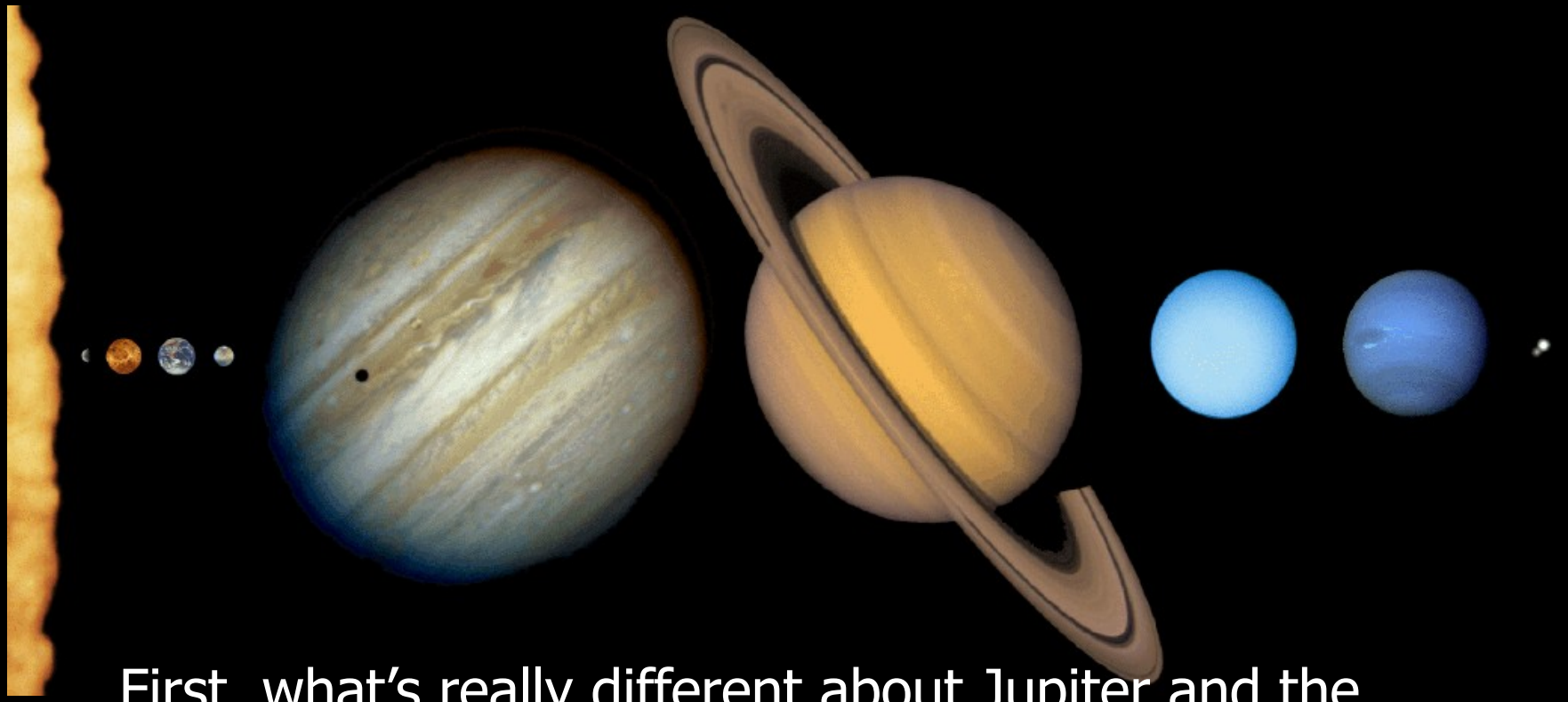
# Jupiter as a mini solar system

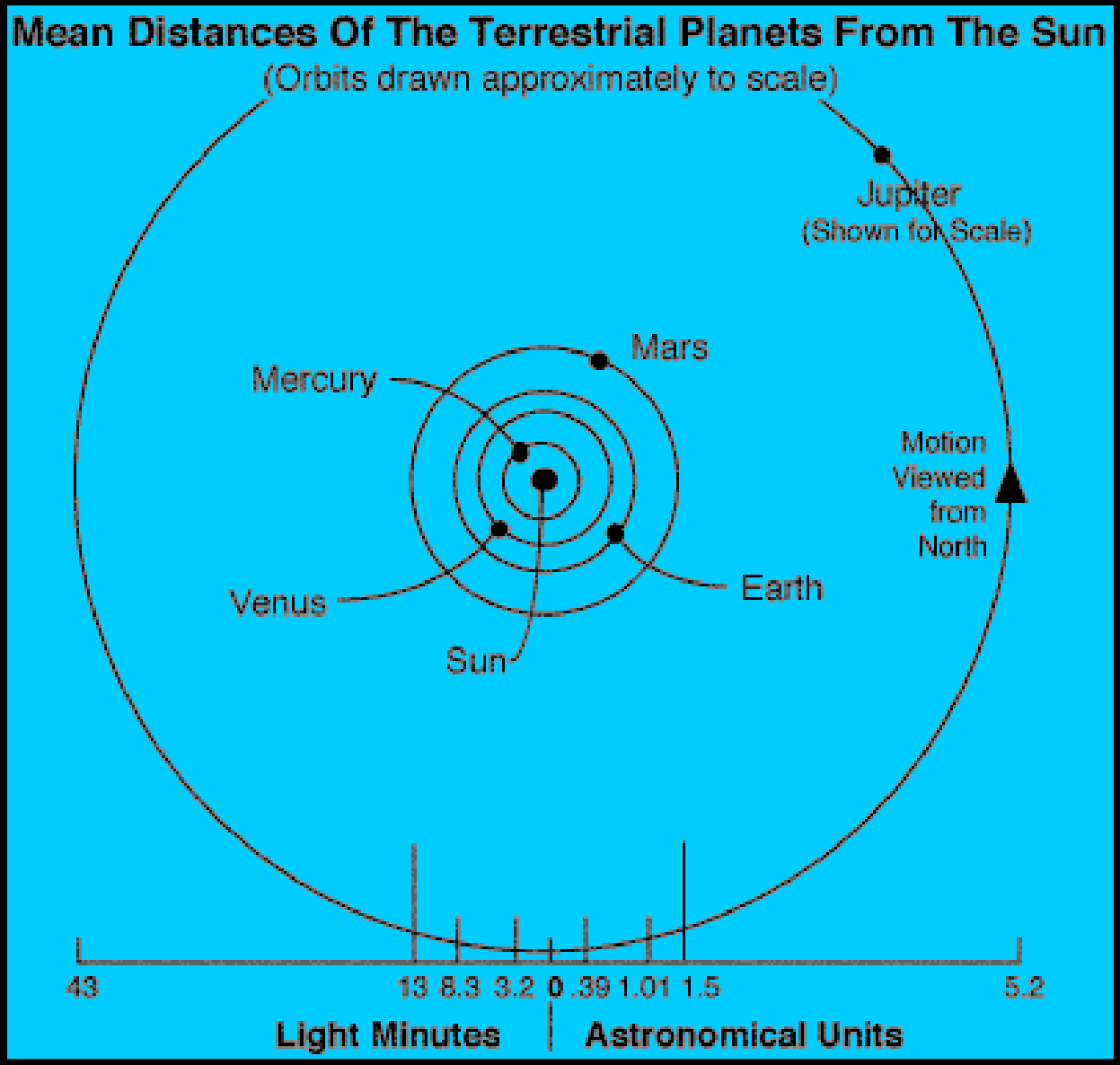
Philip Judge, High Altitude Observatory, NCAR

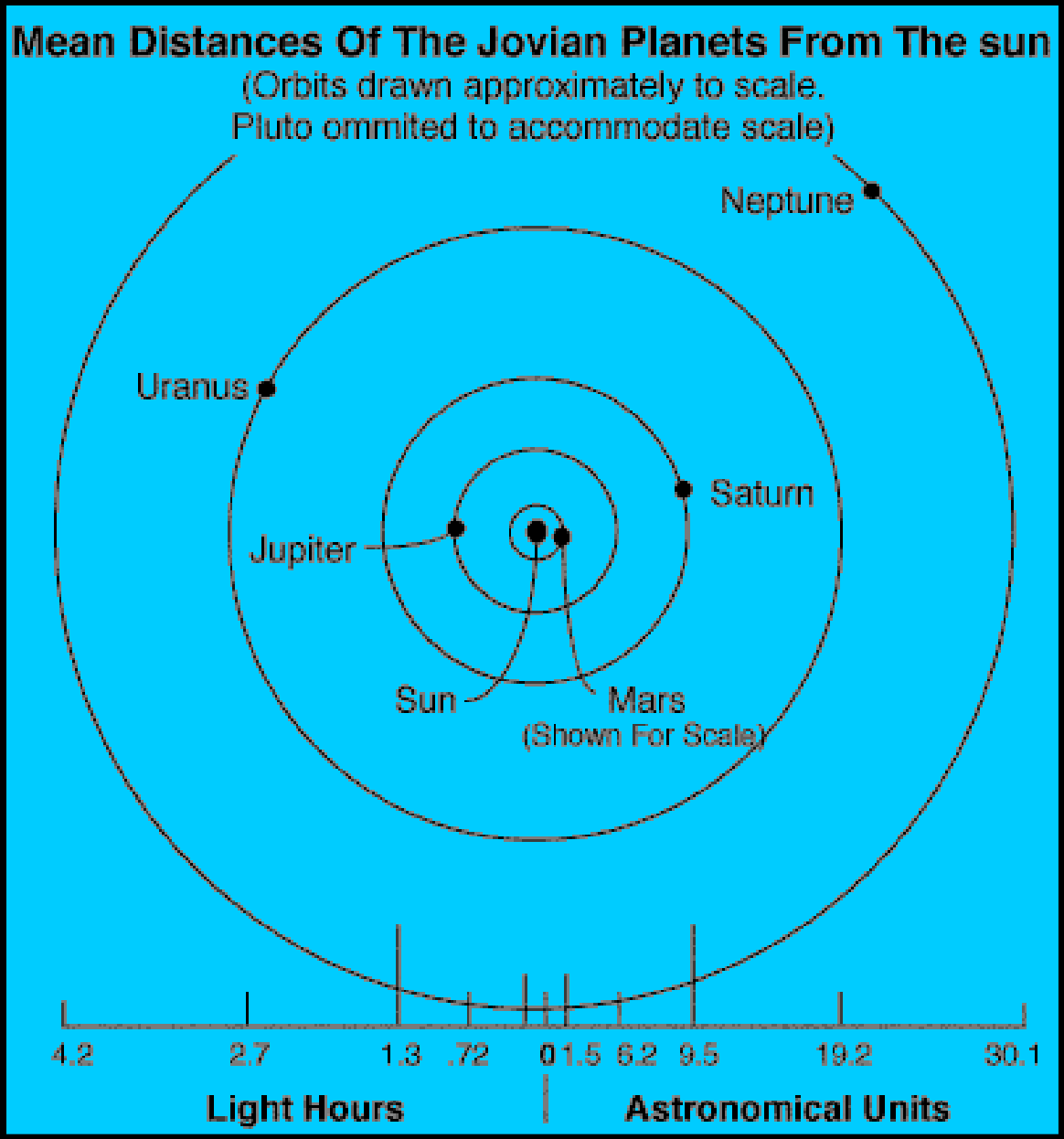


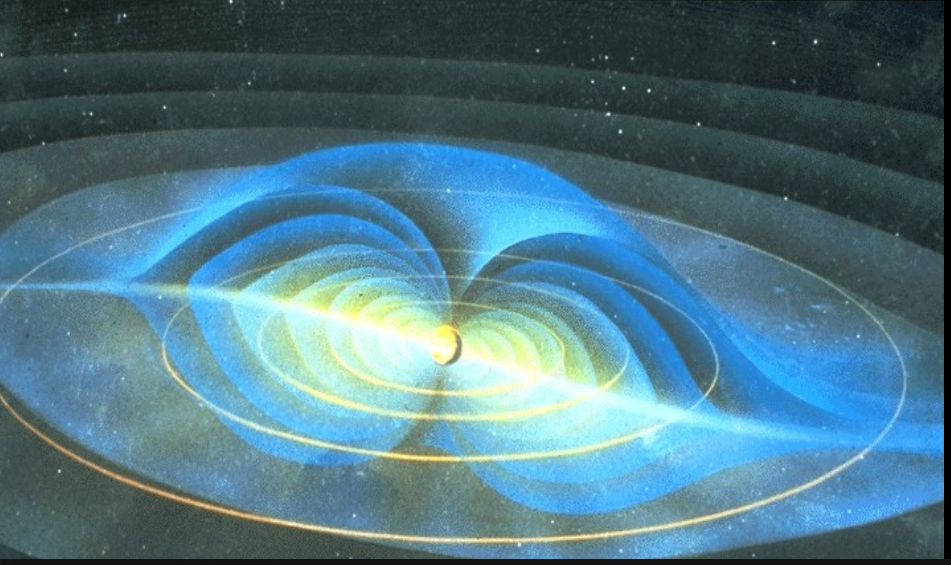
First, what's really different about Jupiter and the Sun?

Second, well talk about gravity

Next (fun part) we'll explore Jupiter!


Mean Distances Of The Terrestrial Planets From The Sun
(Orbits drawn approximately to scale)
Jupiter
(Shown for Scale)
Mars
Mercury
Motion
Viewed
from
North
Earth
Venus
Sun
43
13 8.3 3.2 0 .39 1.01 1.5
5.2
Light Minutes
Astronomical Units

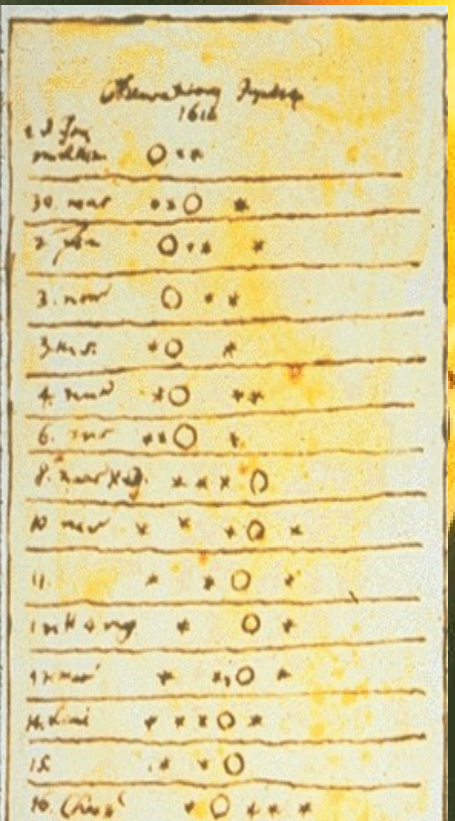

Mean Distances Of The Jovian Planets From The sun
(Orbits drawn approximately to scale.
Pluto ommited to accommodate scale)
Neptune
Uranus
Saturn
Jupiter
Sun
Mars
(Shown For Scale)
4.2
2.7
1.3
.72
0
1.5
6.2
9.5
19.2
30.1
Light Hours
Astronomical Units

