

“I repeat, all planet leave is canceled. I've just had an unhappy love affair, so I don't see why anybody else should have a good time.”

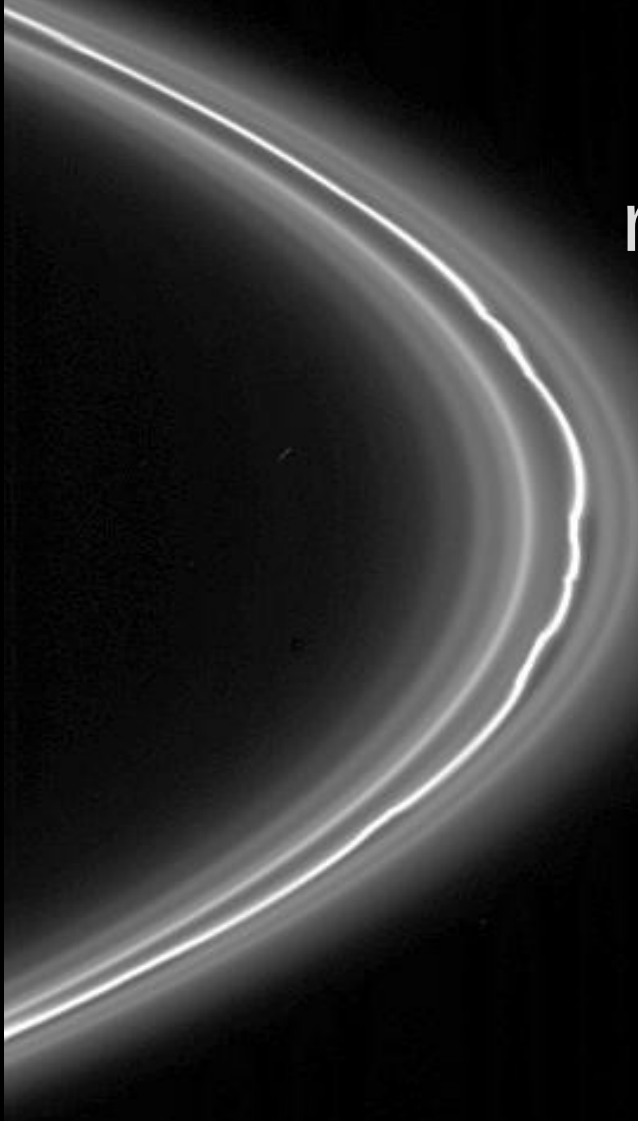
Prostetnic Vogon Jeltz
The Hitchhiker's Guide to the Galaxy

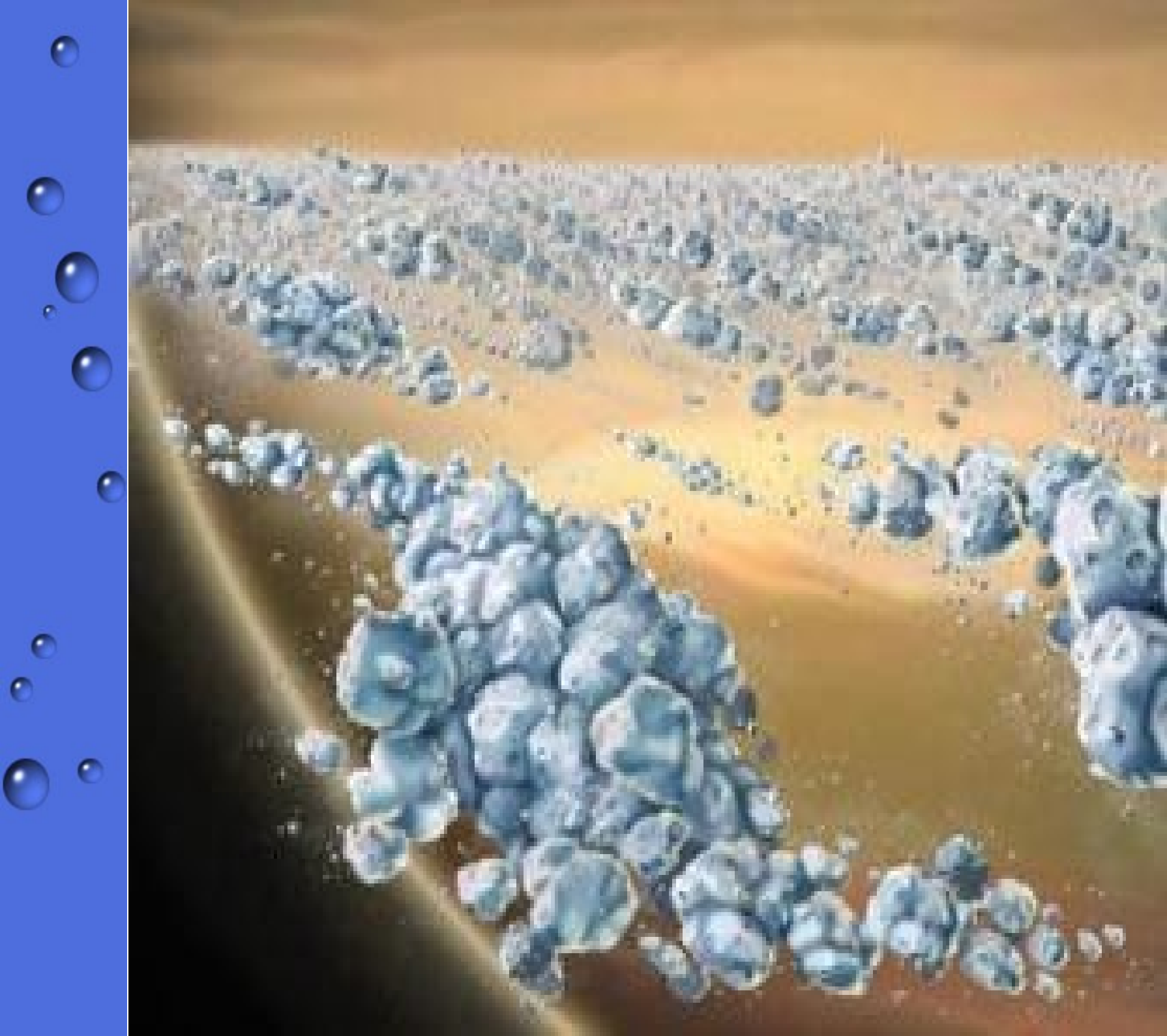
Reading: Chapter 11: Gas Giants
Chapter 12: Rings, moons, dwarf planets.
HW2 is due on Friday- questions?

Saturn

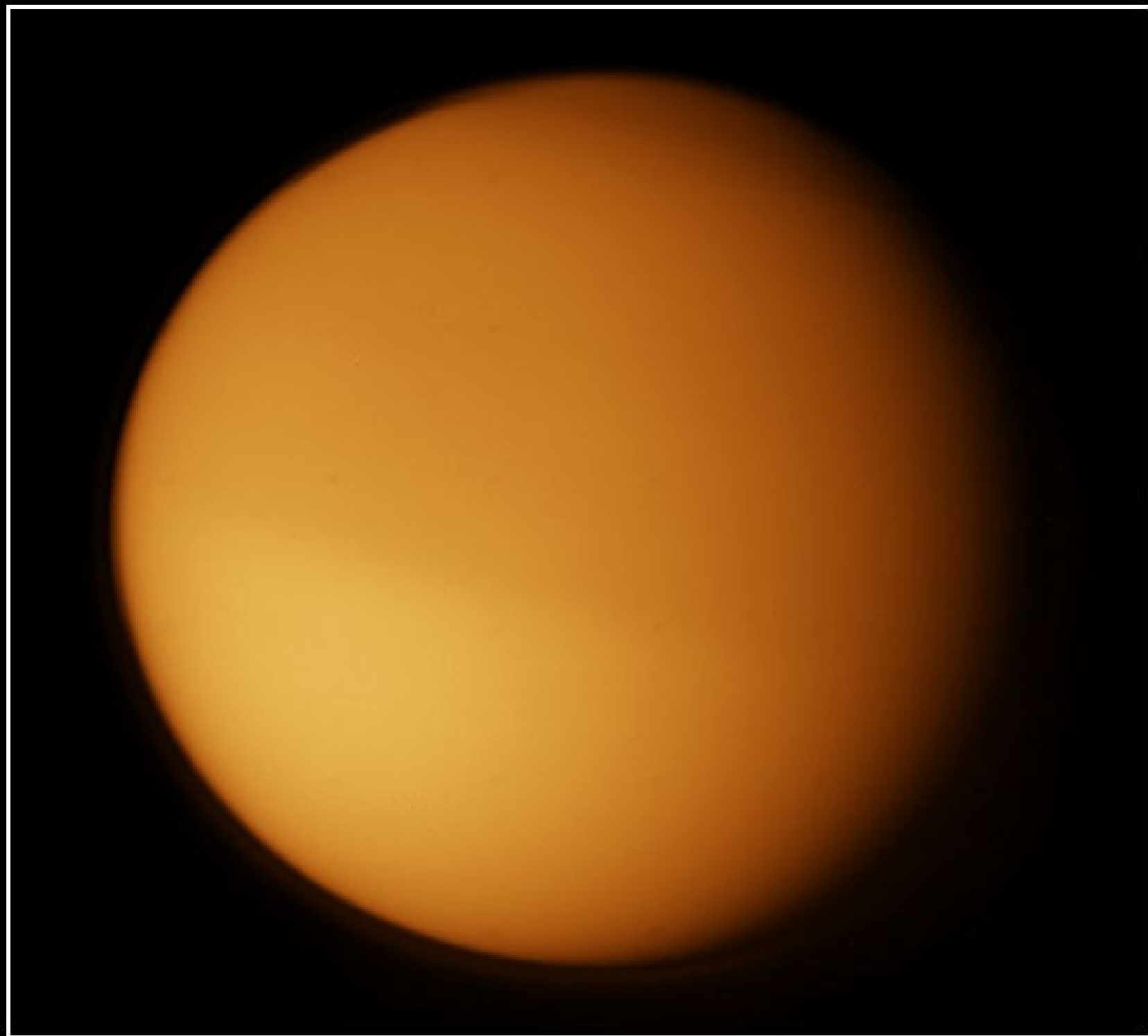


Shepherd moons shape the rings. But do they make them stable? An open question. Prior to Galileo's study of the rings, it was thought they were about 200Myrs old and would only last another 200Myrs.



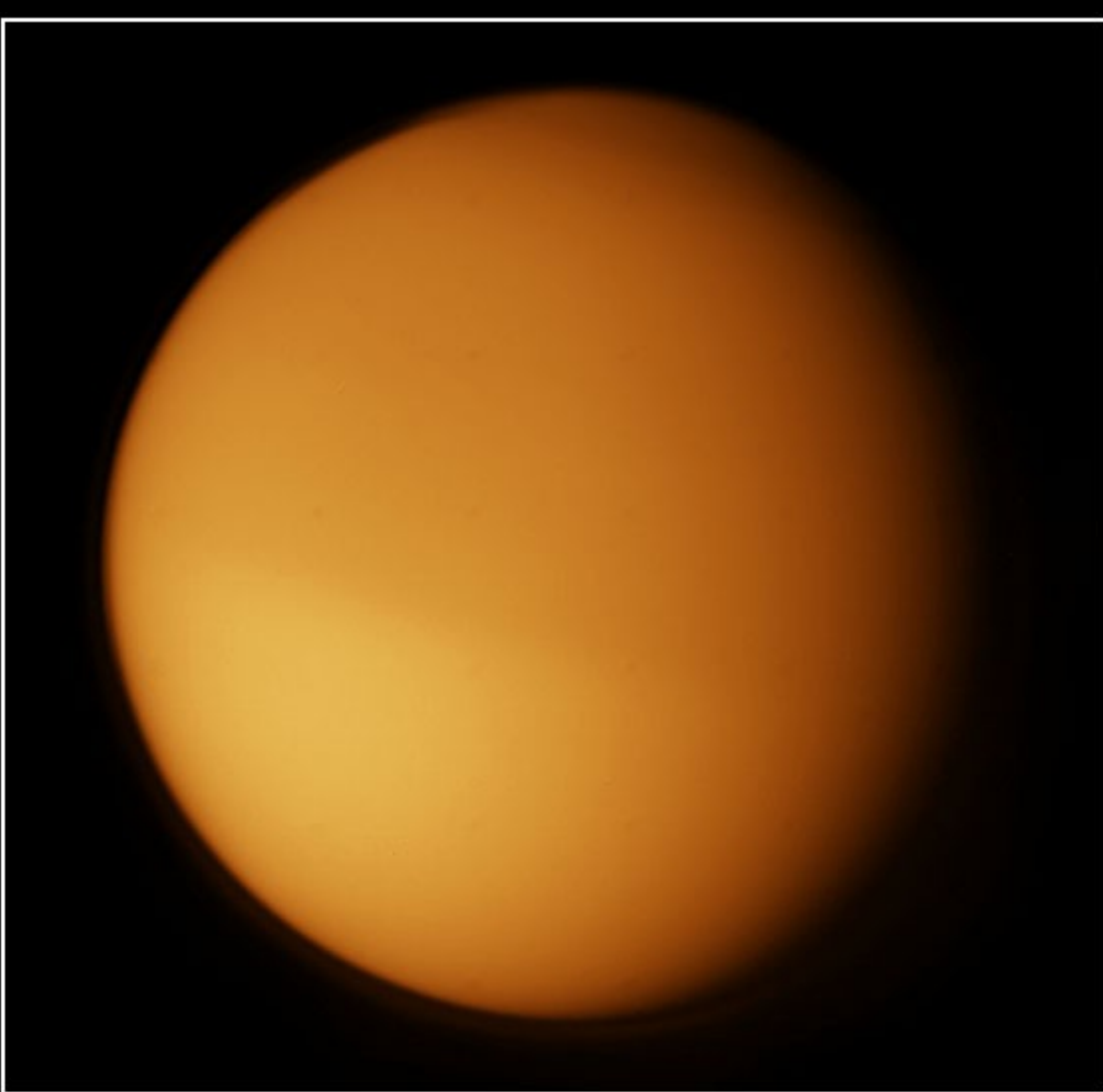






Titan

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Titan

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*Titan is larger than Mercury and more massive than Pluto.

