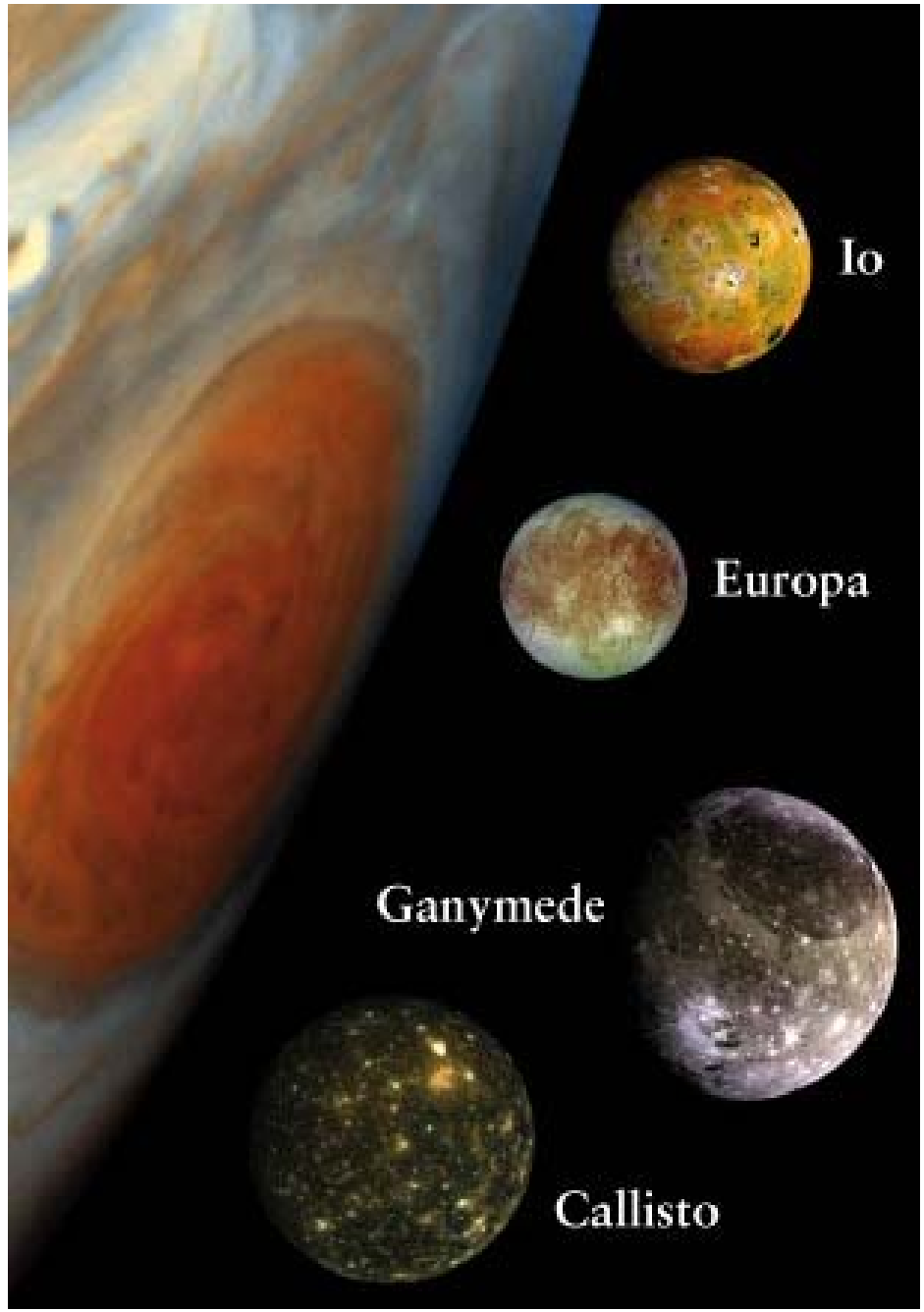
Jupiter's 4 Main Moons

- **4 main moons discovered in 1610 by Galileo: The *"Medici Stars"***
- **Named after 4 mythical lovers and companions of Zeus.**
- **Similar in size to our Moon.**



General Properties:

Property	Io	Europa	Ganymede	Callisto
Orbit radius*	5.90	9.38	15.0	26.3
Orbit period†	1.77	3.55	7.15	16.7
Size (km)	3640	3130	5270	4800
Mass (*x* Moon ‡)	1.22	0.65	2.02	1.46
Density (kg/m^3)	3500	3000	1900	1900

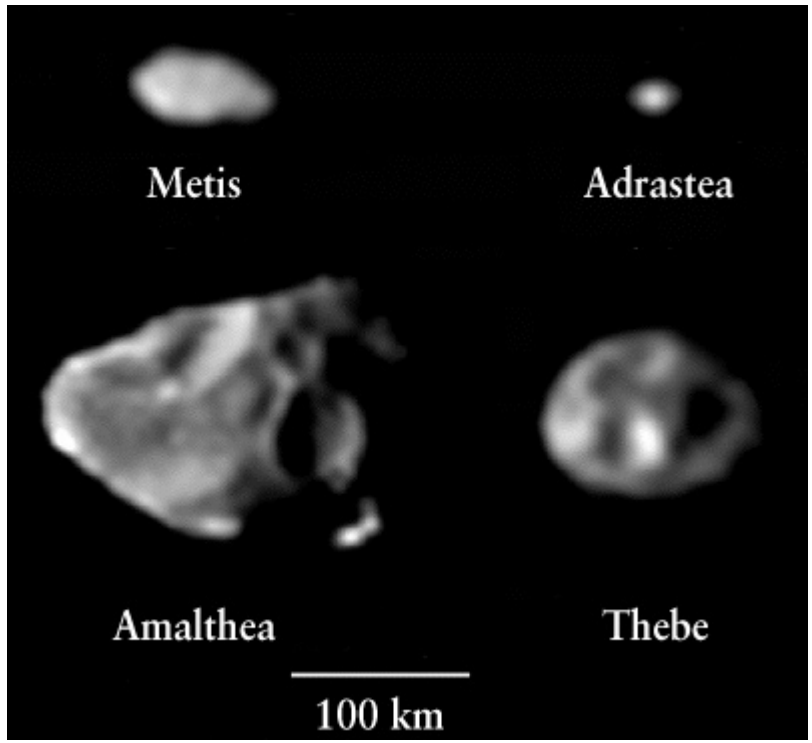
* *Jupiter radii (~71492km)* † *in Earth days*

