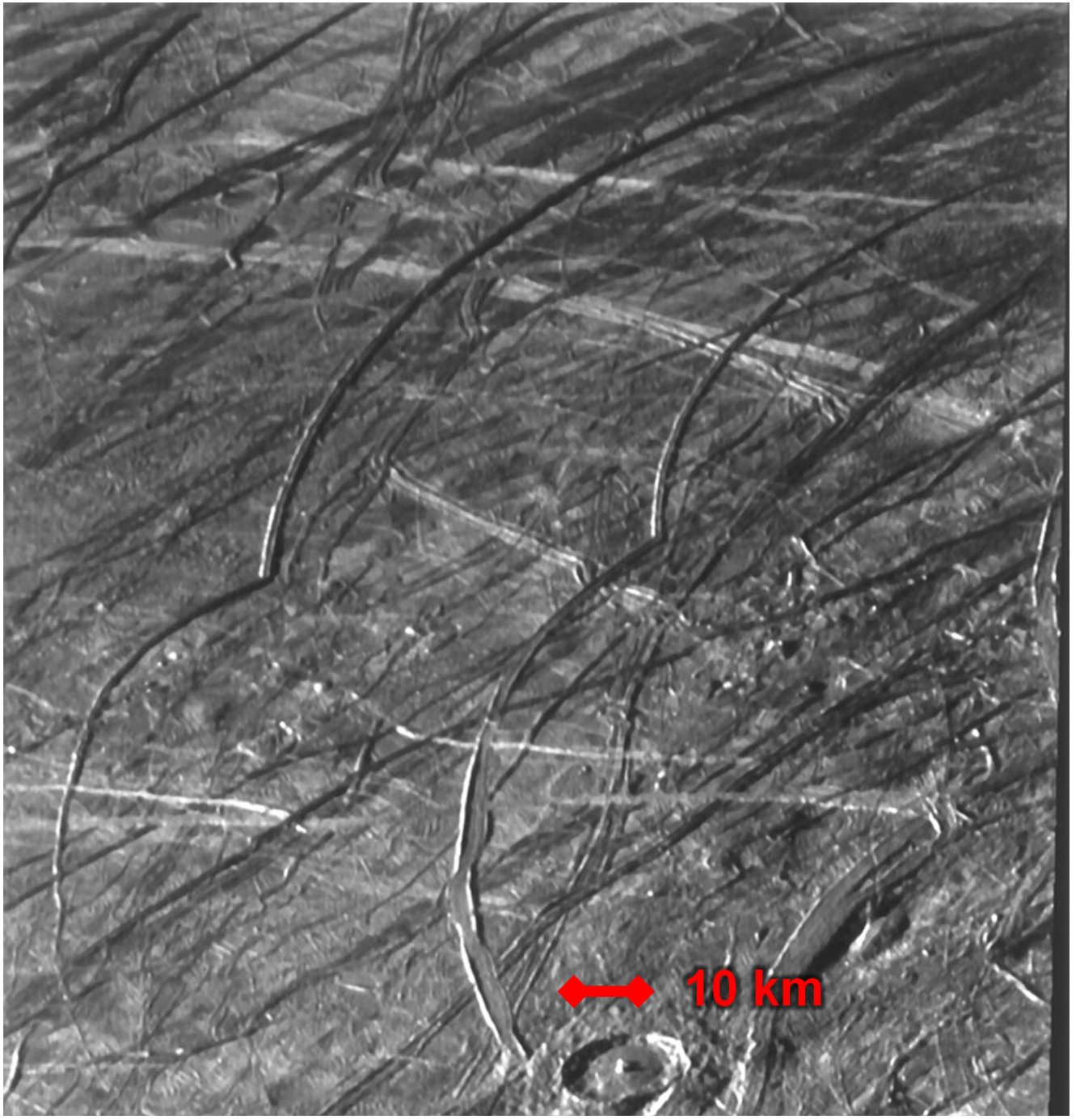


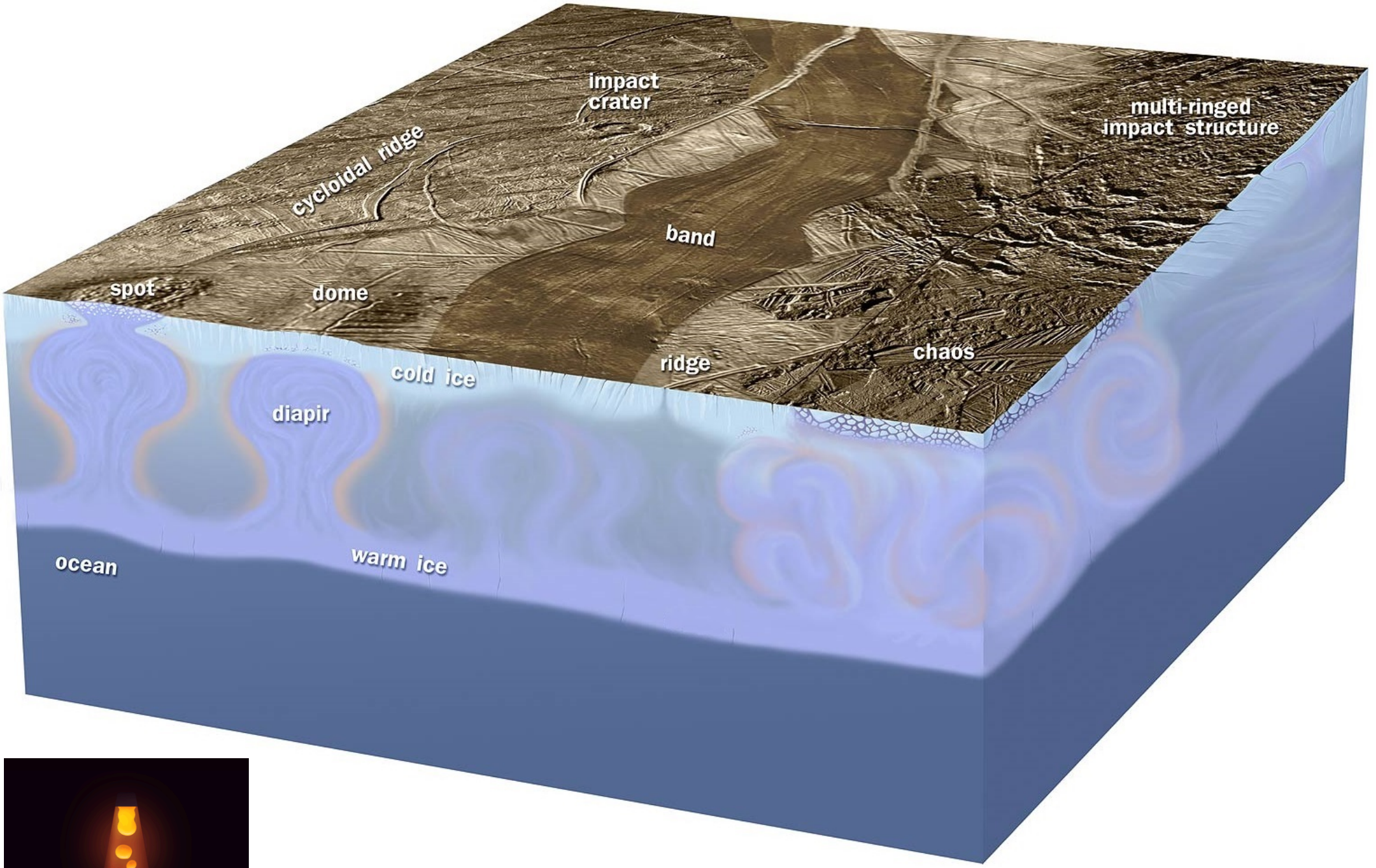
Double Ridges

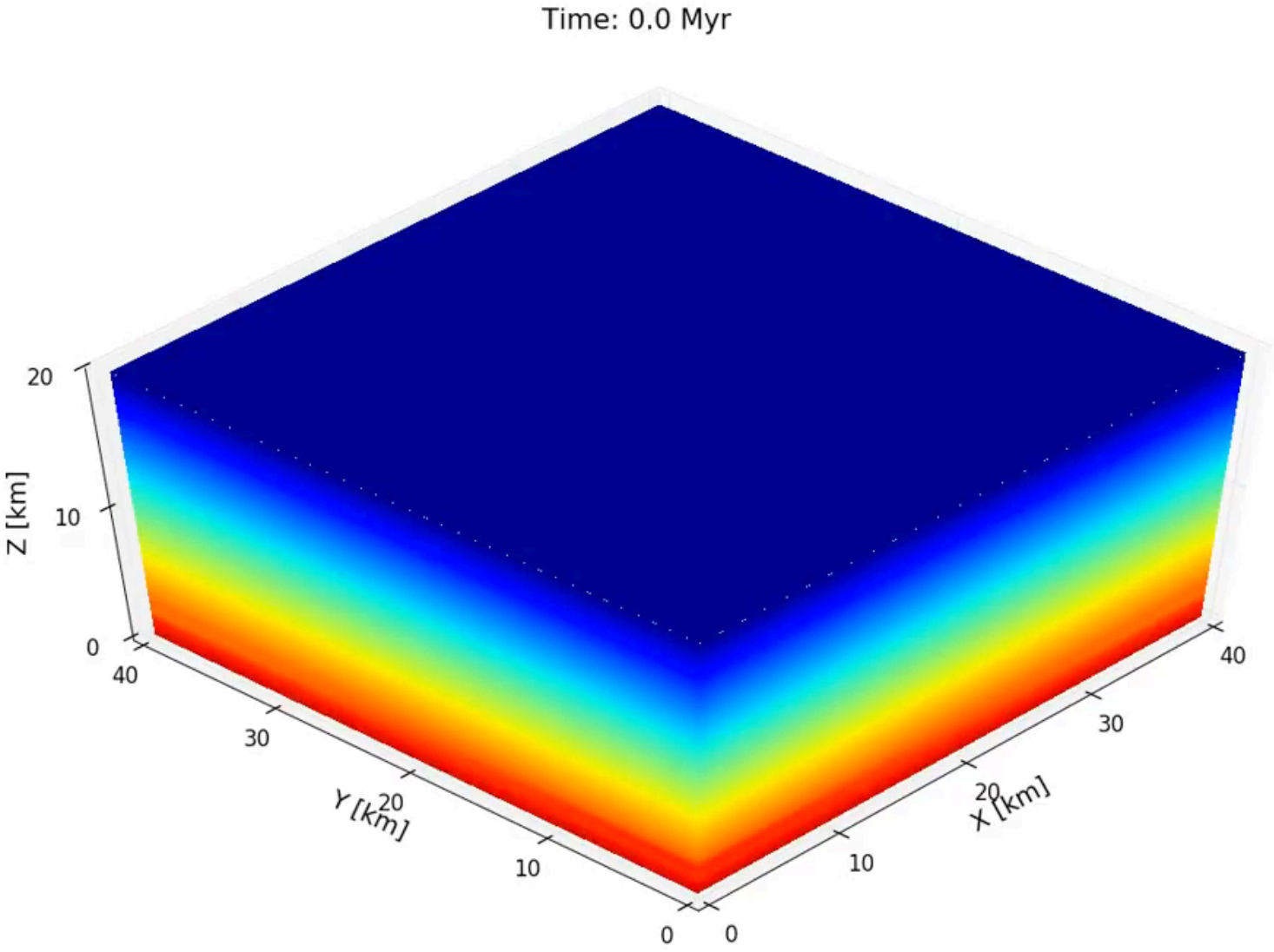


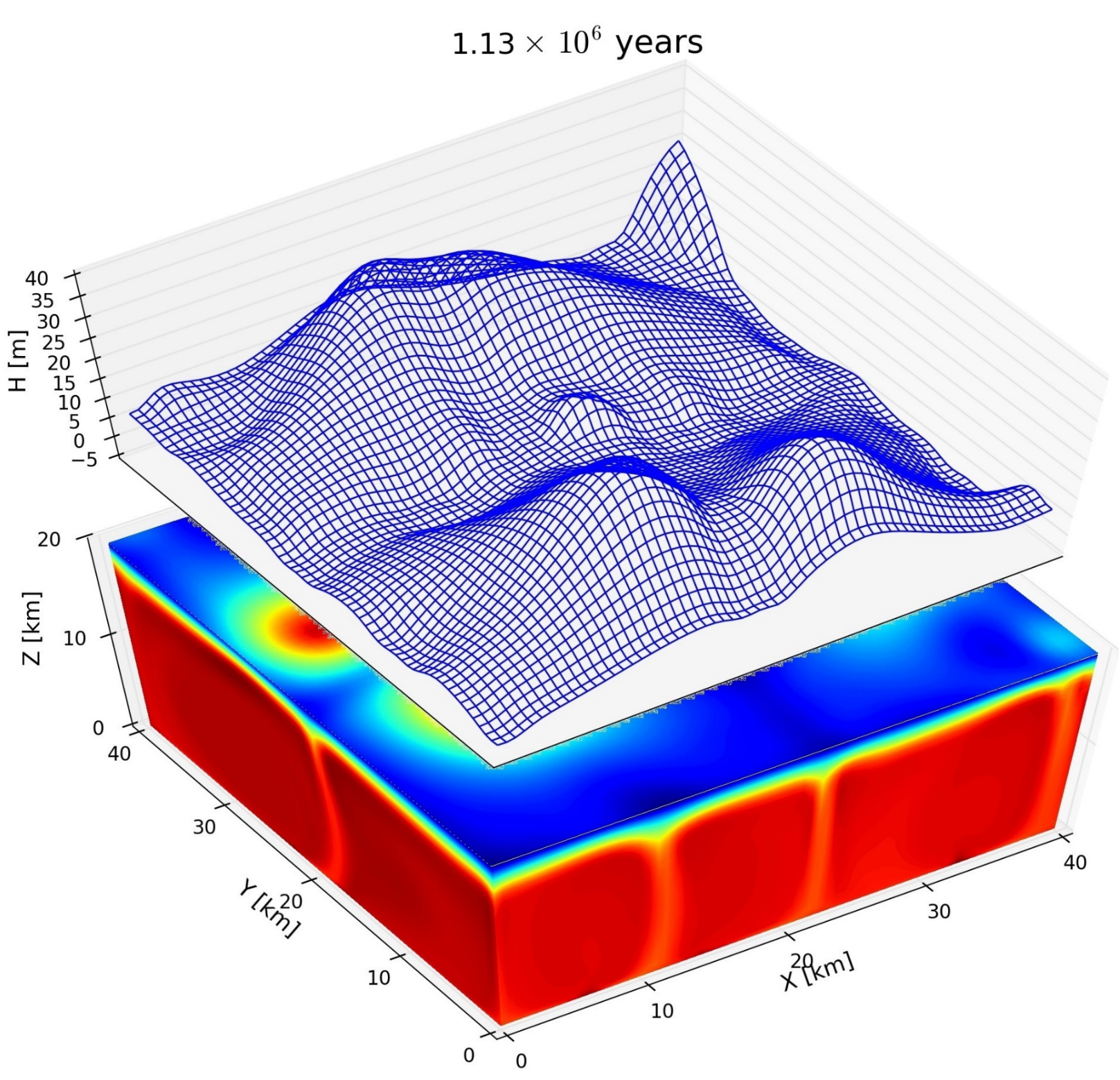


Cycloids




impact crater
multi-ringed impact structure
cycloidal ridge
band
spot
dome
ridge
chaos
cold ice
diapir
ocean
warm ice


Time: 0.0 Myr
Z [km]
20
10
0
40
30
20
10
0
Y [km]
0
10
20
30
40
X [km]