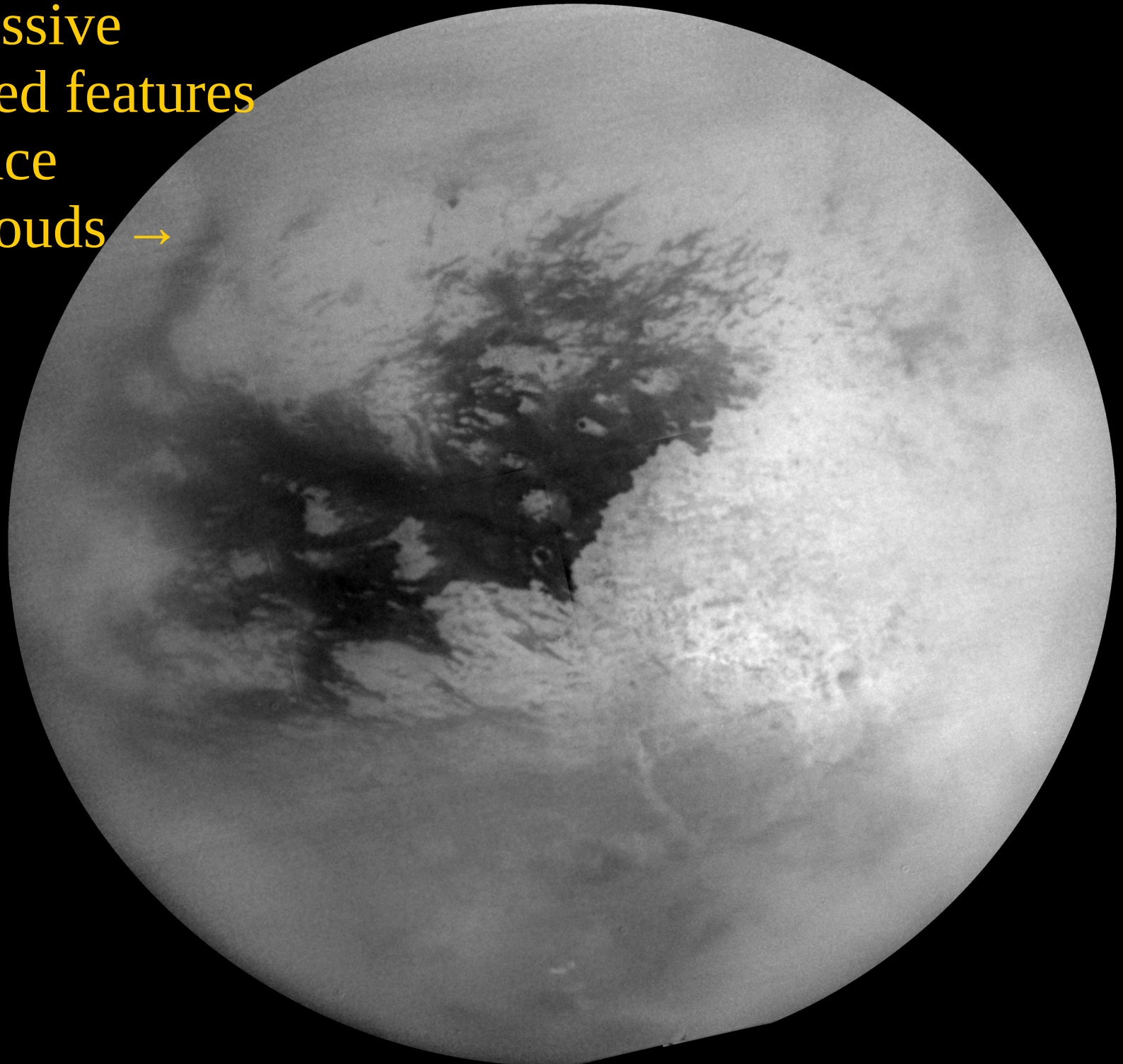
*It has an extremely thick atmosphere.

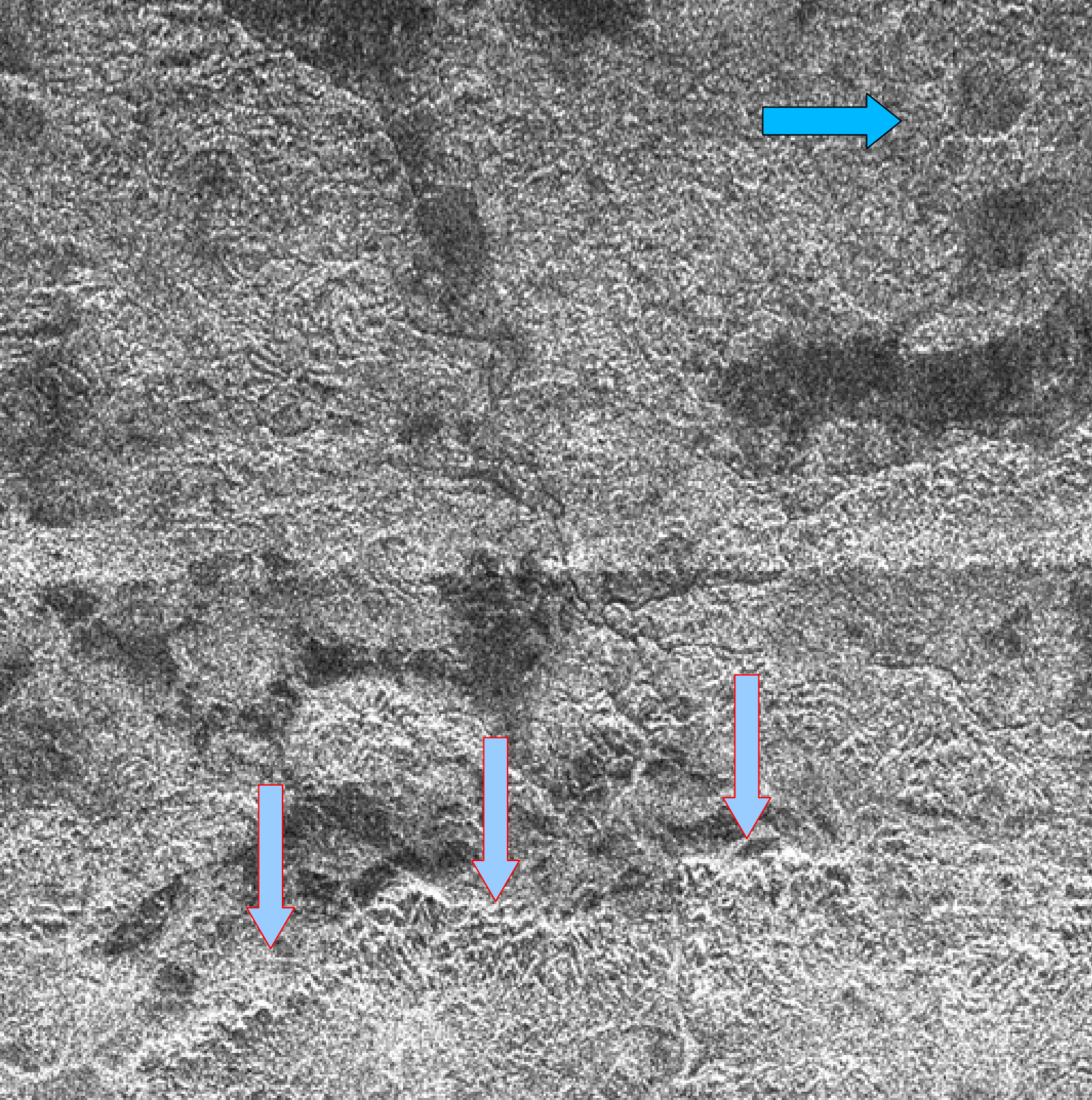
Composed mostly of N_2 like Earth's but 50% thicker than ours.

*94k (- 290F) at Titan's surface.

*At its distance from the Sun, Titan is at the triple point of ethane/methane

Round → massive
Clearly defined features
→ solid surface
Hazy edge/clouds →
atmosphere

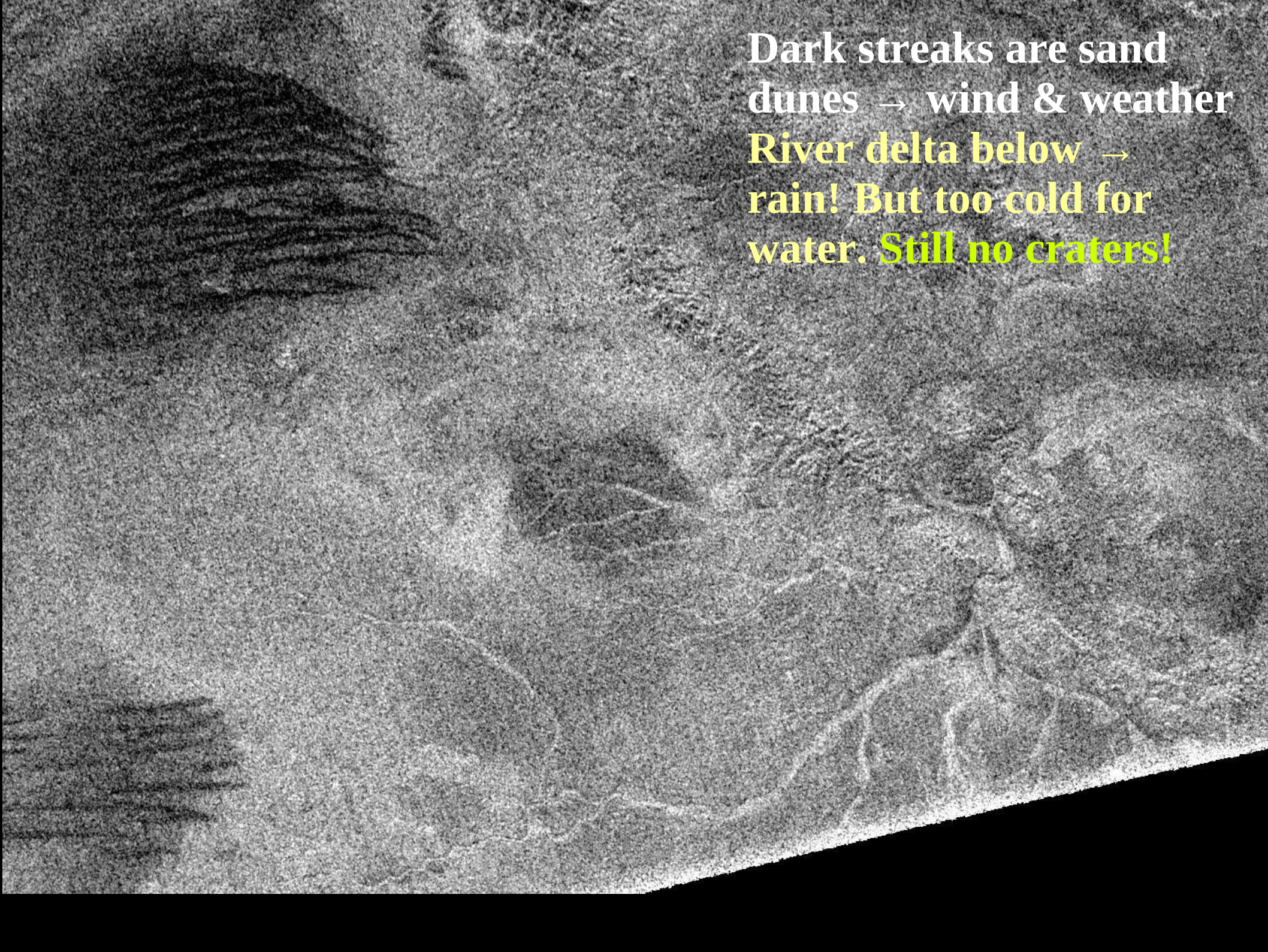




Radar image:
Crater; one of
only a dozen
or so!

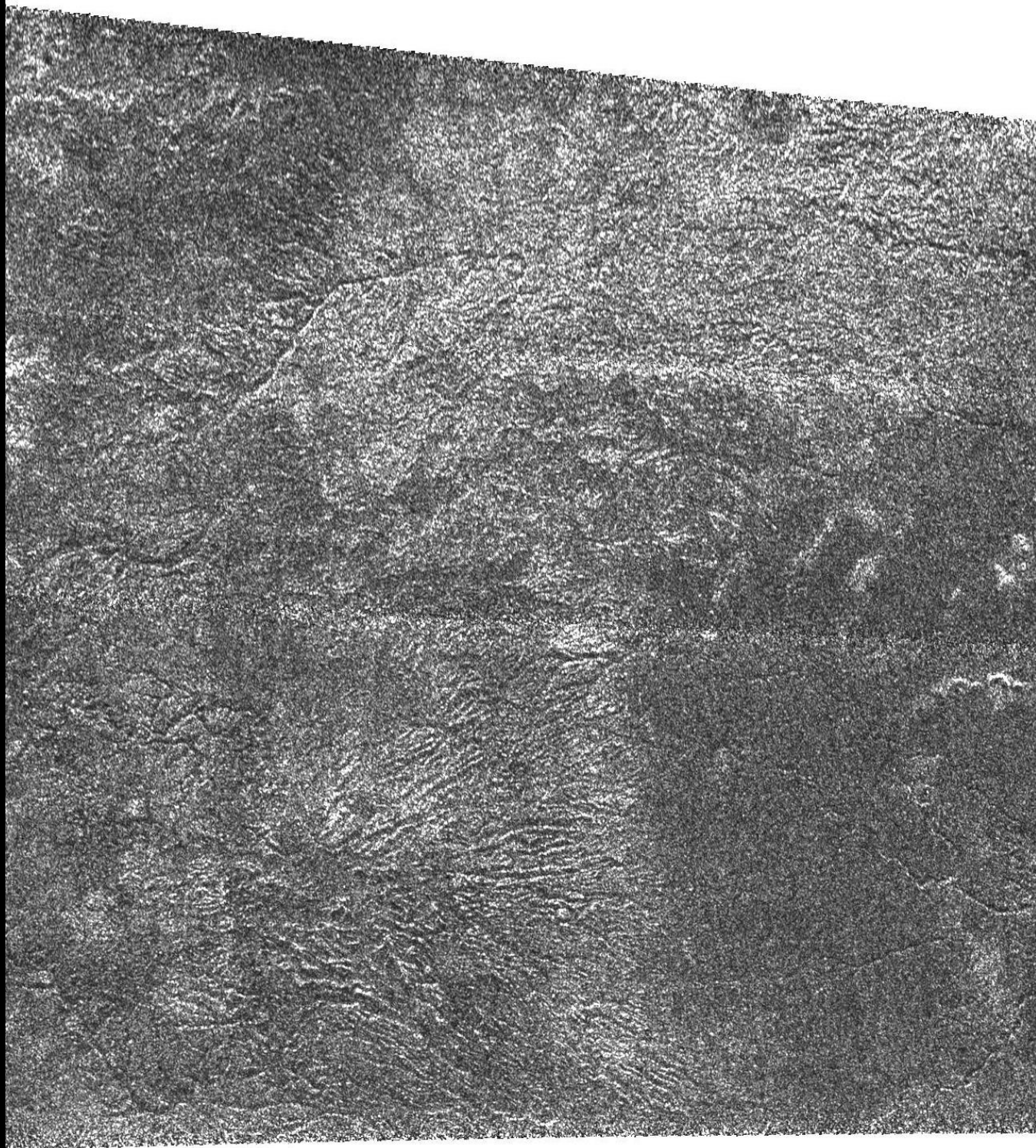
Young surface
100s Myrs

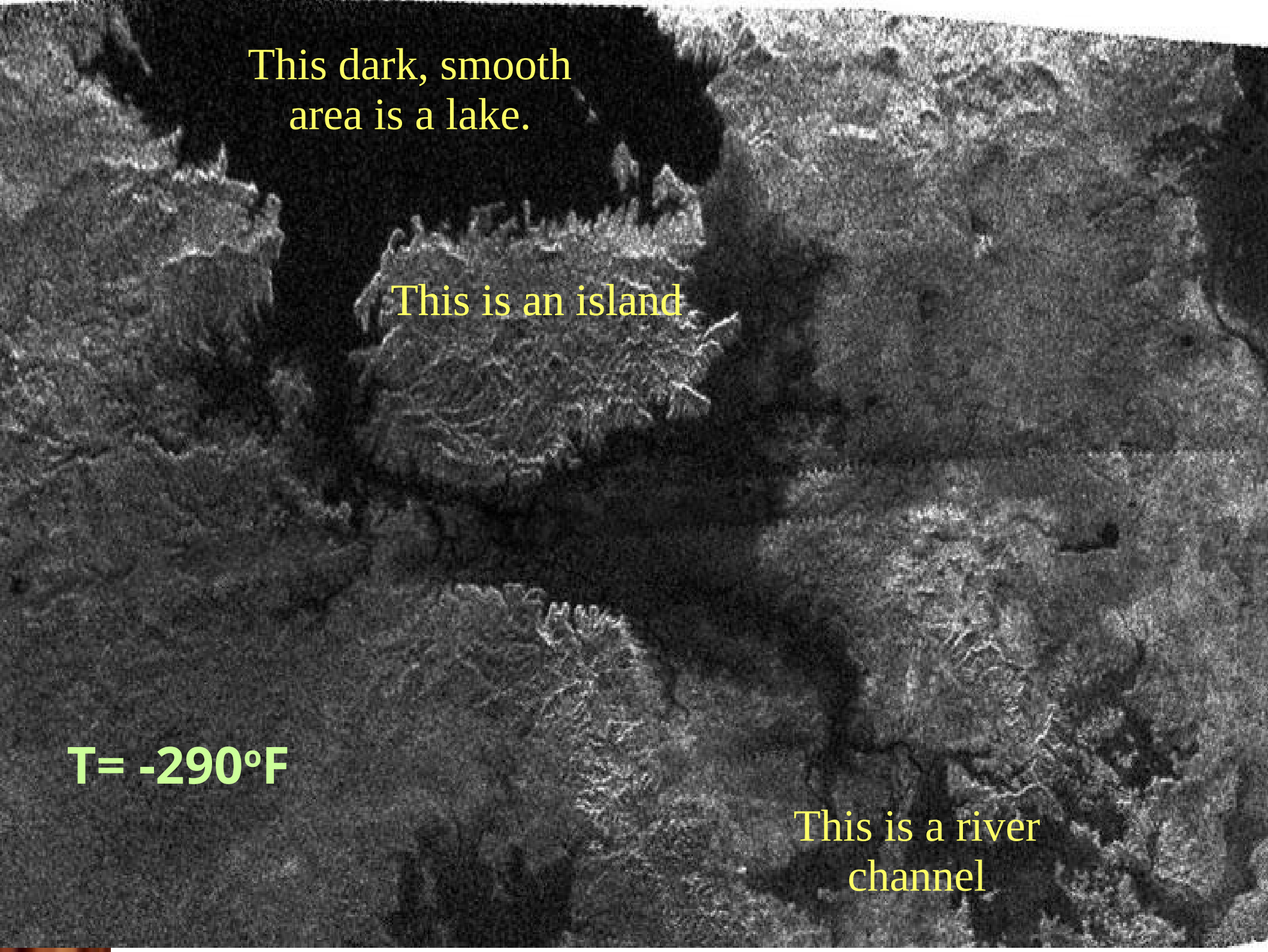
Mountain
range → plate
tectonics!