‡ *Moon mass ~3.9x10^{-5} Jupiter mass = 7.4 x10^{22}kg*

Jupiter's Other Satellites

- **63 'moons' in total, some only ~km big.**
- ***Amalthea*** **(1892)**

  ~260 *x* 150km
- ***Himalia*** **(1904) ~170km**
- ***Elara*** **(1905) ~80km**
- ***Thebe*** **(1979) ~100km**
- **Others <40km in size.**



Above: **The 4 Moons closer than Io; Metis, Adrastea discovered by Voyager (1979)**

Jupiter's Other Outer Satellites

- **4 grouped at ~11,500,000km (~160 R_J)**

  Including *Himalia*

- **Outermost 4 at ~23,000,000km (~320 R_J) have *retrograde* orbits!**

  Both groups most probably single 'asteroid' body captured by Jupiter's gravity and then fragmented.

- **In 2000, more small 'moons' discovered:**

  Picked-up 'space junk'

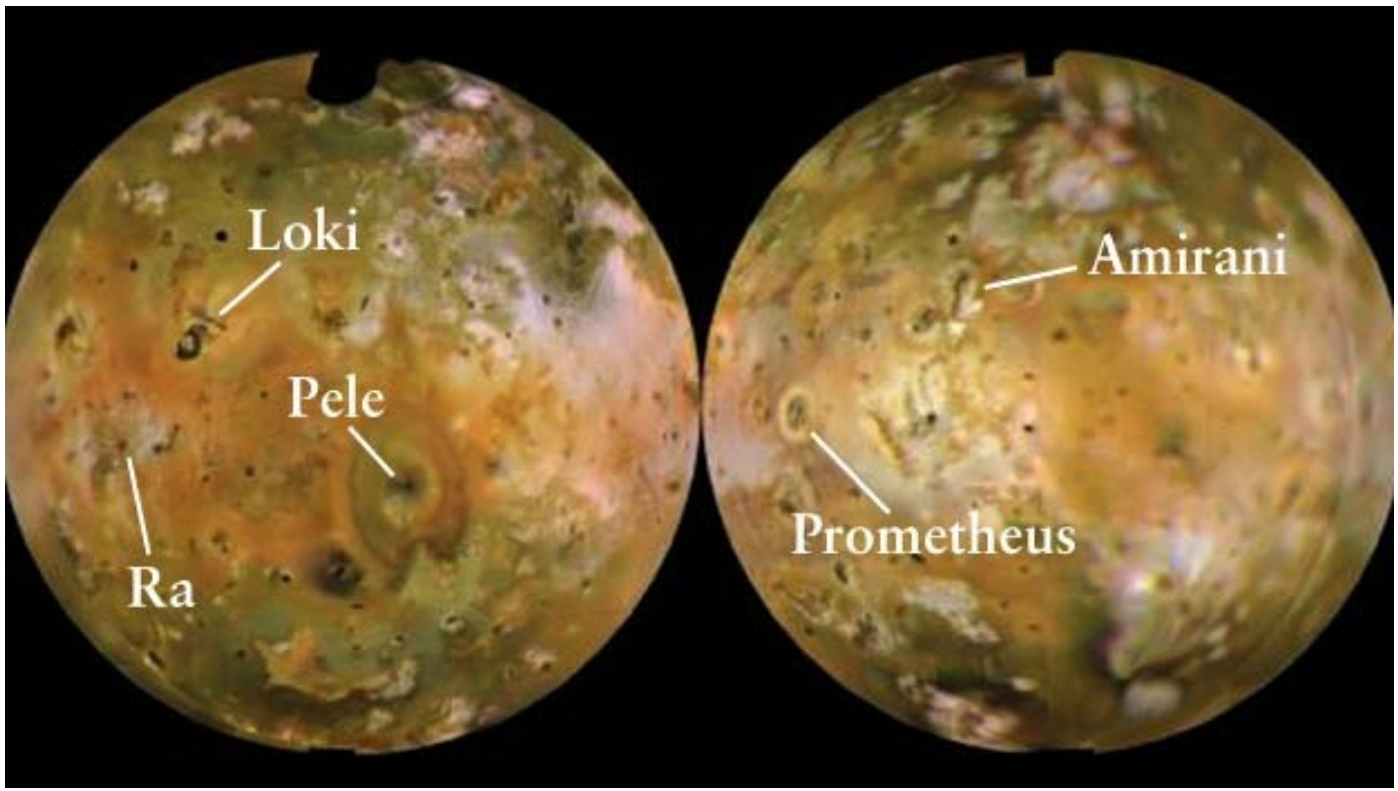
Io: Innermost Moon

- **Similar mass and size to our Moon.**
- **Huge *erupting* volcanoes.**
- **Surface *not* cratered – *smooth!***
- **Thin, temporary atmosphere of volcanic gases: SO_2**