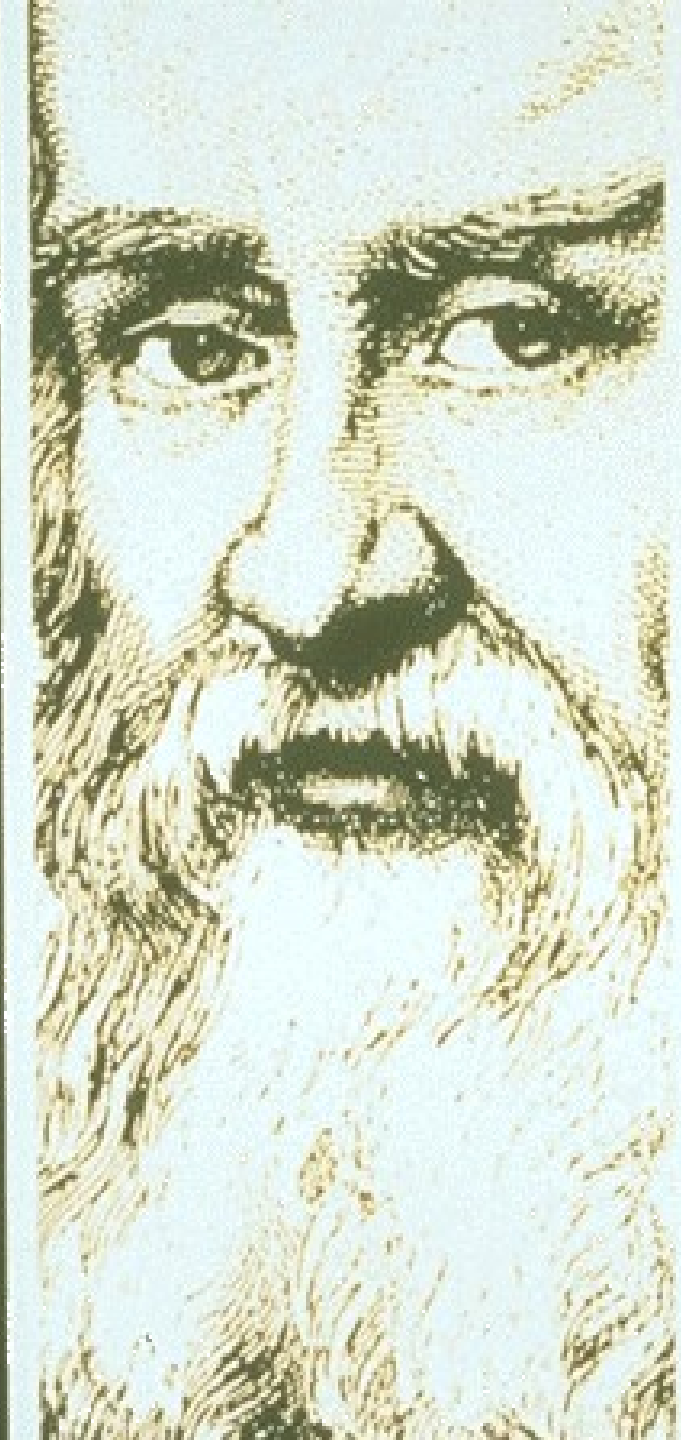


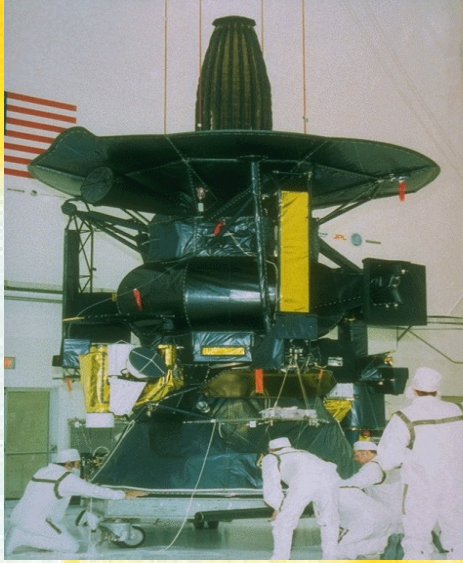
# *Voyages to Jupiter*

## *Galileo & Cassini*

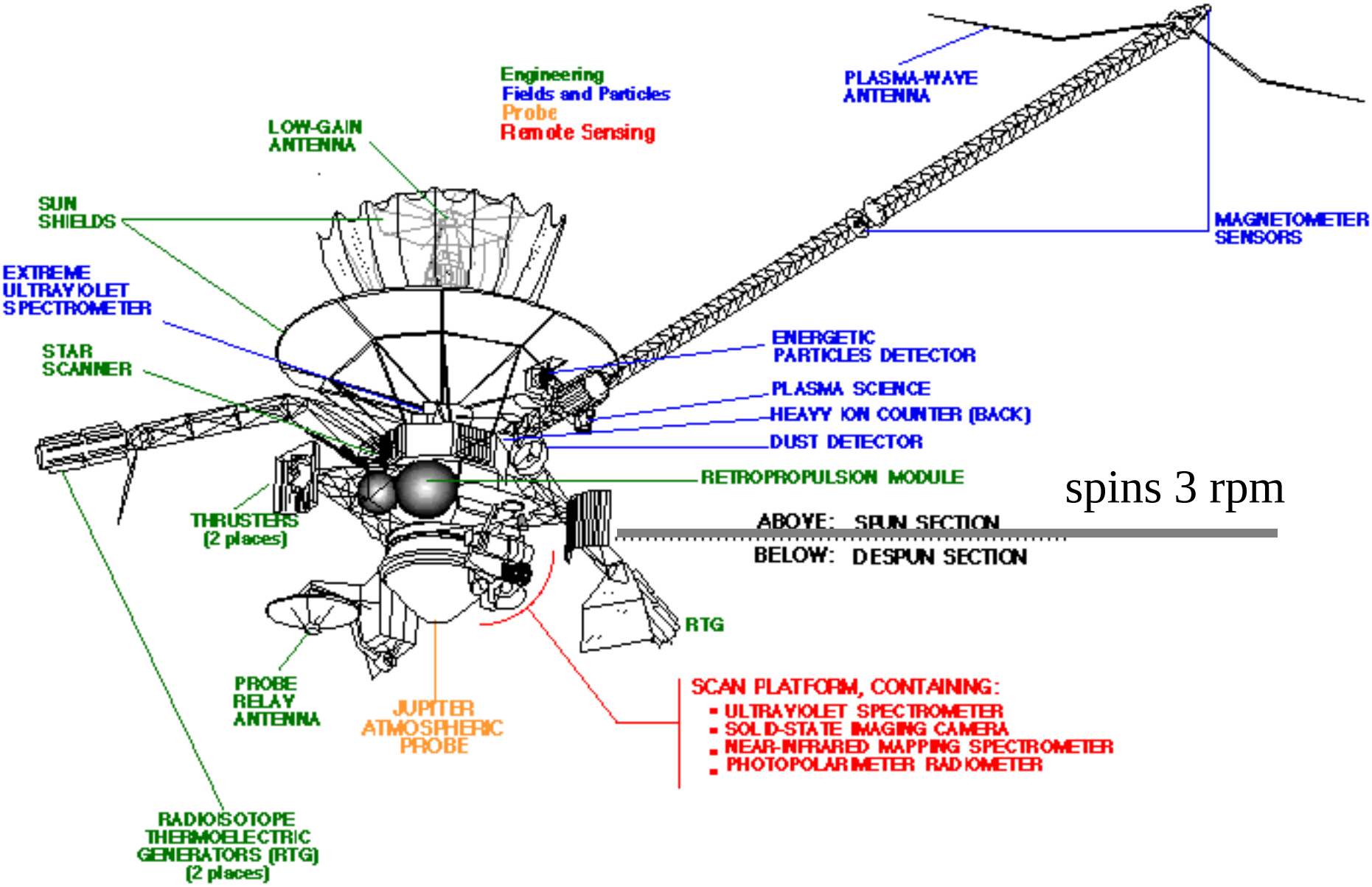
# Galileo Mission



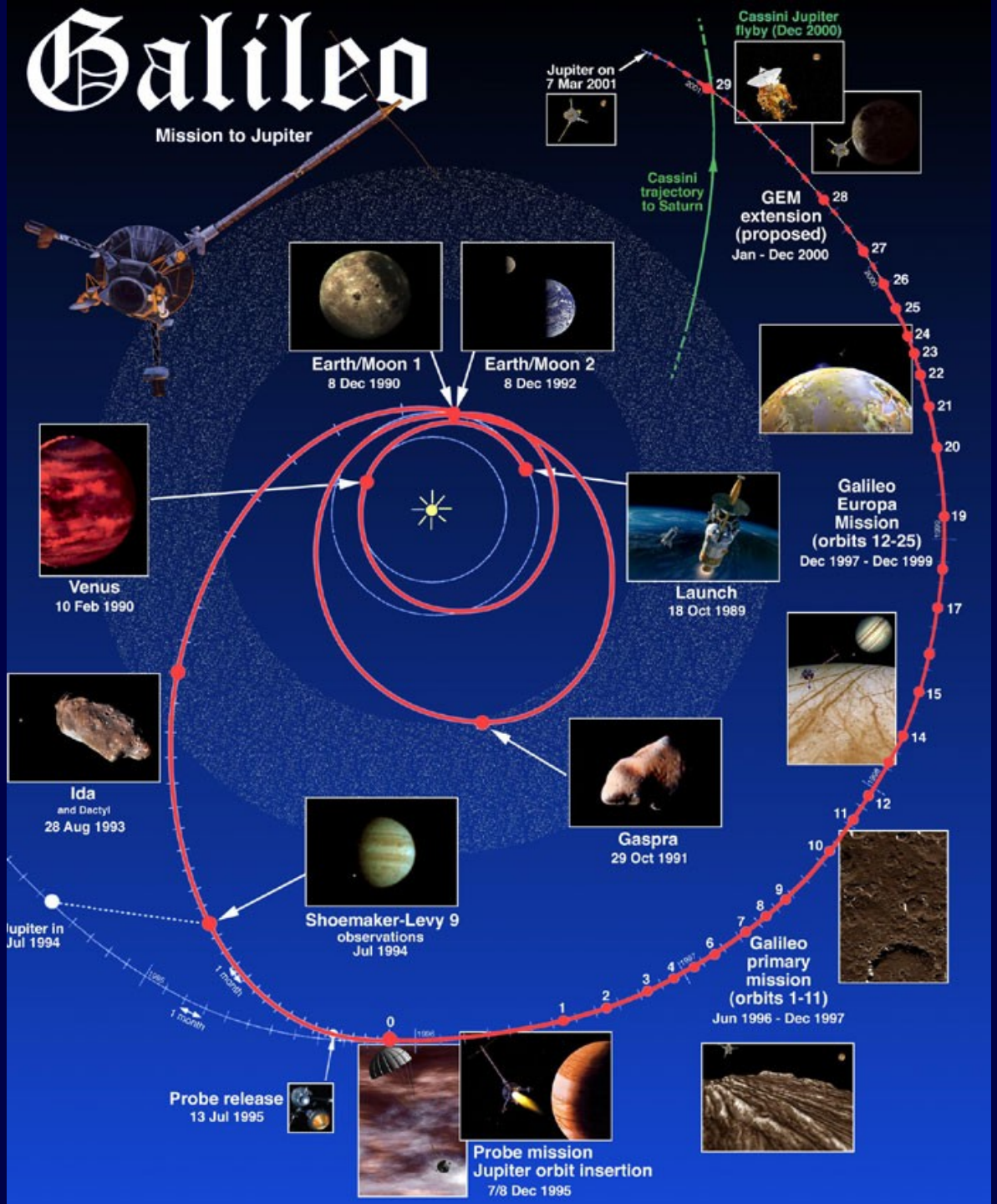



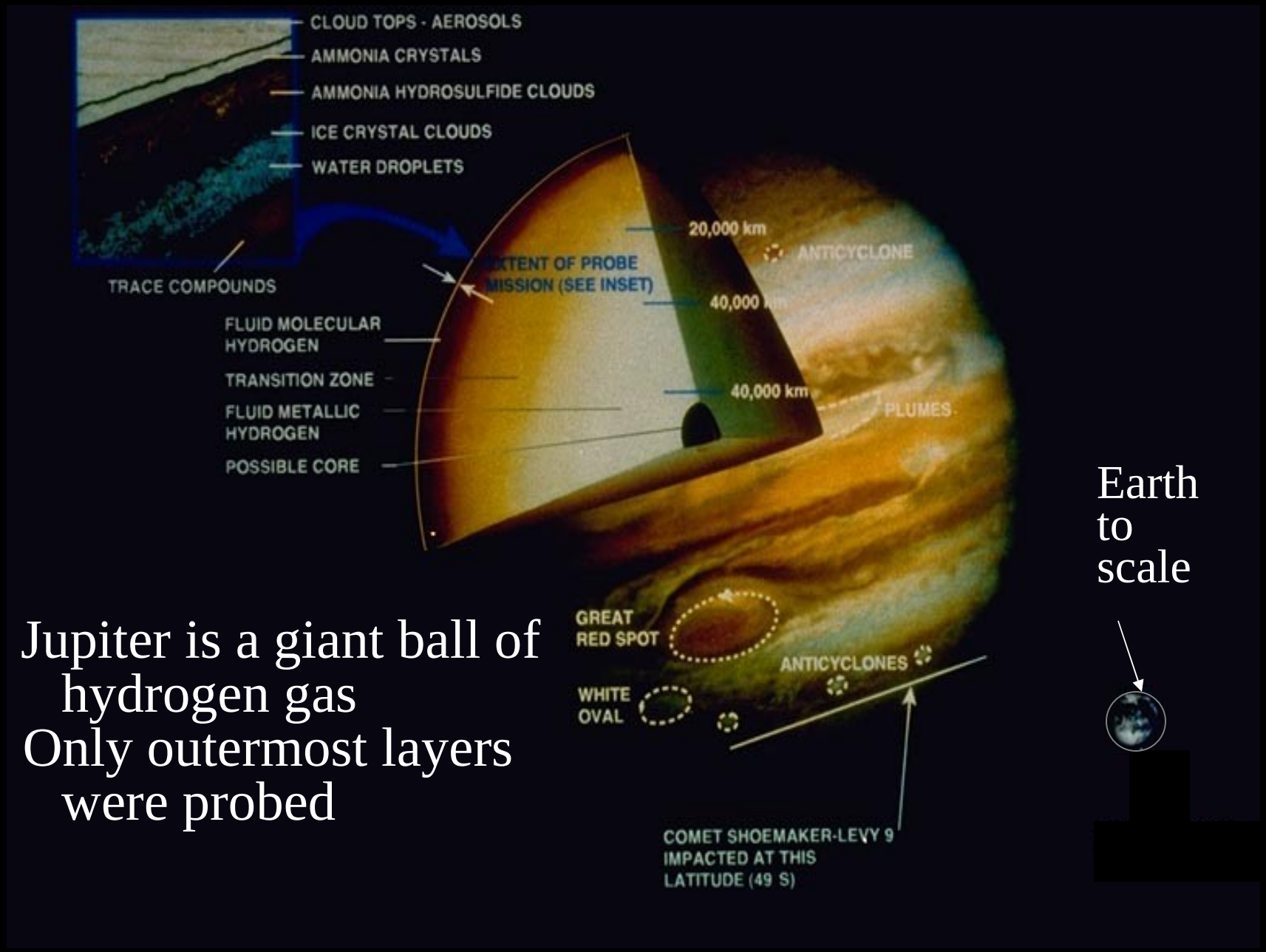


# *Galileo Spacecraft*




spins 3 rpm


Galileo
Mission to Jupiter
Cassini Jupiter flyby (Dec 2000)
Jupiter on 7 Mar 2001
Cassini trajectory to Saturn
GEM extension (proposed)
Jan - Dec 2000
Earth/Moon 1
8 Dec 1990
Earth/Moon 2
8 Dec 1992
Venus
10 Feb 1990
Launch
18 Oct 1989
Galileo Europa Mission (orbits 12-25)
Dec 1997 - Dec 1999
Ida
and Dactyl
28 Aug 1993
Gaspra
29 Oct 1991
Shoemaker-Levy 9
observations
Jul 1994
Jupiter in Jul 1994
Galileo primary mission (orbits 1-11)
Jun 1996 - Dec 1997
Probe release
13 Jul 1995
Probe mission
Jupiter orbit insertion
7/8 Dec 1995

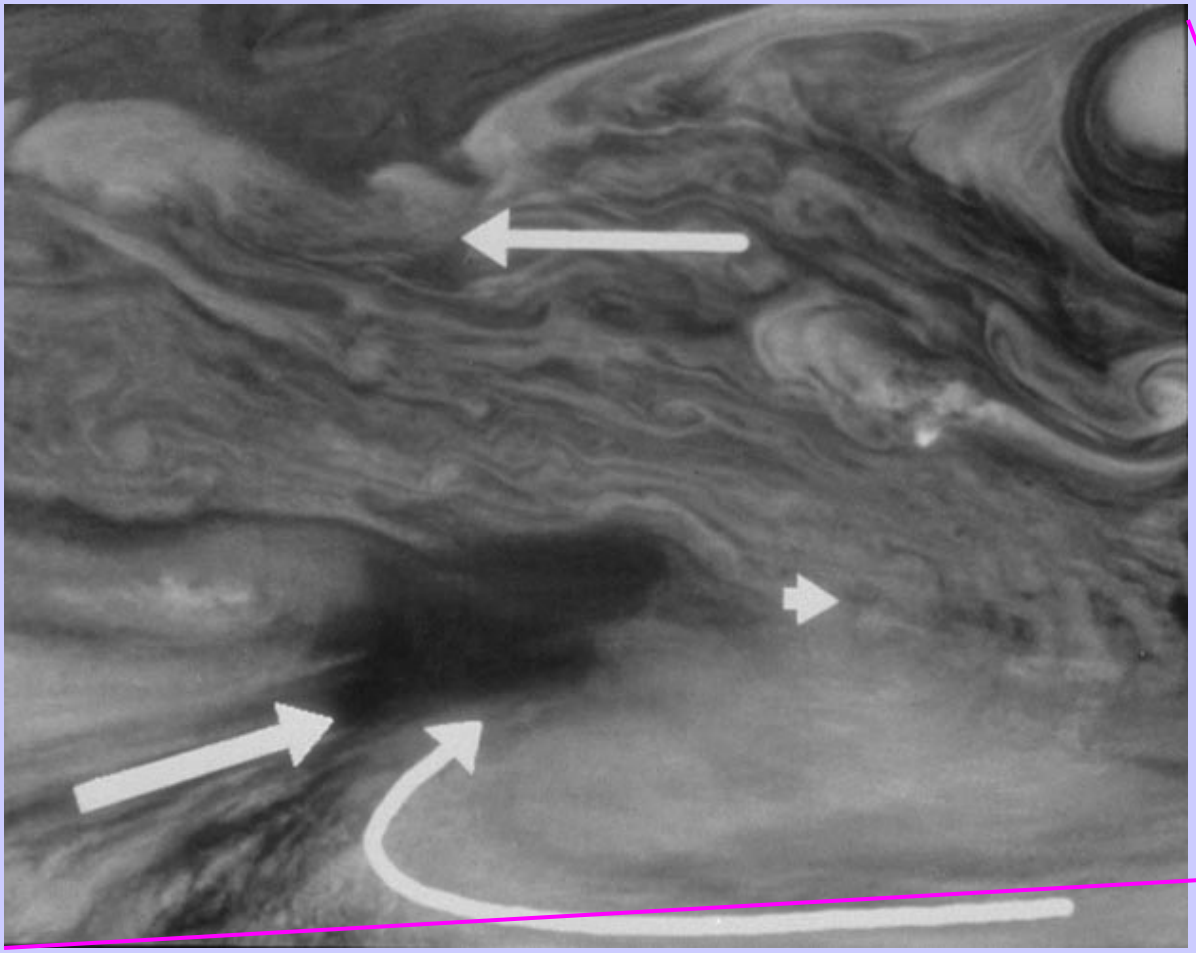


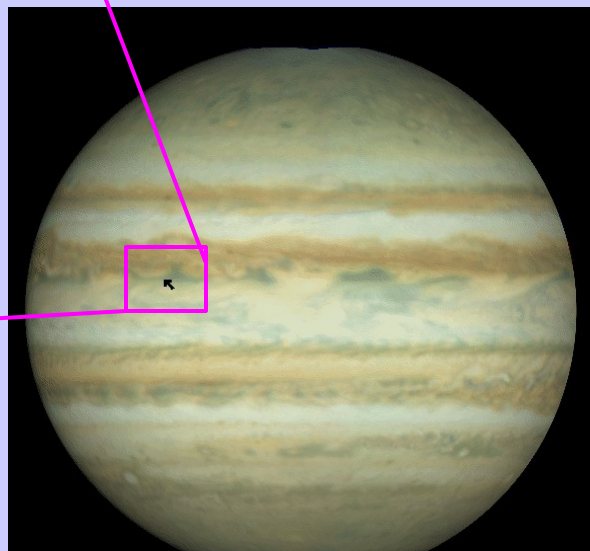

Jupiter is a giant ball of hydrogen gas

Only outermost layers were probed

Earth to scale

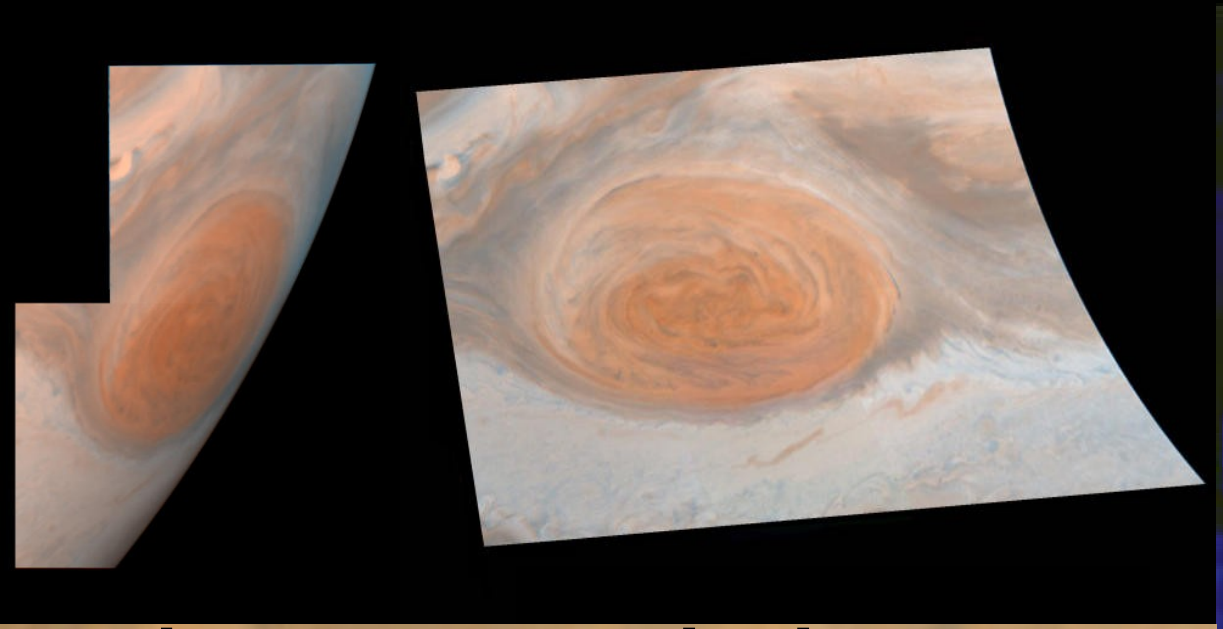
# *Probe Entered Downdraft Region Between Clouds*

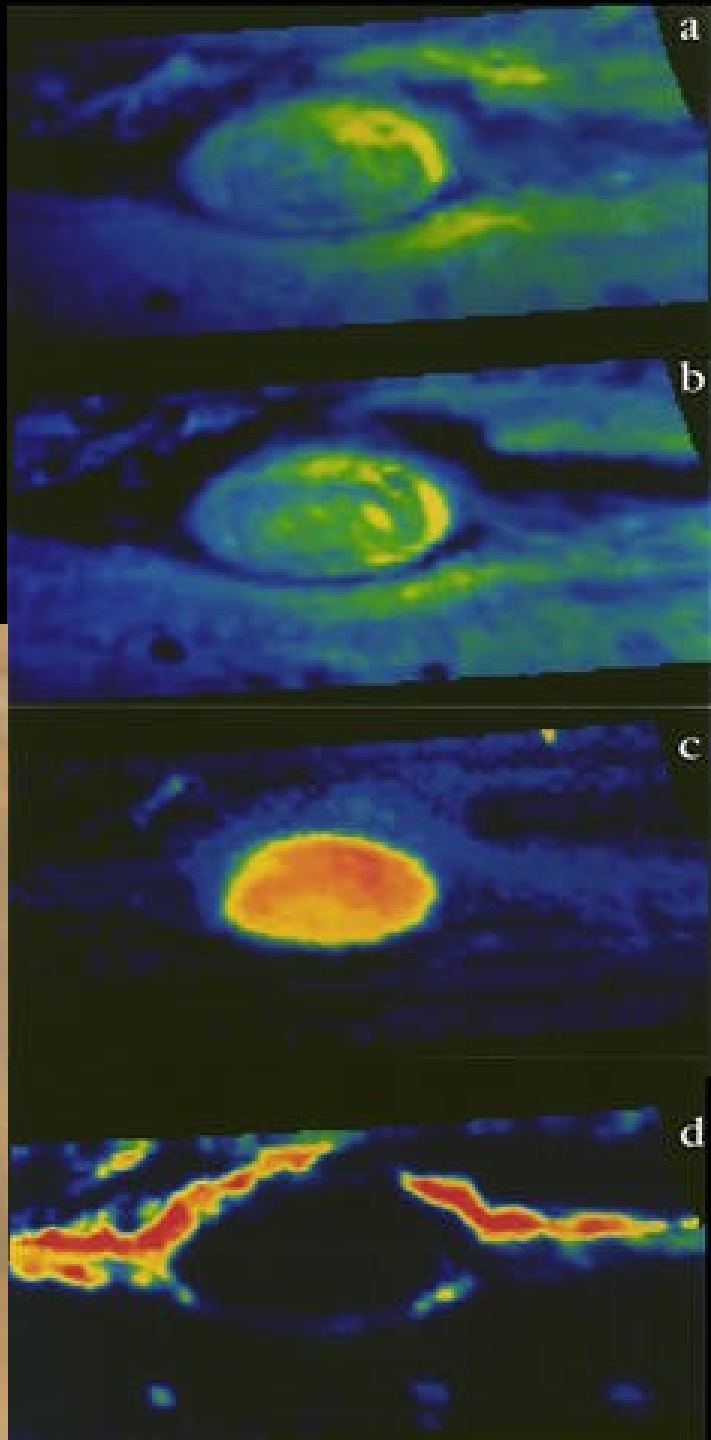




# Probe Results

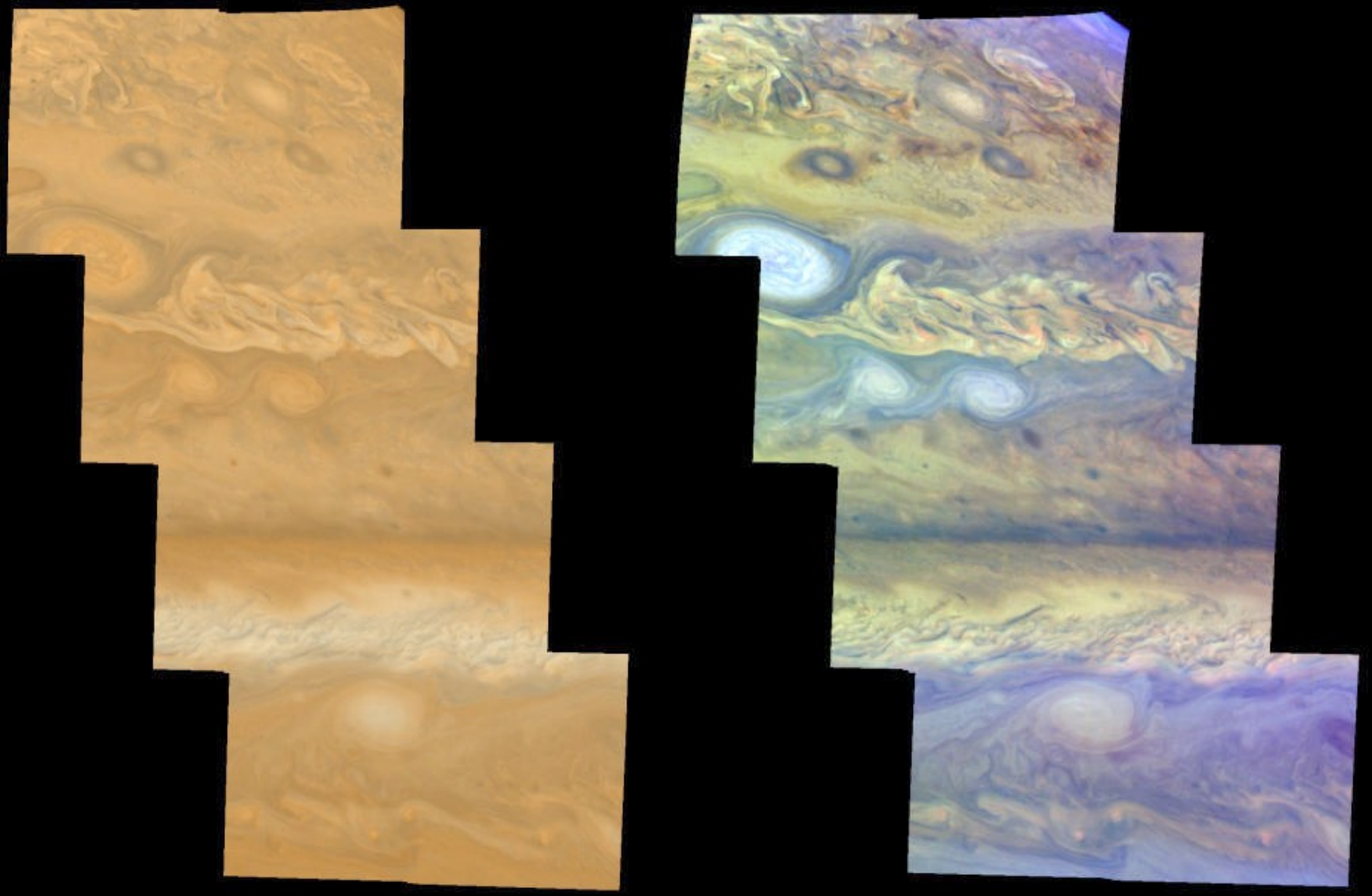
- Probe measured temperature, pressure, wind speed and chemical composition as it descended ~ 100km.
- Probe detected
  - Only tenuous clouds
  - Very dry air
  - Strong winds >600 km/hr
- Chemical composition consistent with solar abundance + cometary material