1.13 × 10^6 years
H [m]
40
35
30
25
20
15
10
5
0
−5
Z [km]
20
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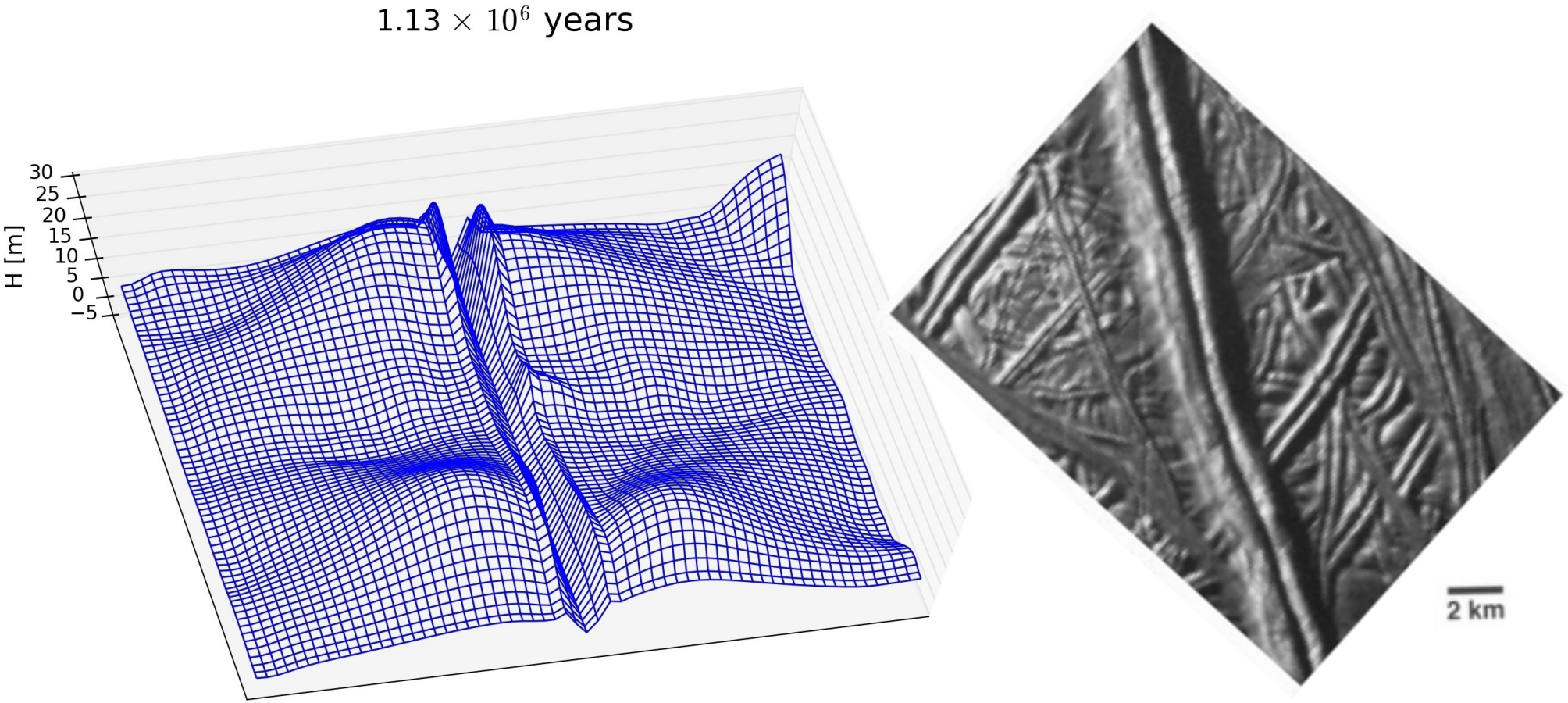
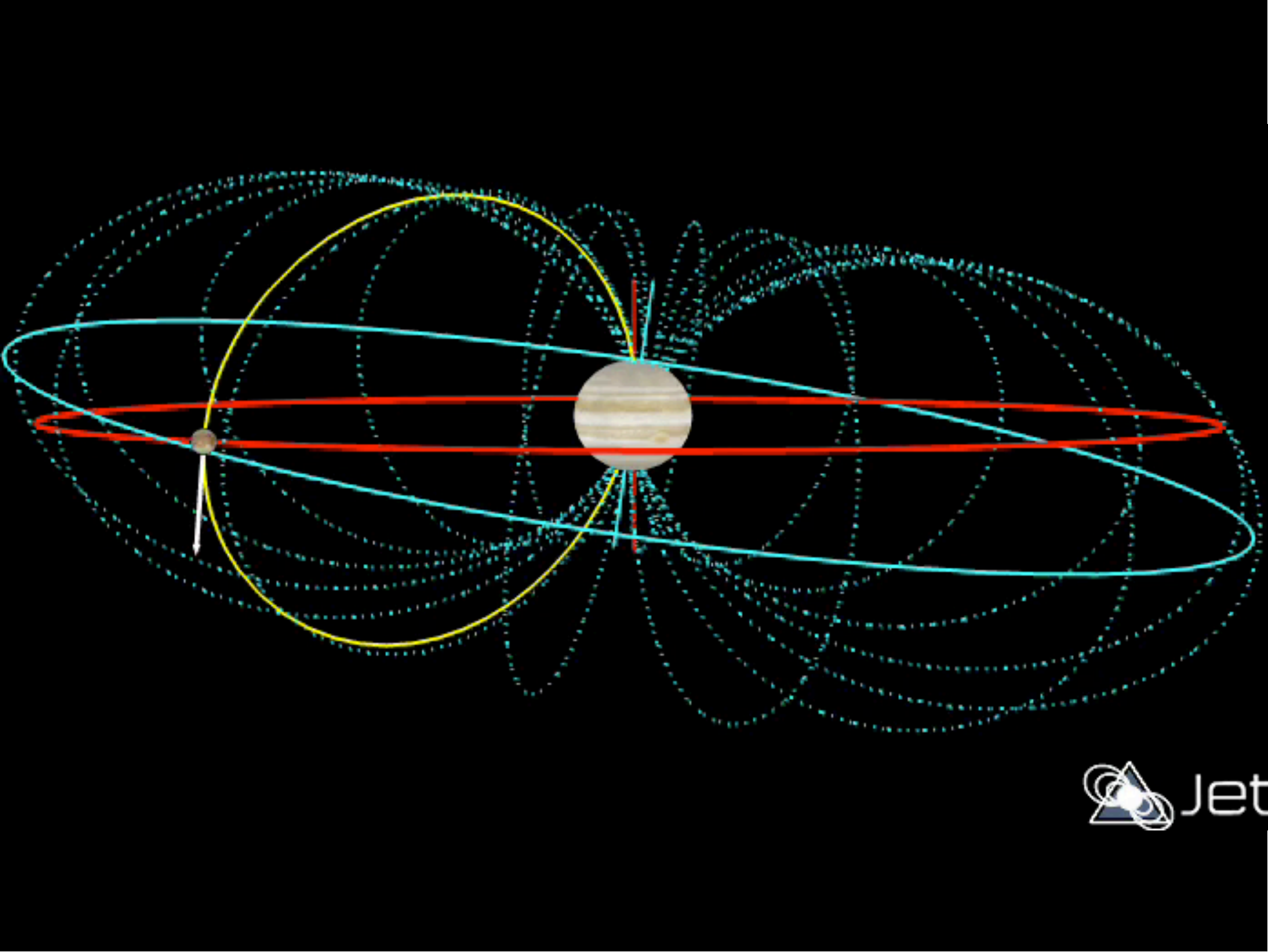
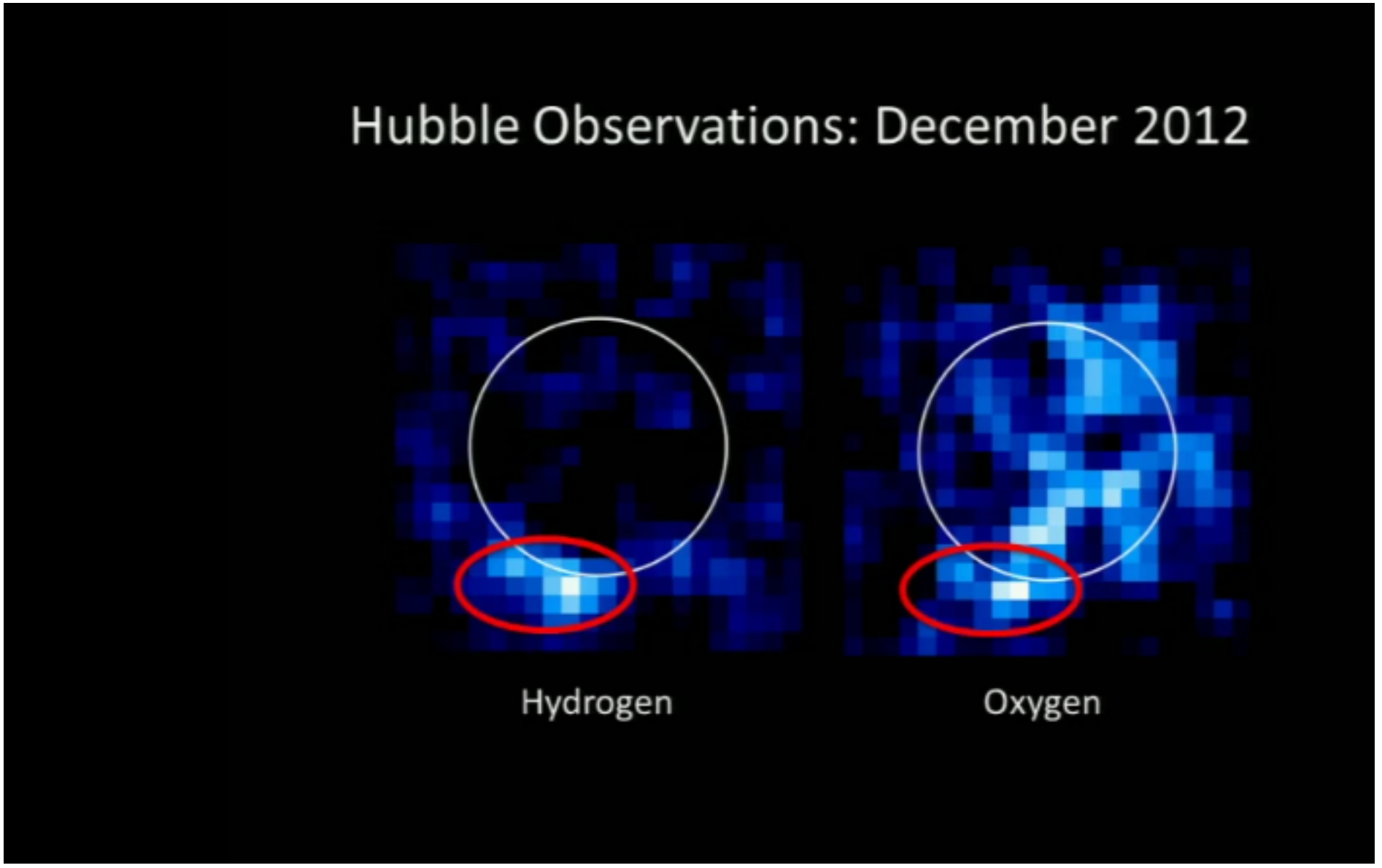
0
Y [km]
40
30
20
10
0
X [km]
0
10
20
30
40