**Dark streaks are sand
dunes → wind & weather
River delta below →
rain! But too cold for
water. Still no craters!**

Maybe 1 crater
here.
Obvious rivers,
could be lava
channels too (but
they're not in this
case).
Smooth plain too.



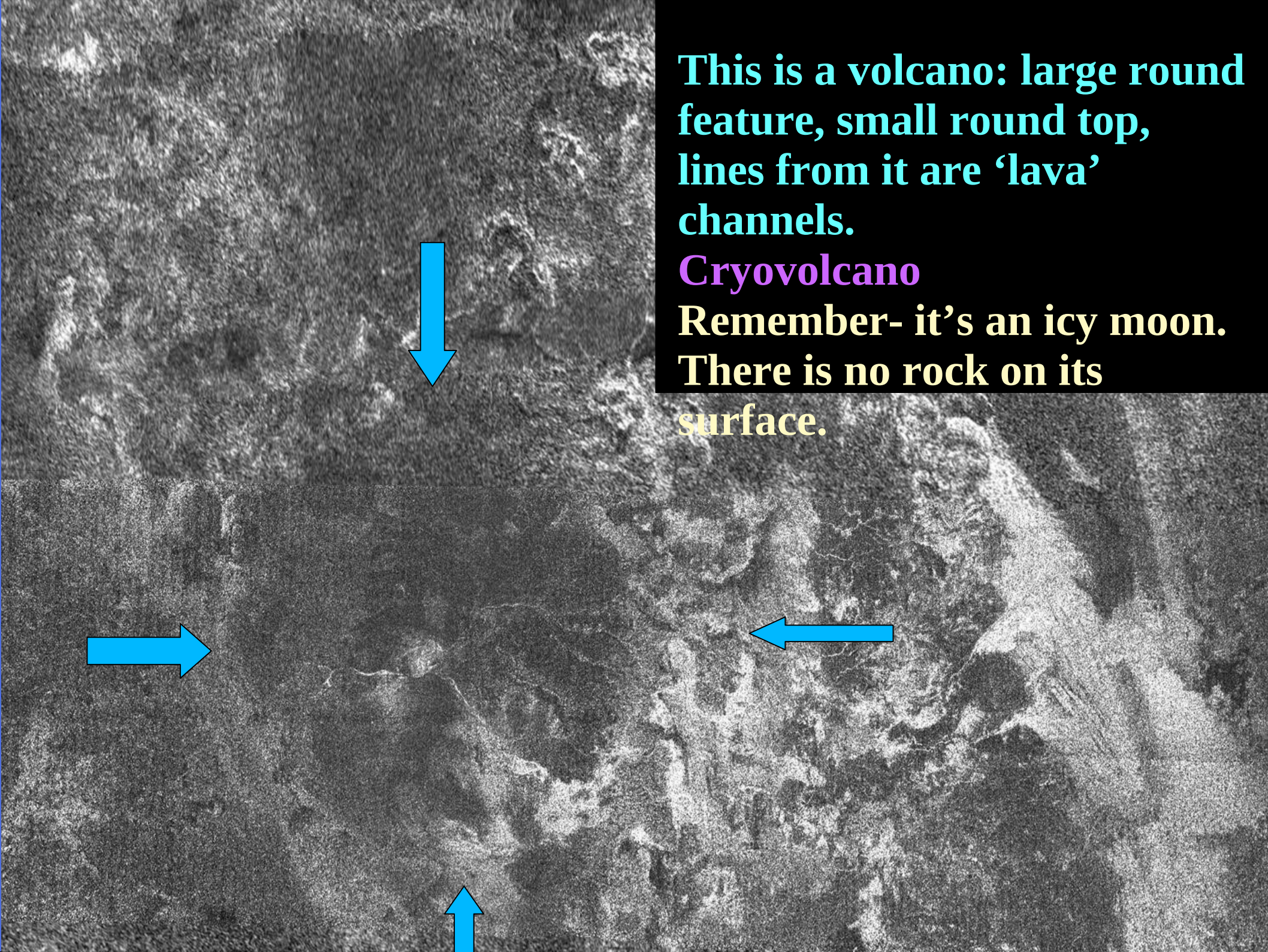


This dark, smooth
area is a lake.

This is an island

T = -290°F

This is a river
channel

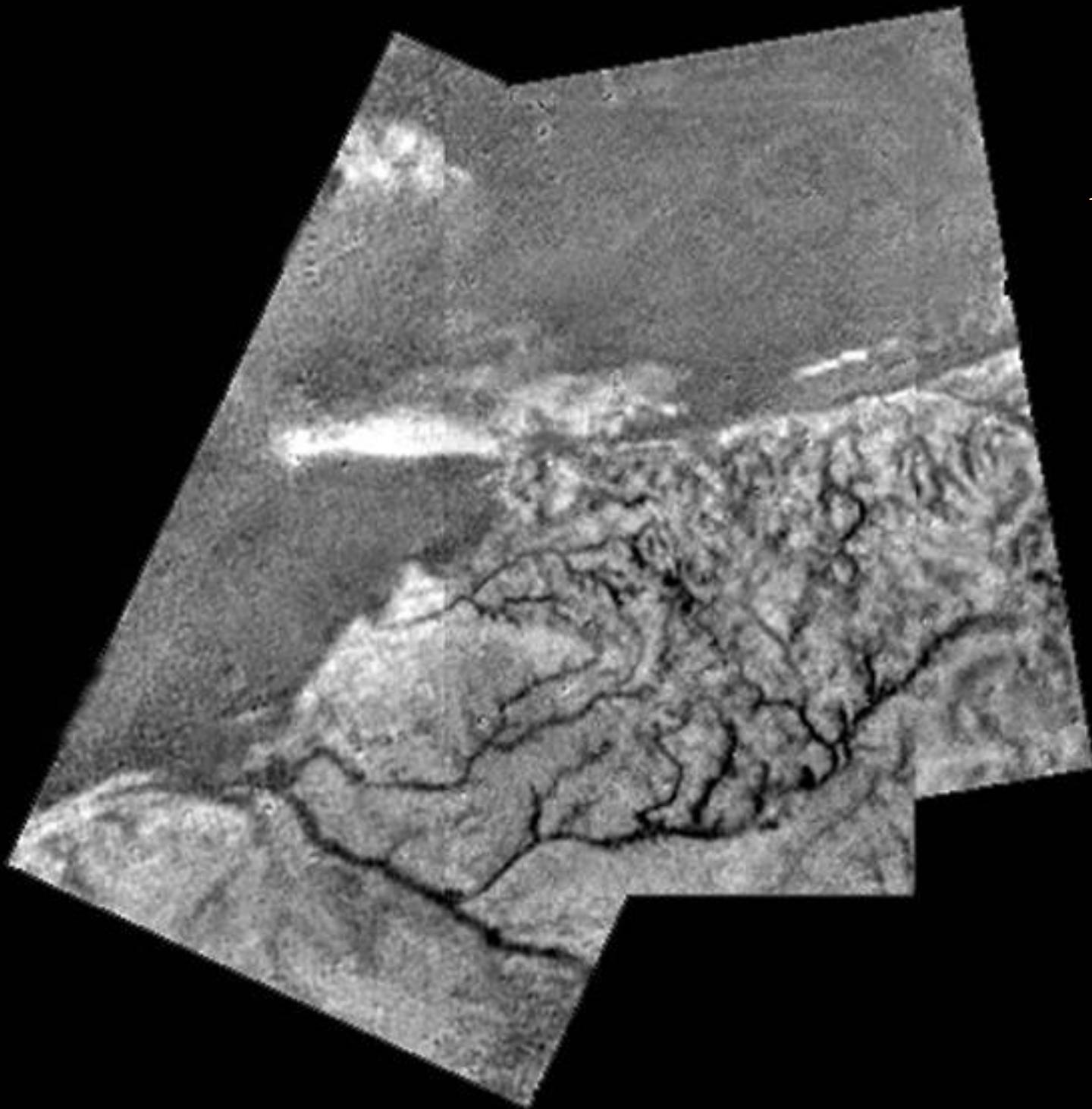


This is a volcano: large round feature, small round top, lines from it are 'lava' channels.

Cryovolcano

**Remember- it's an icy moon.
There is no rock on its surface.**





The top is a
(dry at the
time) lake bed.
Bottom are
hills with river
channels. This
means there is
rain!!!!



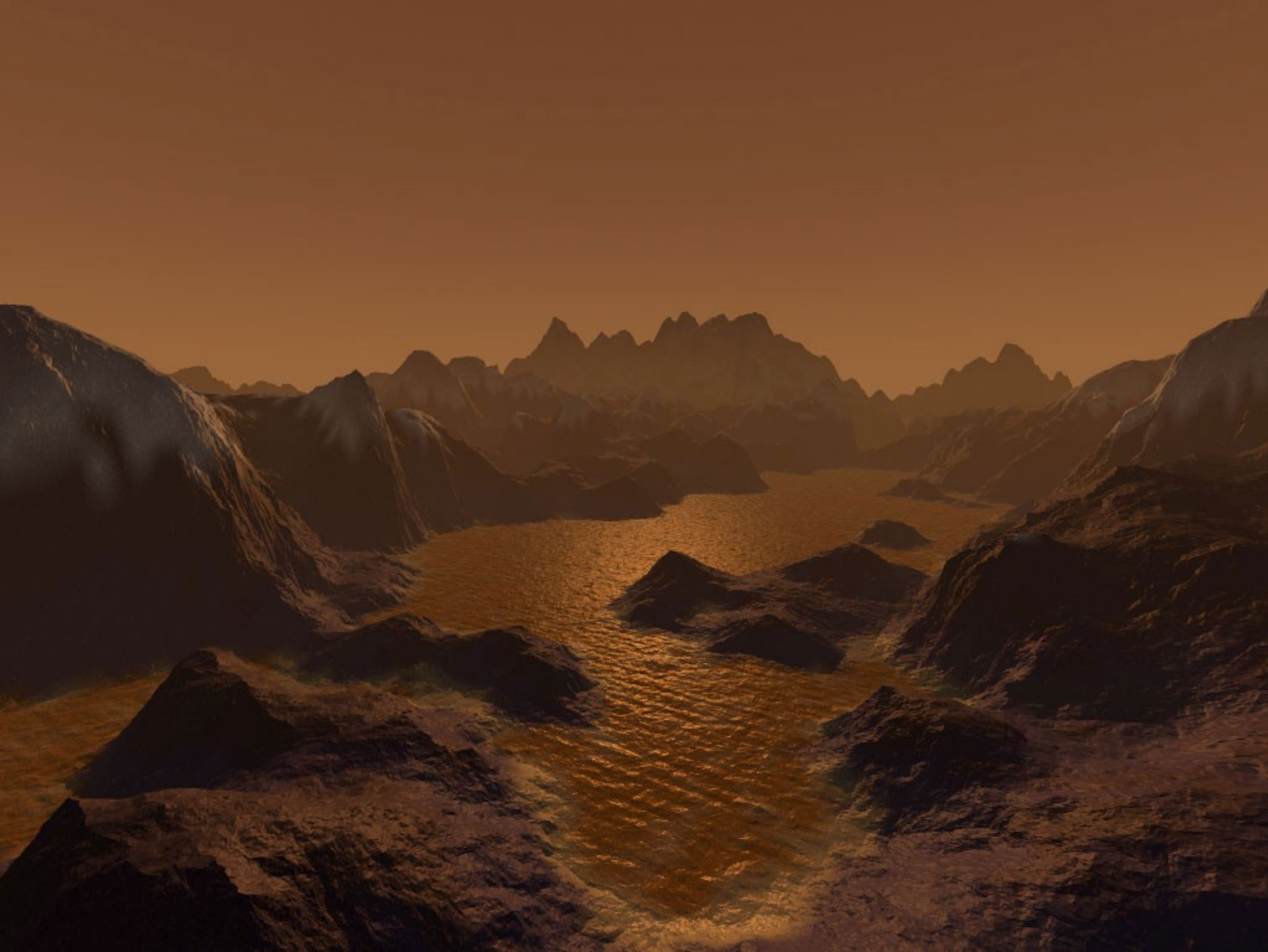
True color image from the surface.

Look around the 'rock' in the middle- see how it has been washed out around it? Like flowing liquid.