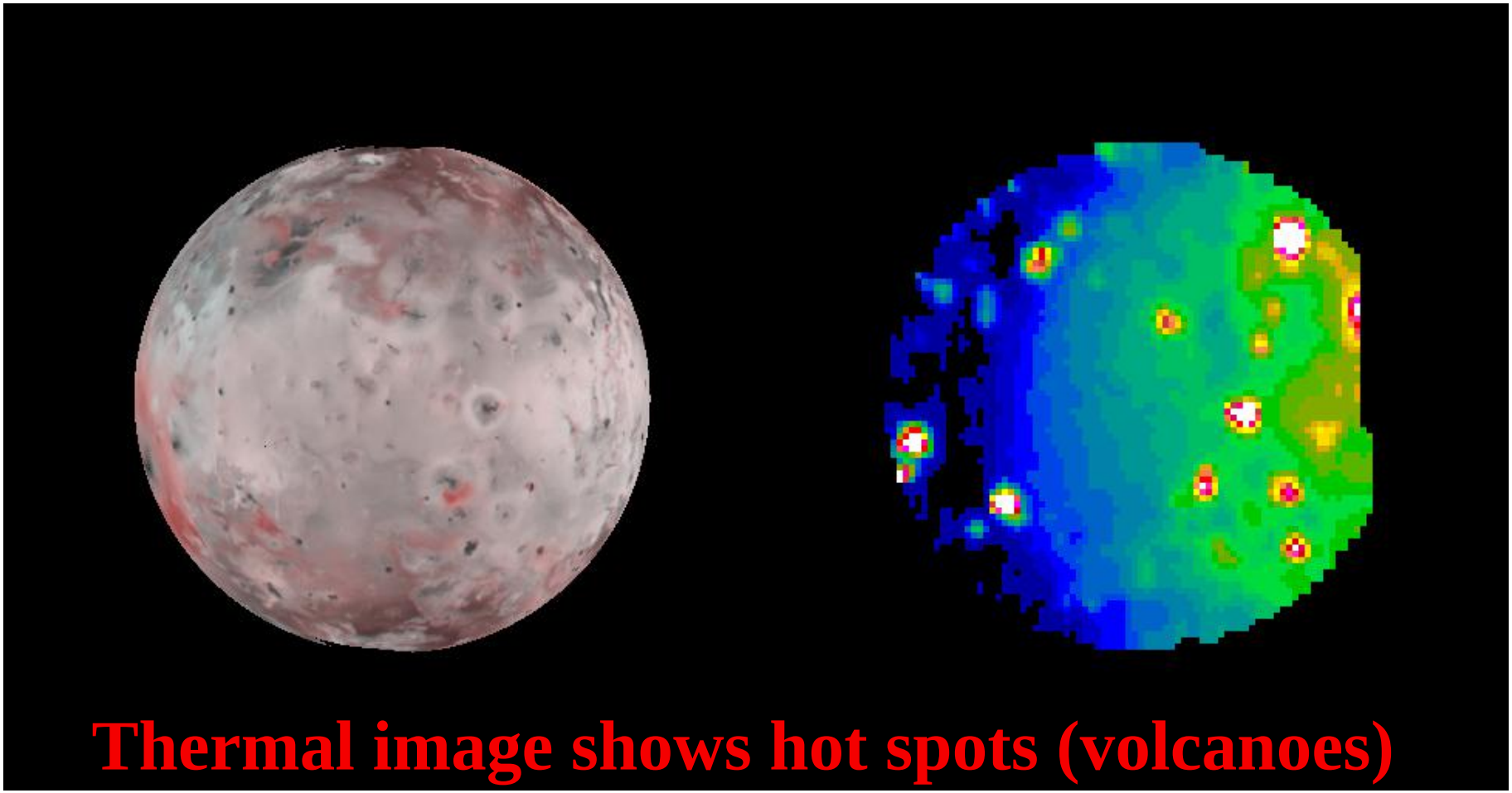
Io: The Most Active Moon

- **Interesting colours due to sulphur compounds ejected from Io's *active* volcanoes.**

Large volcanoes are named after sun and fire gods in various cultures.

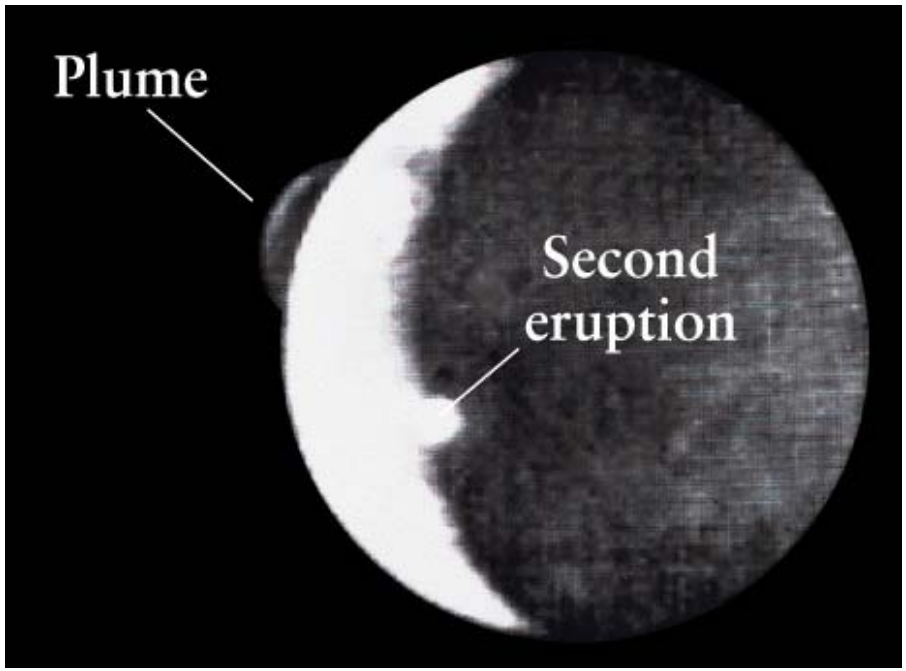


Io: Day and Night!

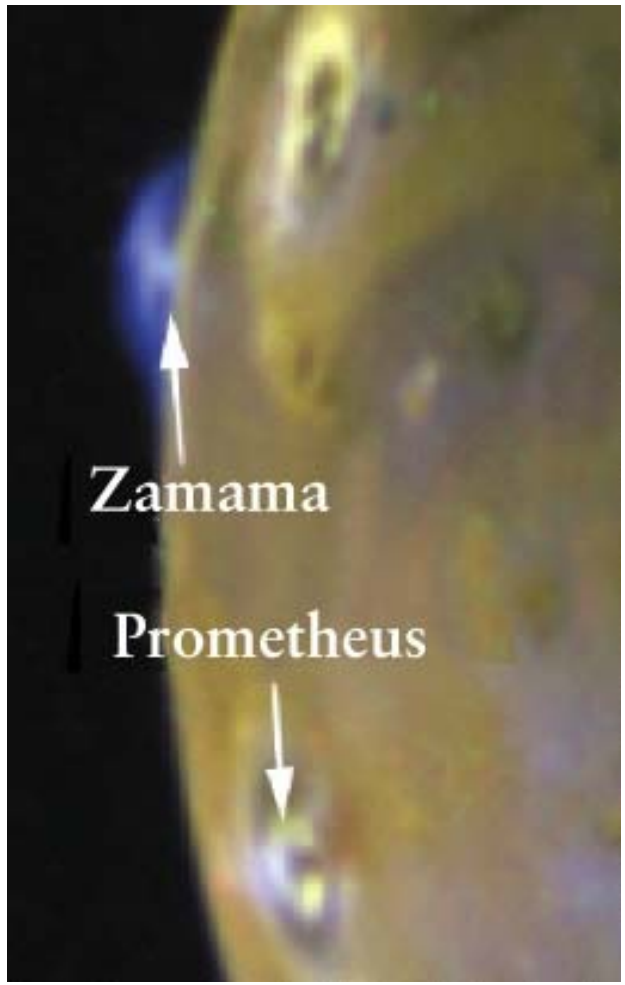


Thermal image shows hot spots (volcanoes) and temperature gradient

Huge Volcano ‘Plumes’