Double ridges

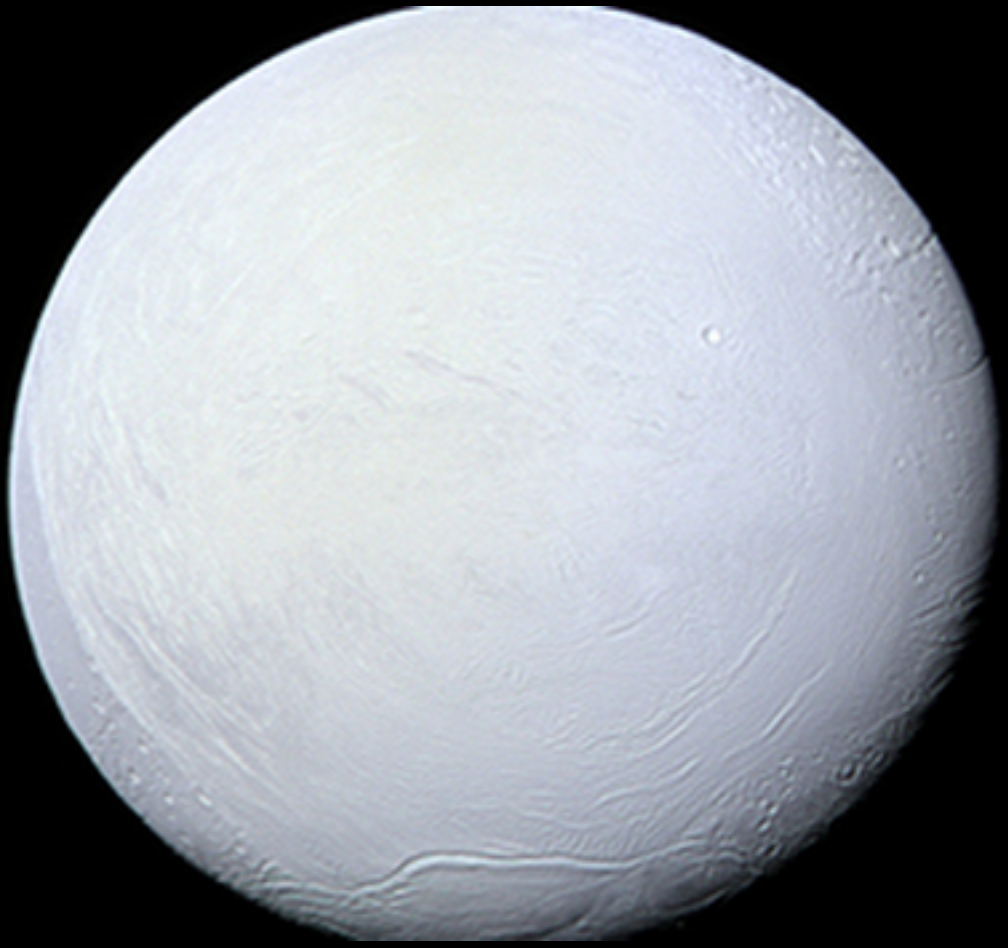



Jet

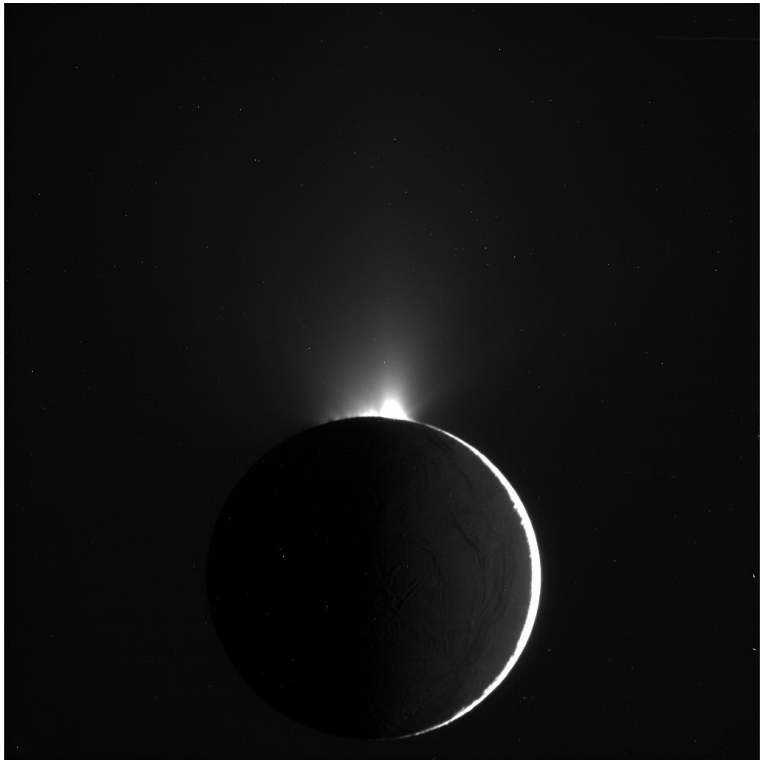
Water Plumes



Enceladus

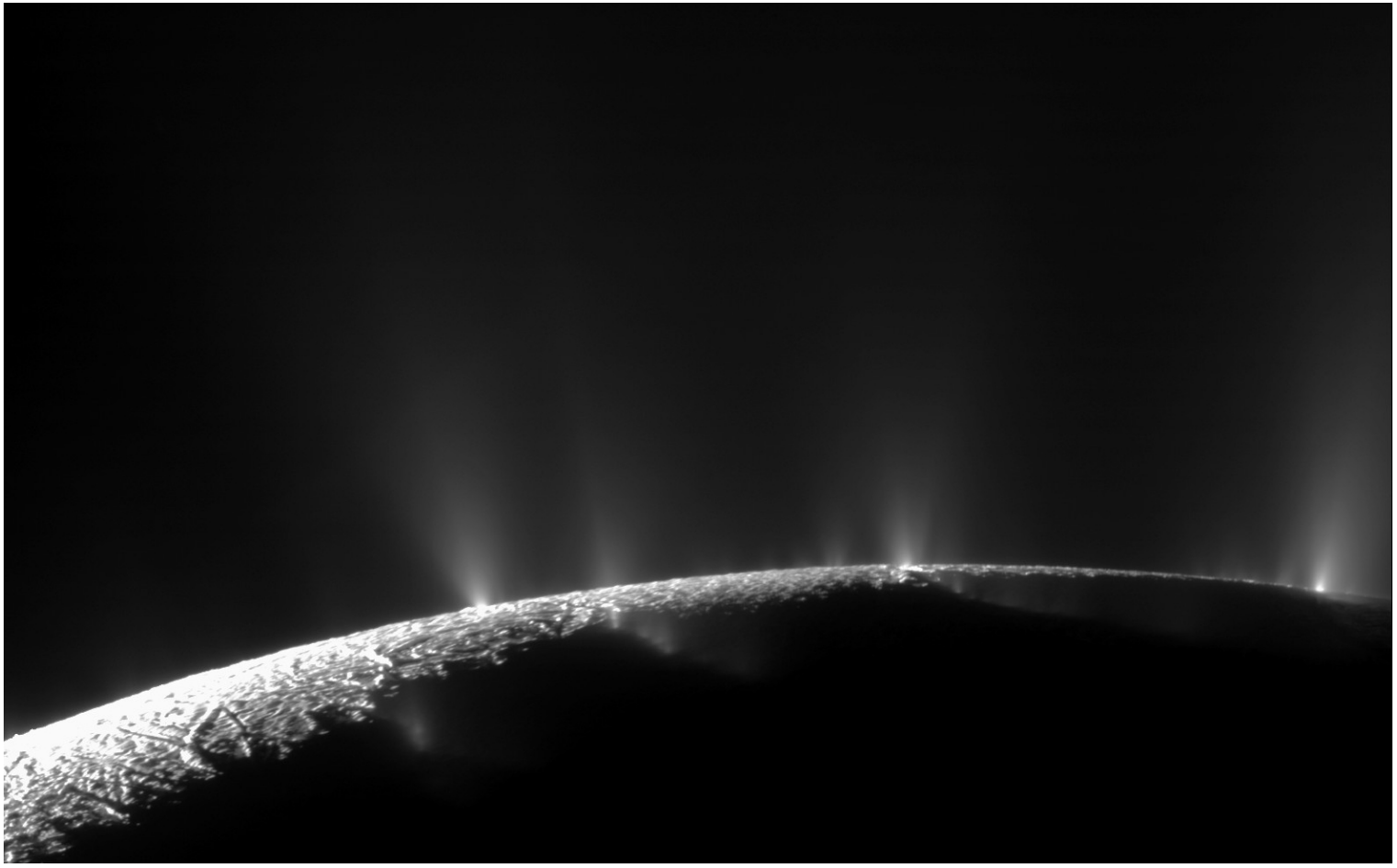


Enceladus

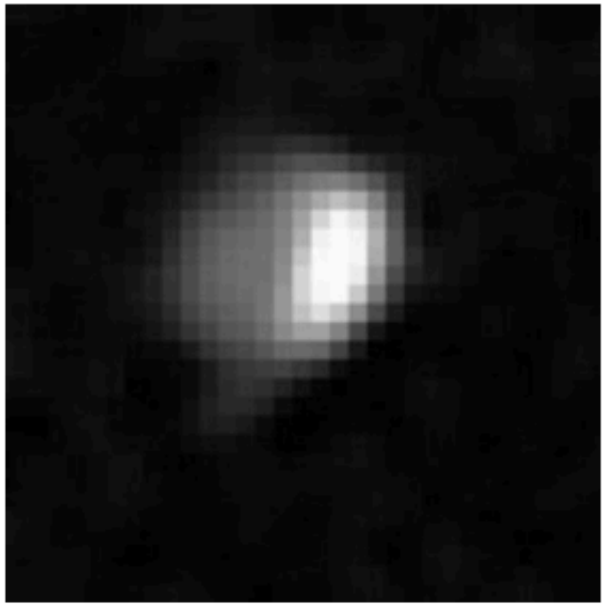


Plumes imaged by Cassini

Enceladus



Close up of the plumes



NASA / JPL-Caltech / Ted Stryk

ENCELADUS FROM VOYAGER 1 ON NOVEMBER 13, 1980

The right side is illuminated by the sun, the left by reflected light from Saturn, and the plume can be seen at the bottom.

Did Voyager 1 capture an image of Enceladus' plumes erupting?

Ted Stryk • February 21, 2017 • 4

Amateur image processor Ted Stryk revisited Voyager 1 data of Enceladus and came across a surprise.

PRE-DISCOVERY DETECTION OF THE PLUMES OF ENCELADUS. T. Stryk, Humanities Division, Roane State Community College, Oak Ridge, Tennessee, United States 37830 (strykt@roanestate.edu).

Introduction: A sequence of wide angle images taken by Voyager 1 on 13 November 1980 include a serendipitous appearance by the moon Enceladus. Unlike the better images taken prior to closest approach, these images were taken at a very high phase angle, showing both solar illuminated areas as well as areas illuminated by planetshine. Most importantly, this sequence represents a pre-discovery detection of the south polar plumes. Here the images are described, with comments on the possibility of other observations or applications of this observation.

Voyager Images: Voyager 1 flew by Saturn on November 12, 1980, returning imagery of the planet, rings, and moons [1]. It did not pass close to Enceladus, though it did do some distant imagery during approach.

As the spacecraft receeded from Saturn, it obtained high phase imagery of the receeding planet. While it never targeted Enceladus as it departed, it did make a cameo. The first image to contain Enceladus was taken at 16:30, with the last at 18:21. The useful images are C3496526, C3496533, C3496608, C3496650, C3496657, C3496704, C3496711, and C3496718. Figure 1 shows an example of one of these images.

The images were calibrated and cleaned. They were then added, with preference given to the better

References: [1] Smith B. A. et al. (1981) *Science, 212,* 163-191. [2] Hansen, C. J. et al. (2006) *Science, 311*, 1422-1425.