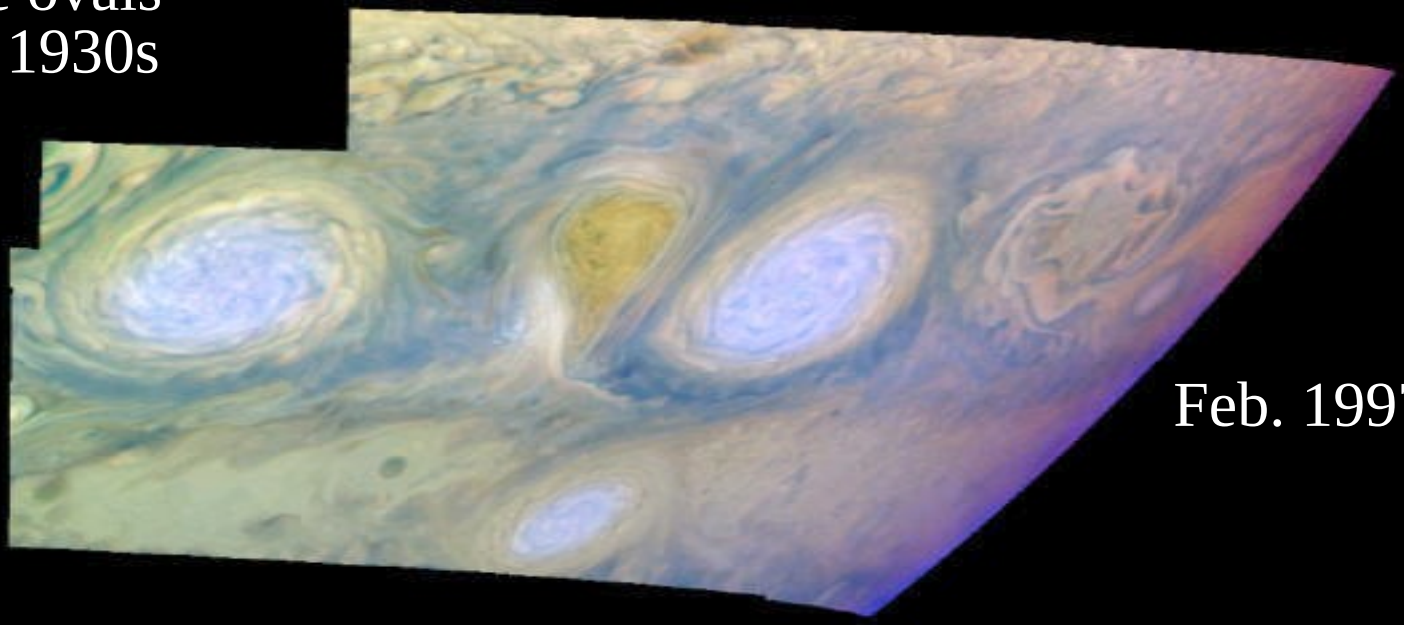

- White = ammonia clouds
- Orange = sulfur-colored ammonia
- Small scale turbulence generated by wind shears coalesce to form large scale vortices.
- Storms such as the Great Red Spot and white ovals last for decades to centuries.

# *Wind Shear and Eddies*



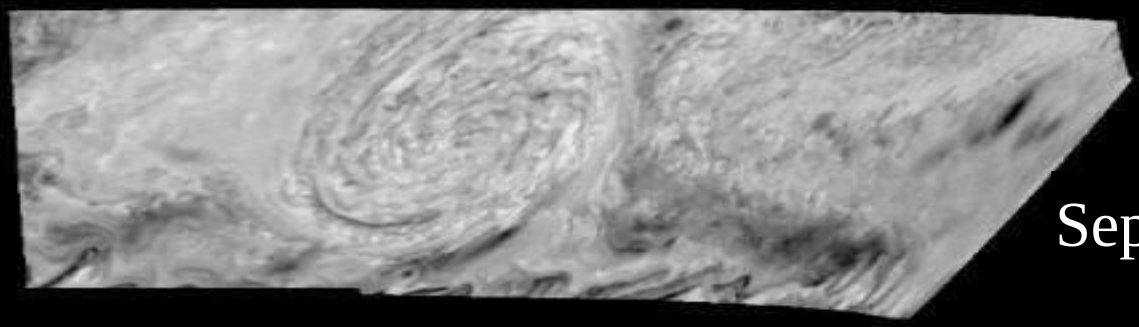
# *Eddies Merging*

Two white ovals
formed in 1930s



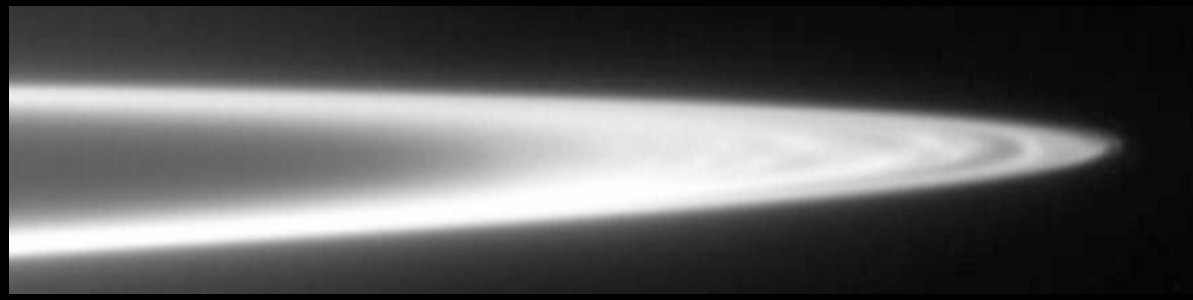
Feb. 1997

Two Merged to
one oval
60+ years later



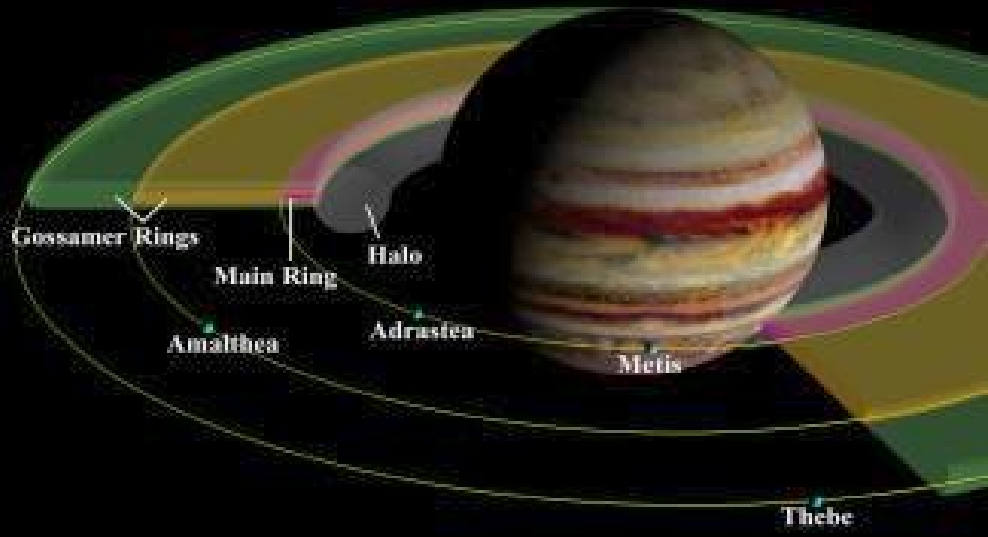
Sep. 1998

# *Jupiter's Ring*

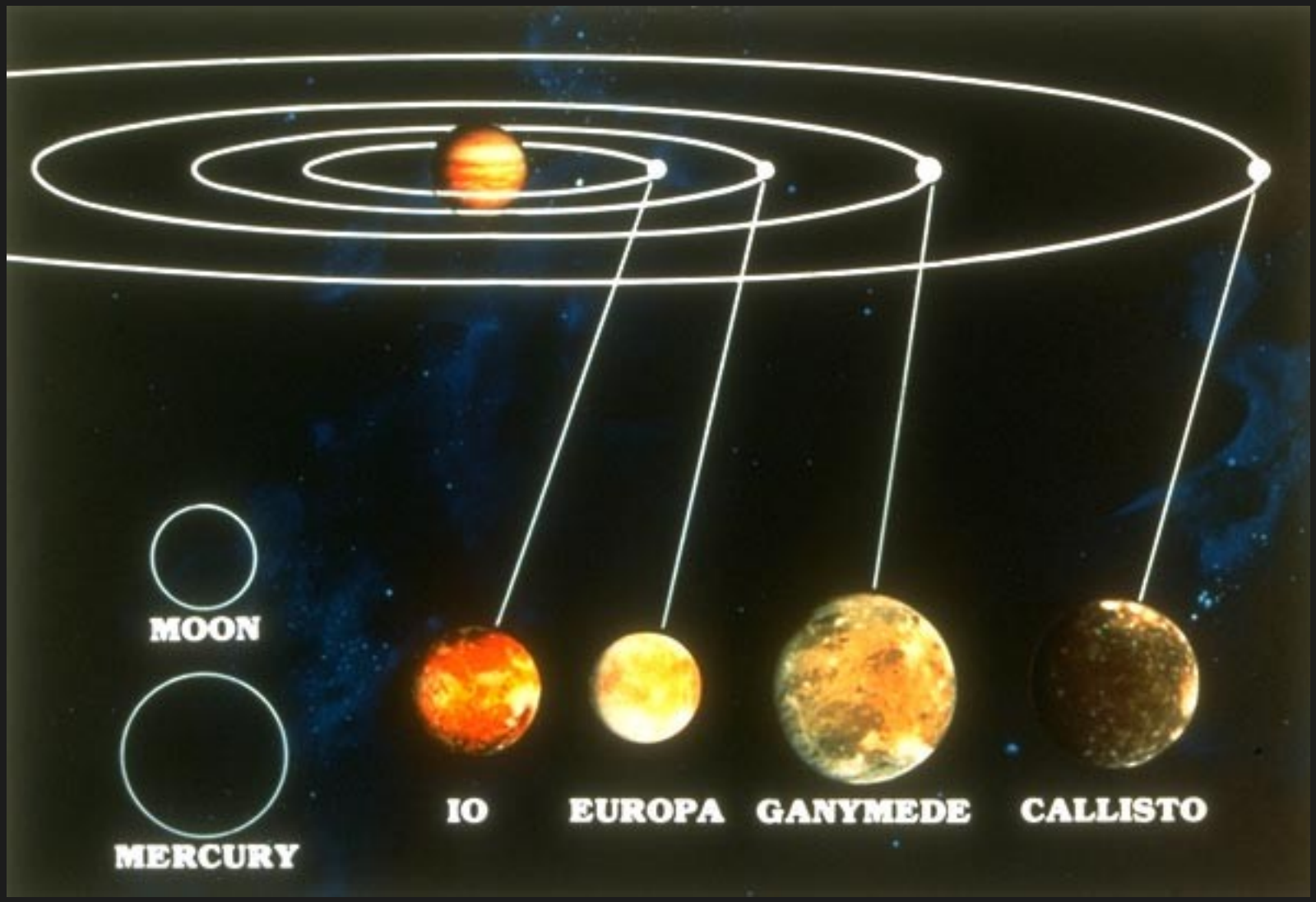


- Faint, tenuous rings of small particles chipped off small inner moons.

- Orbits shaped by satellites, evolve rapidly.

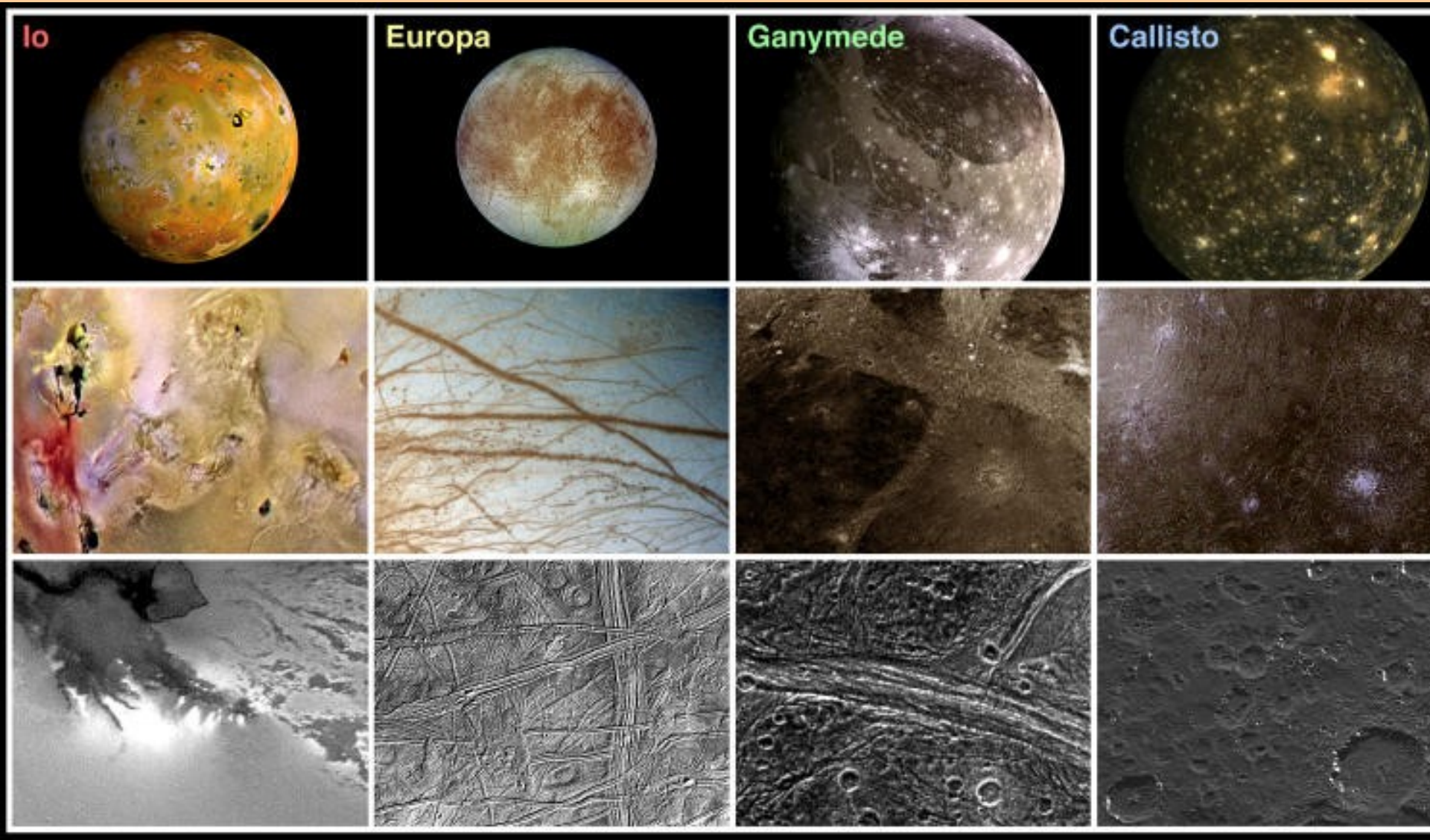


# *The Galilean Satellites*

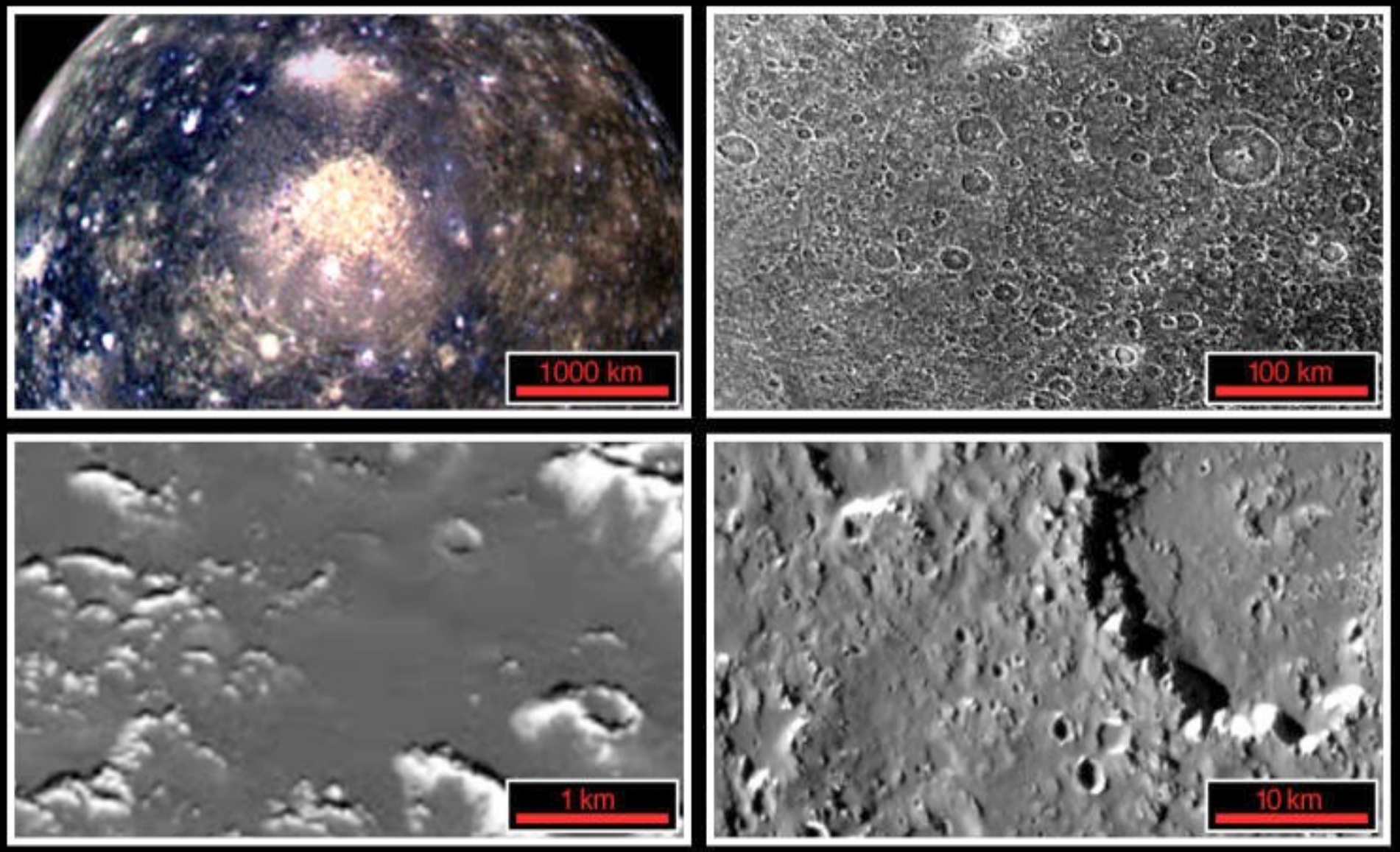



Ganymede
5262 km
Titan
5150 km
Mercury
4880 km
Callisto
4806 km
Io
3642 km
Moon
3476 km
Europa
3138 km
Triton
2706 km
Pluto
2300 km
Titania
1580 km
The Largest Moons and Smallest Planets
© Copyrgiht 1999 by Calvin J. Hamilton