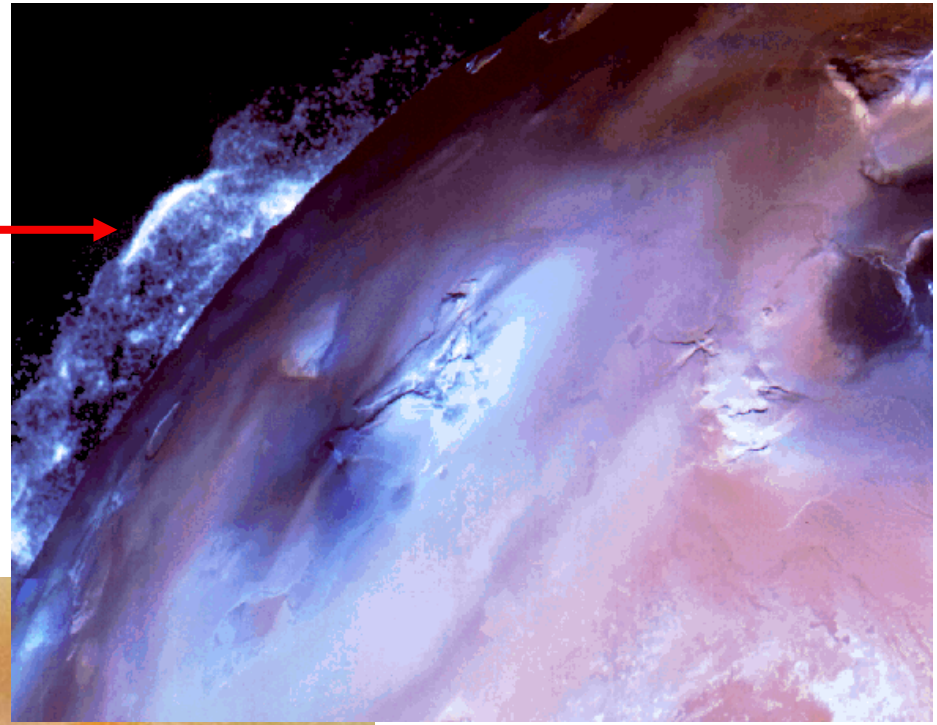


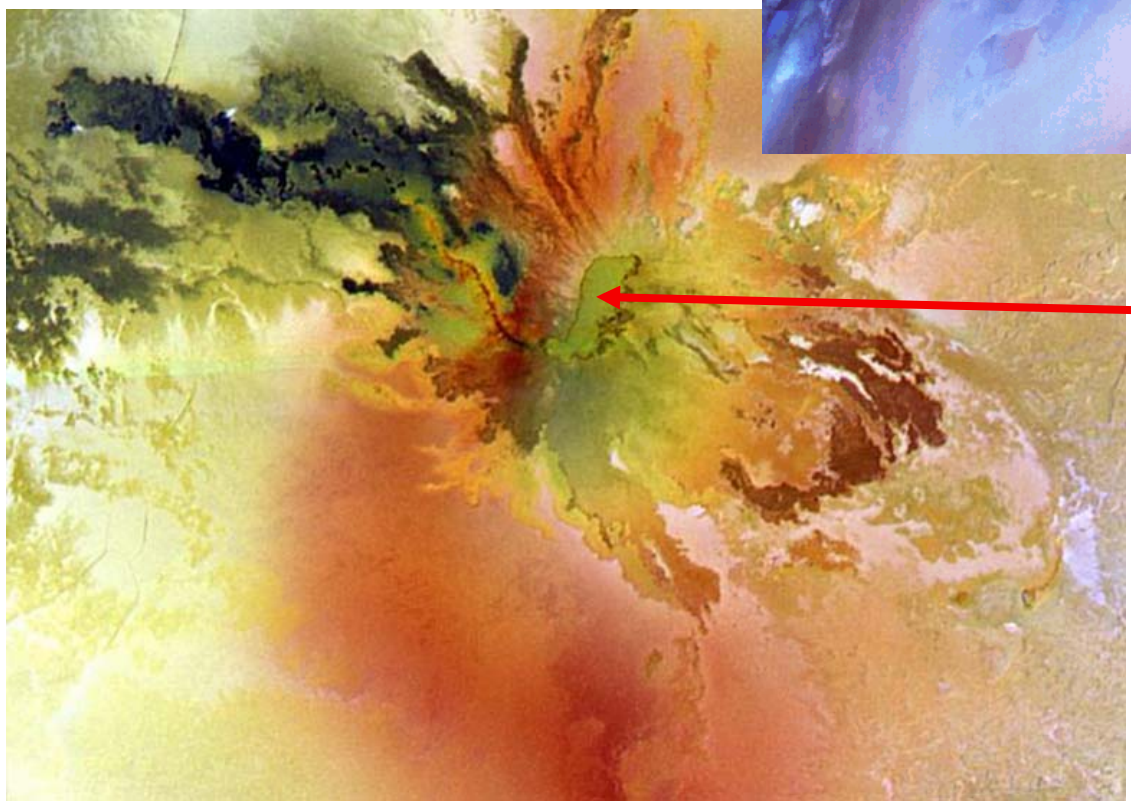
Rising Plume!