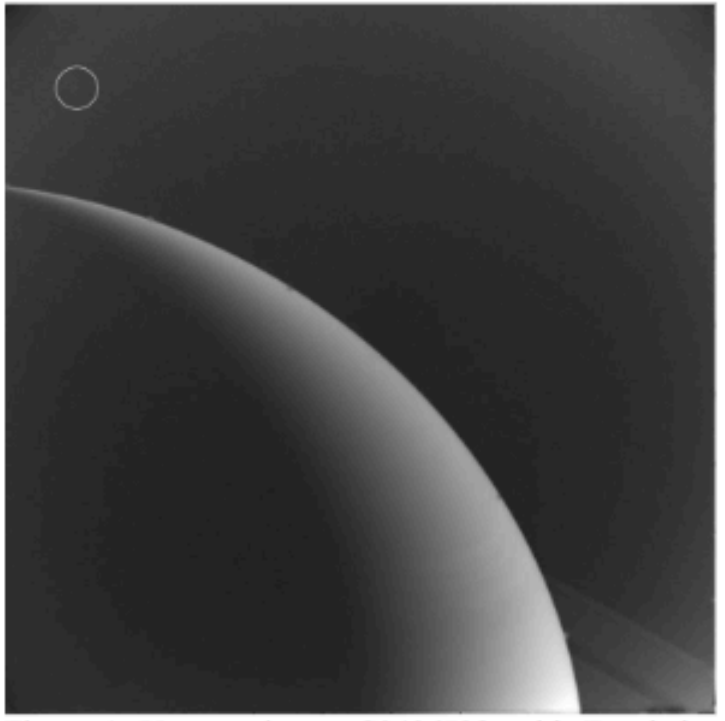
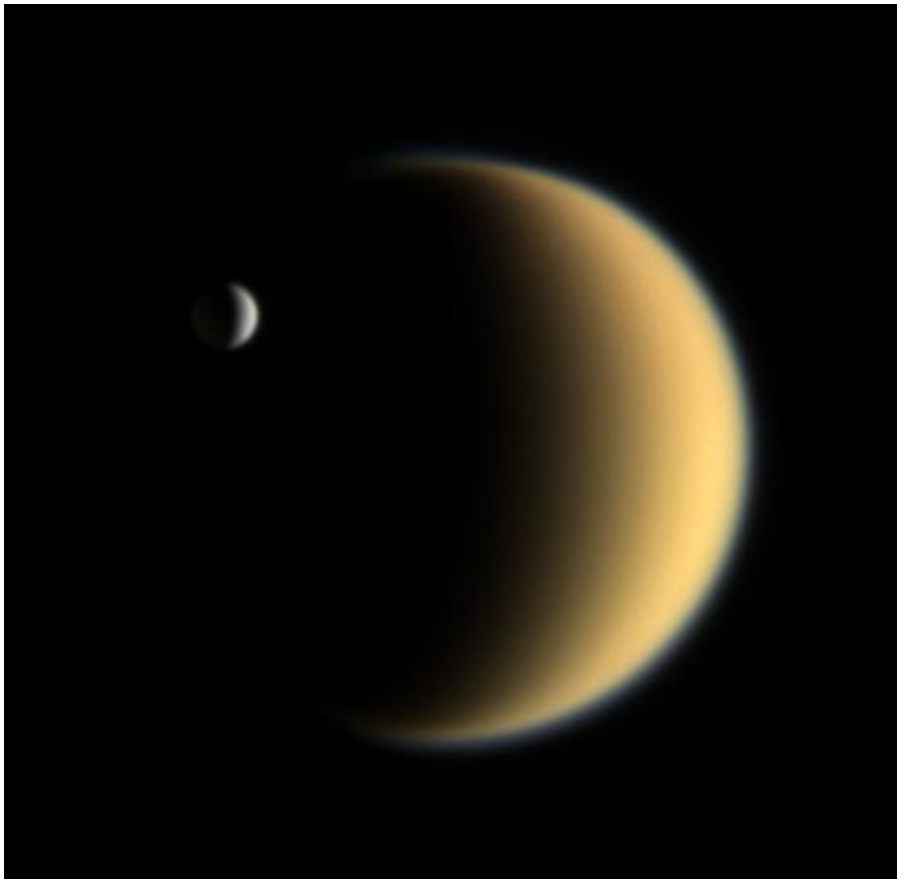


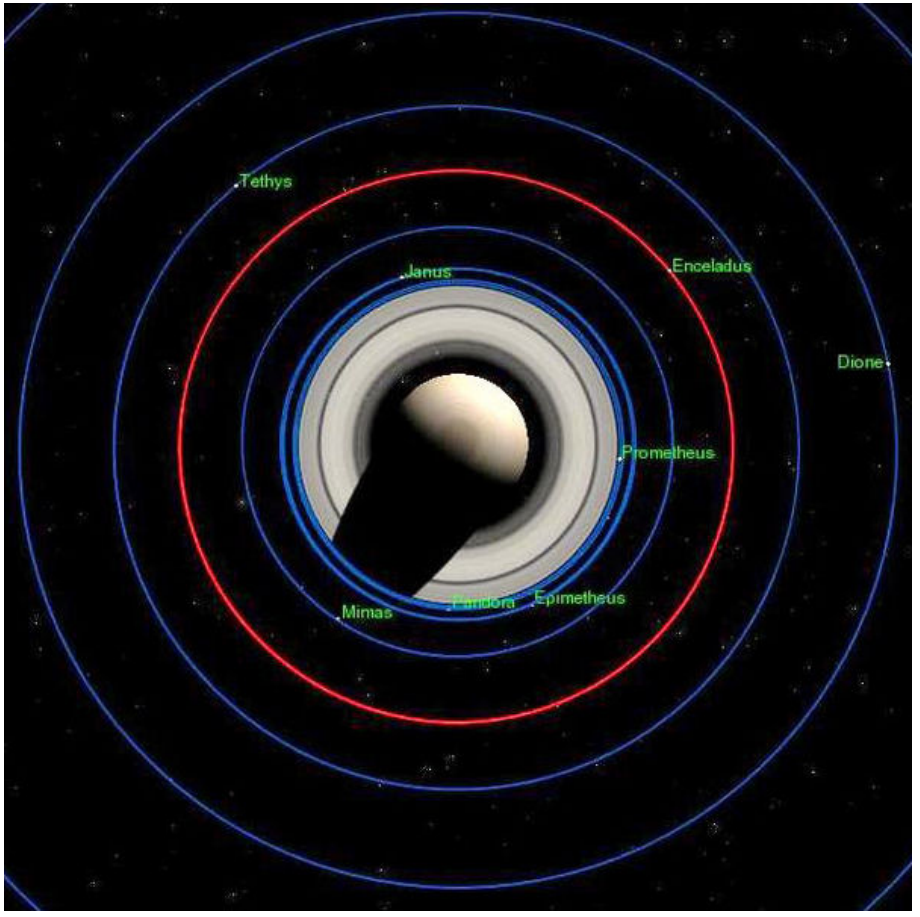
Figure 1. Voyager image C3496728, with Enceladus circled.

Enceladus

Enceladus and Titan



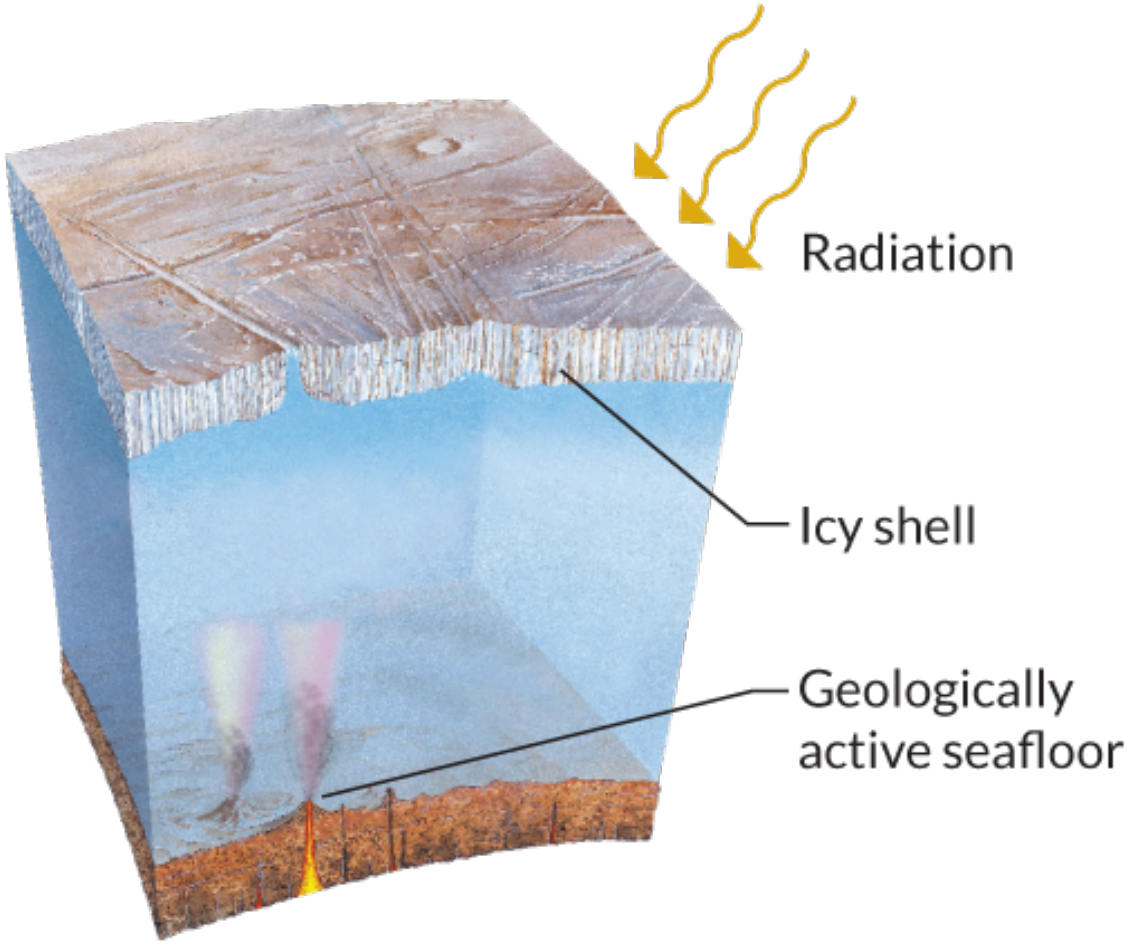
Tidal Heating!