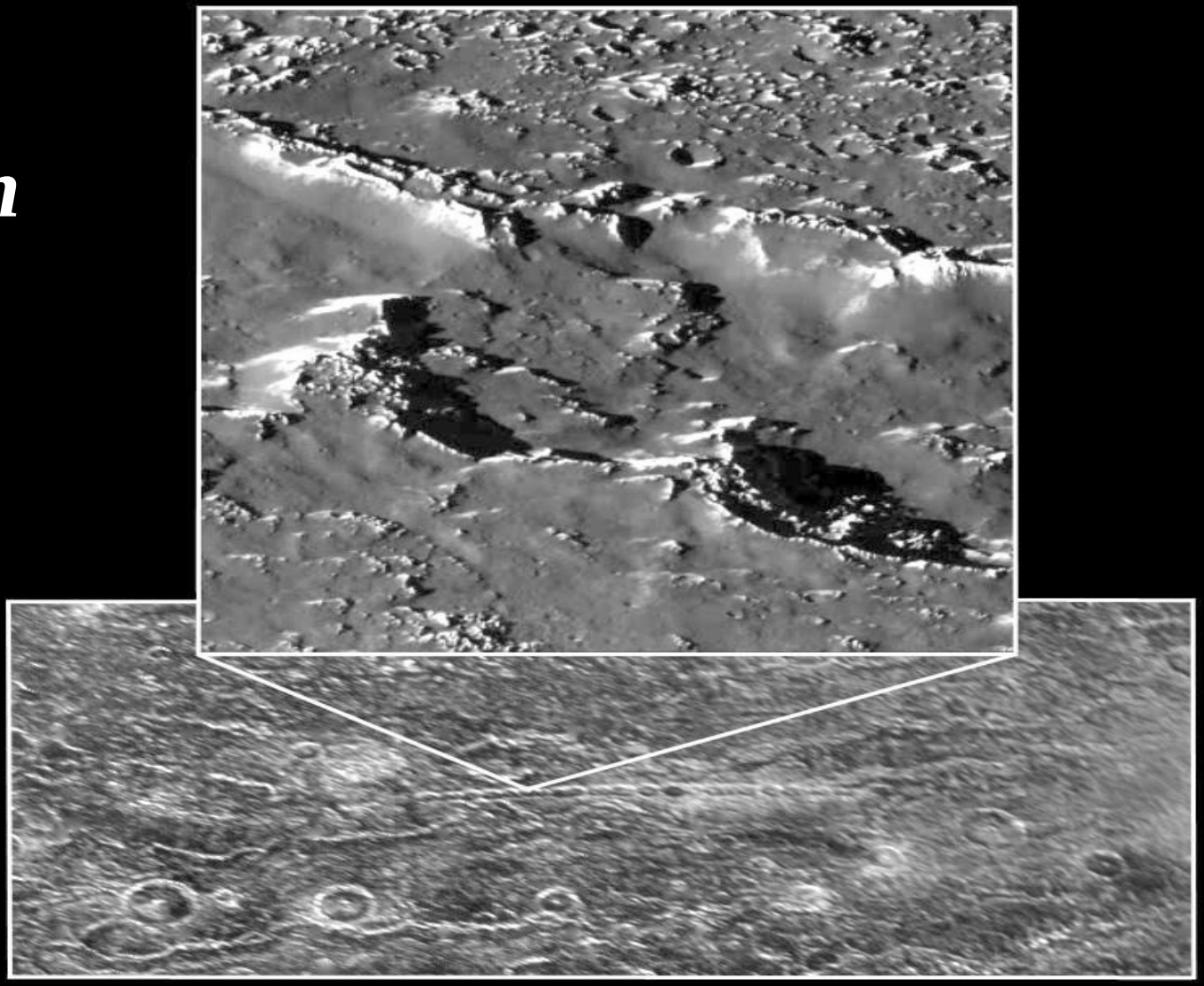
# Galilean Satellite Geology



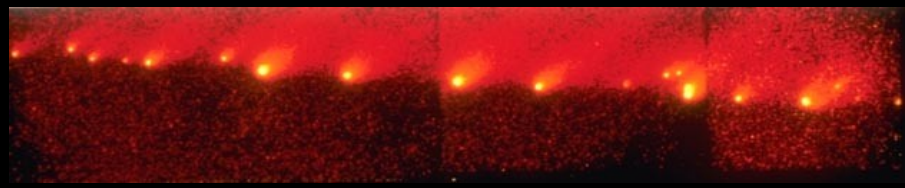
# *Zooming in on Callisto's Craters*



# *Chain of craters on Callisto*



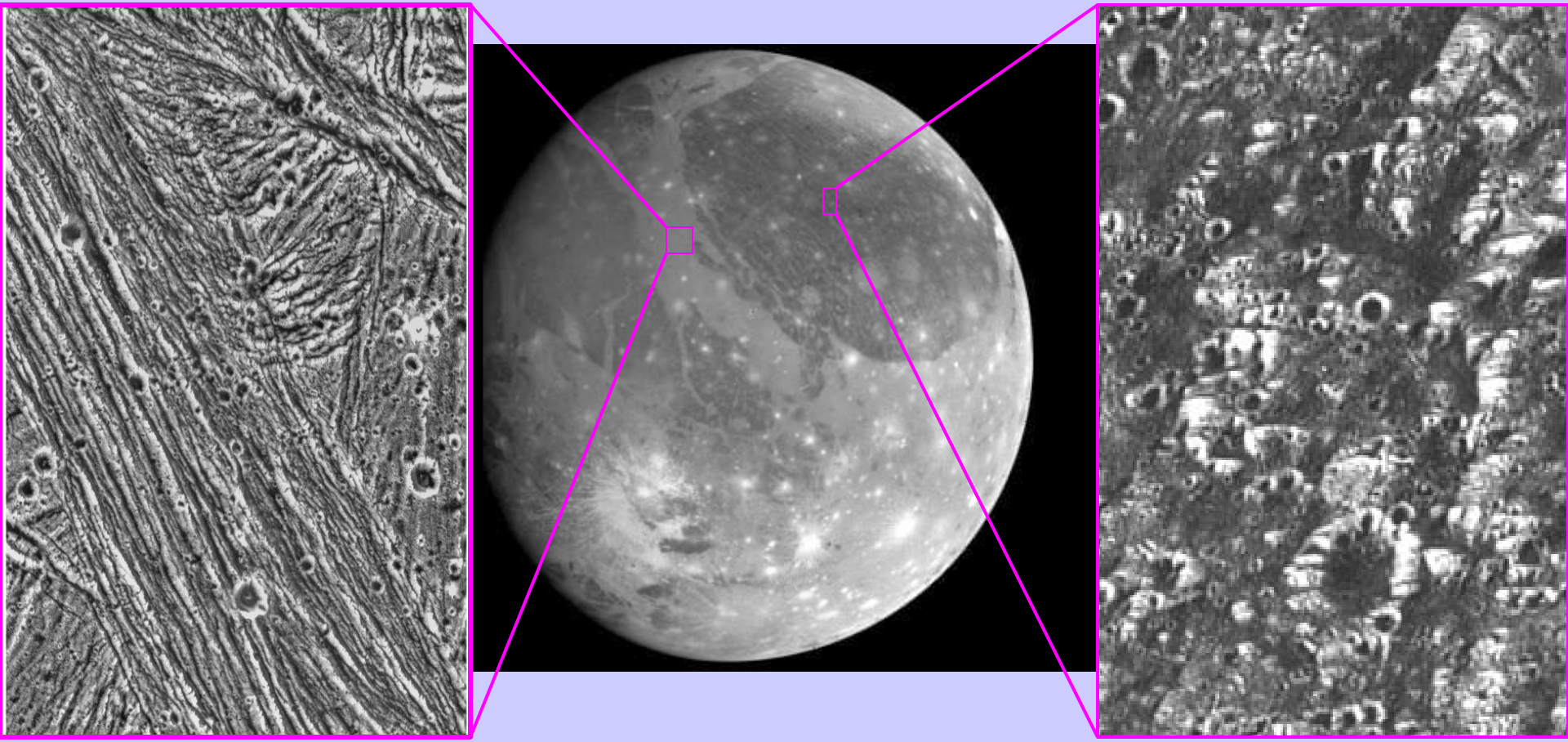
Caused by broken up comets
- such as Comet Shoemaker-Levy 9



# *Ganymede's Varied Geology*

Bright Terrain

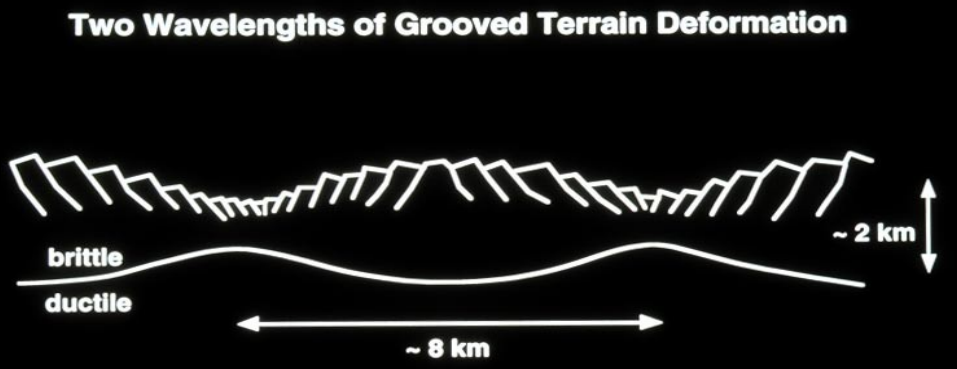
Dark Terrain

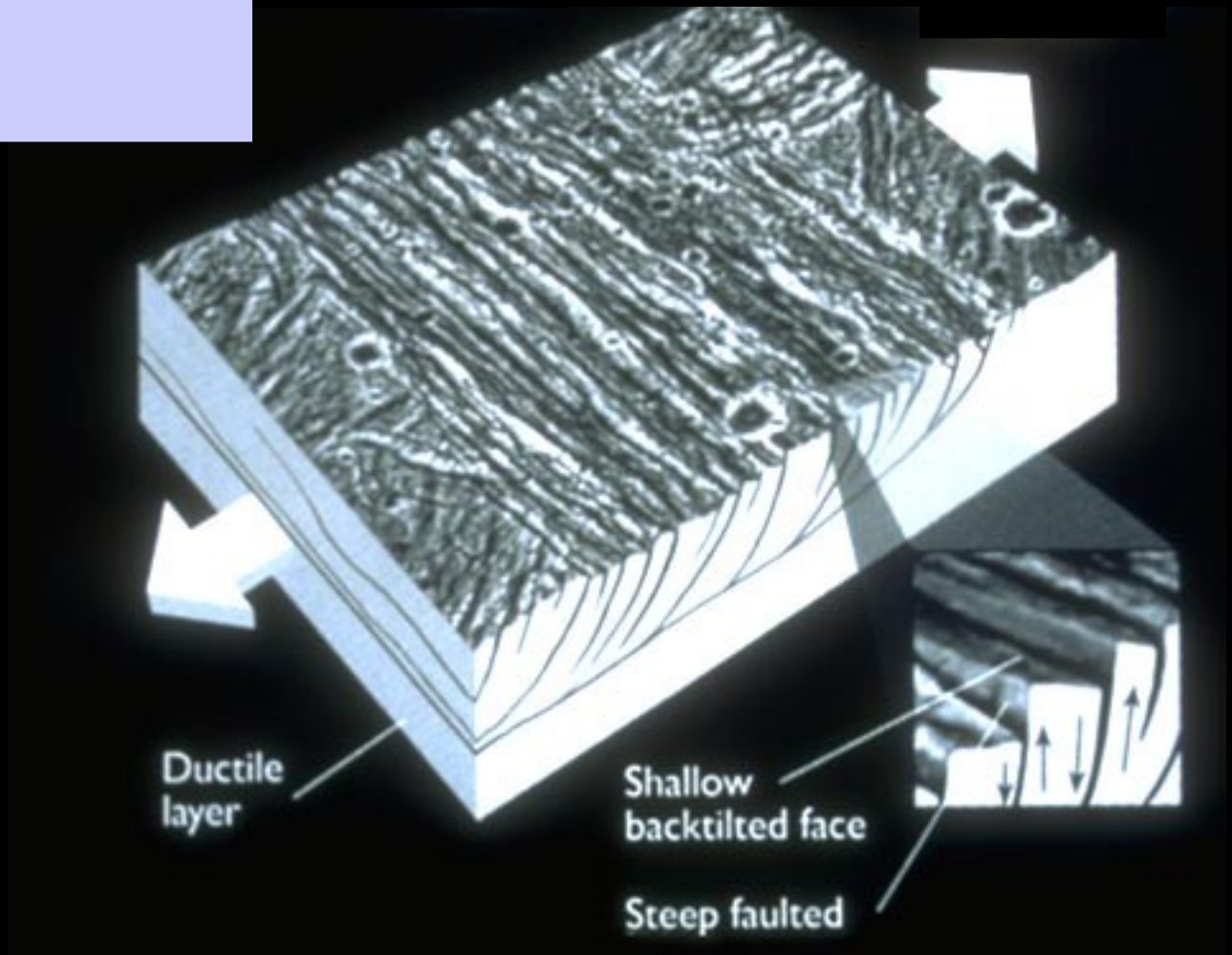


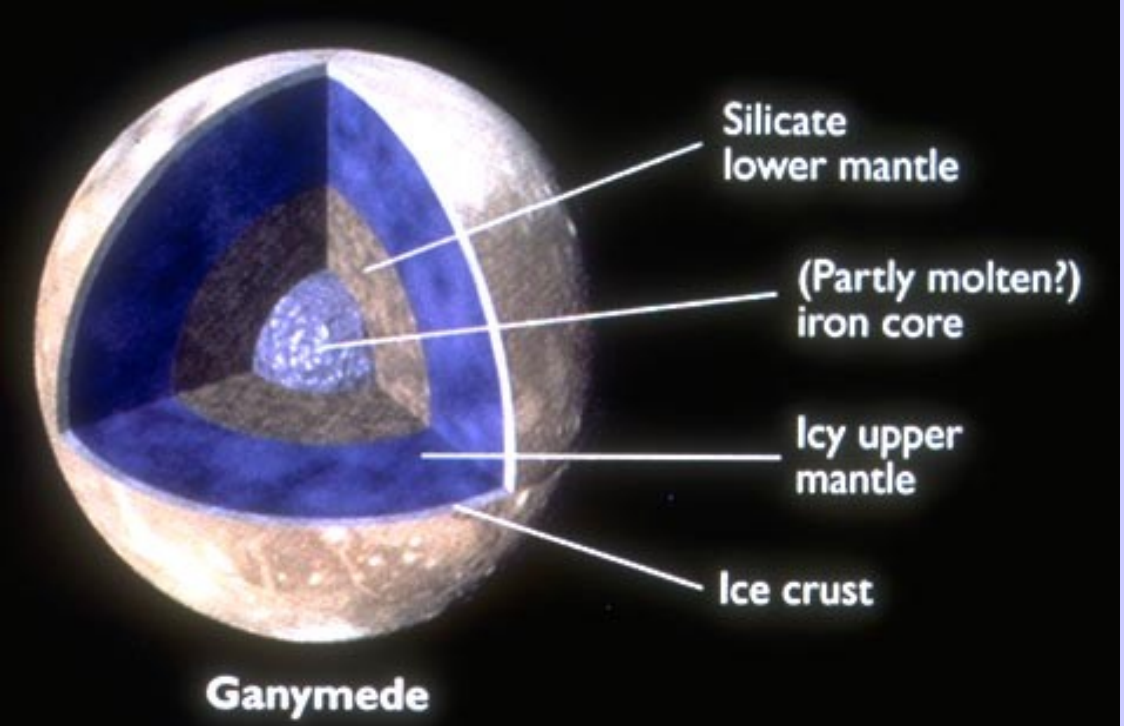
Fewer craters
Younger
Grooved & folded

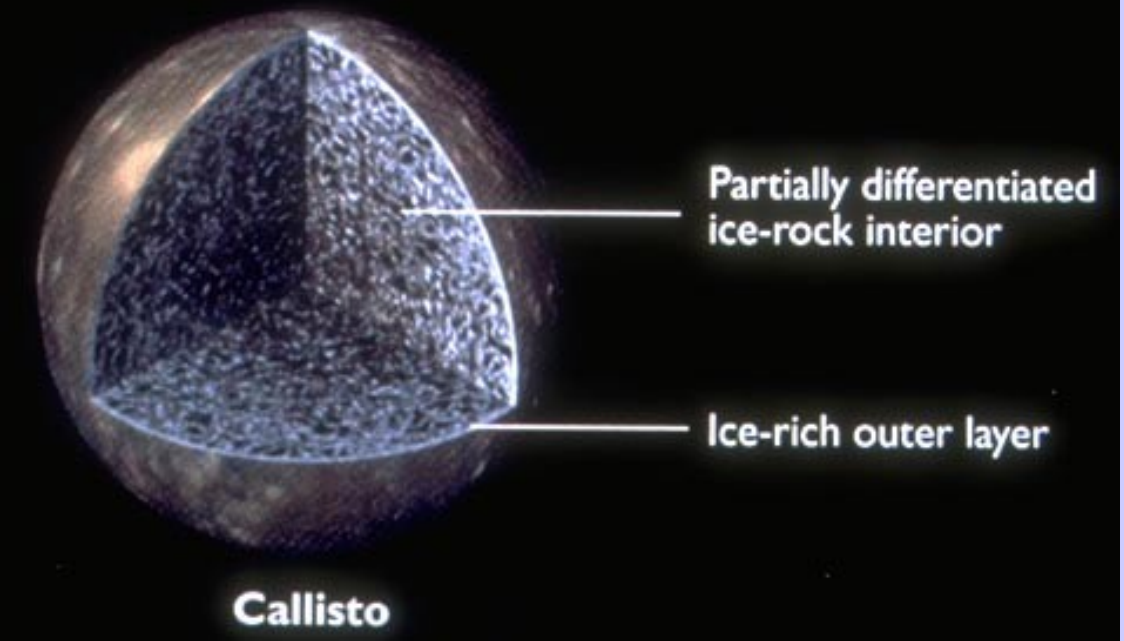
Many craters
Older

# *Grooves caused by expansion of Ganymede's crust*





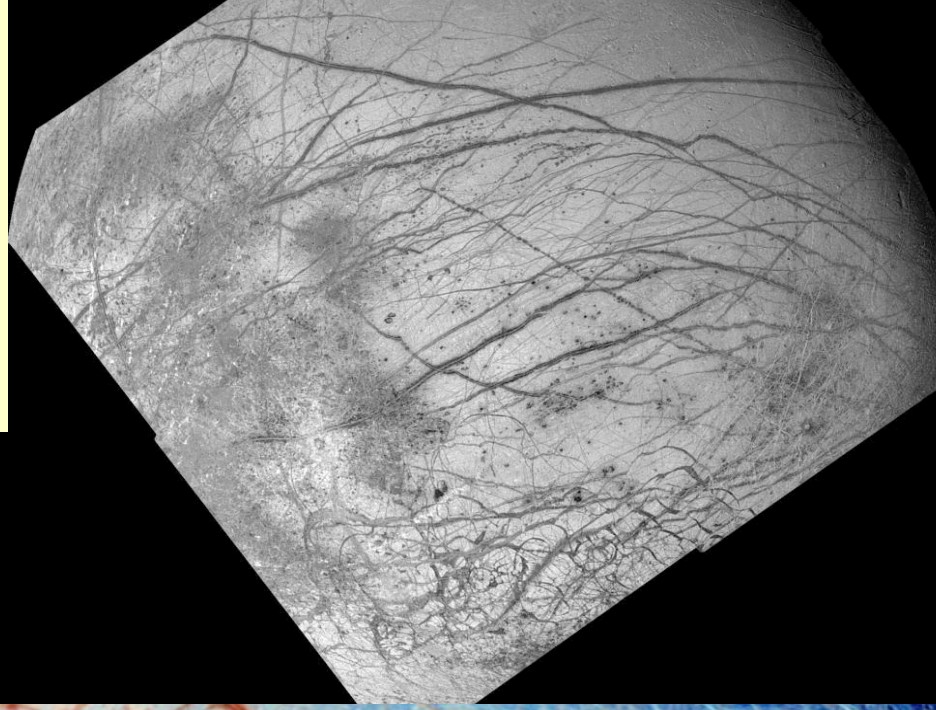



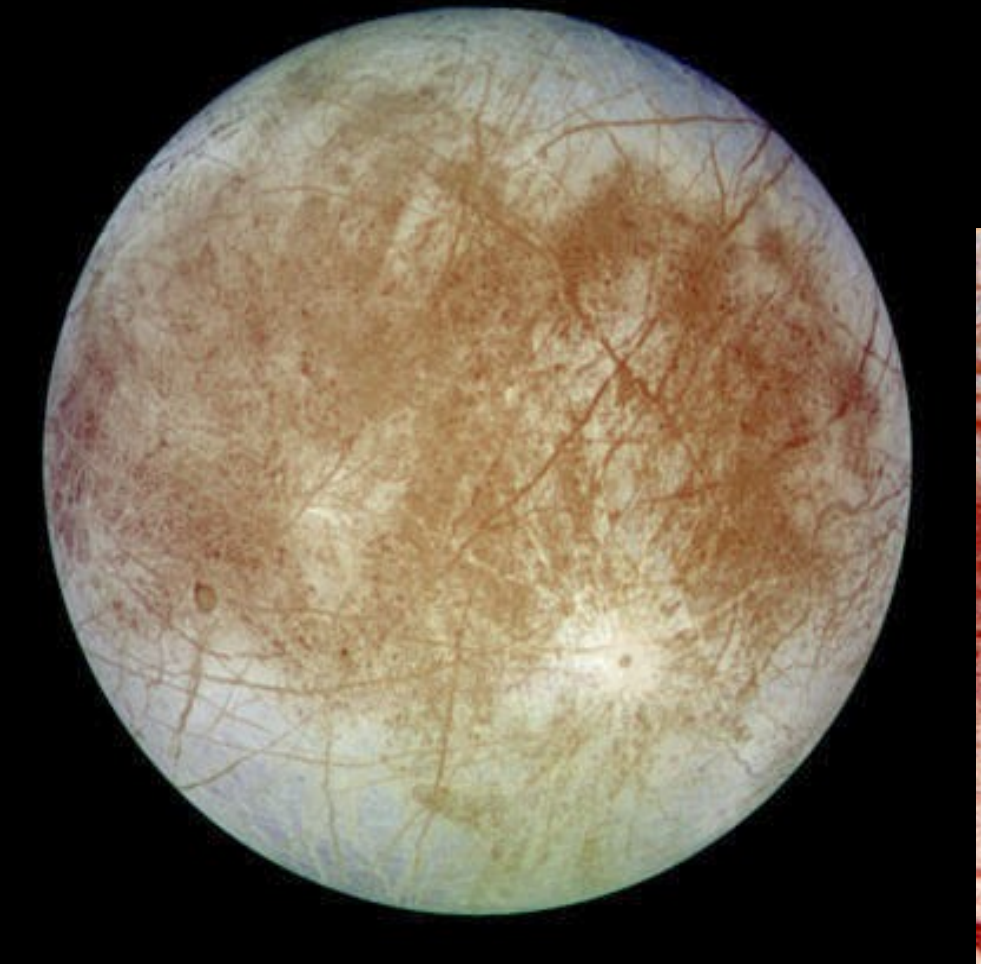

# *Callisto and Ganymede*

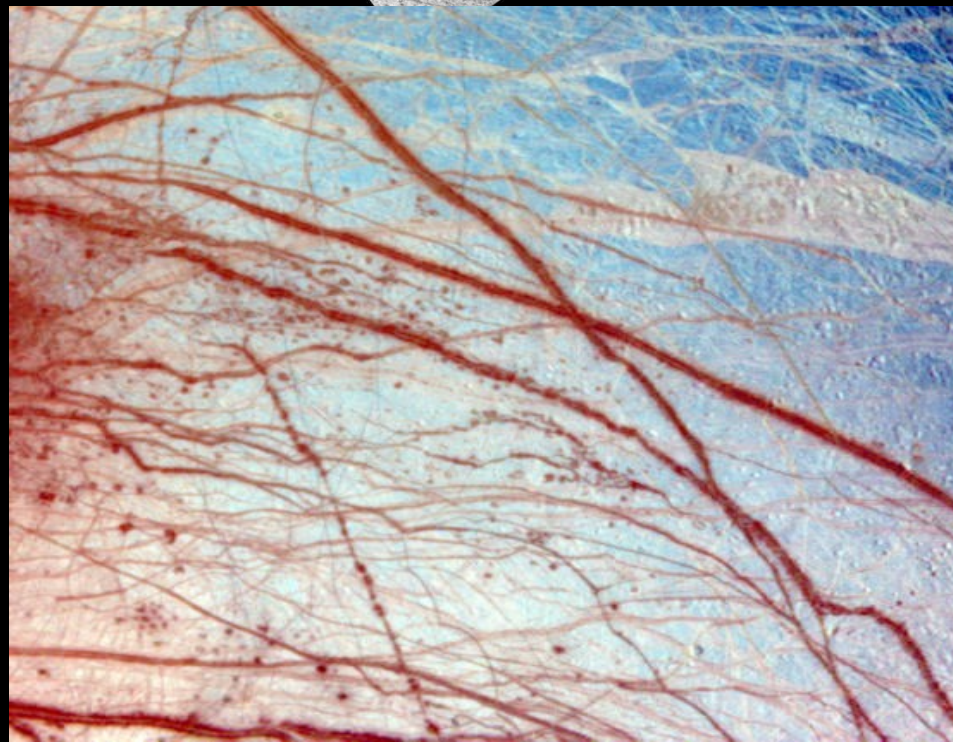
- Heating of Ganymede led to separation of dense iron core, surrounded by rock with thick layer of ice on top.
- Dark dust has accumulated on older surfaces of Callisto and Ganymede, burying small craters
  - Callisto suffered little heating and remains a mixture of ice and rock