- ***Above*: Pele’s Plume rises ~260km *Voyager 1***
- ***Right*: Plumes rise 100km, 250km wide *Galileo***

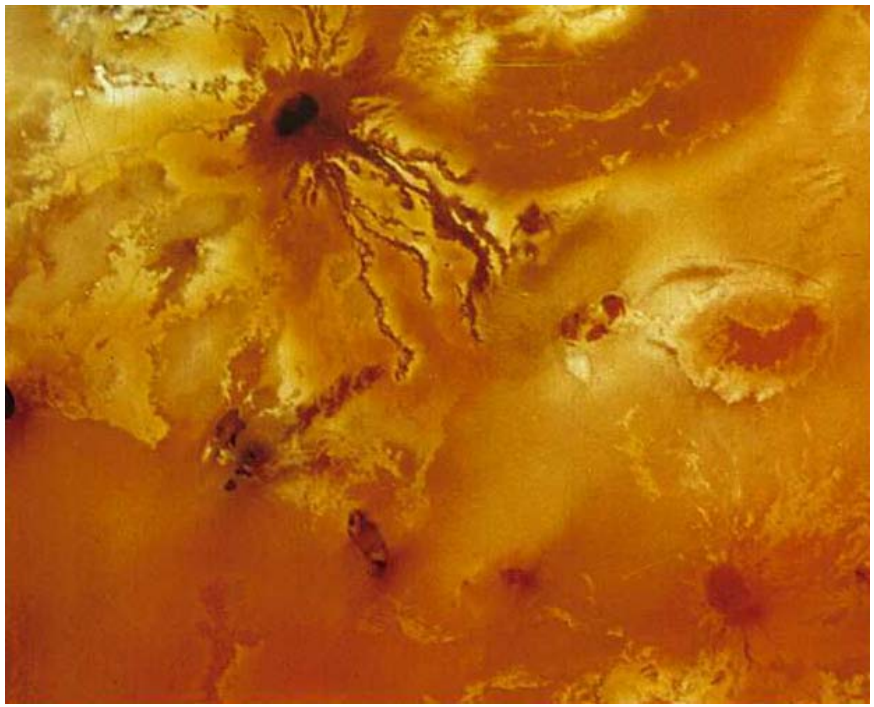
A Volcanic Plume on Io

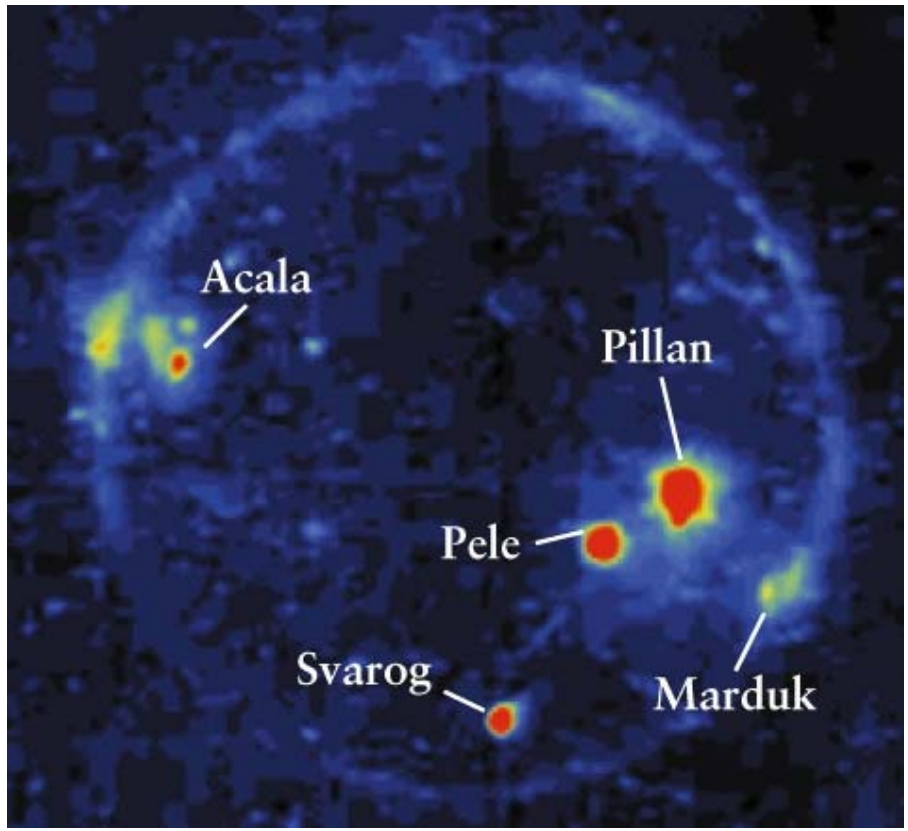




Lava river and lake

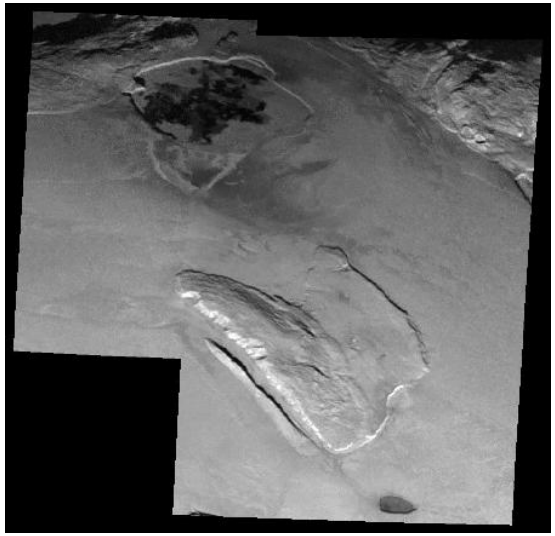
Closer Views



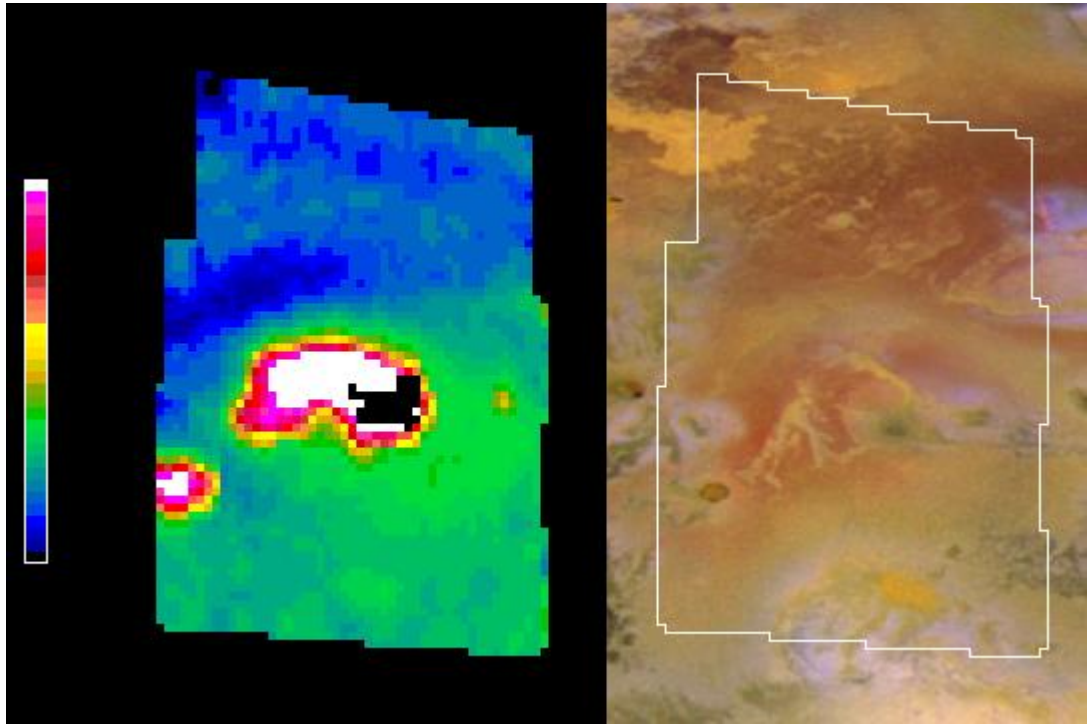