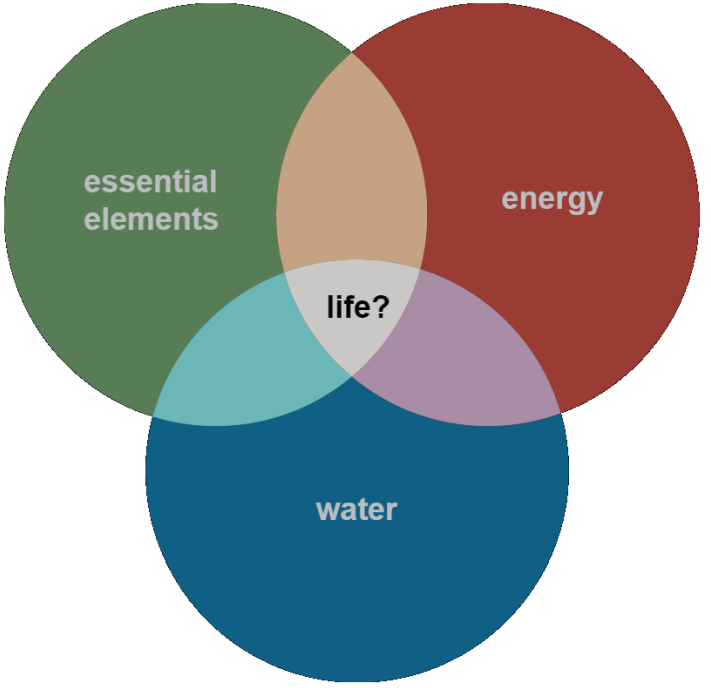


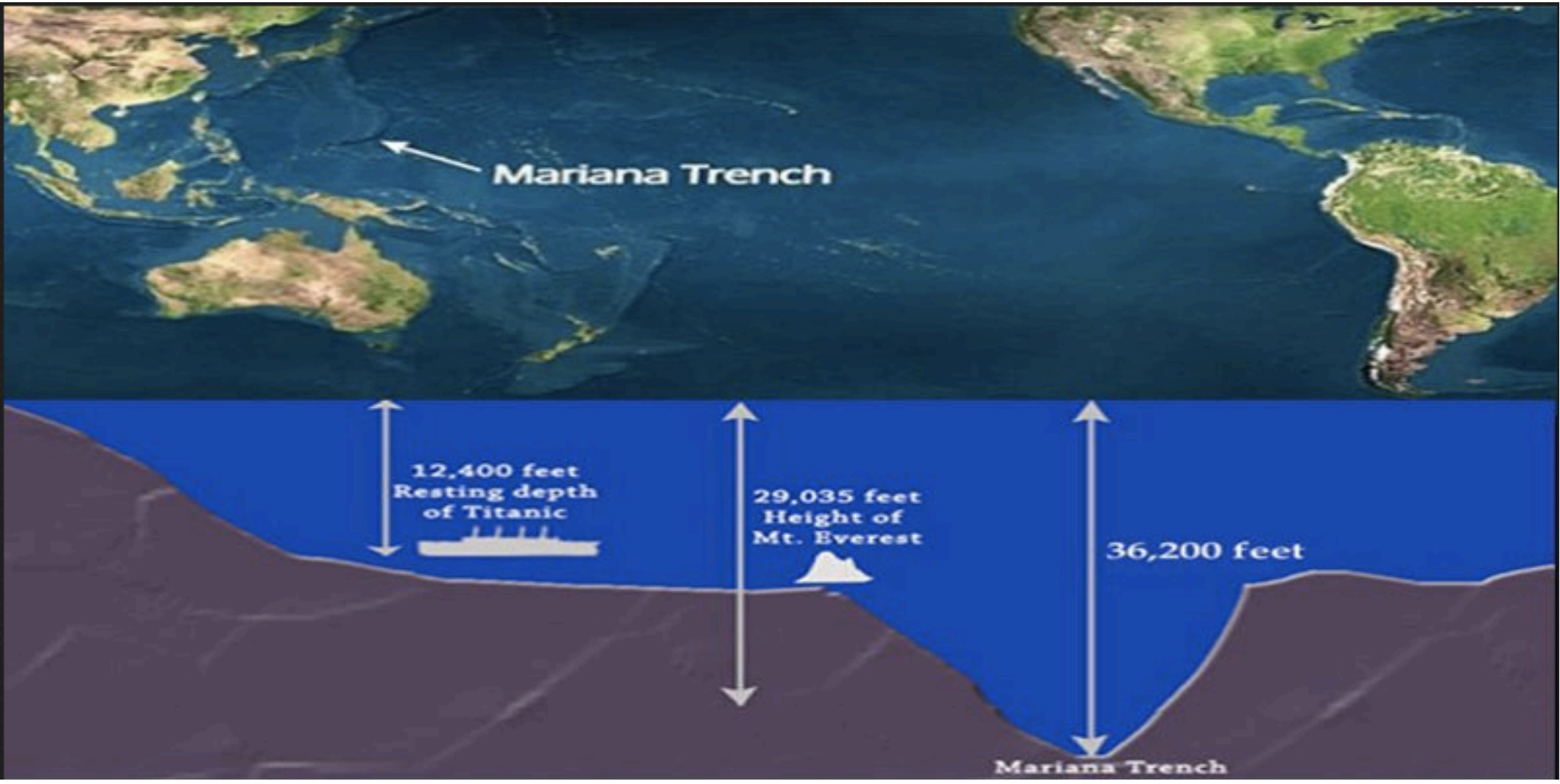
2:1 resonance with Dione

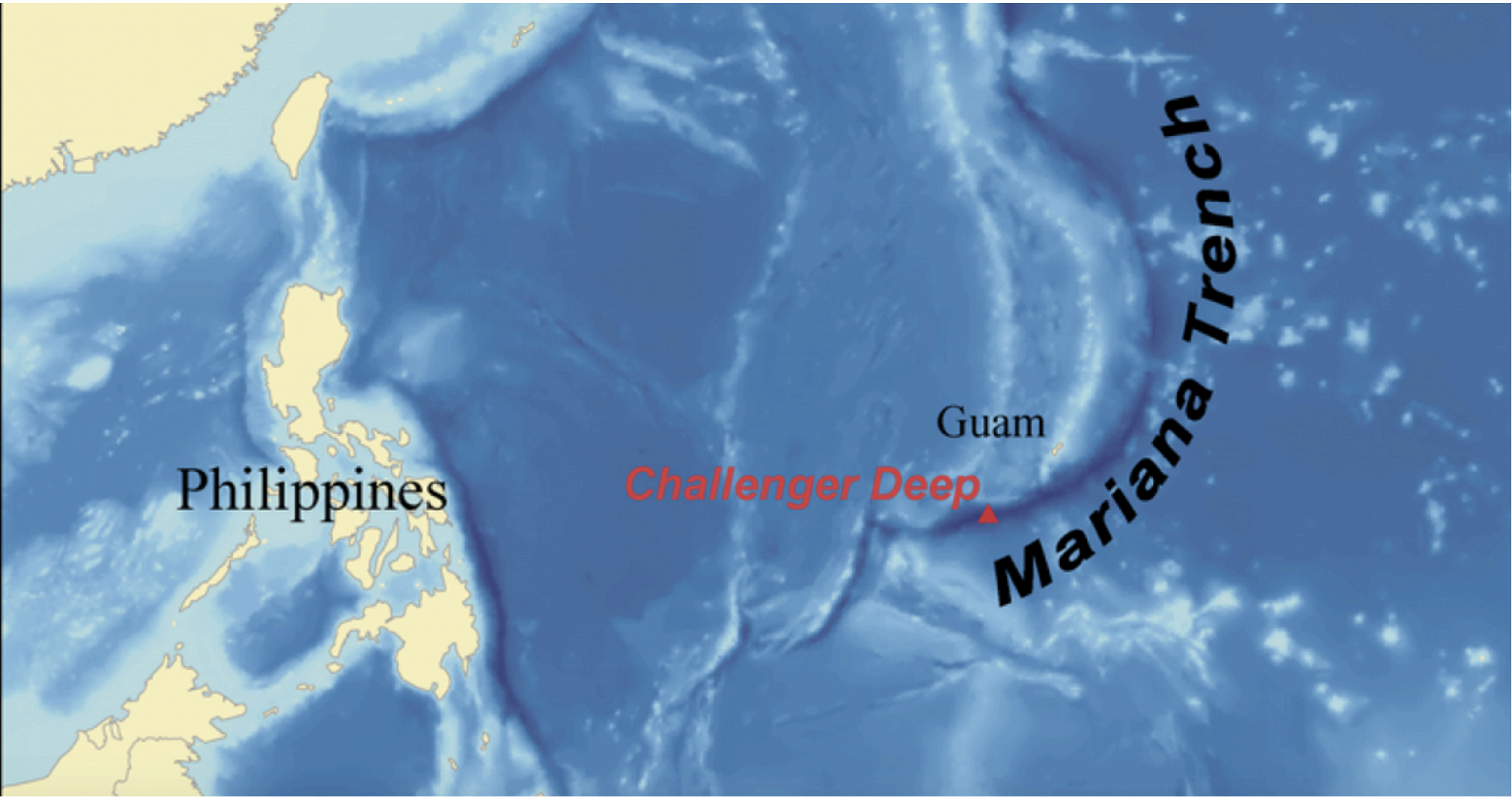
keeps Enceladus' orbit eccentric

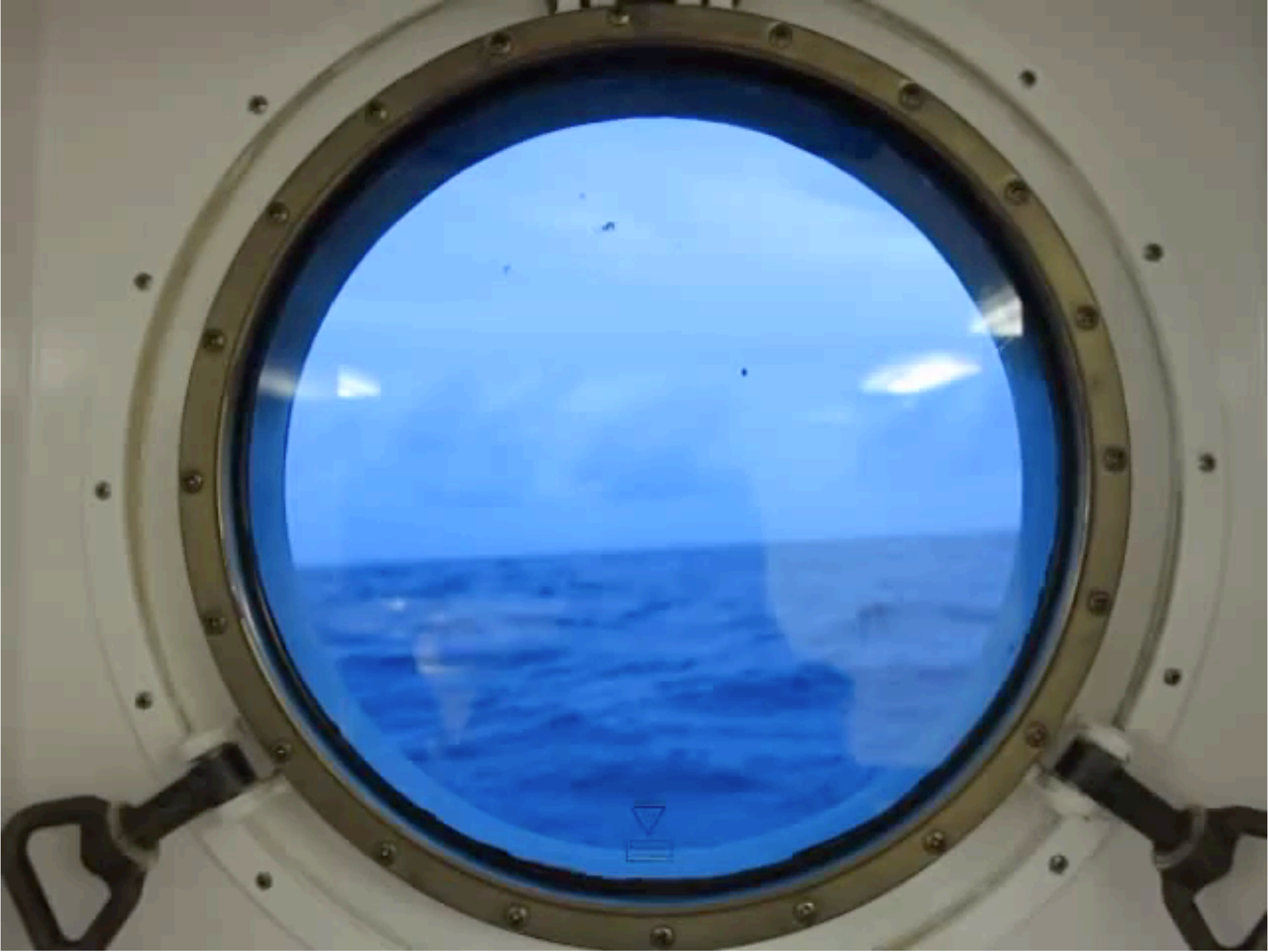
Life?

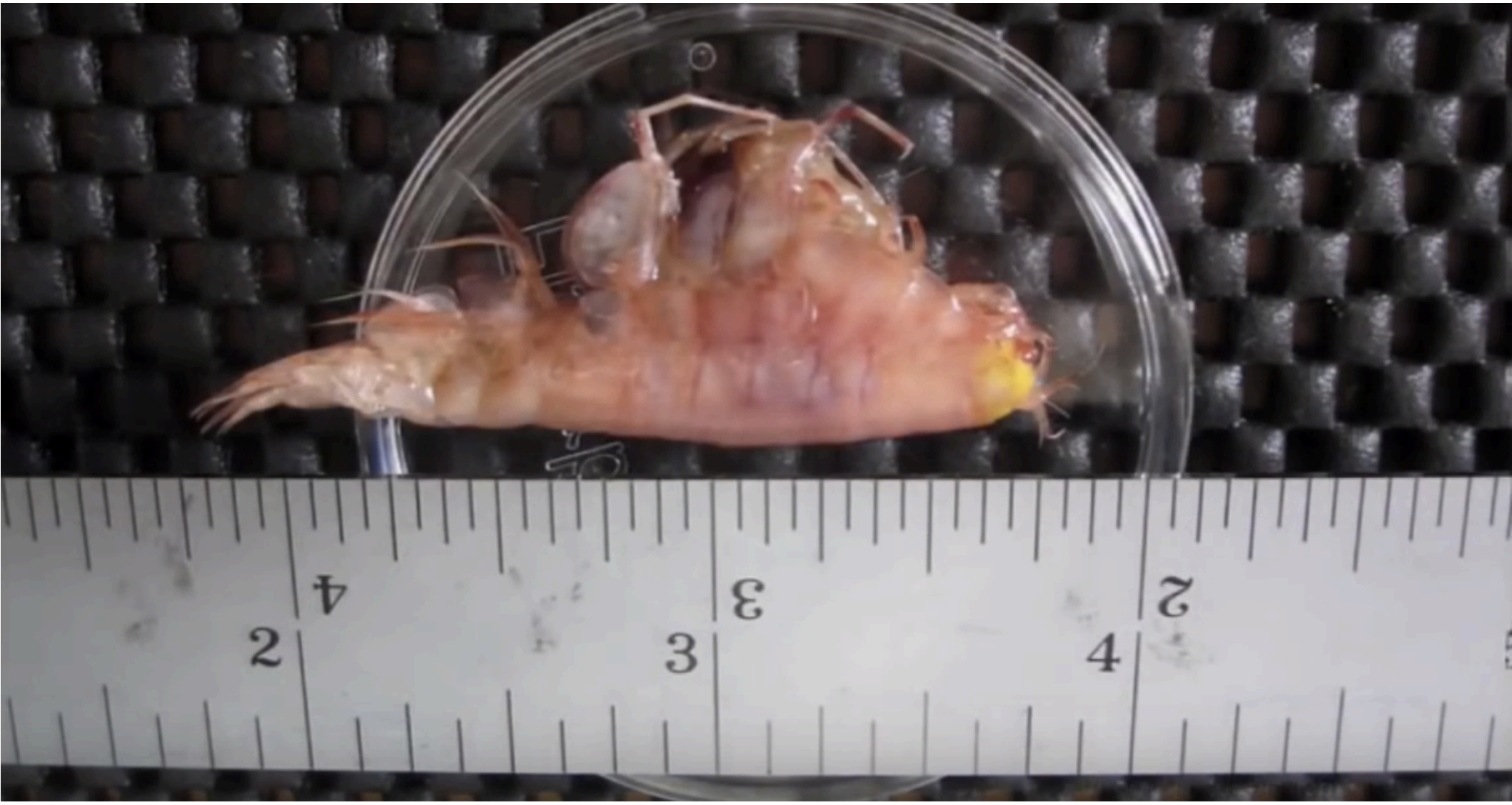

Radiation
Icy shell
Geologically
active seafloor


essential
elements
energy
life?
water


Mariana Trench
12,400 feet
Resting depth
of Titanic
29,035 feet
Height of
Mt. Everest
36,200 feet
Mariana Trench


Philippines
Guam
Challenger Deep