# *Europa*

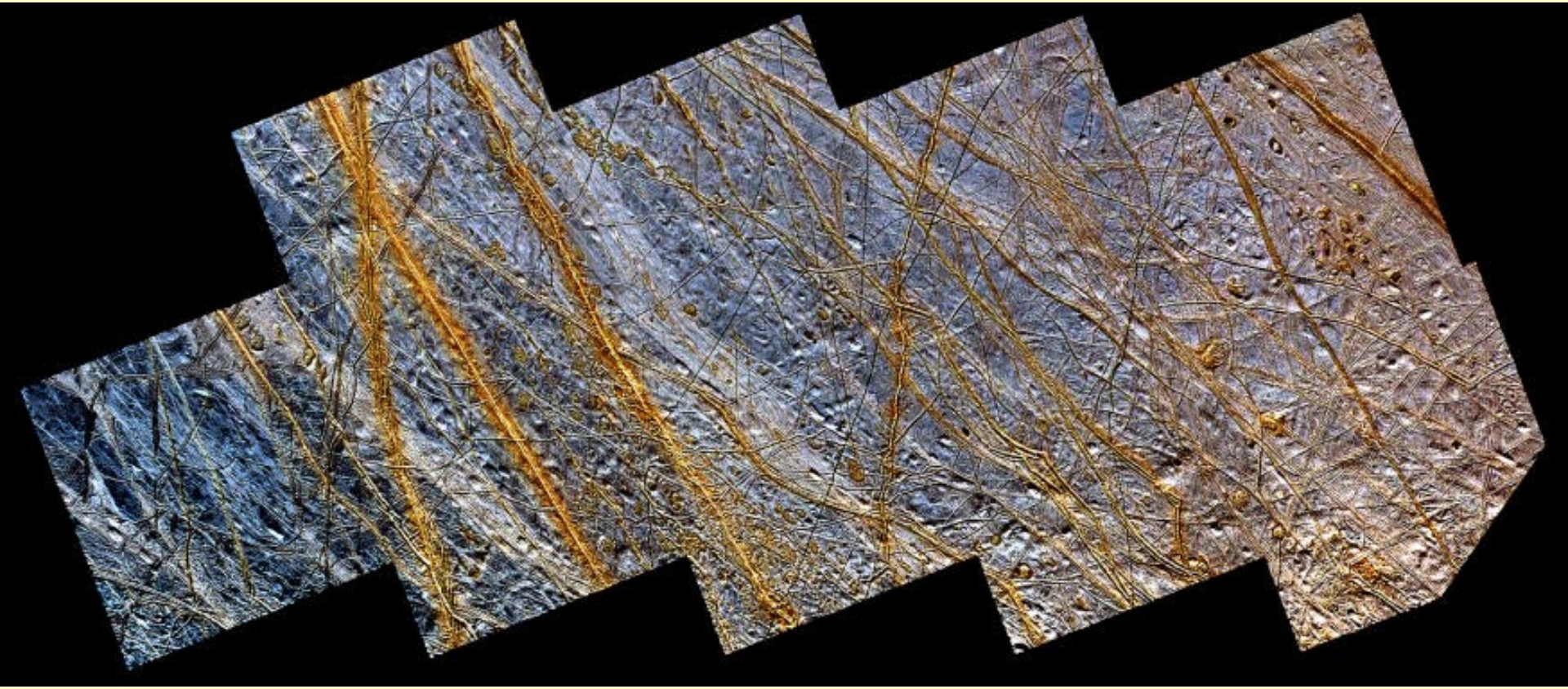
## *Dark Material Seeping Through Cracks*





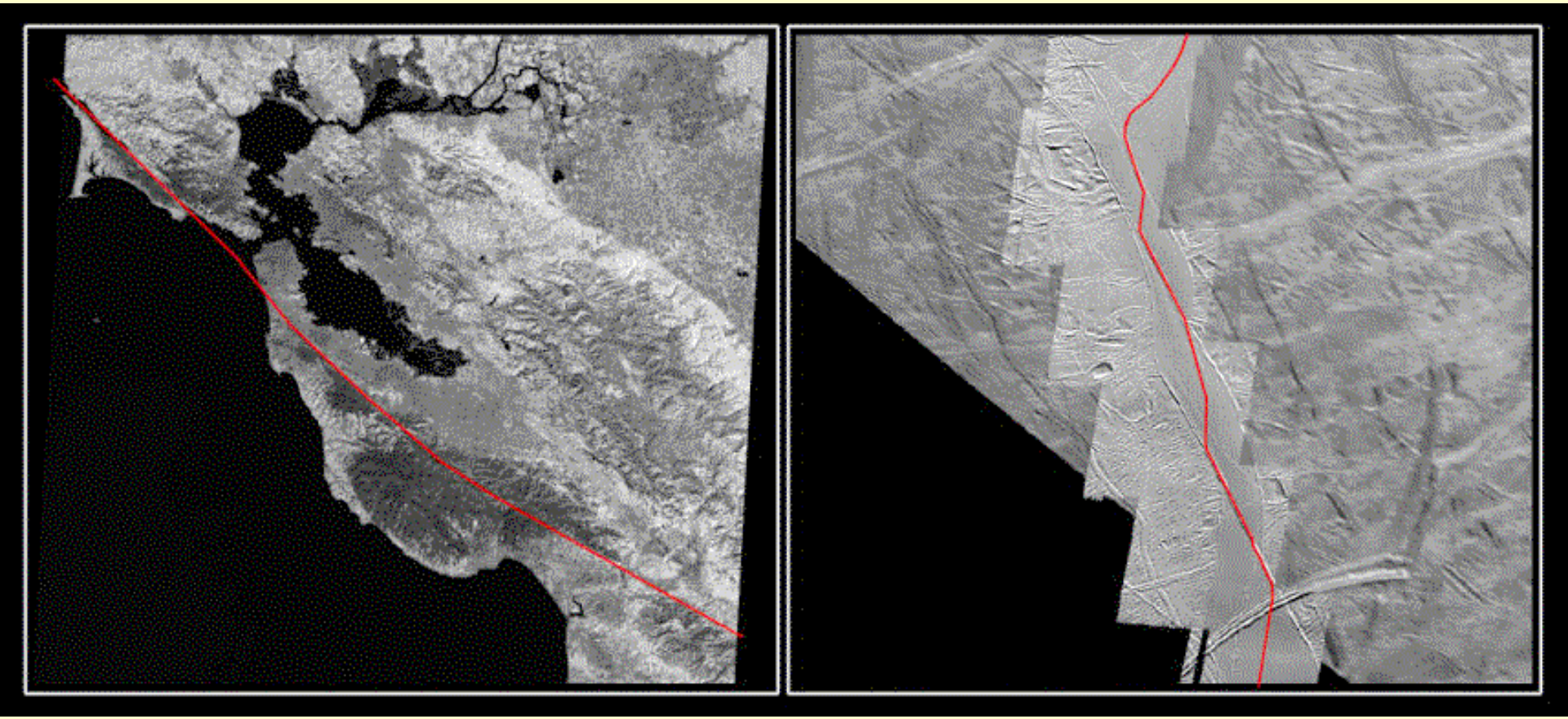


# Ridges, Spots & Smooth Icy Plains



**California**

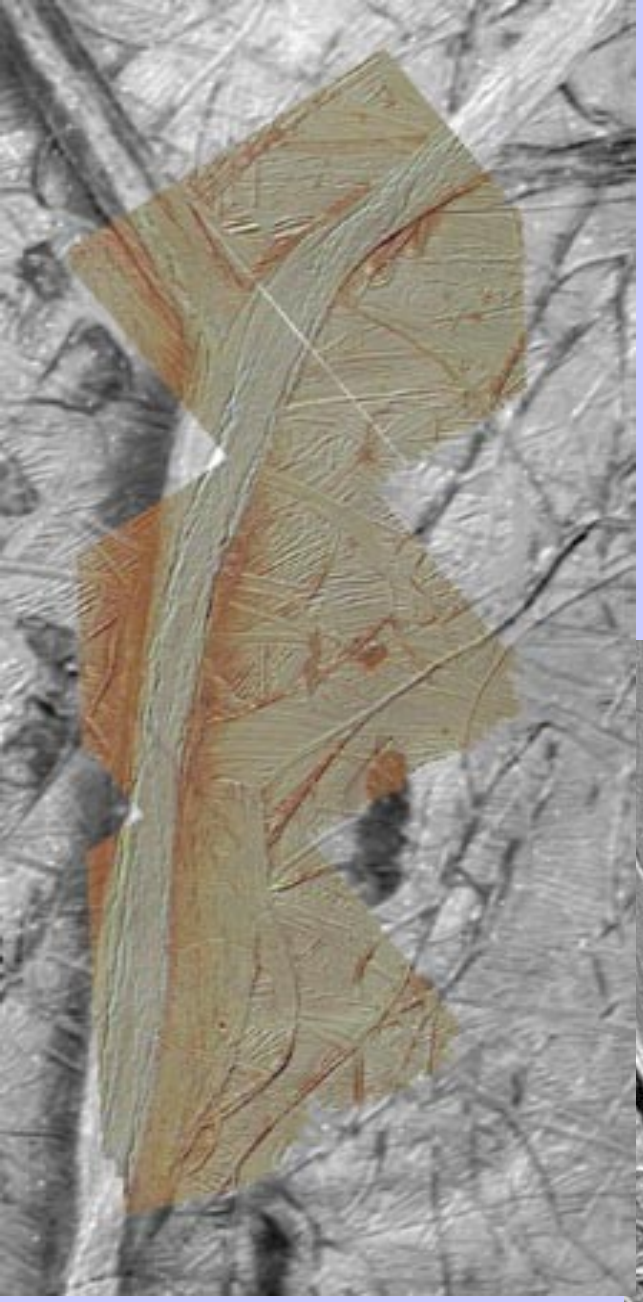
**Europa**



San Andreas Fault

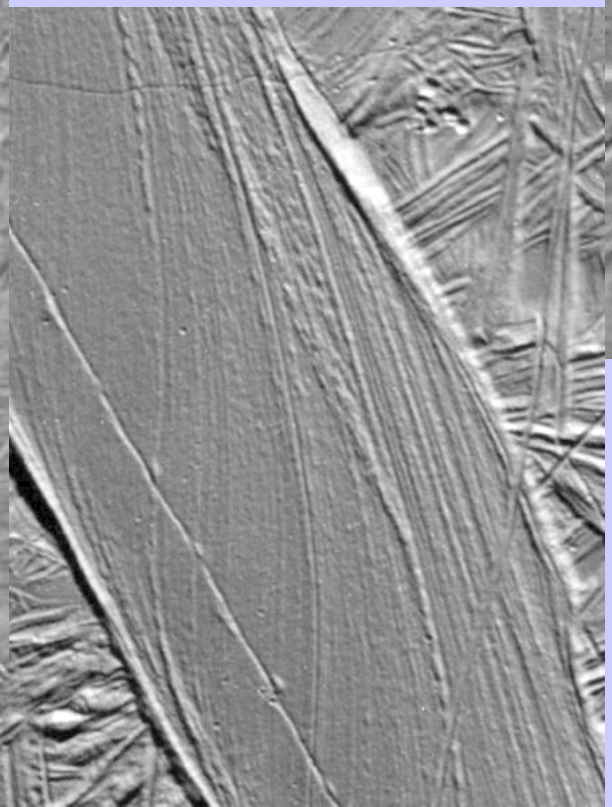
Astypalaea Linea

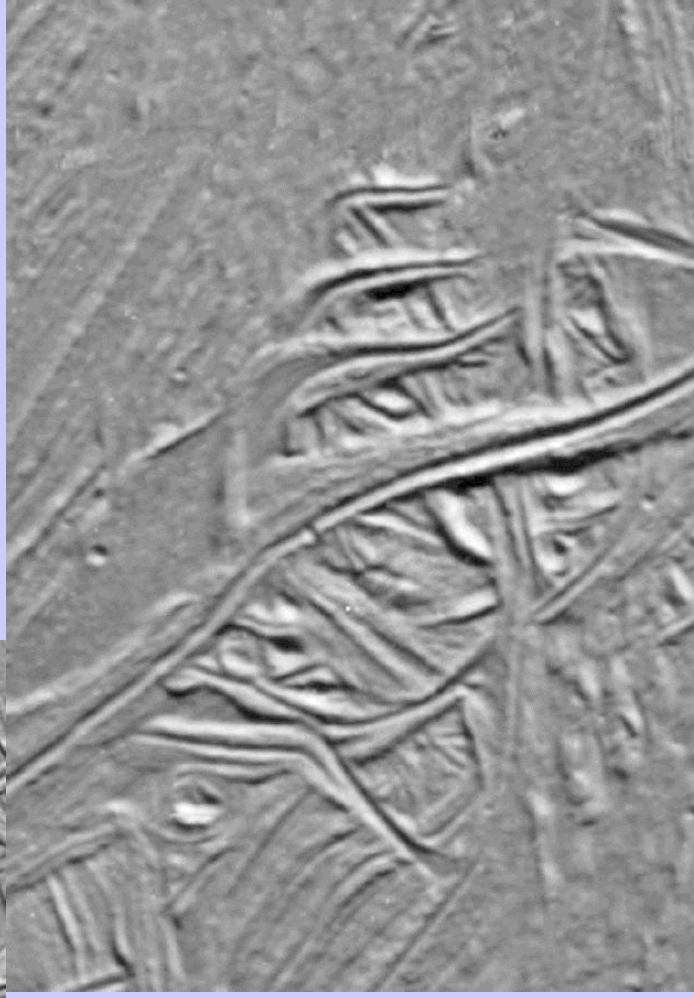
# *Zooming in on Cracks and Flows*



50 km

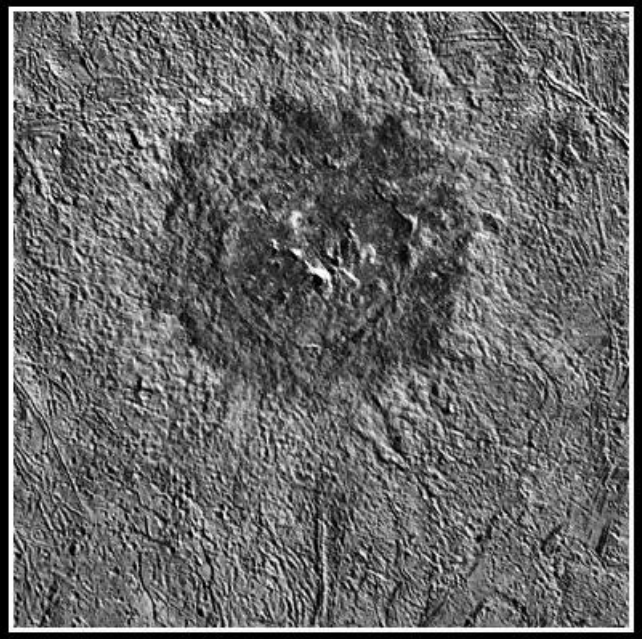
10 km





5 km

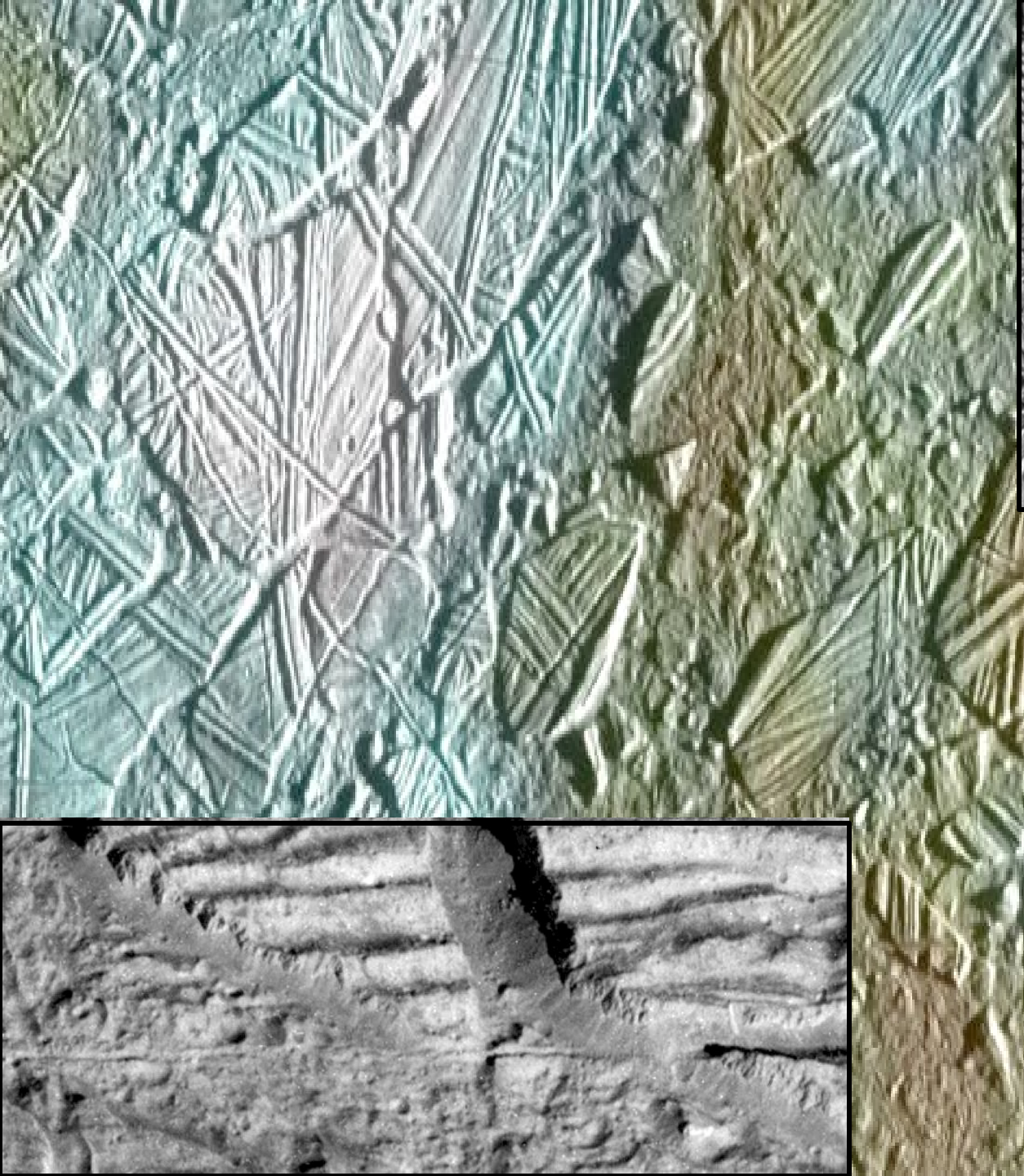
***Ice - sometimes it suddenly cracks, sometimes it slowly ƒows***