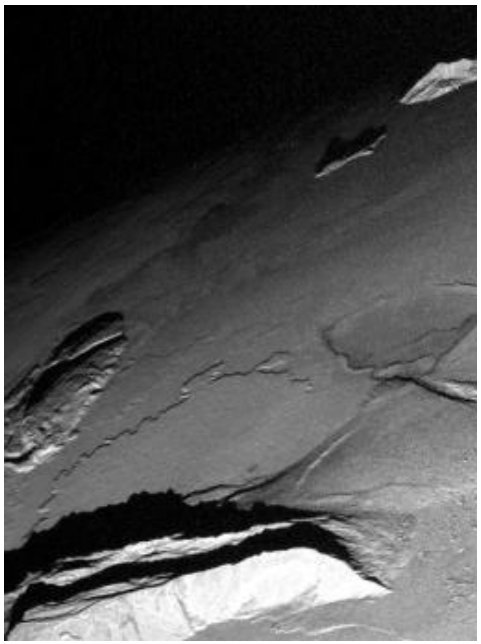
- ***Left*** **: Lava rivers fill in any cracks!**
- ***Right*****: *Infra-red* view of hot volcanoes!**

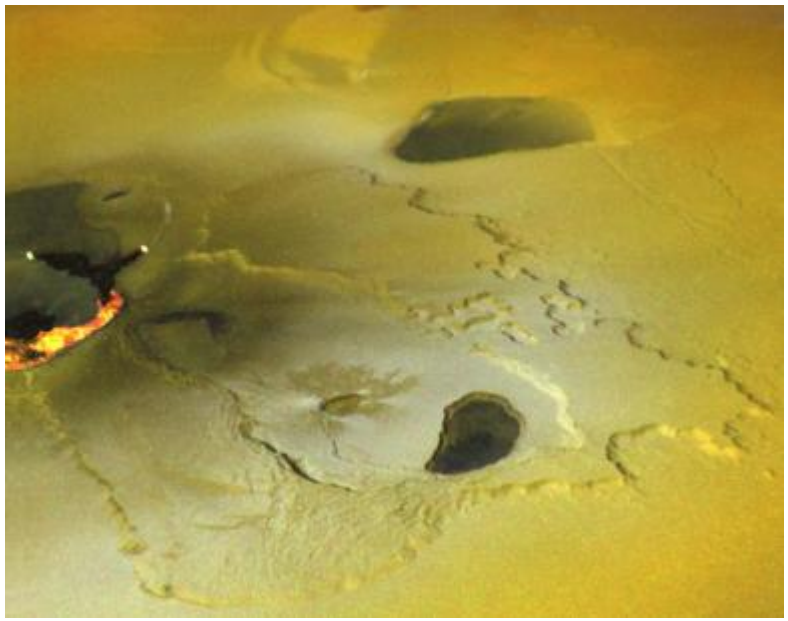
Temperatures ~1450-1750C – *Sulphur vaporises!*



Mountains on Io





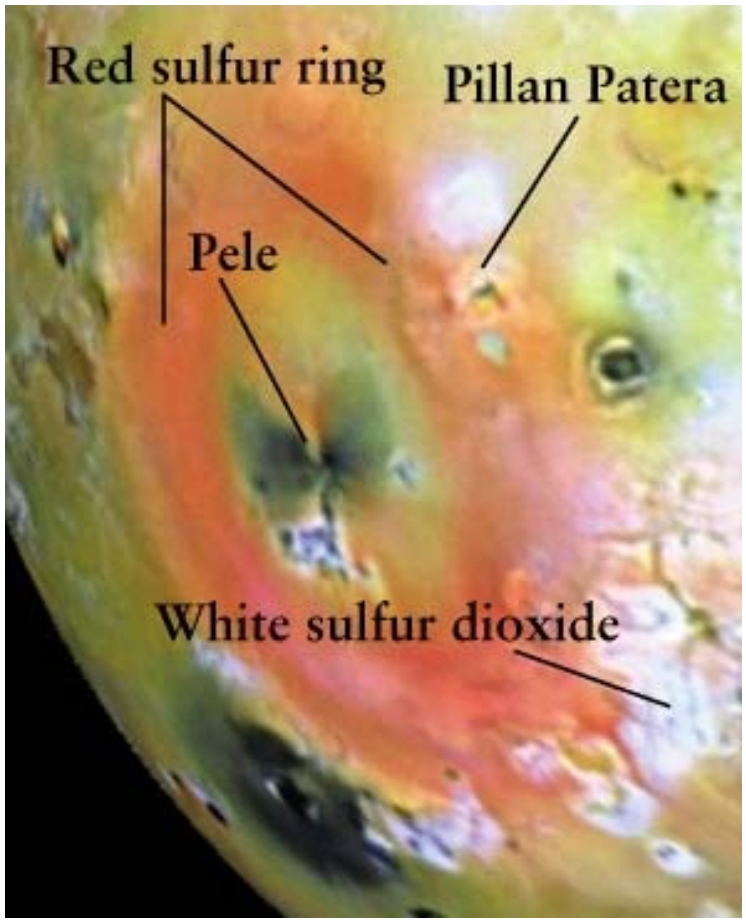


Thermal and visible images of new volcano.