Mariana Trench




2
4
3
4
3
2


Sirena Deep: 10,700 m

Serpentinization

(hydration of olivine)

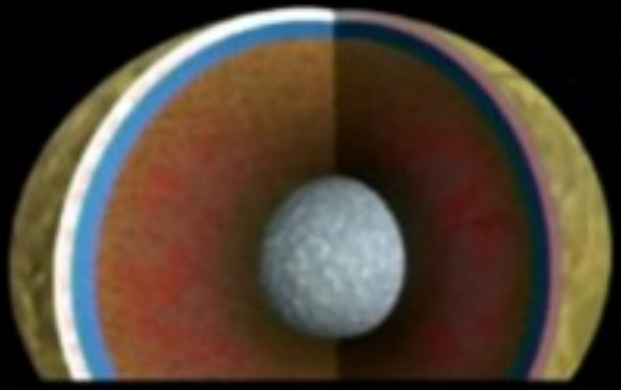
$$\text{Olivine} + H_2O \rightarrow \text{Serpentine}$$

(+ HEAT and Large VOLUME Increase
With high pH and highly reducing conditions)

Olivine (Peridotite)

Serpentinite

The Big Question: Is Europa Habitable?

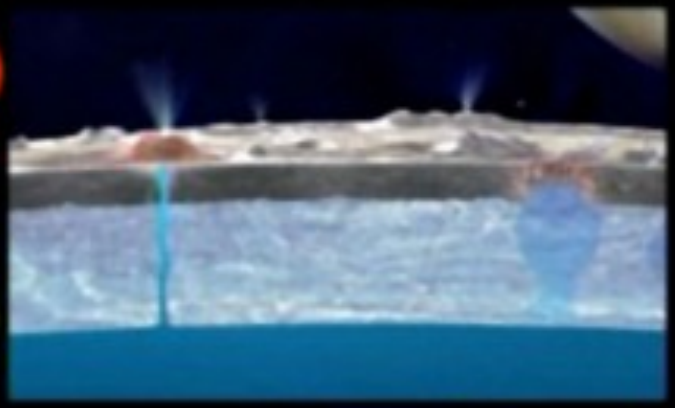


How deep and salty is the ocean?

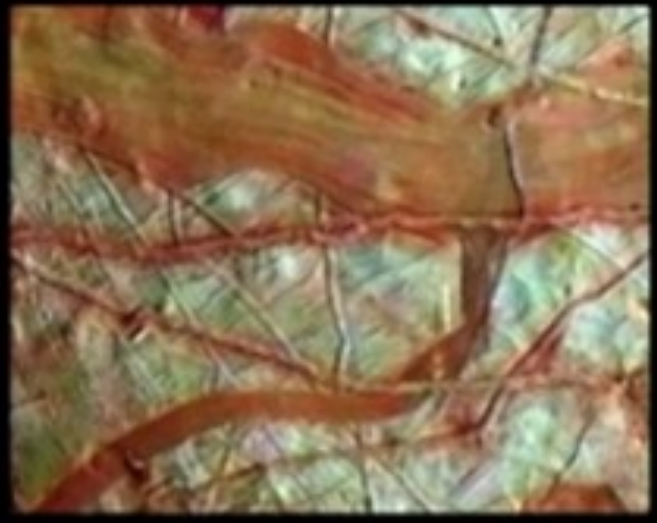
How thick is the ice shell?