# *Europa's young surface shows few craters*

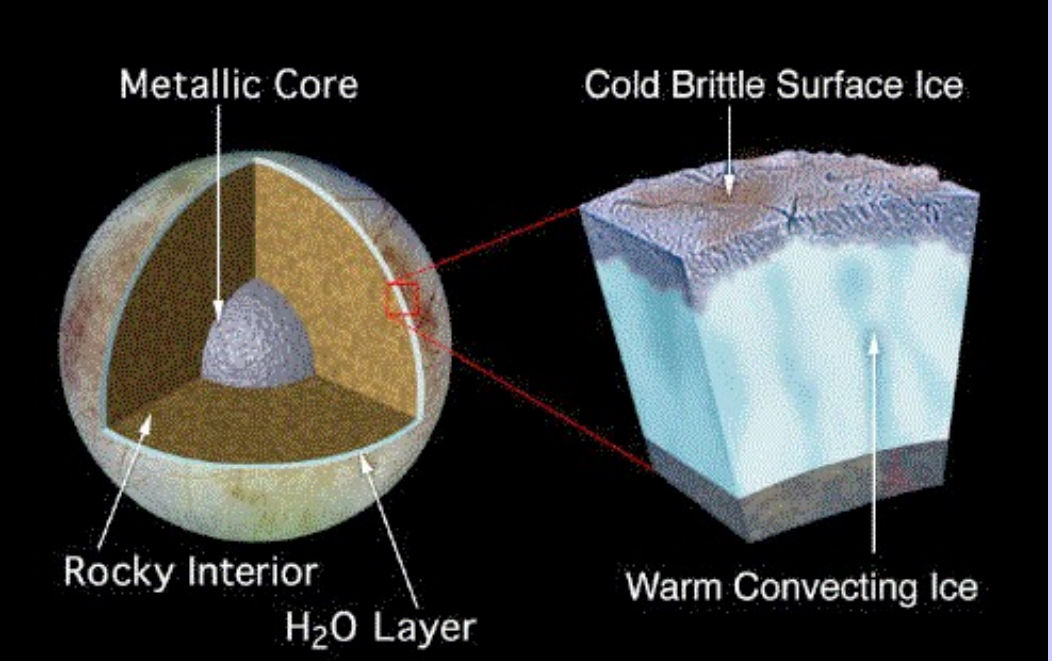
*Did this impactor crash right through the ice?*

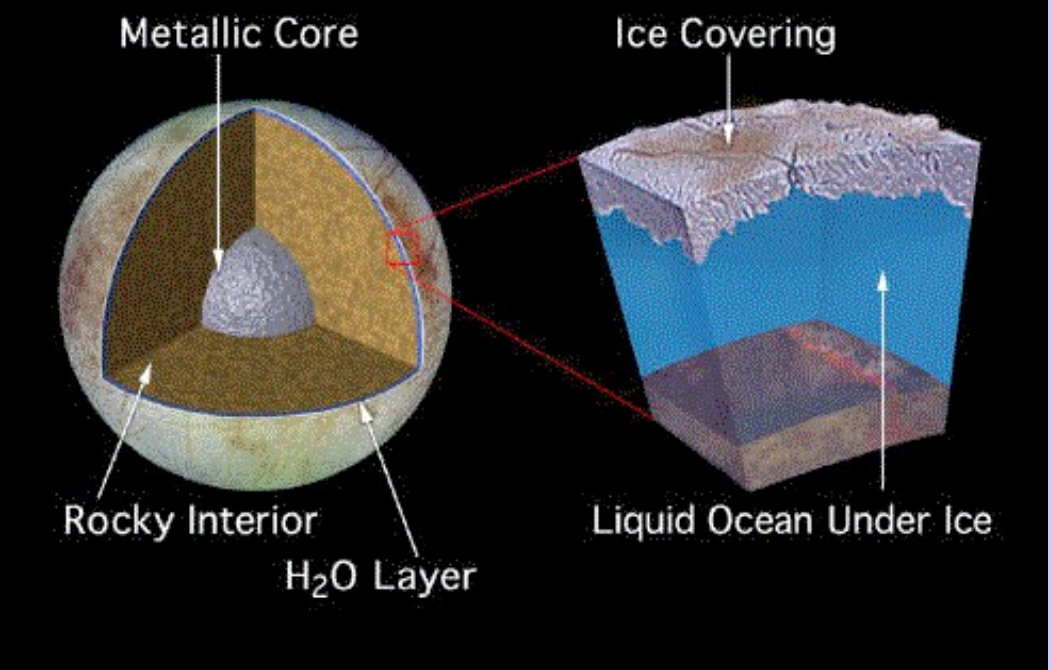
20 km





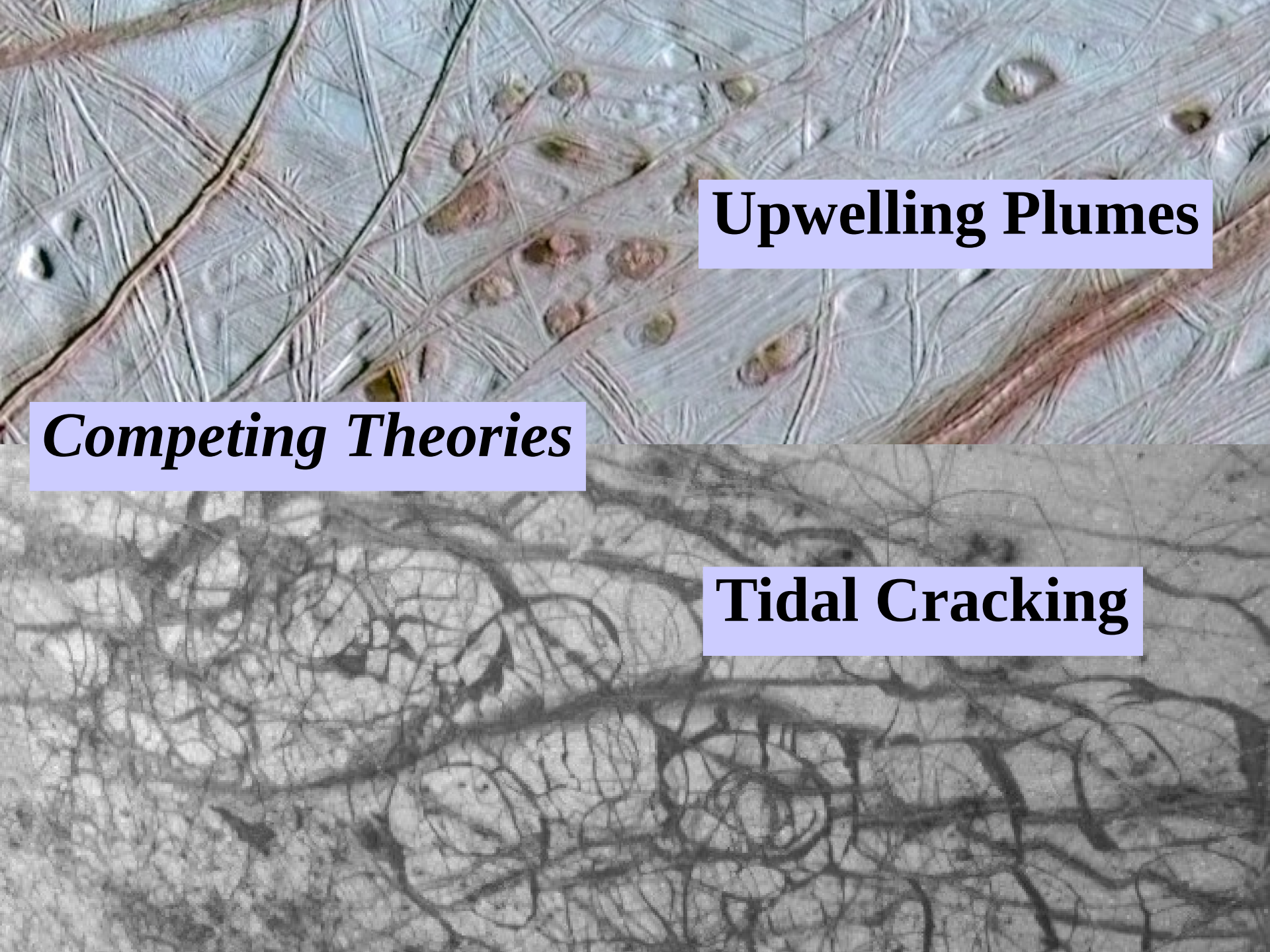
***High resolution images show ice "rafts" - indication of thin ice crust, liquid ocean below?***



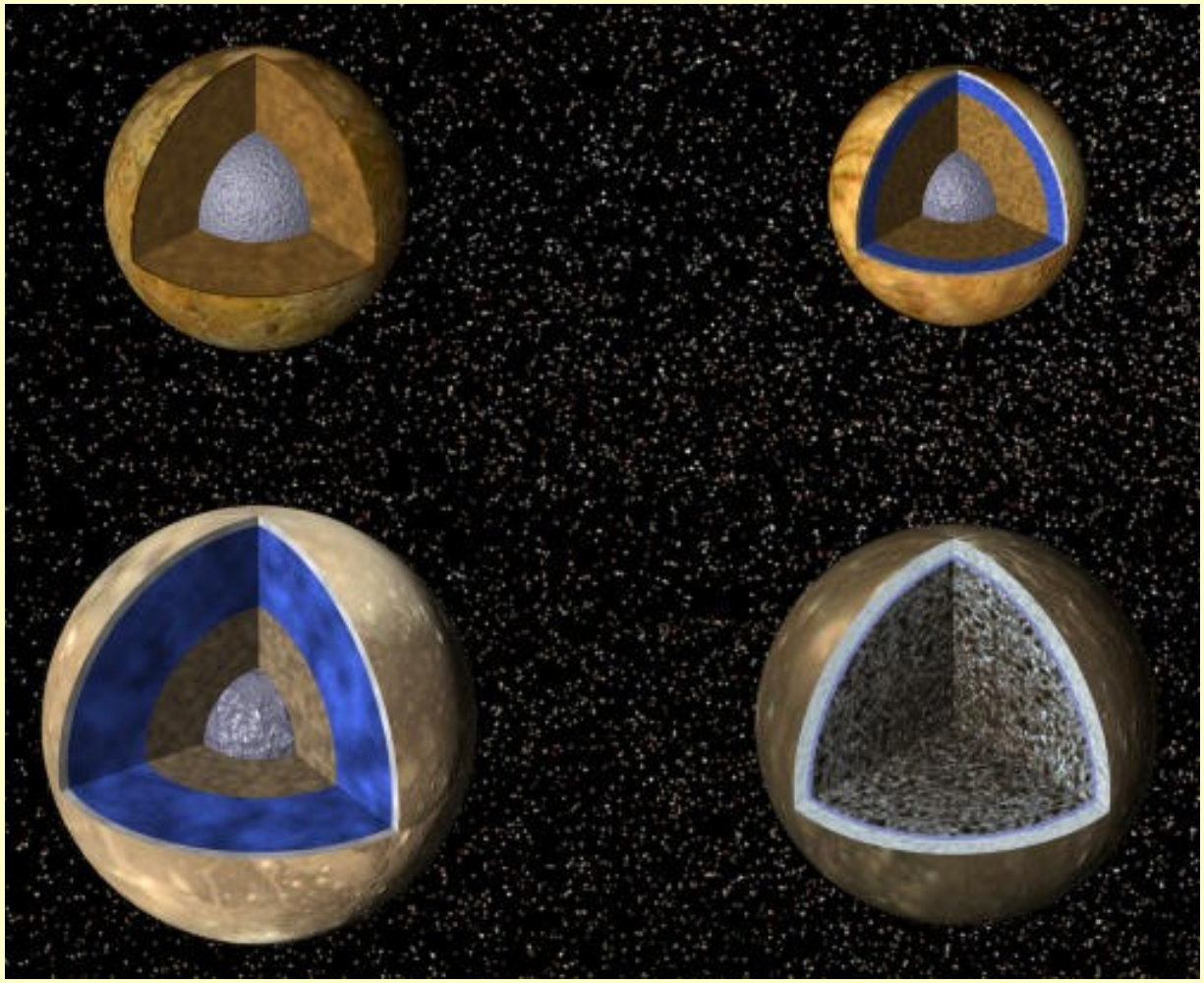




# *Europa*

- The interior is mostly rock covered by a ~150 km layer of water
- A brittle crust (1-10km thick) has been disrupted in the past 10 million years by underlying f uid motions
- Does Europa have a liquid ocean? Could such ocean contain life?
- Or, is the water layer frozen, moving slowly, like a glacier?


Upwelling Plumes
Competing Theories
Tidal Cracking

Io
3.57 g/cc



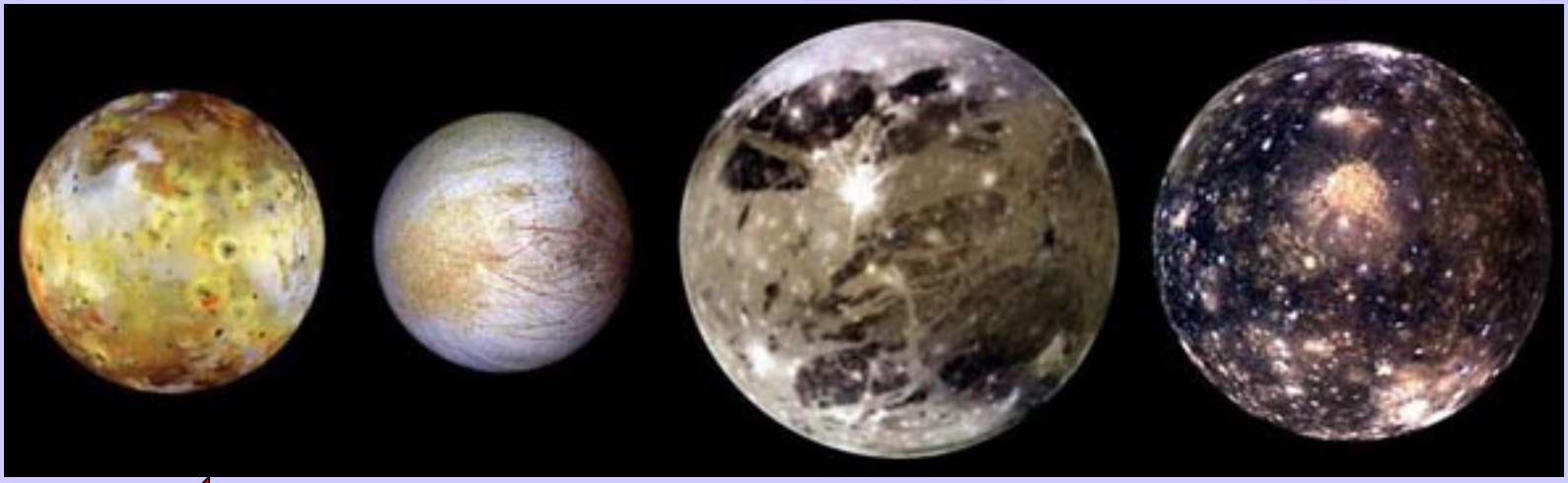
Europa
2.97 g/cc

Ganymede
1.94 g/cc

Callisto
1.86 g/cc

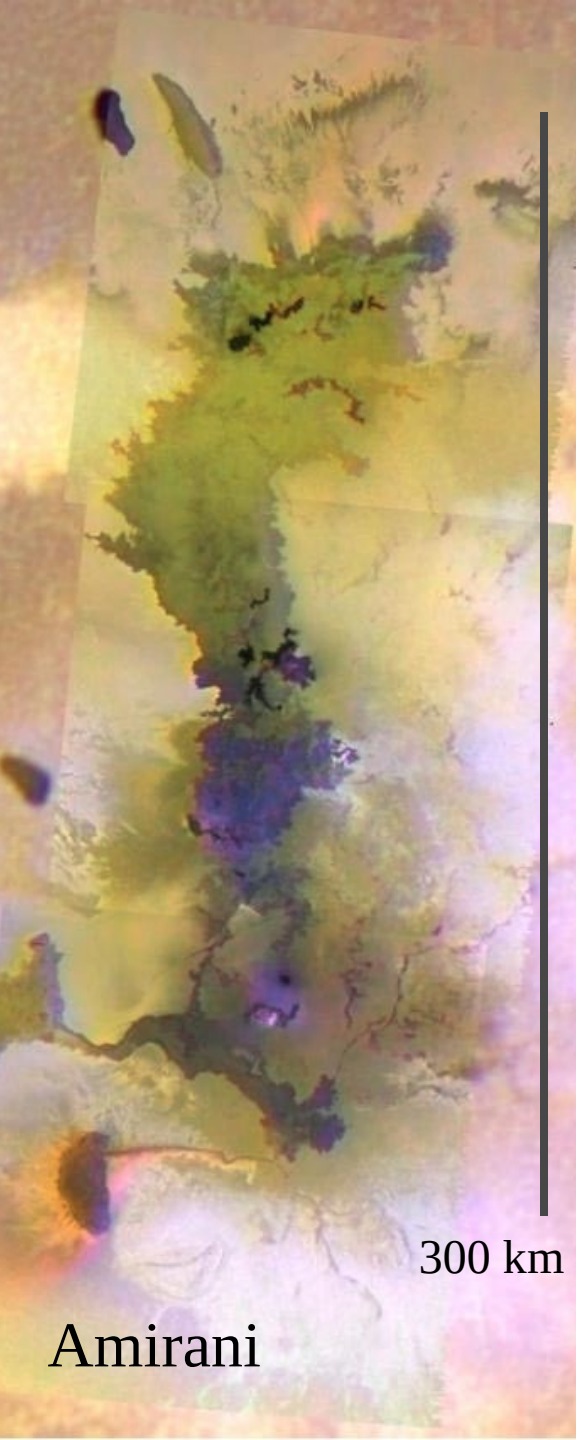
# Tidal Heating

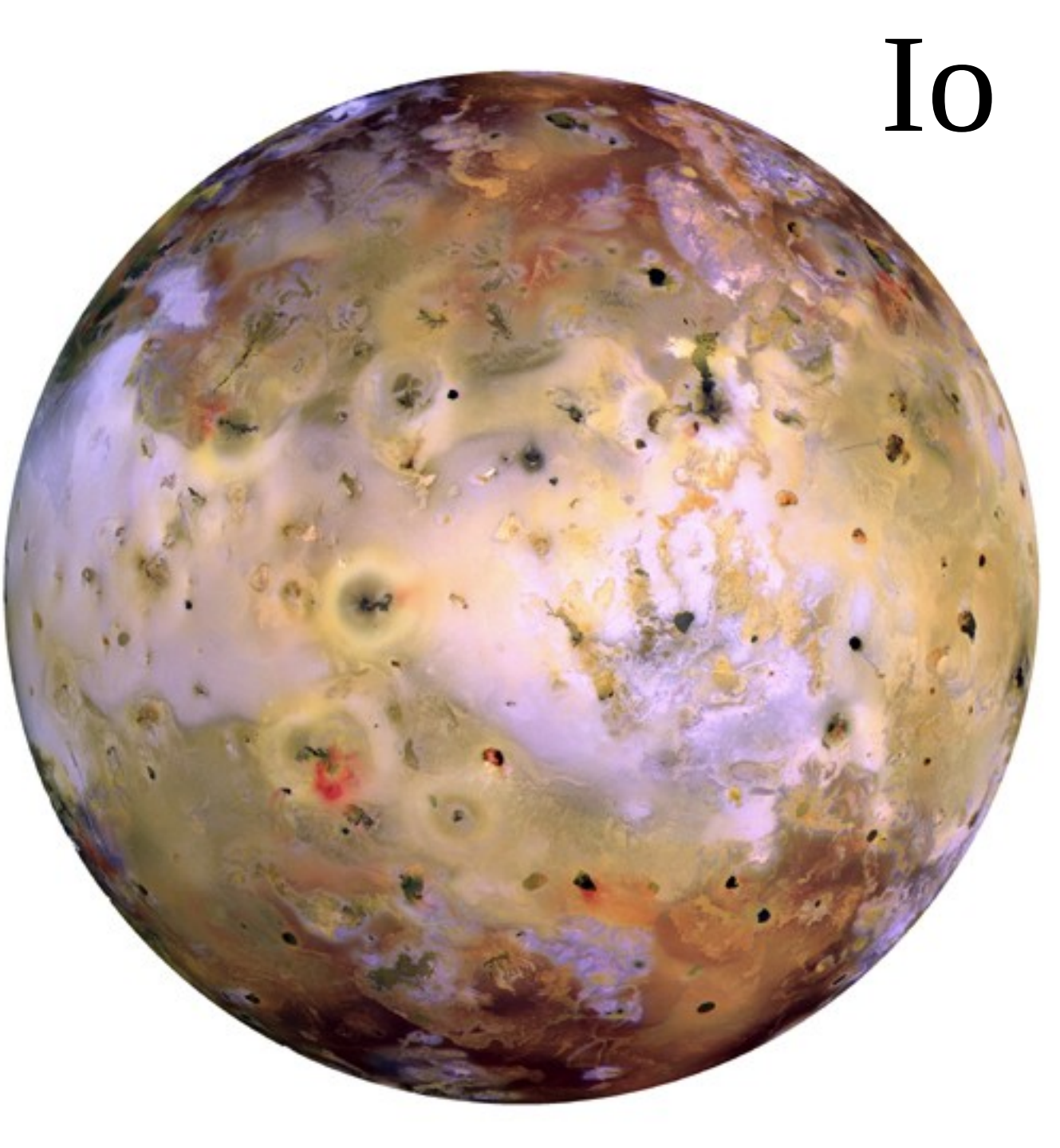
**Laplace orbital Resonance**



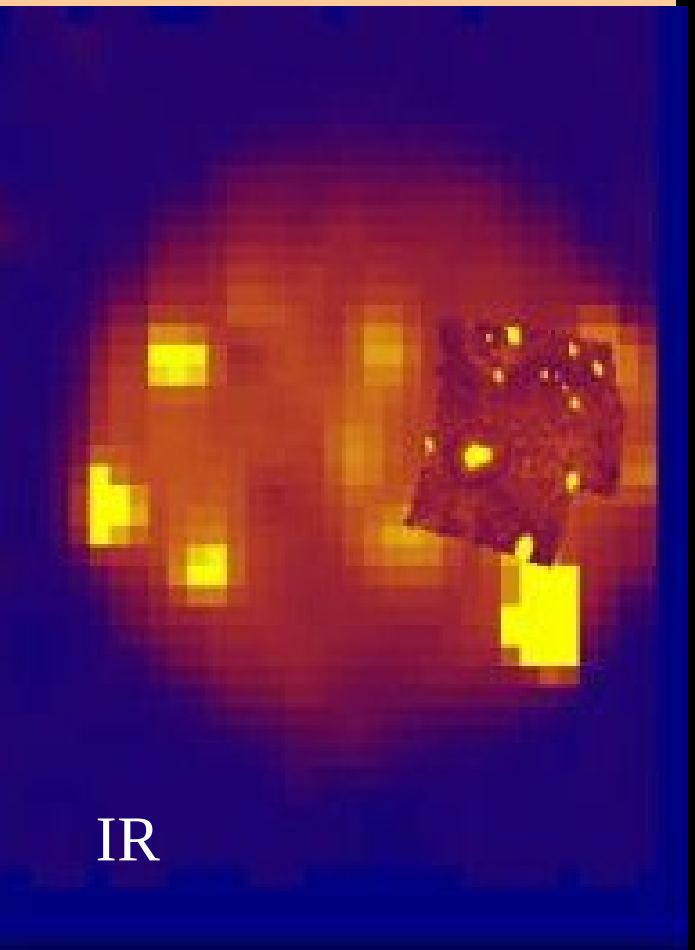
Tidal forces increase strongly closer to Jupiter