(Above)

Lava Flow

Rapidly Changing Moon



April 1997 and few months later

SO_2 is white snow!

Galileo

- **New grey deposits ~ 400km from *Pillan Patera***

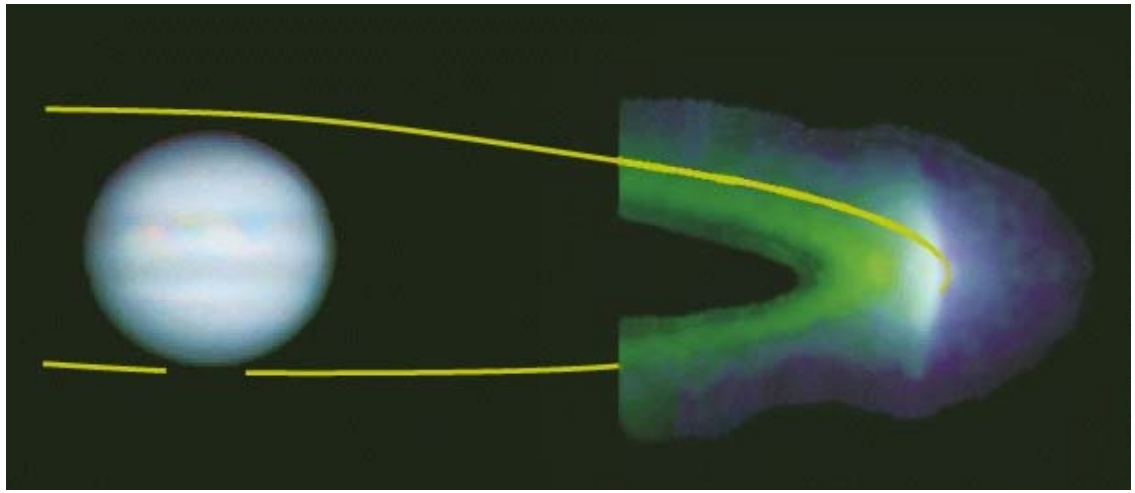
Why so Active?

- **Strong gravitational (tidal) forces on inner Moon – *major stresses***
- **All Galilean Moons have near 1:1 synchronism (*i.e.: All have same face to planet.*)**
- **But not quite! *They wobble or 'rock' a bit***

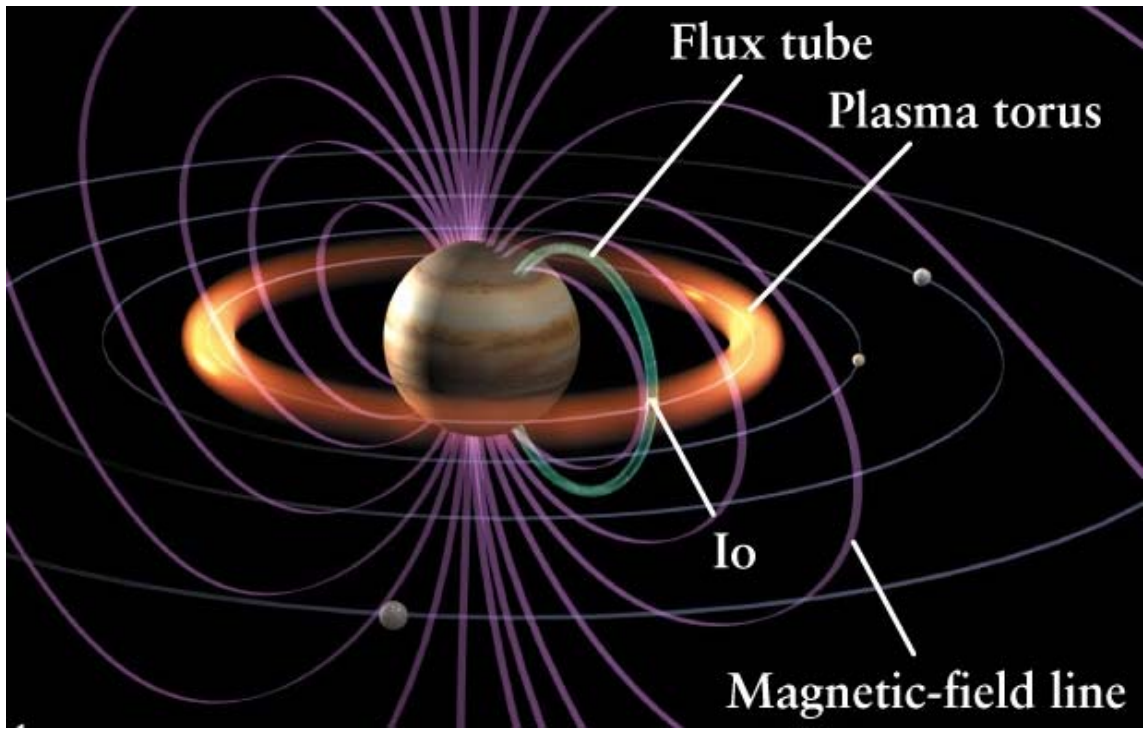
  Due to gravitational interactions with *each other*.
- **Hence tidal forces flex Io's interior**

Without Jupiter nearby, no such activity!

Io's Plasma Torus



- *Green* 'cold' ions 10,000K
- Purple 'hot' ions ~600,000K
- Ring of ionised (Na and S) volcanic gases trapped by Jupiter's magnetic field!