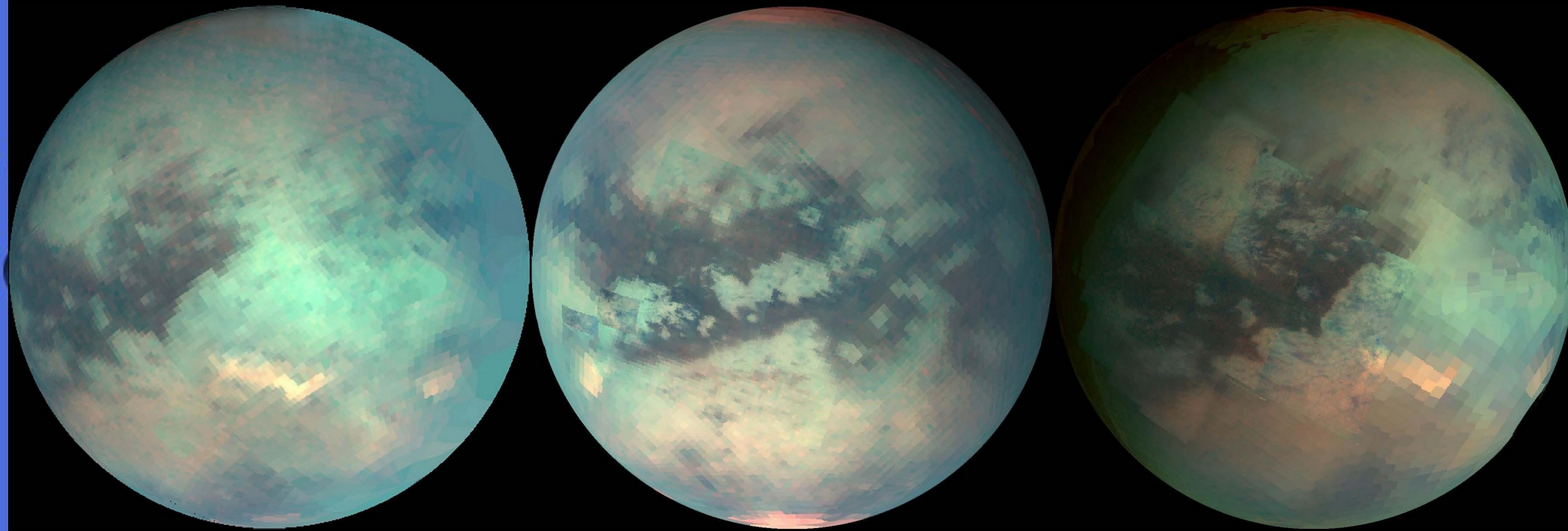
This is like 'rocks' in 'sand' but there is no rock, it is all made of water ice.



**300 miles
across.
The blue
things are
lakes!**



Titan is a round, massive, solid object surrounded by a thick, opaque atmosphere. The surface is incredibly young, indicating many erosive processes including plate tectonics (mountain ranges), rain (river channels), and volcanoes.



Density = 1.88 g/cc
A liquid region
within the ice.

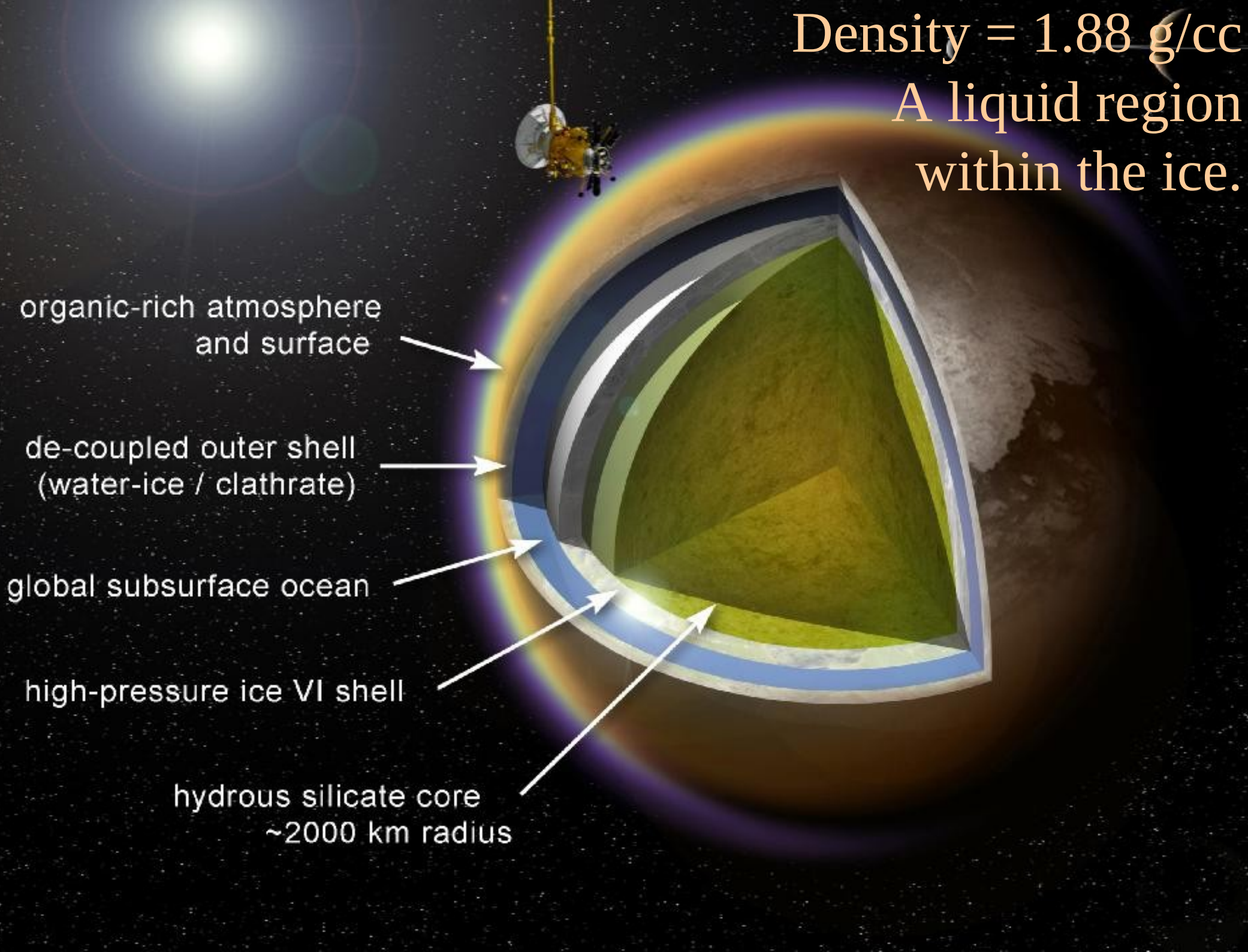
organic-rich atmosphere
and surface

de-coupled outer shell
(water-ice / clathrate)

global subsurface ocean

high-pressure ice VI shell

hydrous silicate core
~2000 km radius



Titan... the other Earth.

It rains, it pours, it snows, it evaporates.

There are volcanoes and plate tectonics, and few (49 estimated) craters.

There's wind, sand dunes, river beds, and lots of erosion.
And is there life?

Other moons

* Average density of Saturn's moons (except Titan) is $\sim 1.3\text{g/cc}$: basically they may have rocky cores, but contain substantial amounts of ice.

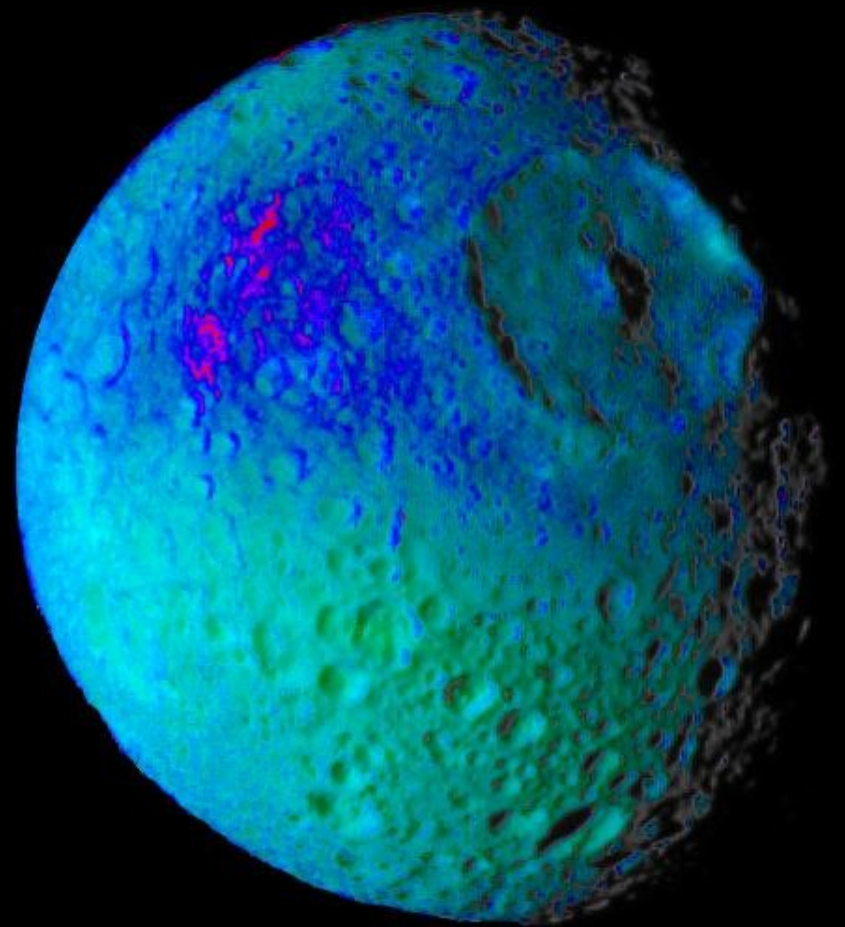
Dione



Quiz 3. The surfaces/crusts of the outer moons are made exclusively of what?

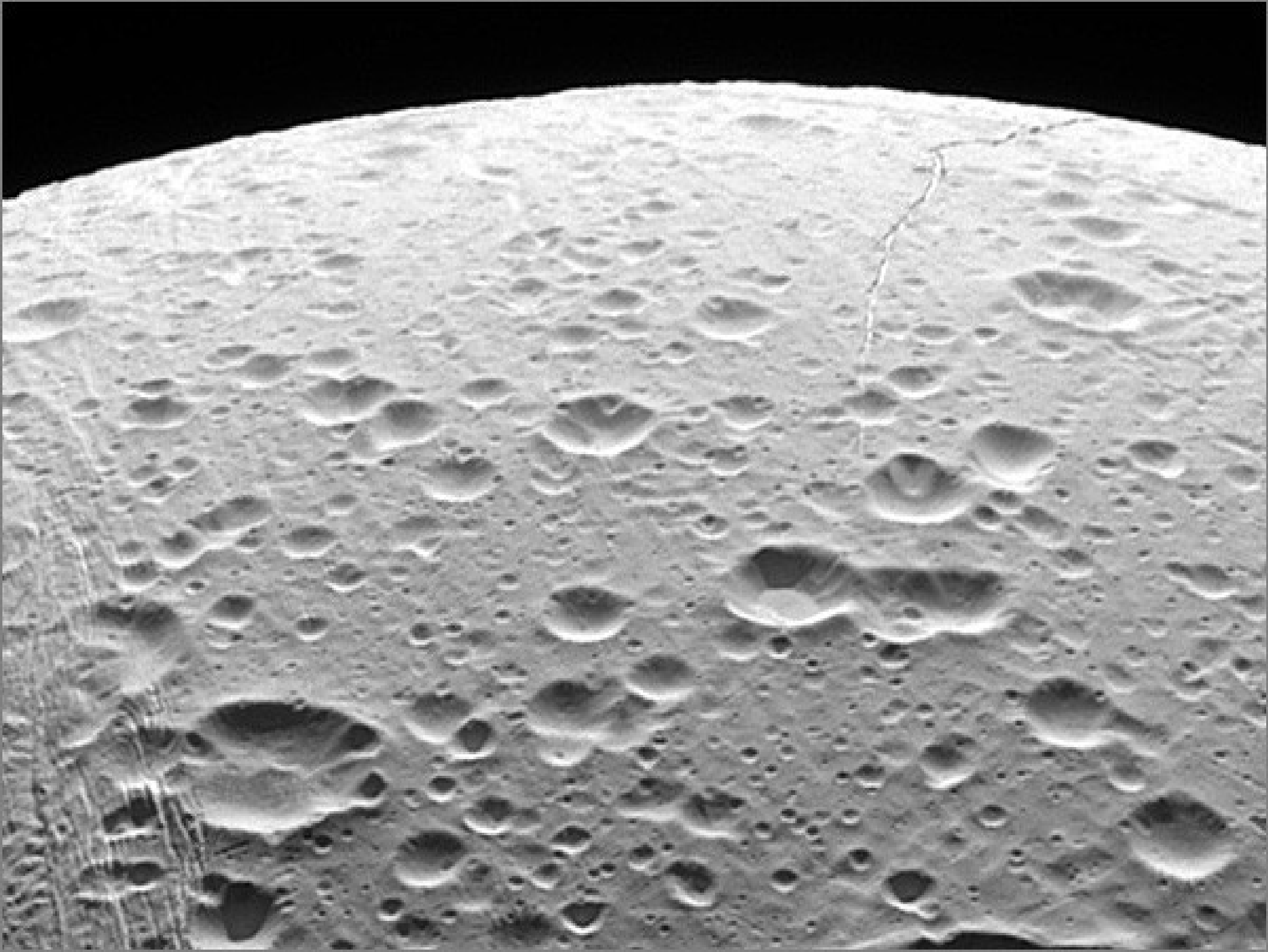
- A) Rock
- B) Hydrogen
- C) Helium
- D) Ice
- E) Chocolate