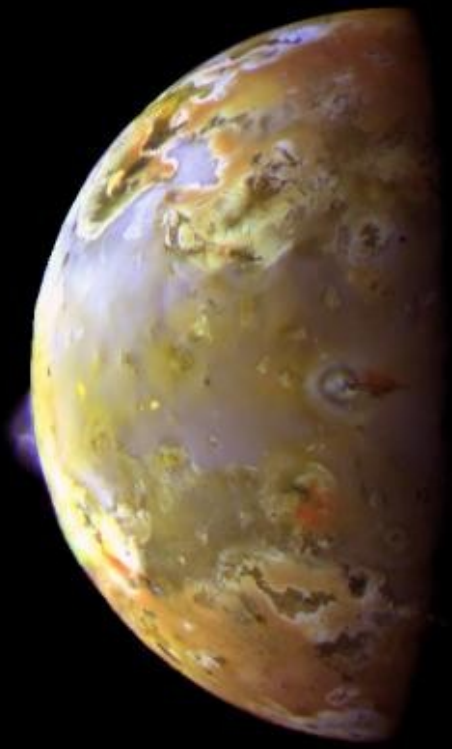
- Heat the interior
- Remove water
- Drive volcanic activity


300 km
Amirani


Io

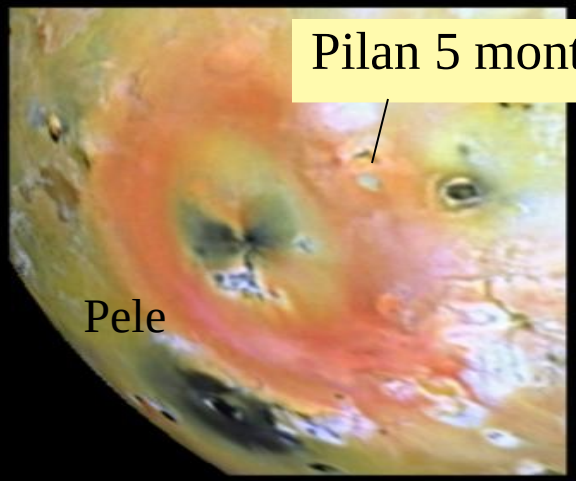
# Io's Volcanoes & Geysers

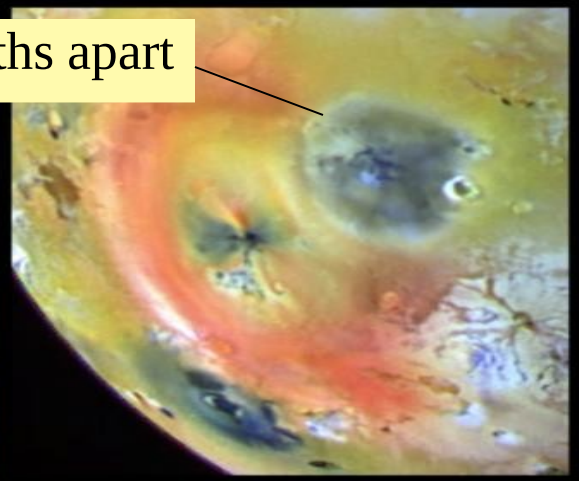


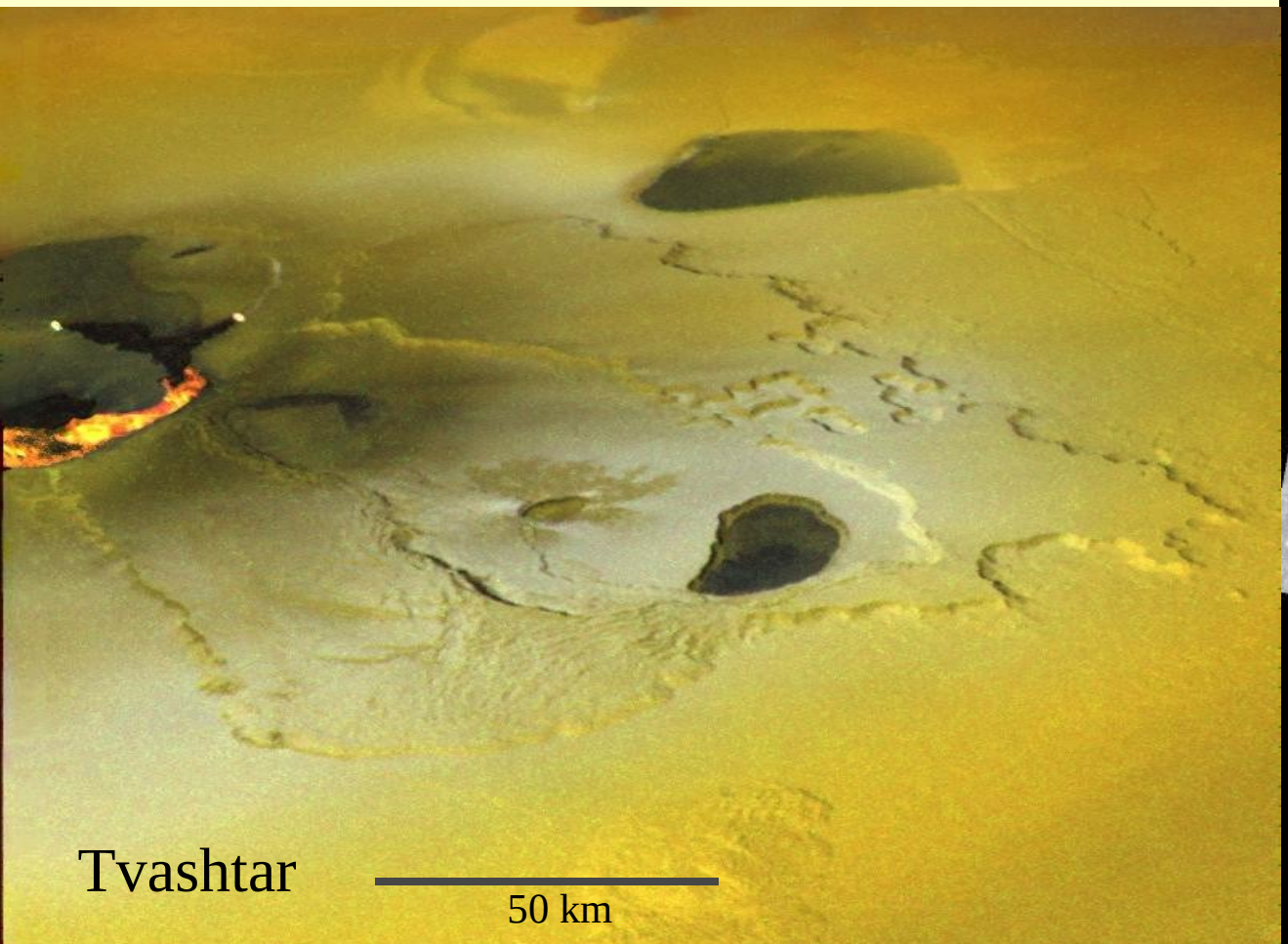
Pilan Plume

Prometheus



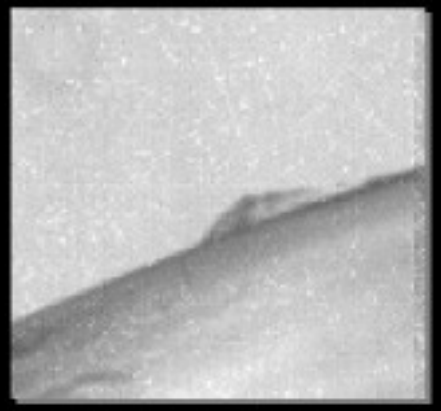



*After quantities of lava are removed from below, the crust cracks and tilts, making tall, blocky mountains.*



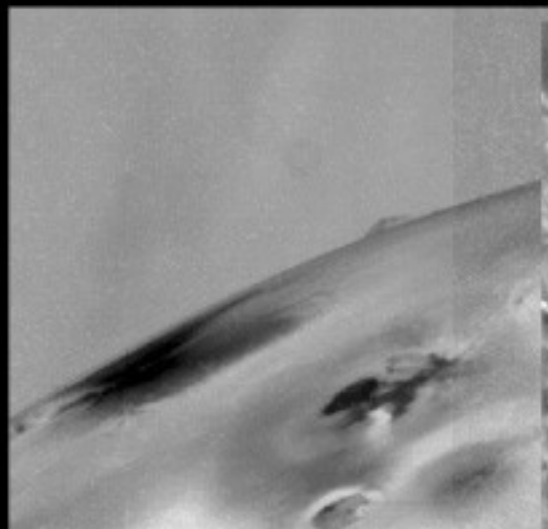

Boosaule Mons

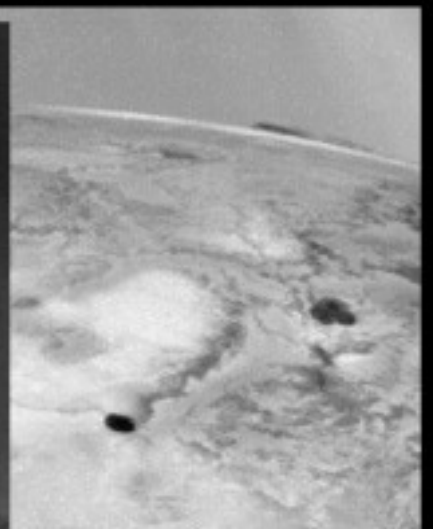
21 km high

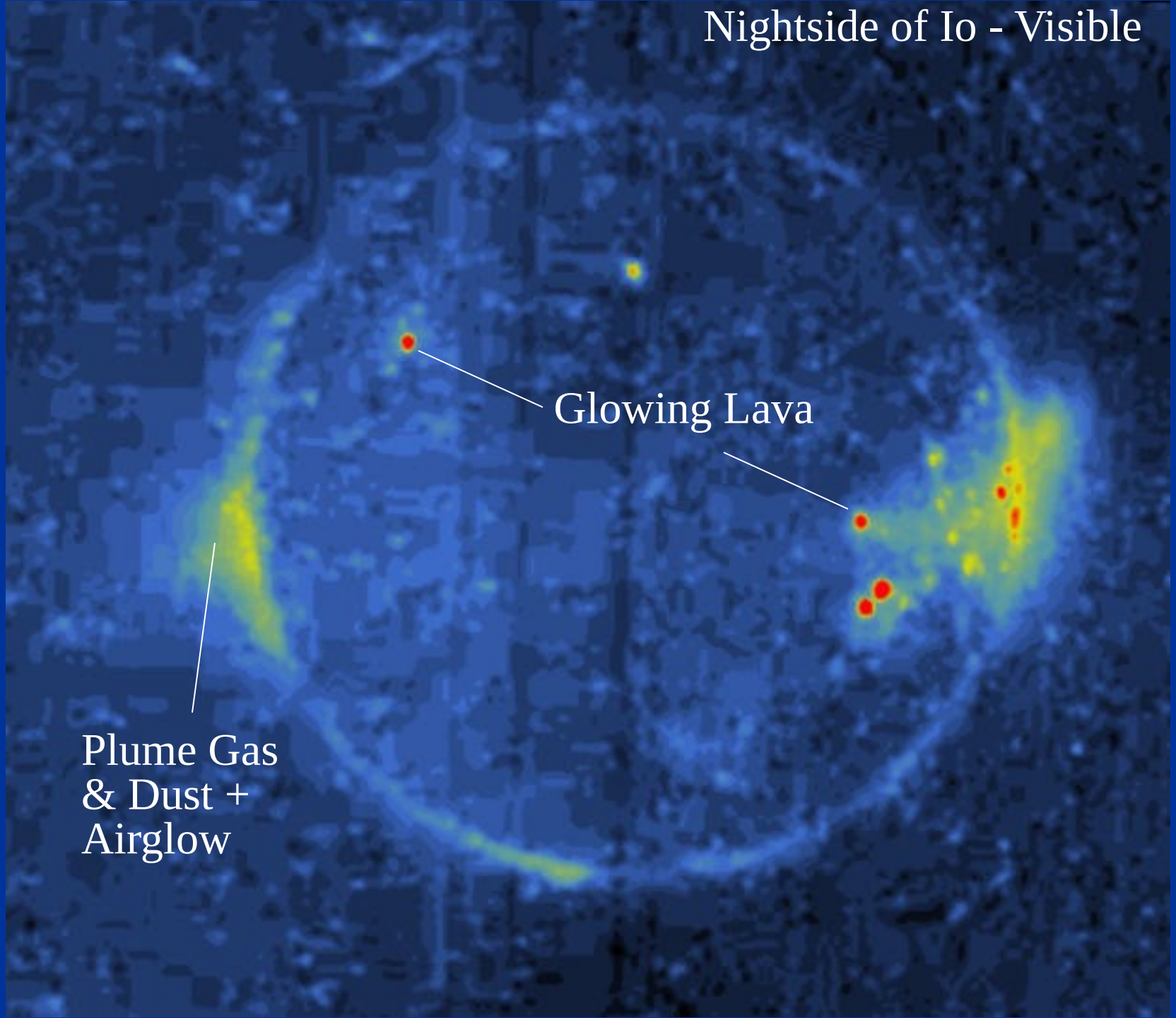


Sakuru Mons

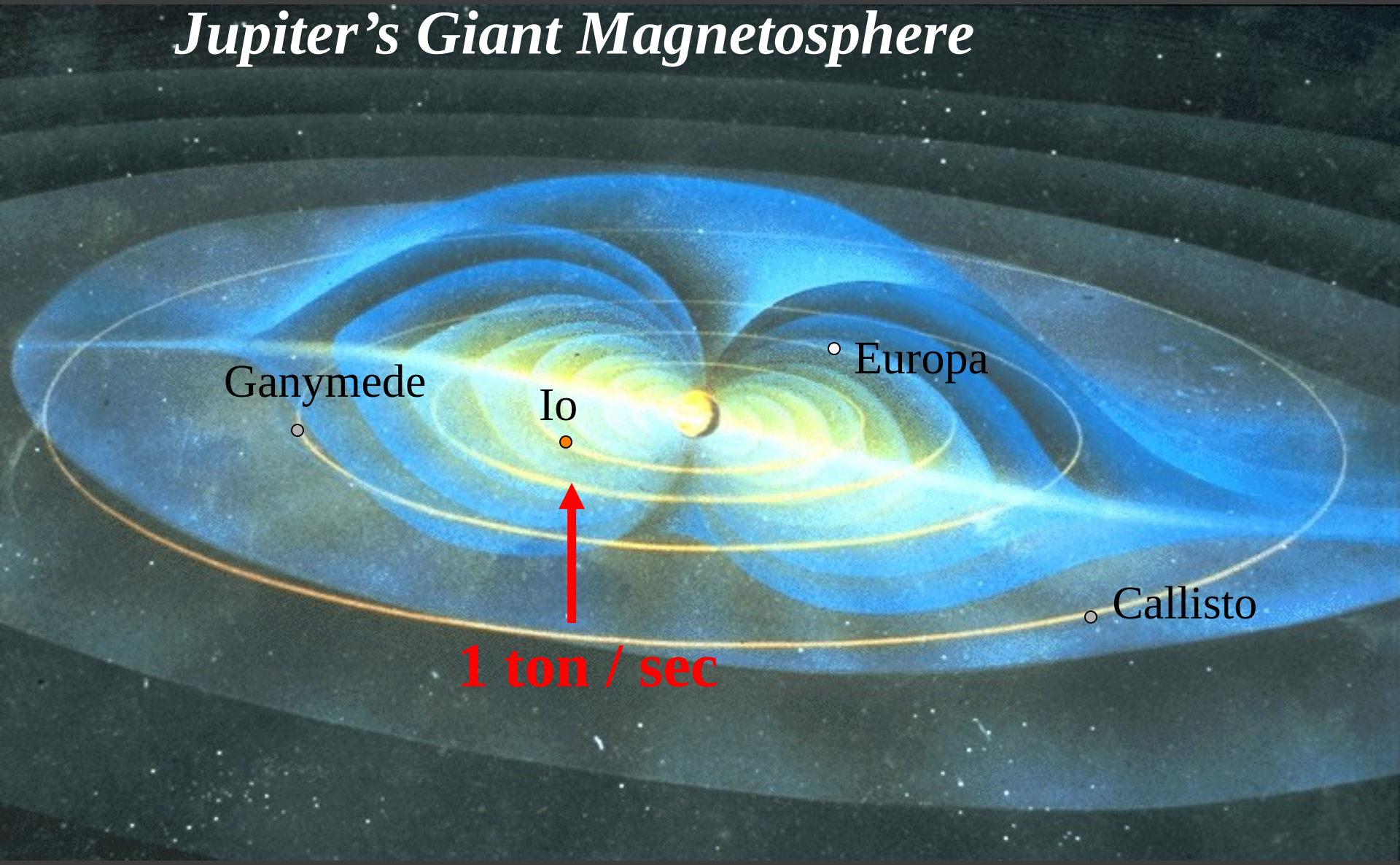
8 km high



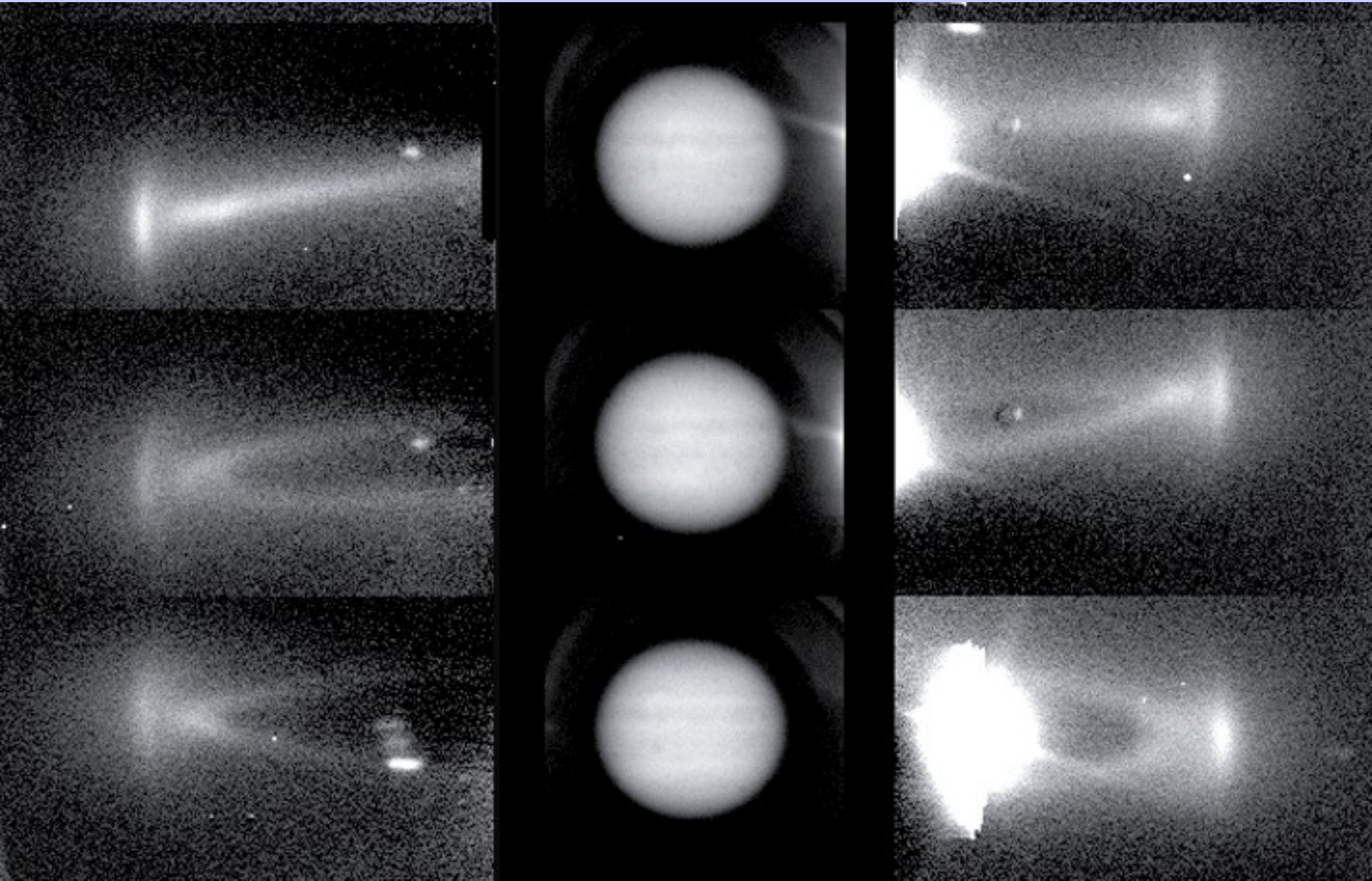



Nightside of Io - Visible
Glowing Lava
Plume Gas
& Dust +
Airglow

# *Jupiter's Giant Magnetosphere*



# Io Plasma Torus *(Schneider & Trauger)*



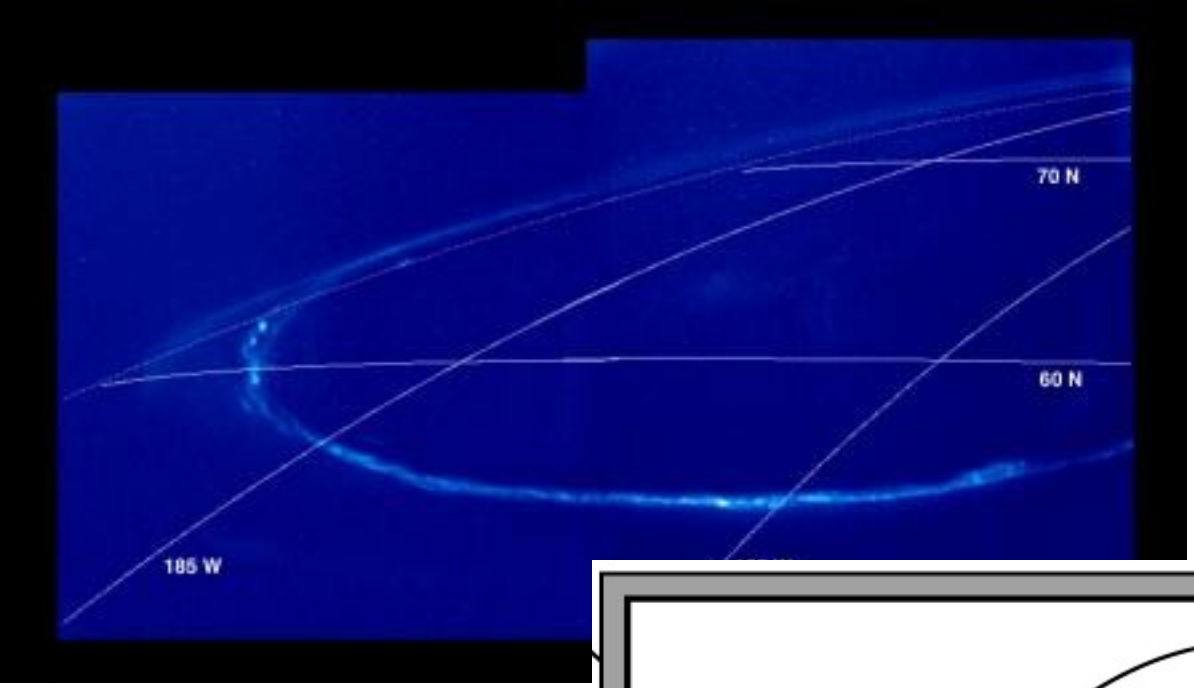
# *Cassini UltraViolet Imaging Spectrometer*