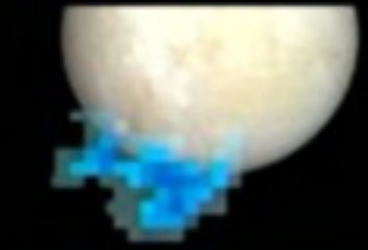
How active is the ice shell?

What's the brown stuff?

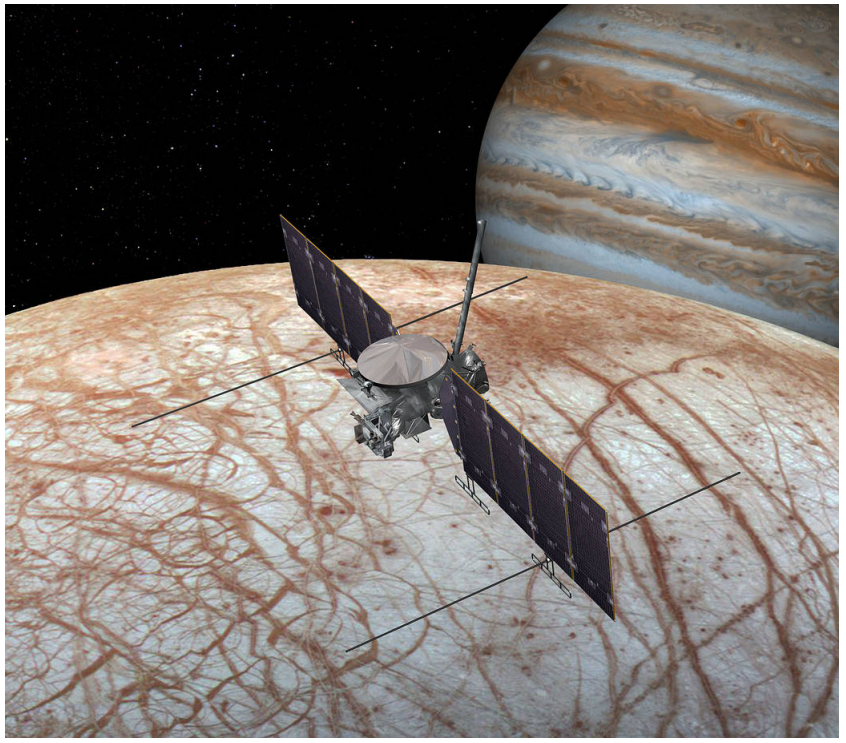


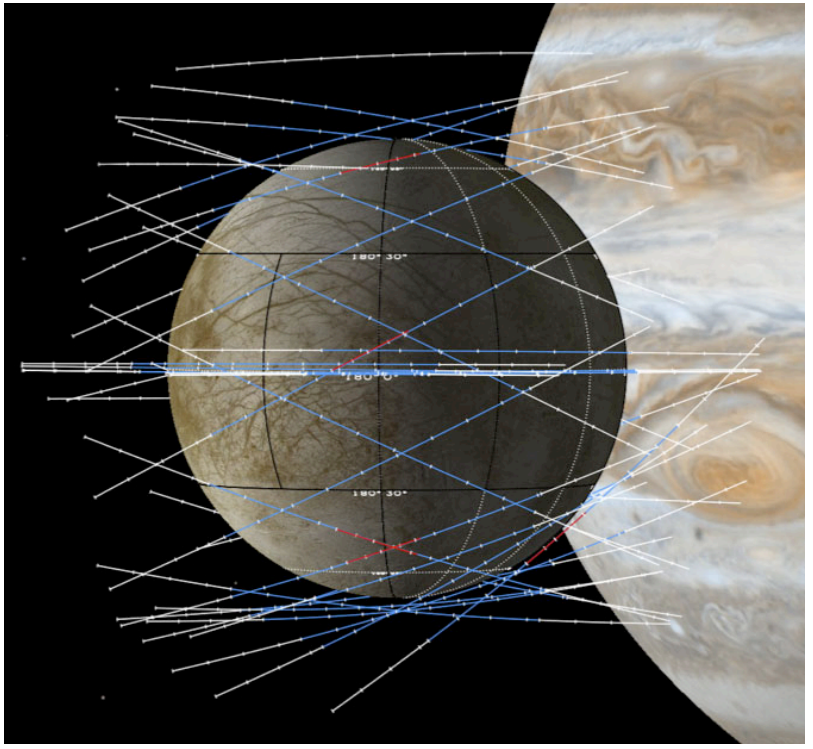
Where are the plumes and what is in them?





Europa Clipper





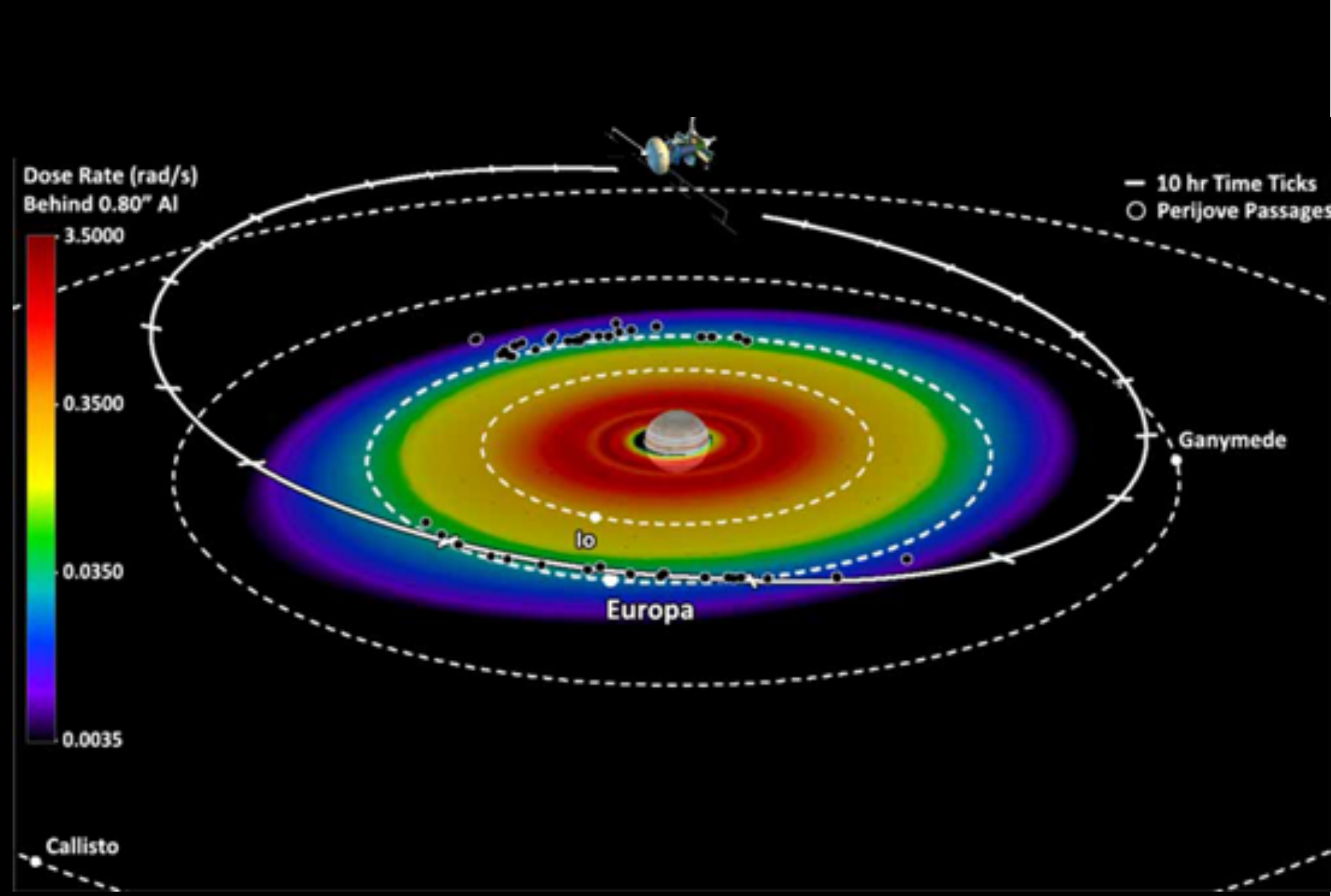
Reconnaissance: 45 flybys, as low as 25km

Radar to determine ice's thickness

High resolution camera

Identify future landing sites

Launch 2020-2021


Dose Rate (rad/s)
Behind 0.80" Al
3.5000
0.3500
0.0350
0.0035
10 hr Time Ticks
Perijove Passages
Ganymede
Io
Europa
Callisto

Europa Thermal Emission Imaging System (E-THEMIS)
Detect Plumes

Mapping Imaging Spectrometer for Europa (MISE)
Map distribution of organics, chemistry of surface

Europa Imaging System (EIS)
High resolution camera (50cm)

Ultraviolet Spectrograph (UVS)
Plumes, exosphere

Radar for Europa Assessment and Sounding: Ocean to Near-Surface (REASON)
Radar mapping

Interior Characterization of Europa using Magnetometry (ICEMAG)
Depth and salinity of ocean

Plasma Instrument for Magnetic Sounding (PIMS)
Magnetic fields external to Europa – aids ICEMAG

Mass Spectrometer for Planetary Exploration/Europa (MASPEX)
Chemistry of tenuous atmosphere or plumes

Surface Dust Mass Analyzer (SUDA)
Chemical composition