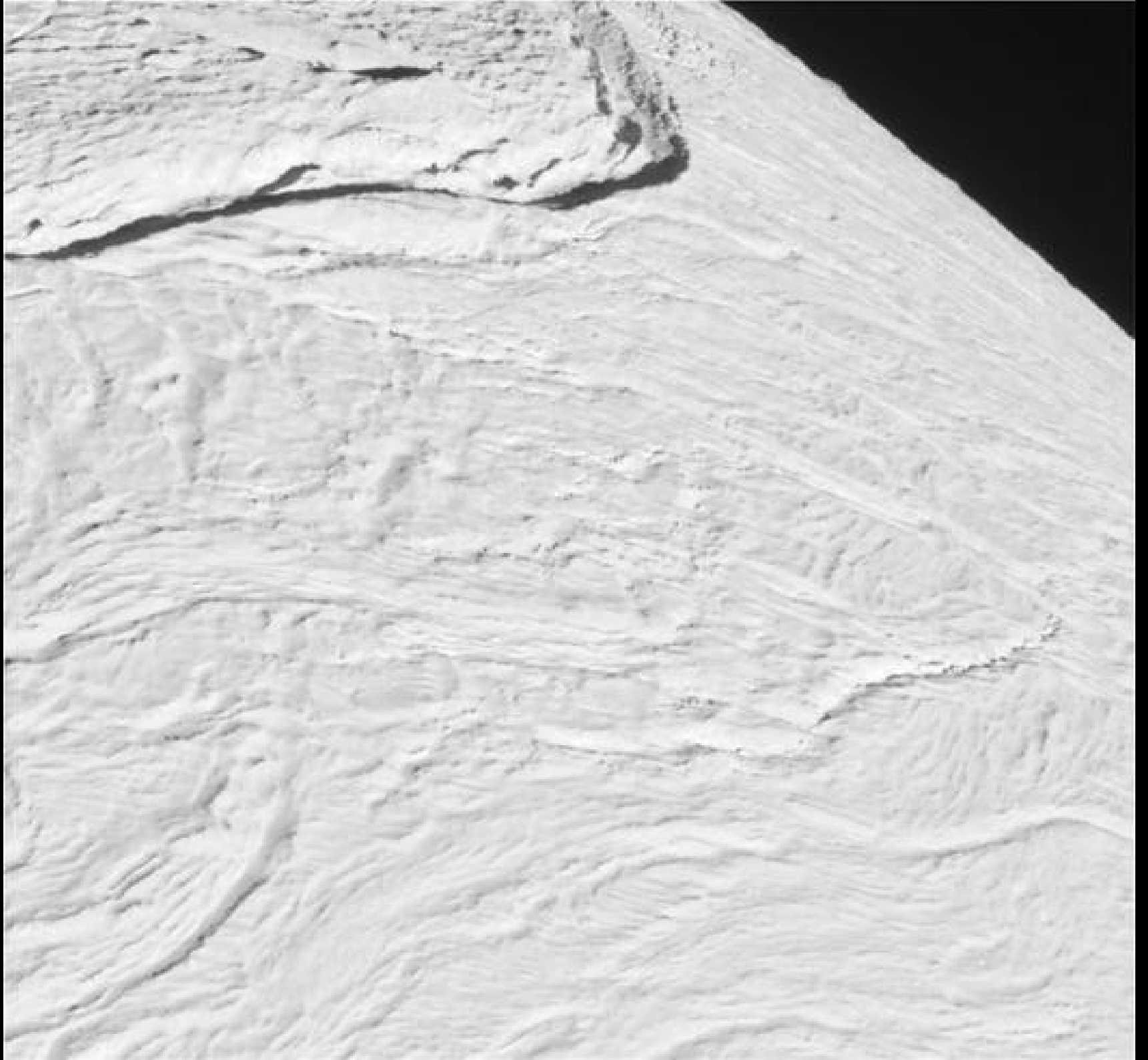
Mimas

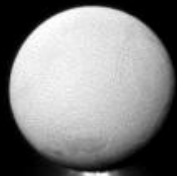


Enceladus

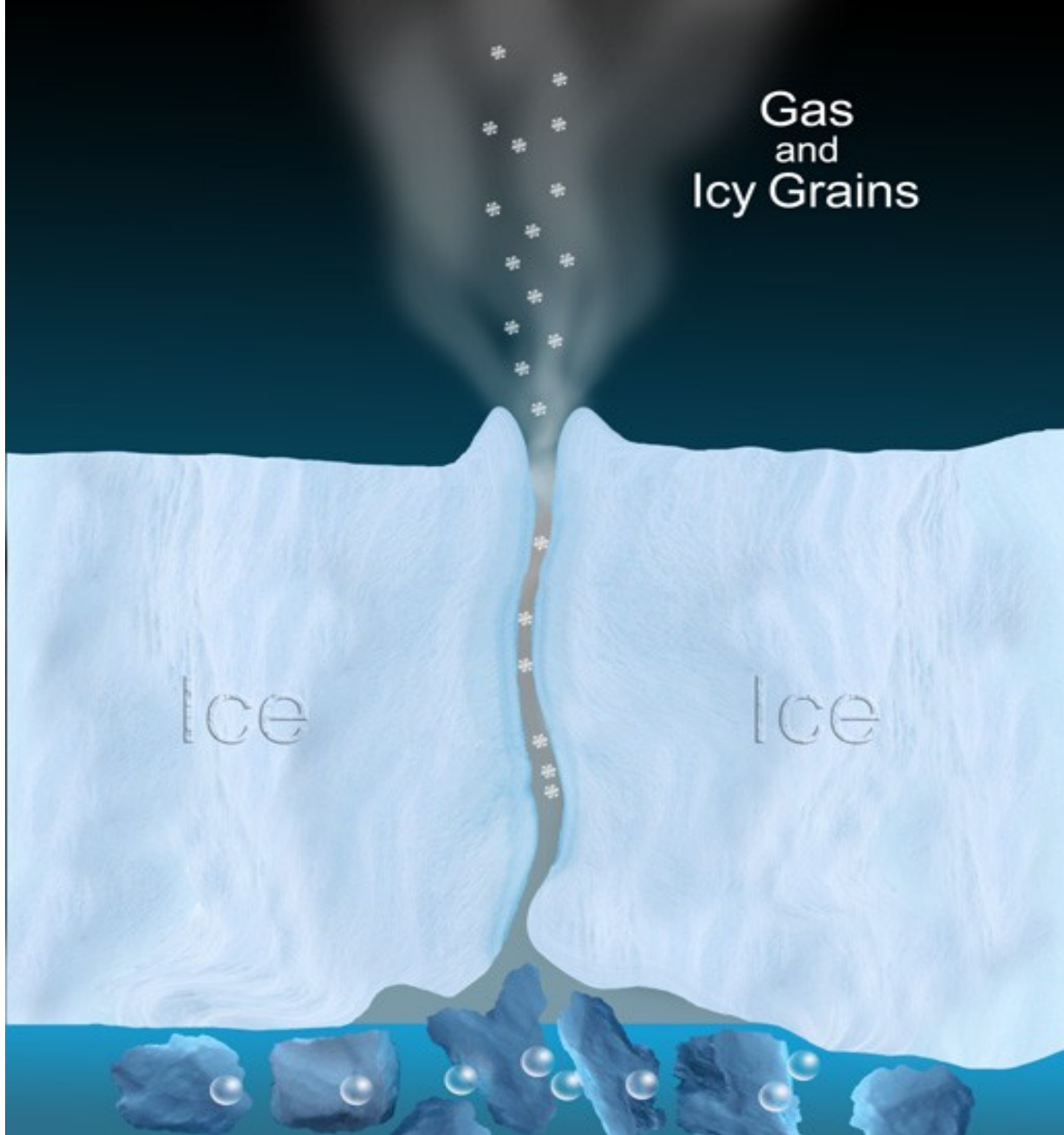


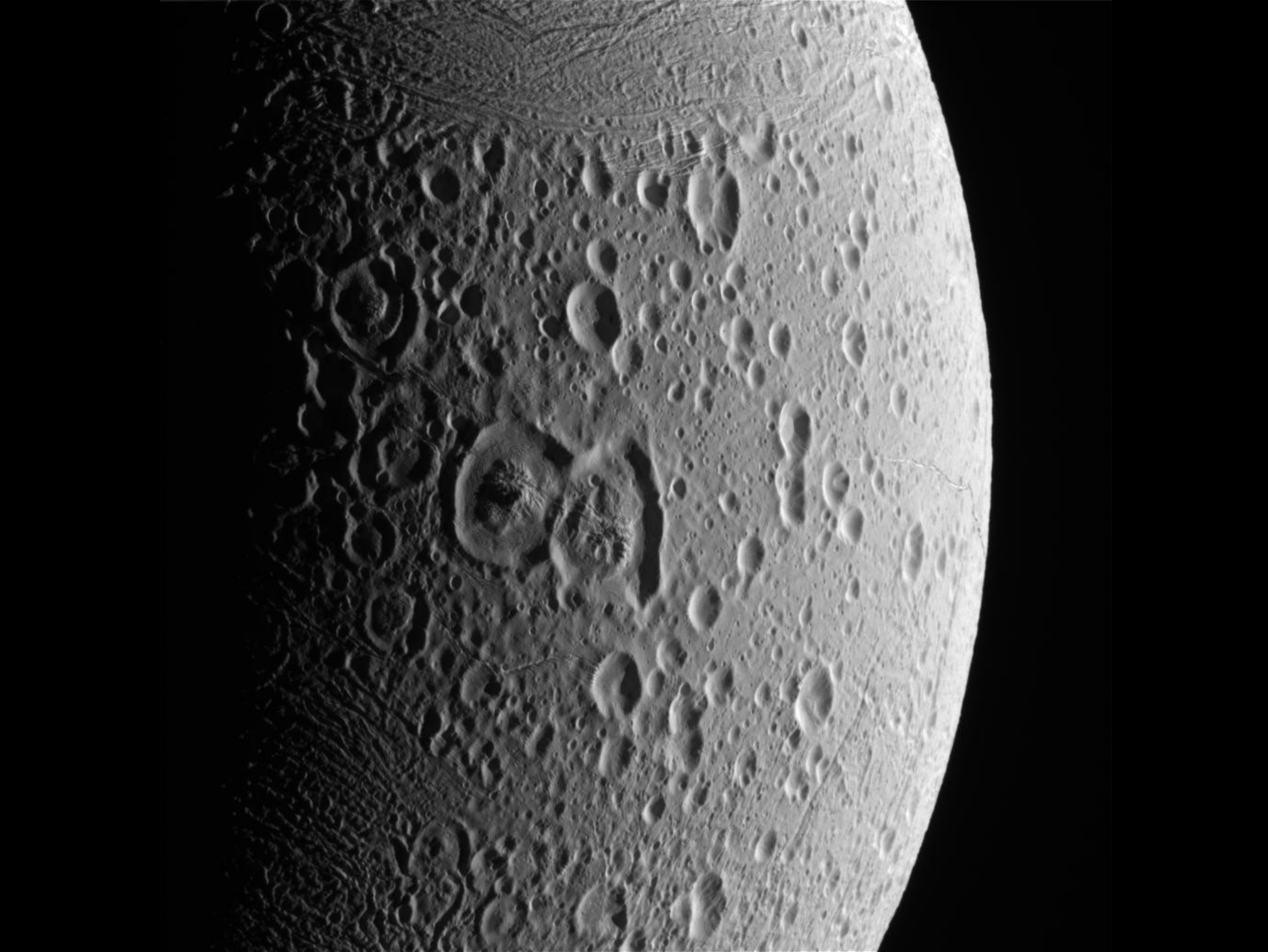






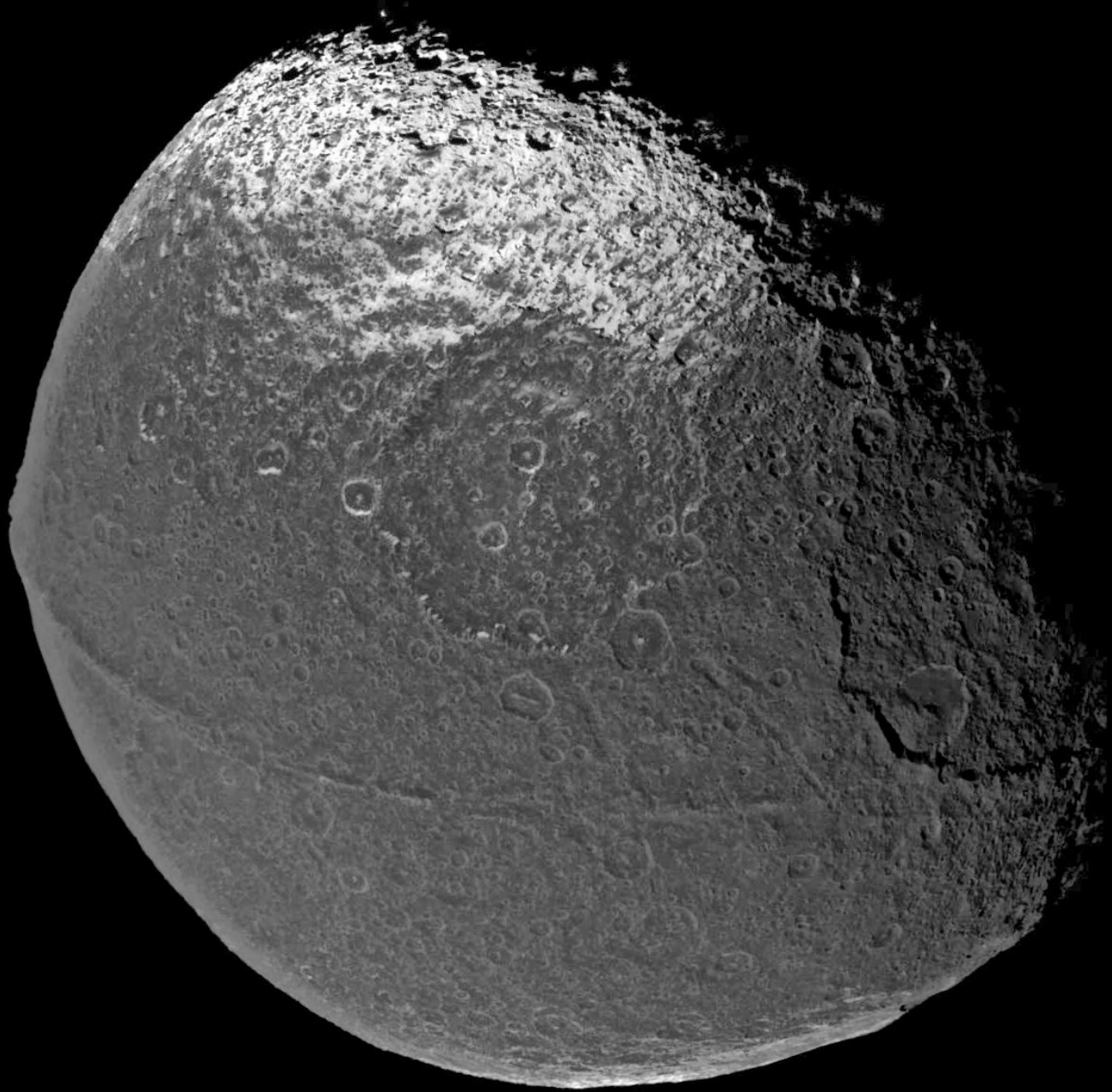
Gas and Icy Grains



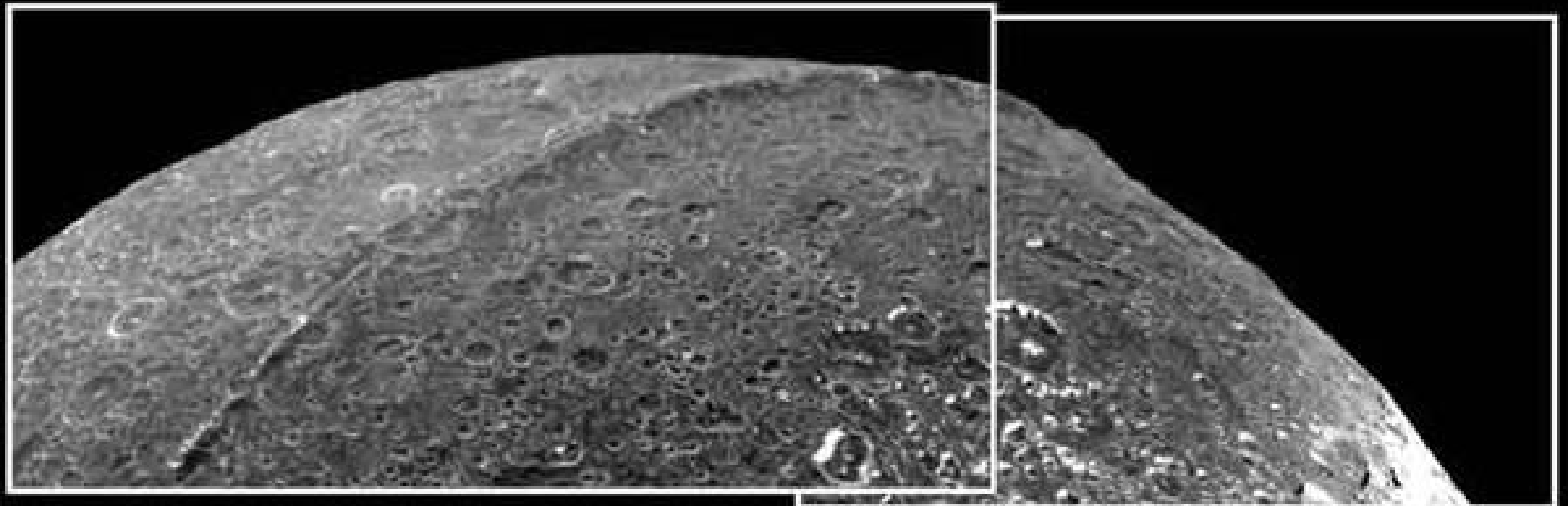
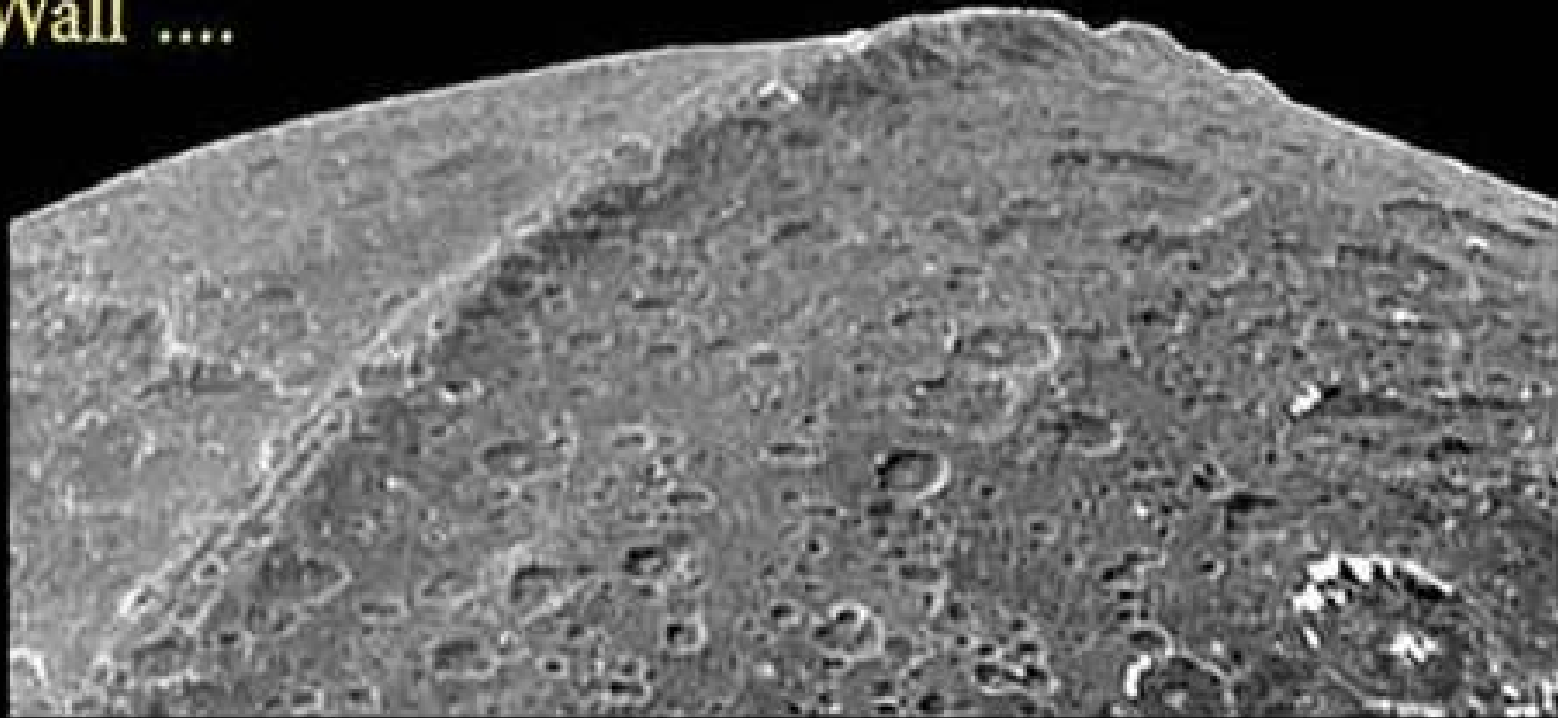