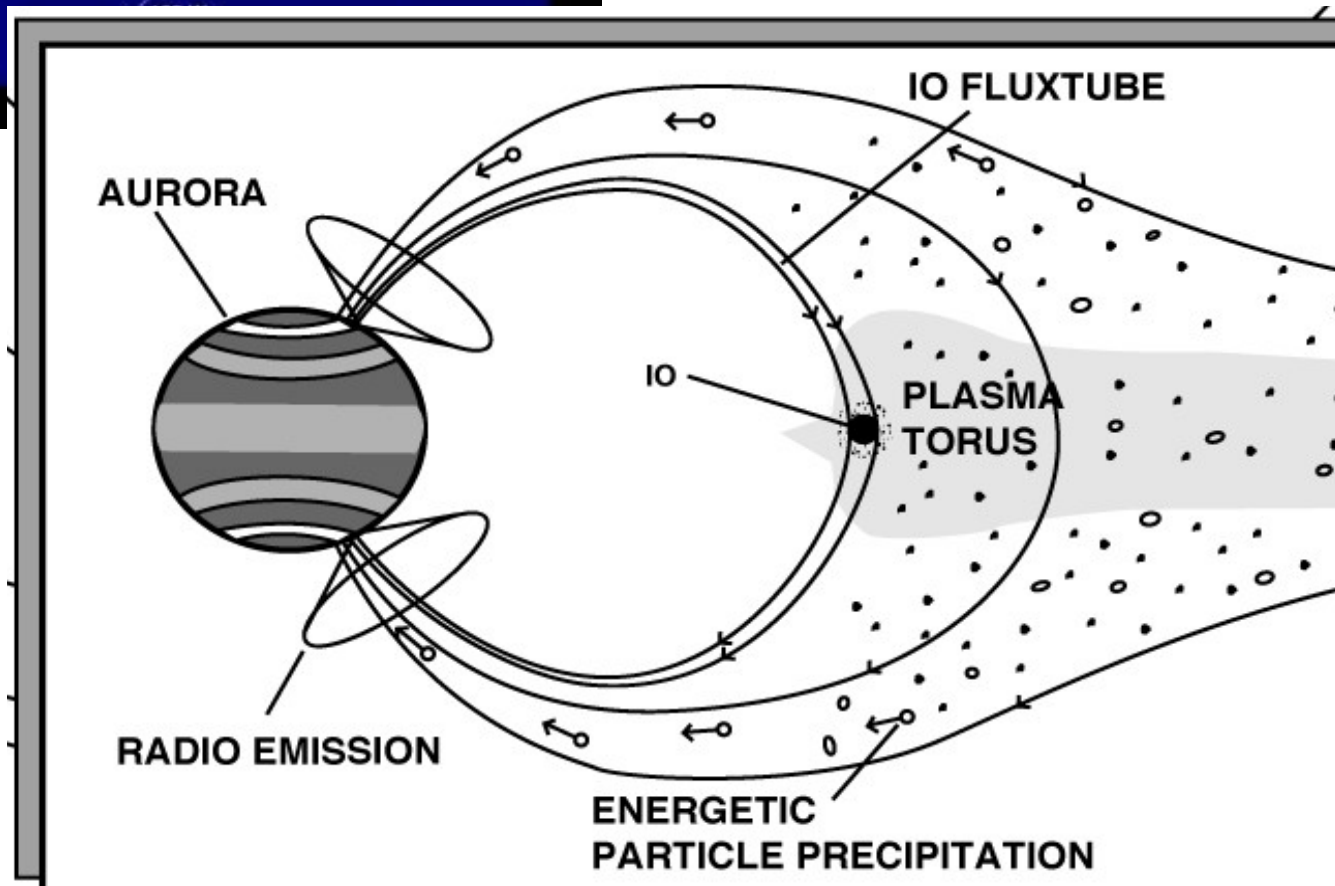
Larry Esposito, University of Colorado

- UV images of the toroidal cloud of ions at Io's orbit,
- The S+ and O+ ions are trapped by Jupiter's magnetic f eld.

- Jupiter is dark at UV wavelengths.

QuickTime™ and a
GIF decompressor
are needed to see this picture.


70 N
60 N
185 W


IO FLUXTUBE
AURORA
IO
PLASMA
TORUS
RADIO EMISSION
ENERGETIC
PARTICLE PRECIPITATION

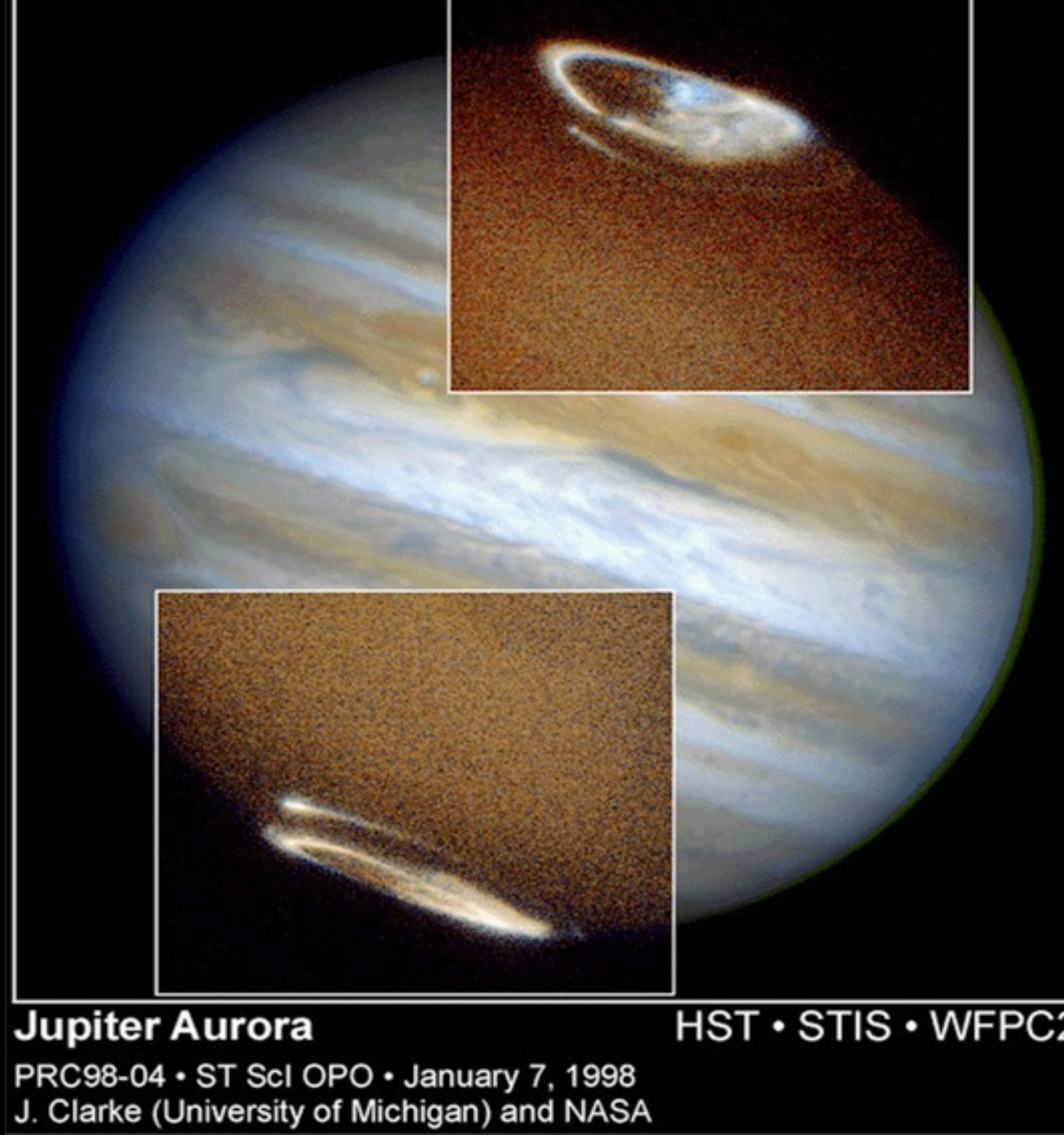
## *Jovian Aurora*

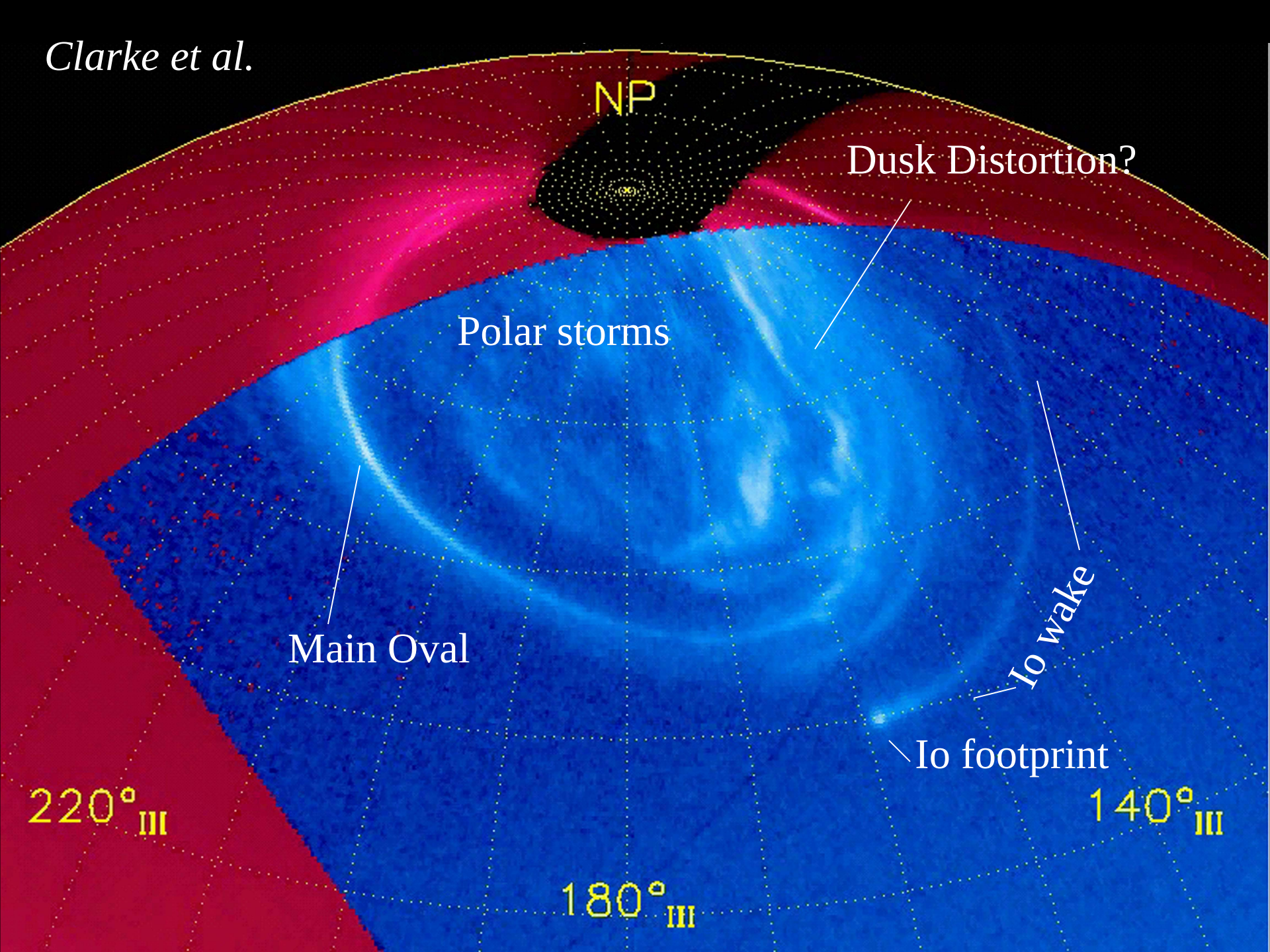
- Radio to X-rays
- Power into polar atmosphere > solar f ux

(1) Main oval linked to middle magnetosphere

(2) Polar storms

(3) Satellite footprints

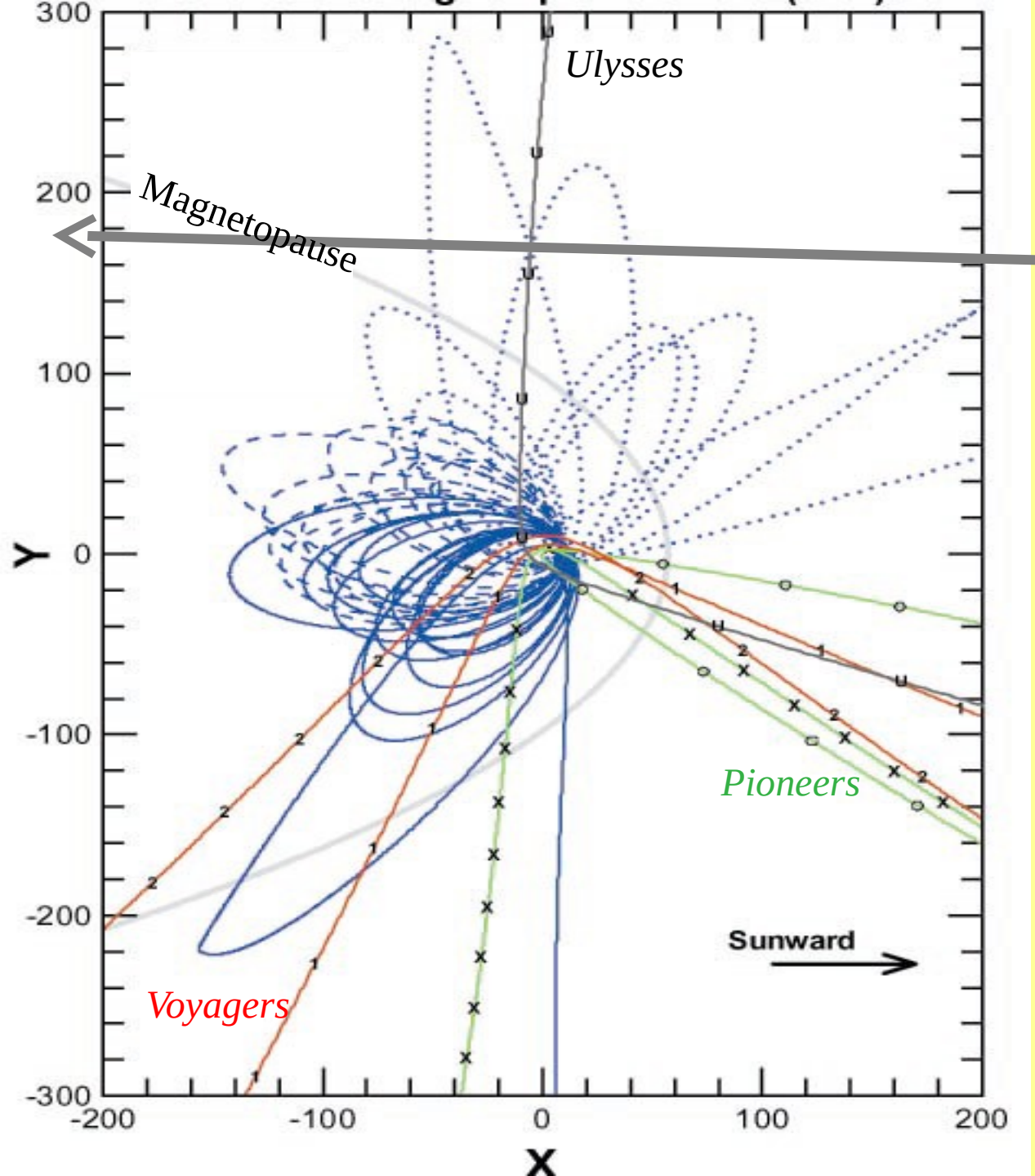



Clarke et al.
NP
Dusk Distortion?
Polar storms
Main Oval
Io wake
Io footprint
220° III
180° III
140° III

# *Galileo: The End Game*

- Must never hit Earth or Europa
- 3 passes close to Io—to determine if Io has a mag f eld
- Hits Jupiter October 20

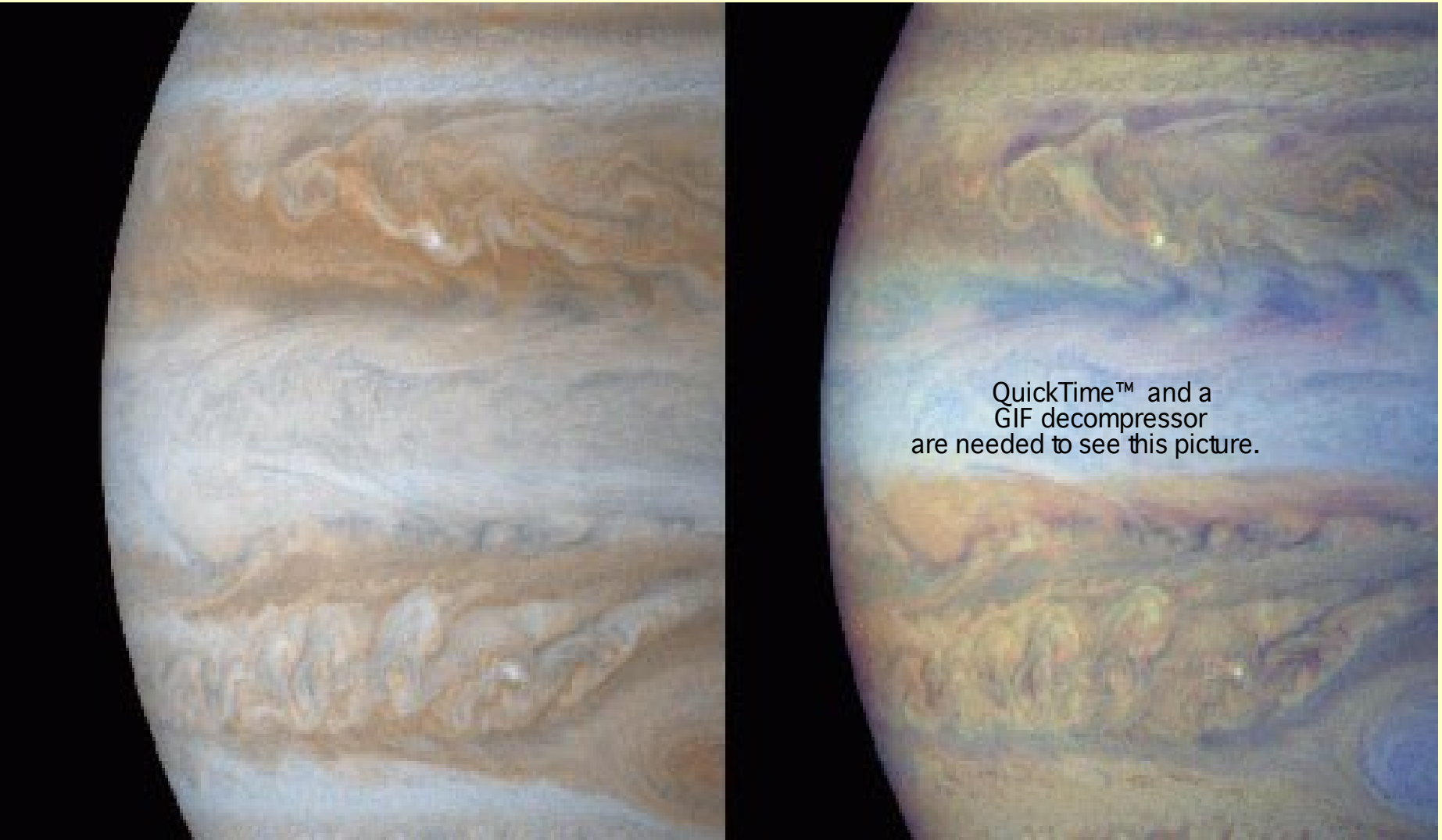
# *Cassini Spacecraft*




***Cassini*** f yby
Dec. 2000

***Galileo Orbiter***
33 orbits
Dec. 1995 to
Oct. 2003

# *Cassini Flyby of Jupiter*




2004
Cassini
Reaches
Saturn