Iapetus

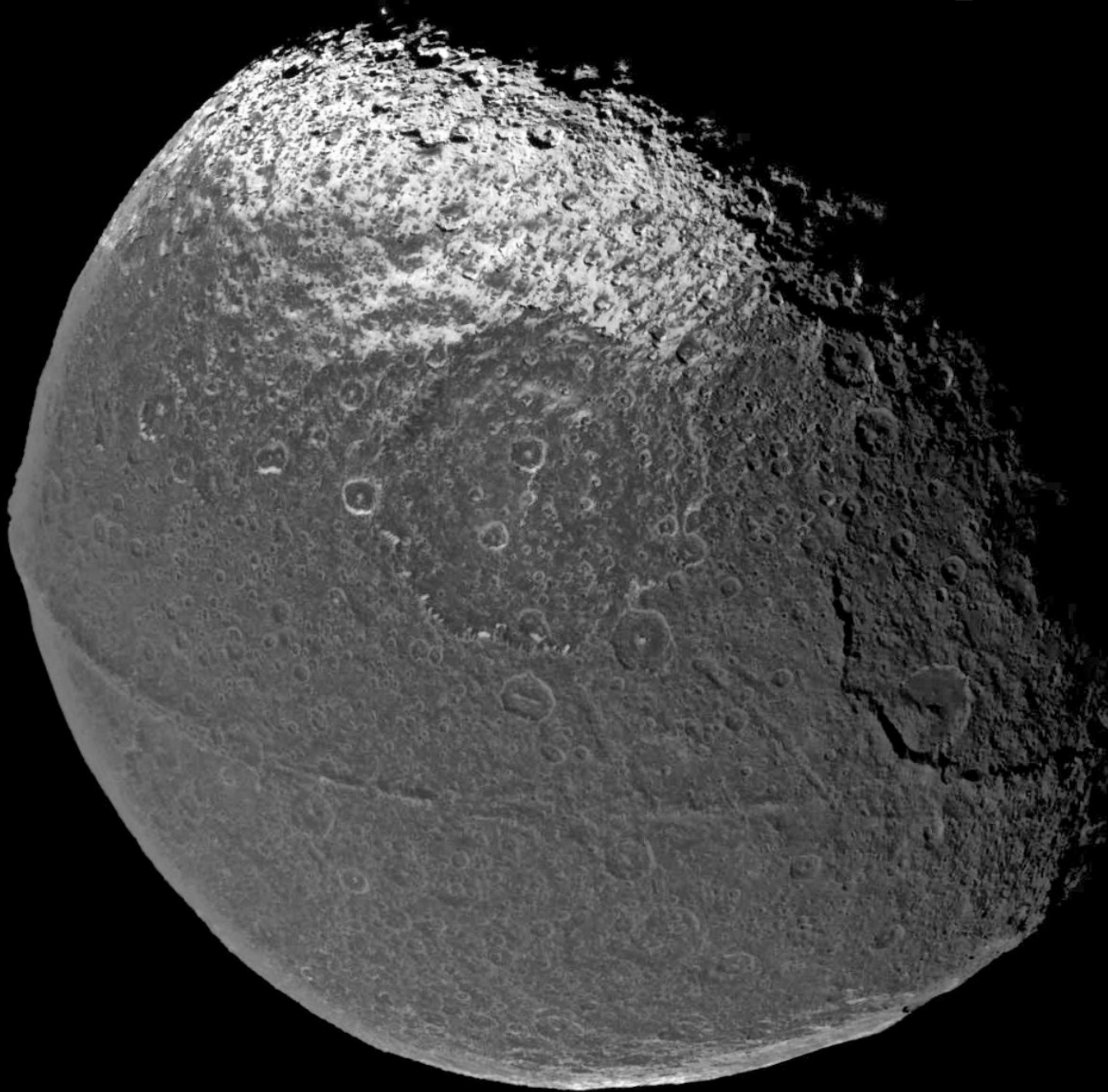


The Wall





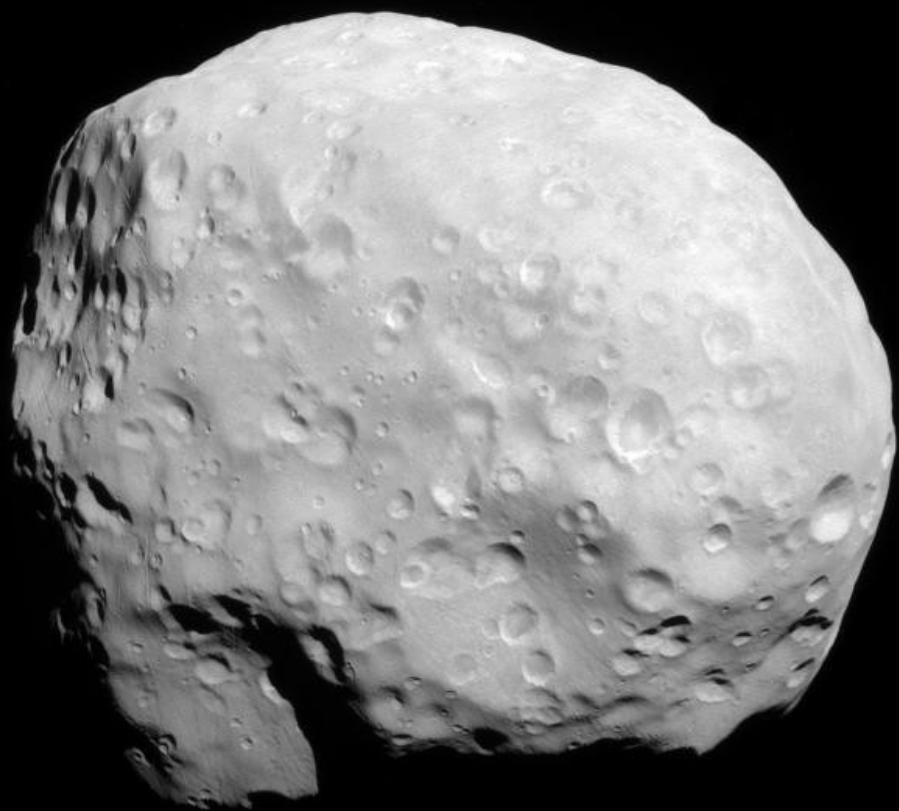
Iapetus: a giant walnut



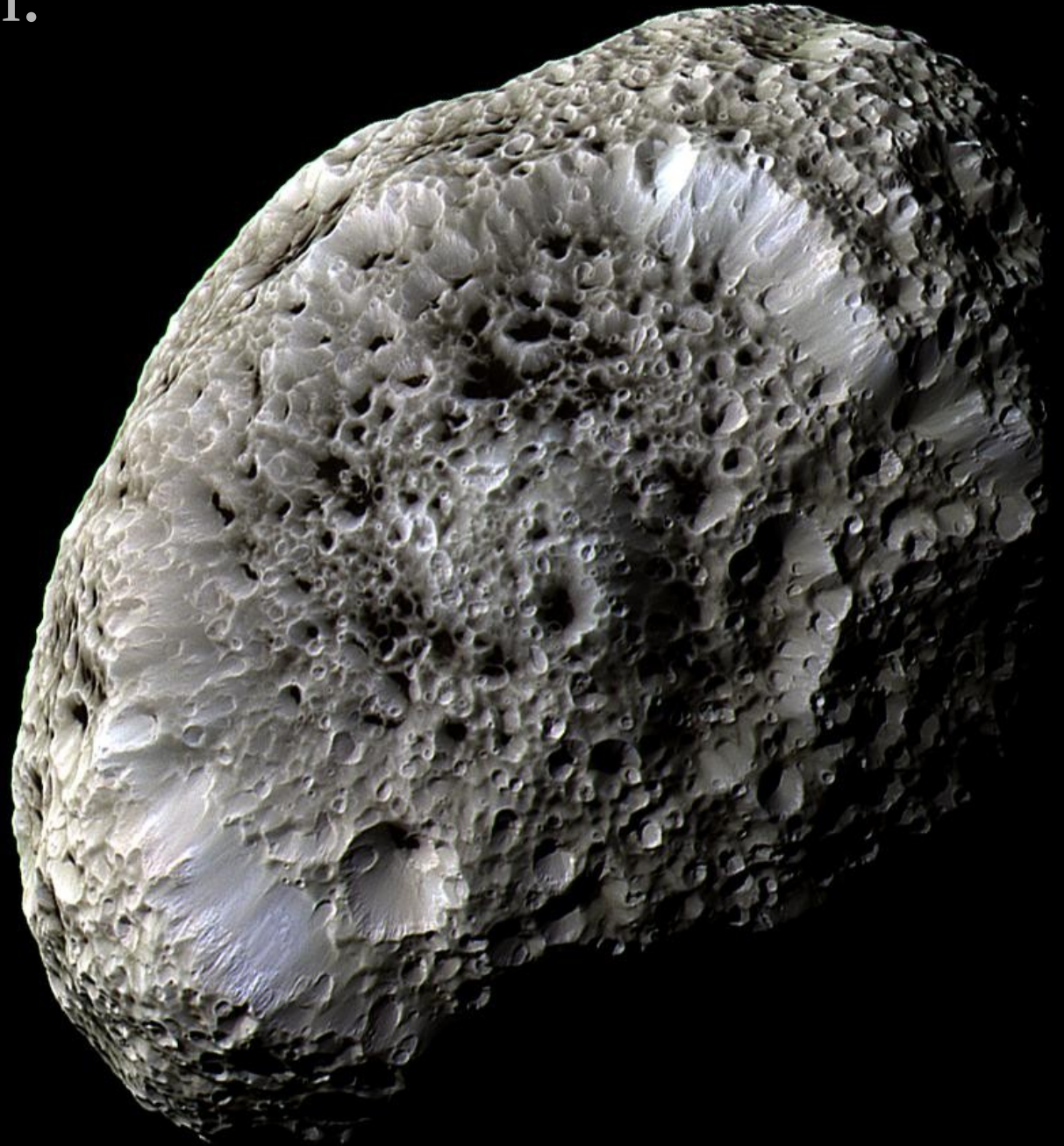


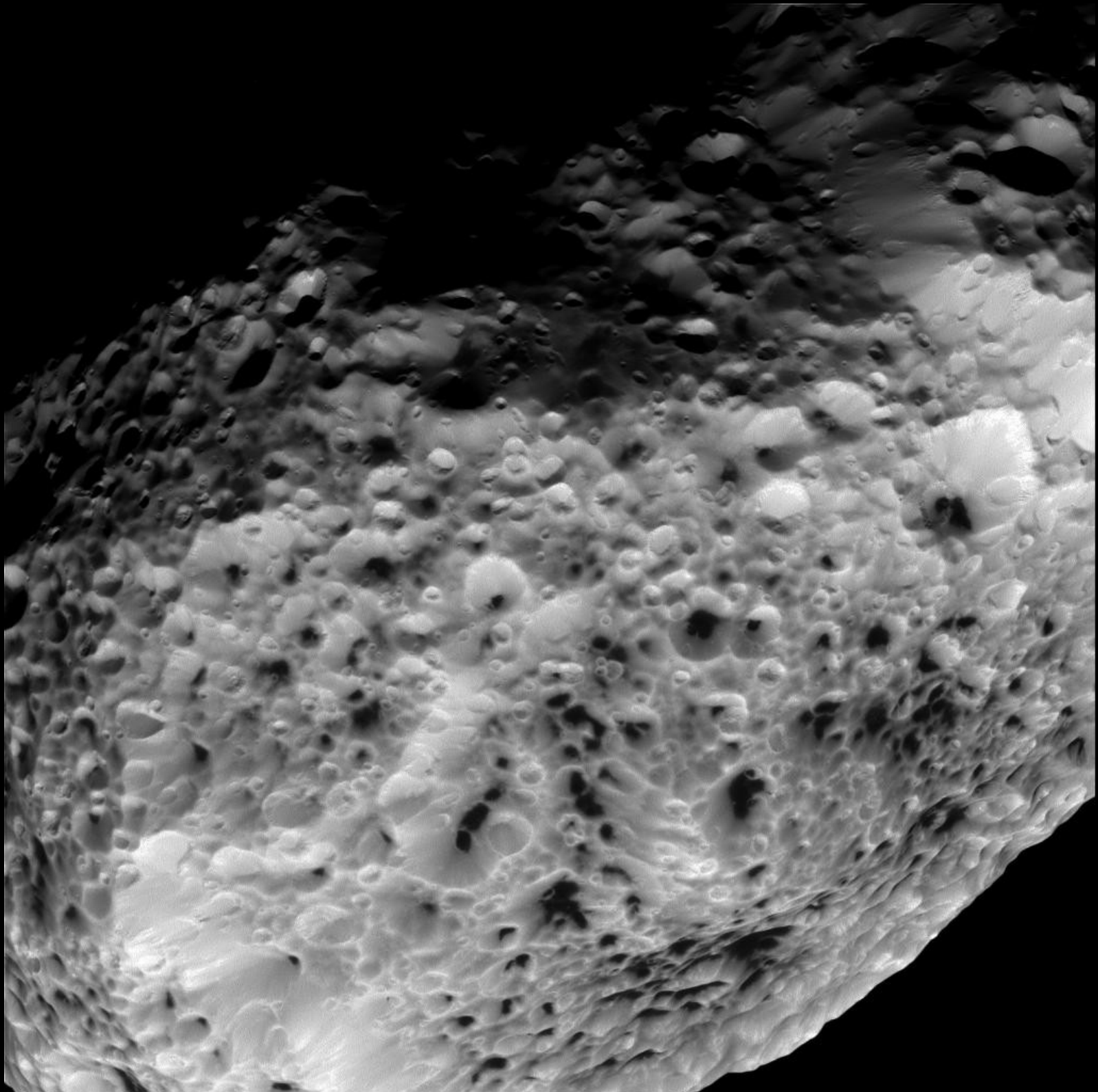
Epimetheus: A captured asteroid?

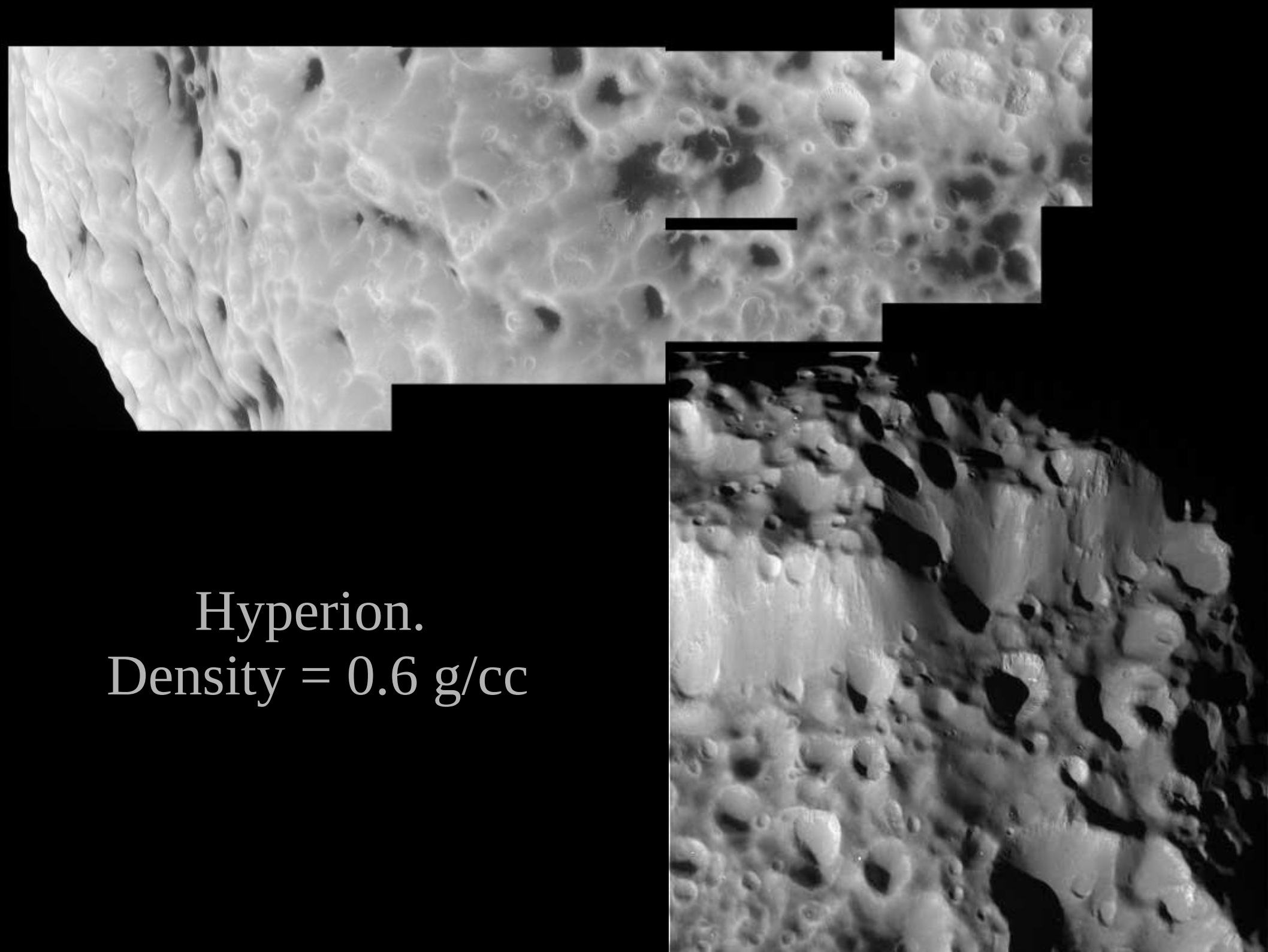




Hyperion.



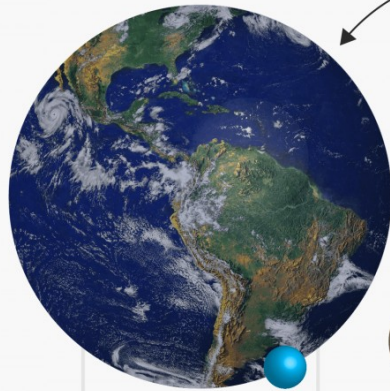




Hyperion.
Density = 0.6 g/cc

Look at all the water!

HOW THE SOLAR SYSTEM'S LARGEST OCEAN WORLDS COMPARE IN SIZE



Earth has a surprisingly small amount of water compared to other worlds in the Solar System. Each measurement is the spherical radius of the world and its water (including ice):

ENCELADUS

Water radius:
140 mi./
220 km.

World radius:
157 mi./
252 km.

DIONE

Water radius:
300 mi./
480 km.

World radius:
349 mi./
561 km.

EARTH

Water radius:
430 mi./
690 km.

World radius:
3,959 mi./
6,371 km.

EUROPA

Water radius:
550 mi./
880 km.

World radius:
972 mi./
1,565 km.

PLUTO

Water radius:
630 mi./
1010 km.

World radius:
738 mi./
1,187 km.

TRITON

Water radius:
730 mi./
1170 km.

World radius:
840 mi./
1,352 km.

CALLISTO

Water radius:
1,120 mi./
1,800 km.

World radius:
1,498 mi./
2,410 km.

TITAN

Water radius:
1,180 mi./
1,890 km.

World radius:
1,601 mi./
2,576 km.

GANYMEDE

Water radius:
1,460 mi./
2,350 km.

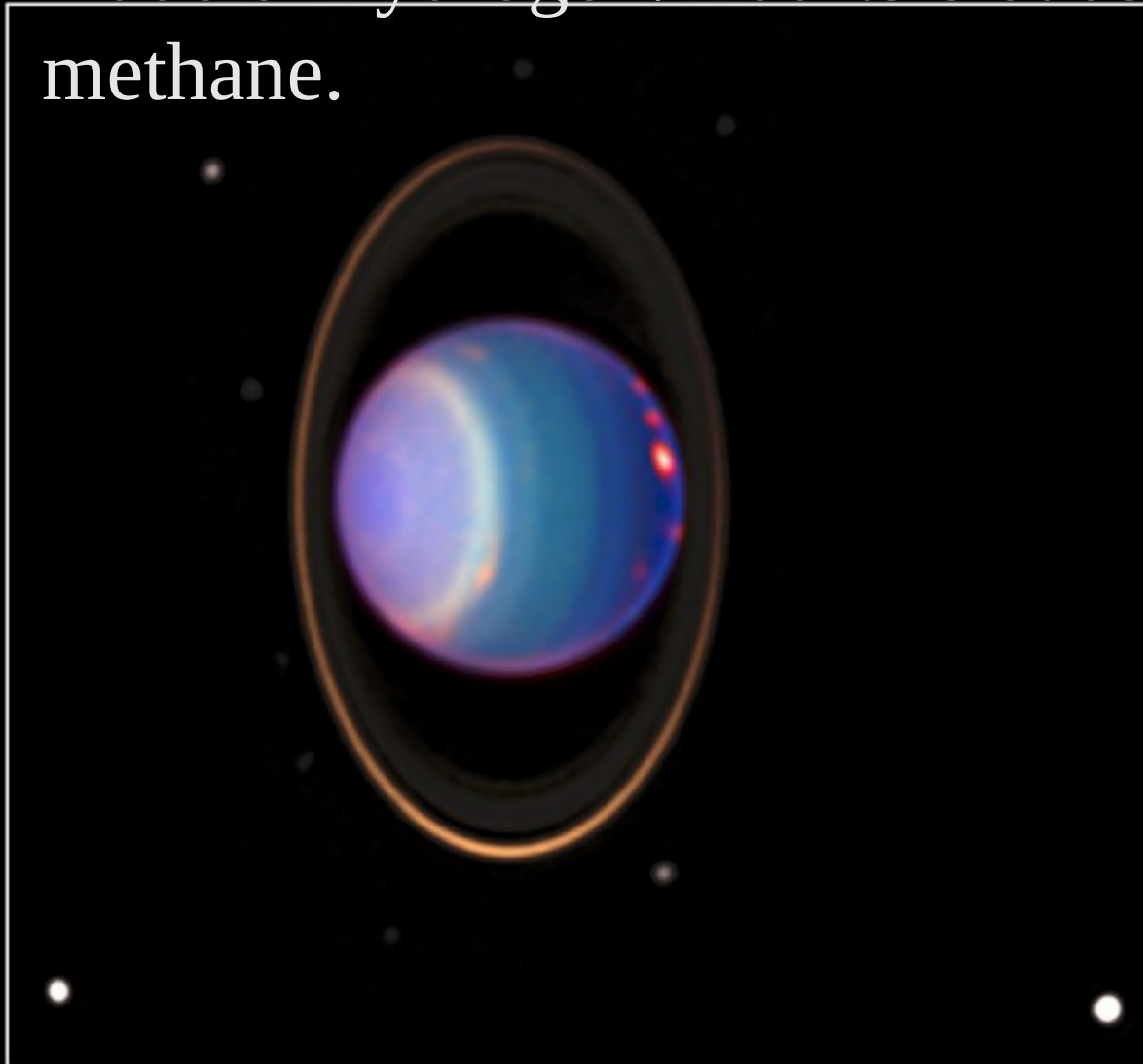
World radius:
1,635 mi./
2,631 km.

Uranus



Uranus

Like Jupiter and Saturn, its atmosphere is mostly made of hydrogen. But its clouds are made of methane.



Uranus • August 8, 1998

HST • NICMOS

PRC98-35b • ST ScI OPO • October 14, 1998

E. Karkoschka (University of Arizona) and NASA



Ariel

Puck

Miranda

Umbriel

Titania

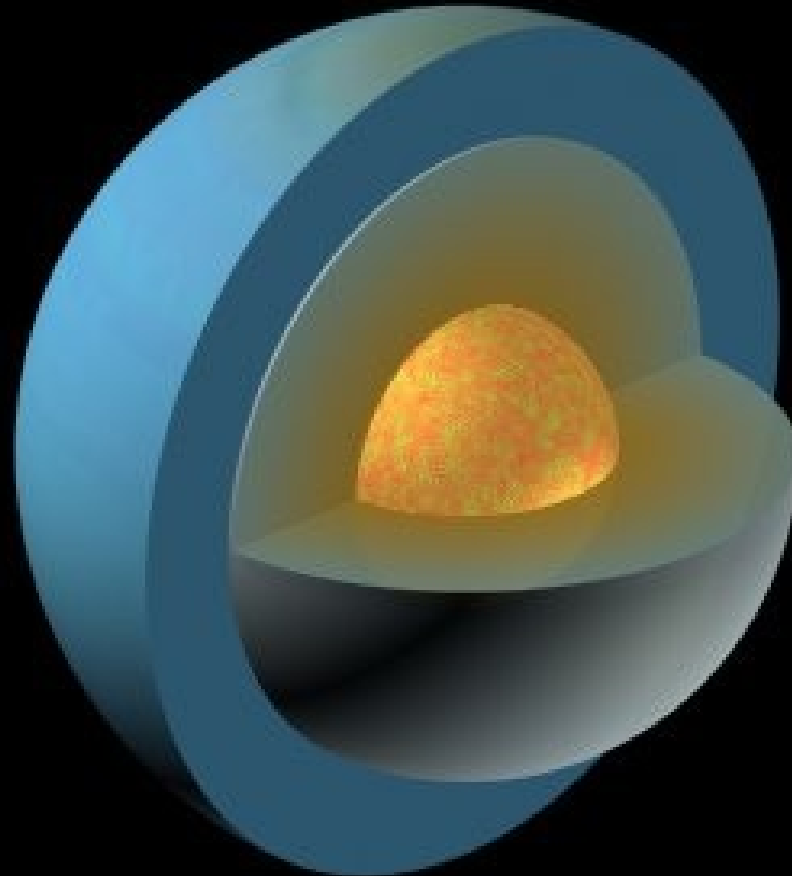
Oberon



Uranus' structure **New for us!**

- * Mostly hydrogen atmosphere. Methane clouds
- * liquid/ice mantle made of water/ammonia/methane
- * rocky silicate core (like Earth's mantle)

5th (and last)
structure in our
solar system.
Neptunian



Ka-Boom

Uranus spins on its side!

Its rings and its moons orbit its equator, which is nearly perpendicular to the ecliptic.

But Uranus' magnetic field is tipped compared to its rotation.

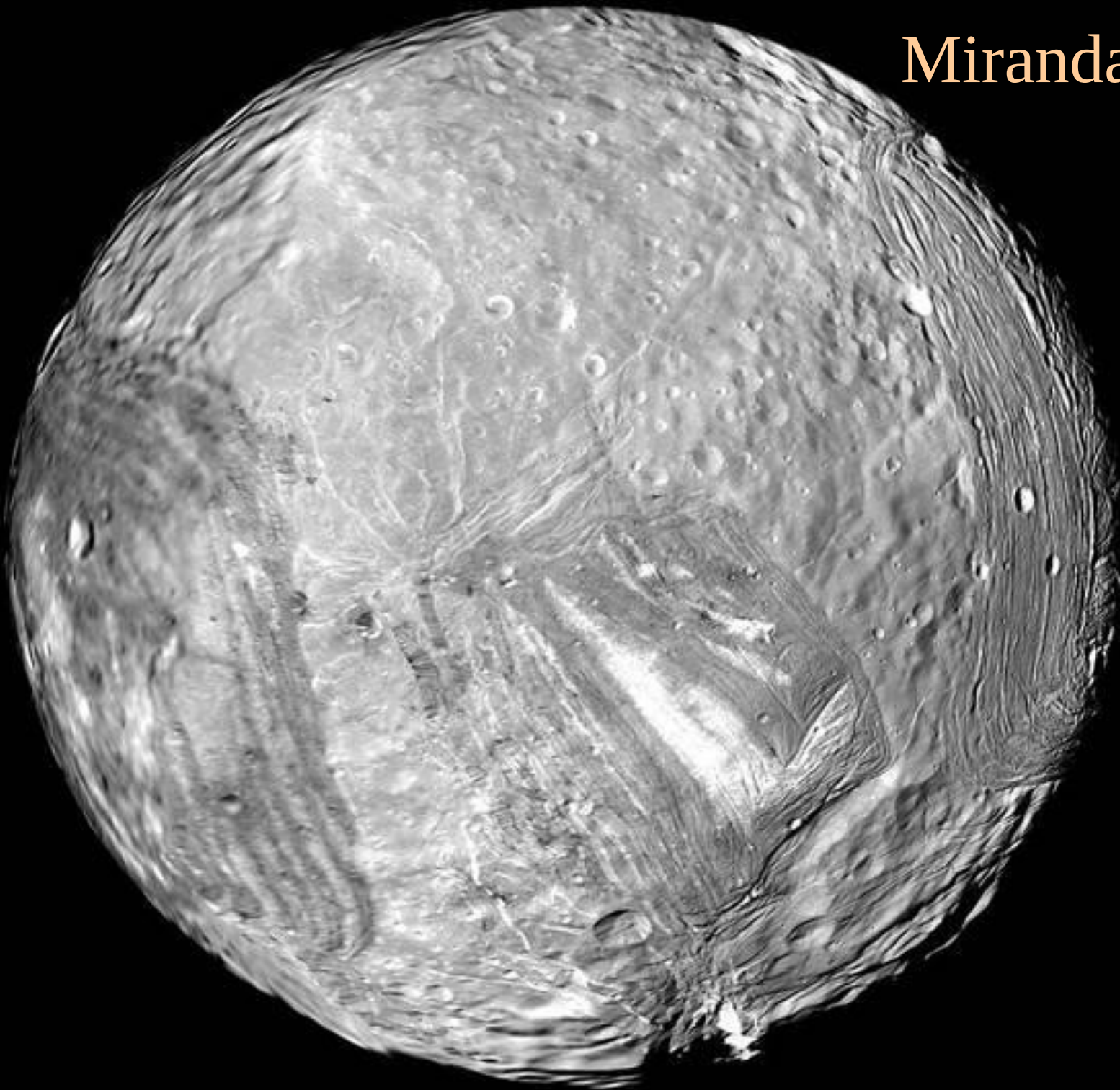
Perhaps Uranus was the victim of a huge collision in the distant past. The debris of which may have become its moons and rings.

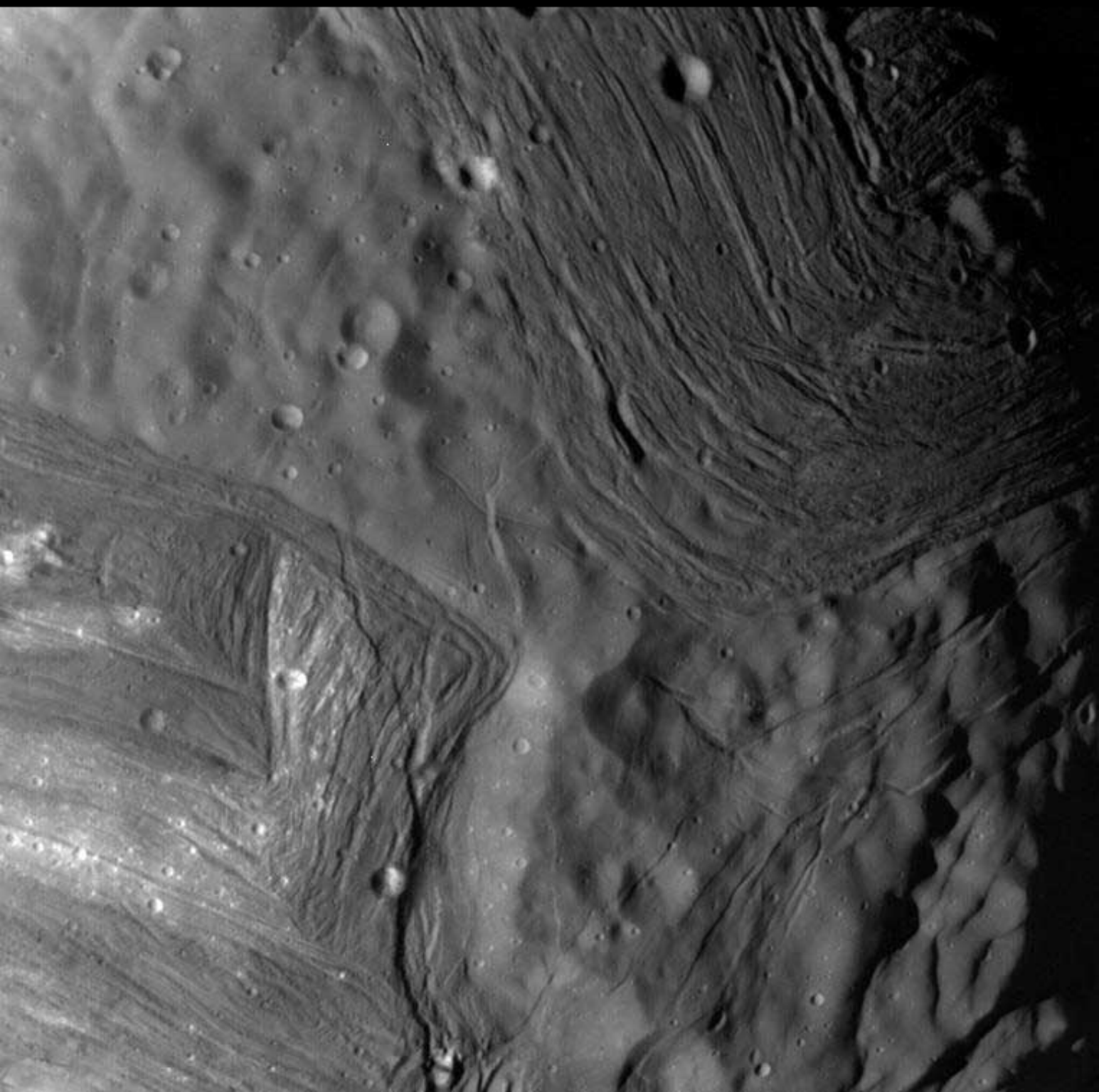
Uranus has at least 21 moons, but only 5 are of reasonable size.

All have densities of "dirty snowballs" between 1.3 and 1.6 g/cc.

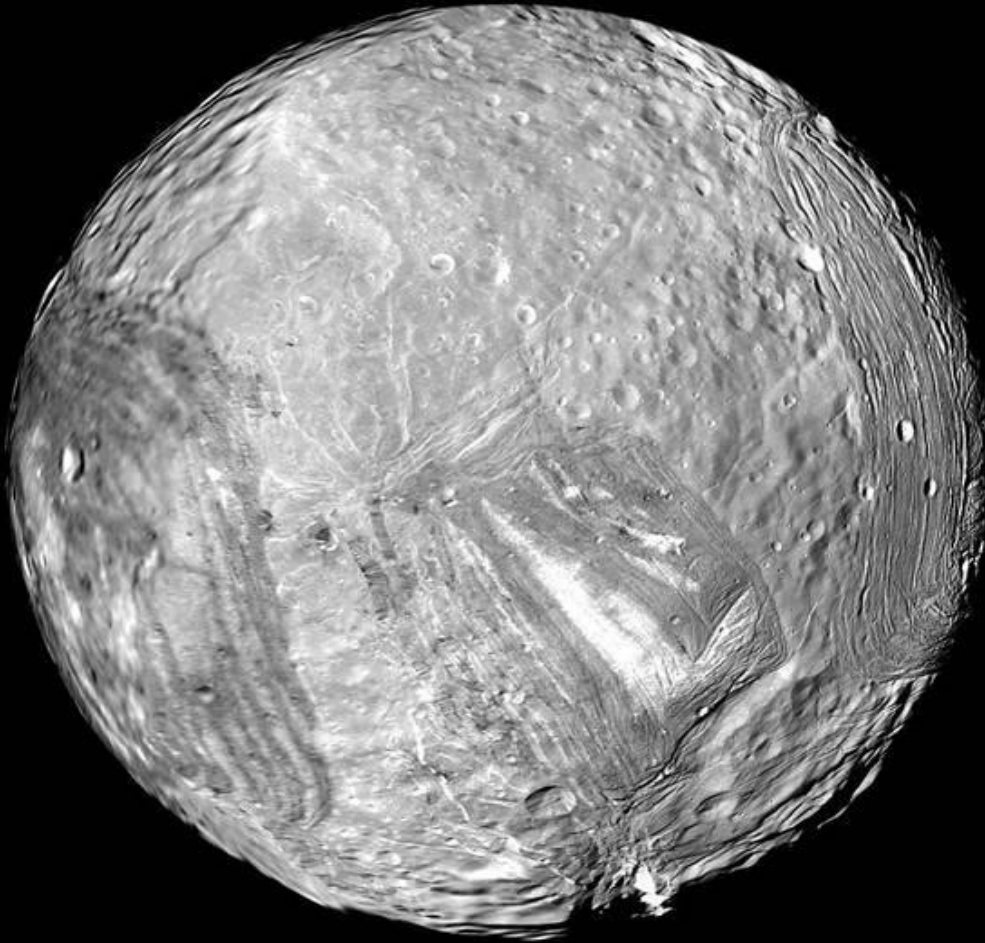


Miranda

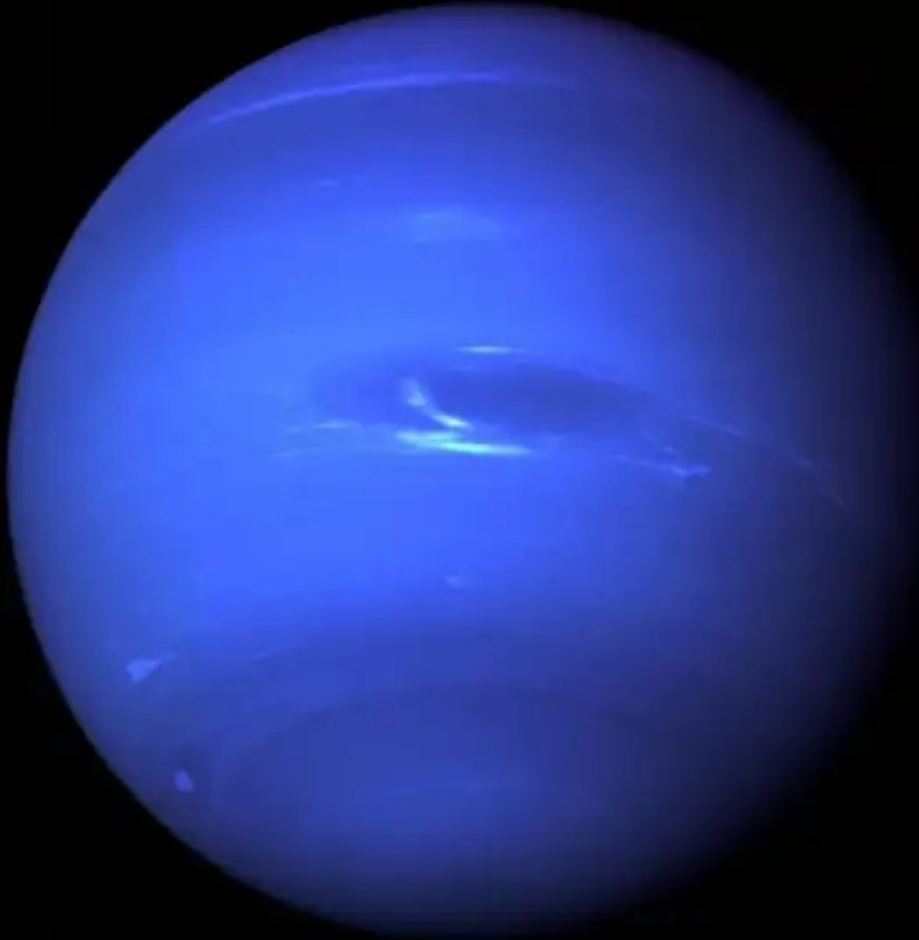




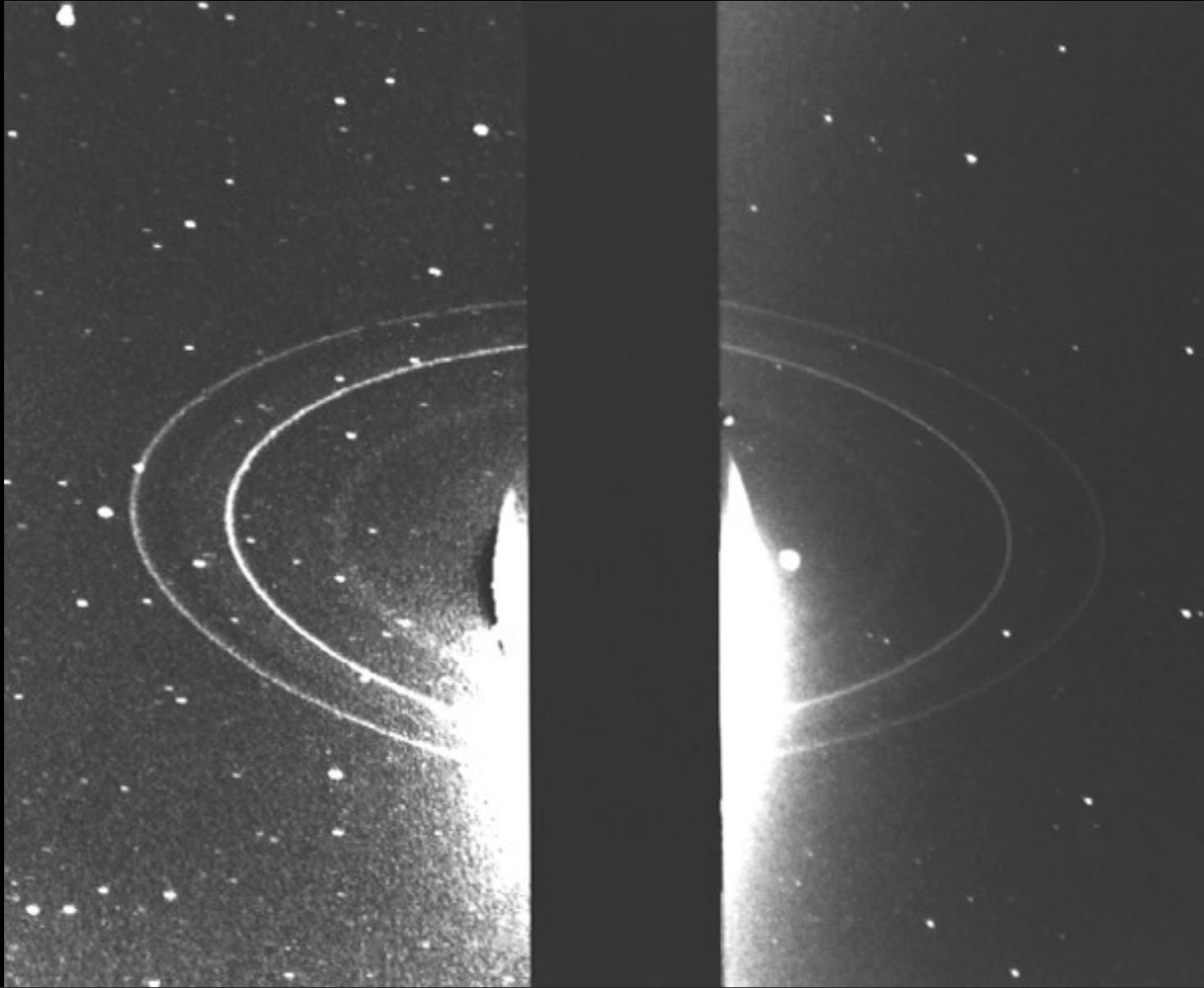
Miranda: 2 ideas: Either Miranda was hit by something just hard enough to break it up, but not disintegrate it; or it partially melted enough inside that the outsides broke up, with some bits flipping over. What do you think?



Neptune



Neptune also has rings!
The main ring is less than 50km wide!





Neptune's structure is identical to Uranus'