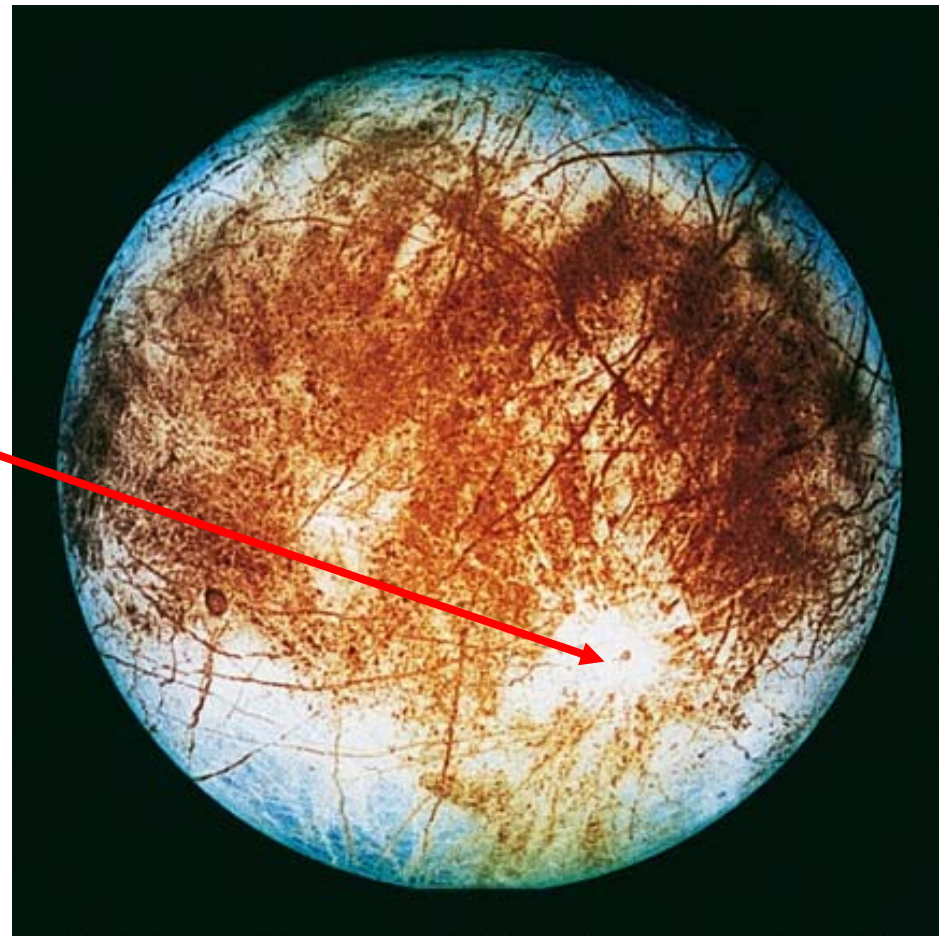


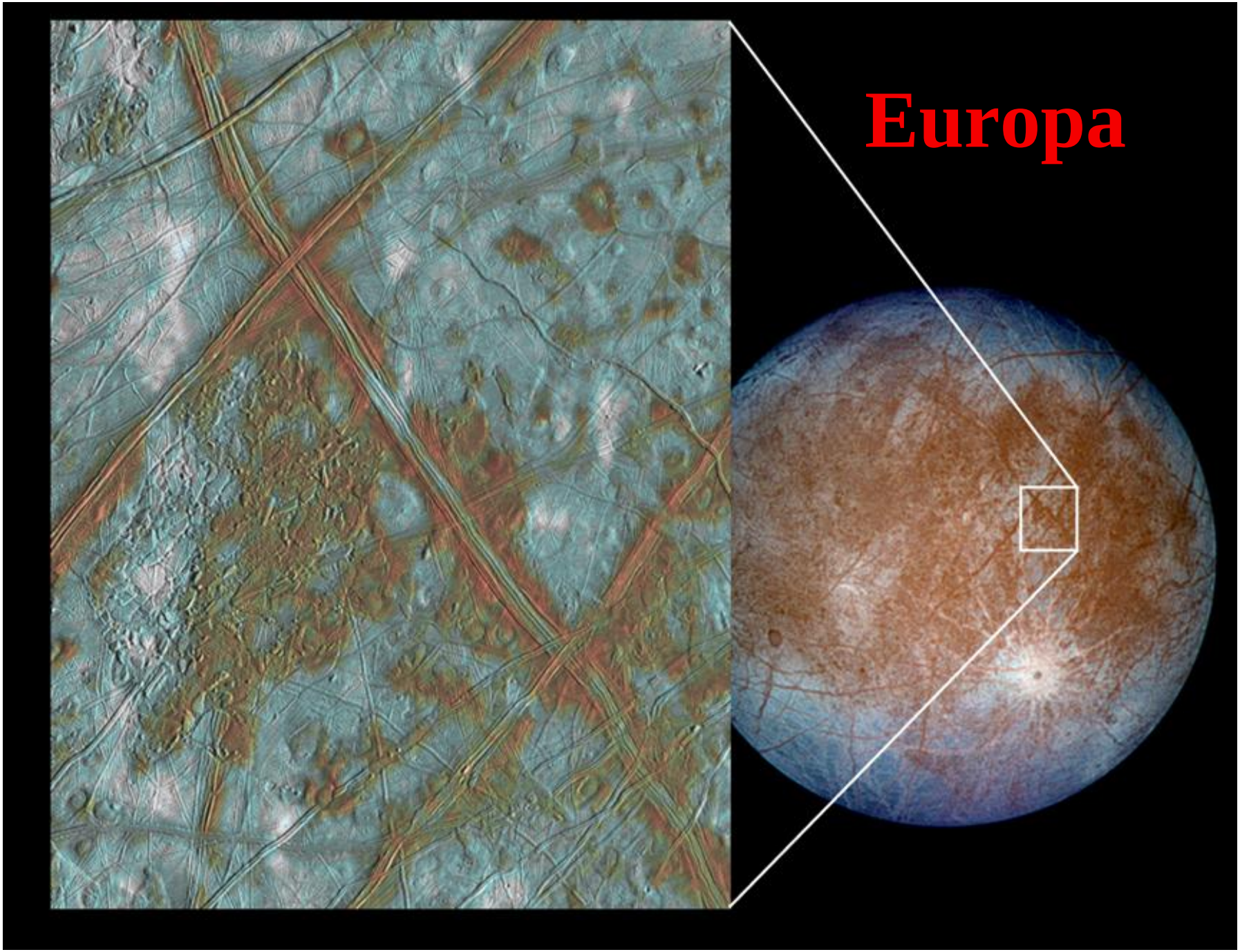
The Next Moon: Europa

- **‘Smoothest’ body in Solar system!**
- **Hills only ~100m high**
- **Few craters…**

  Young surface of Ice!
- **Network of cracks and stripes**

Visible and IR image

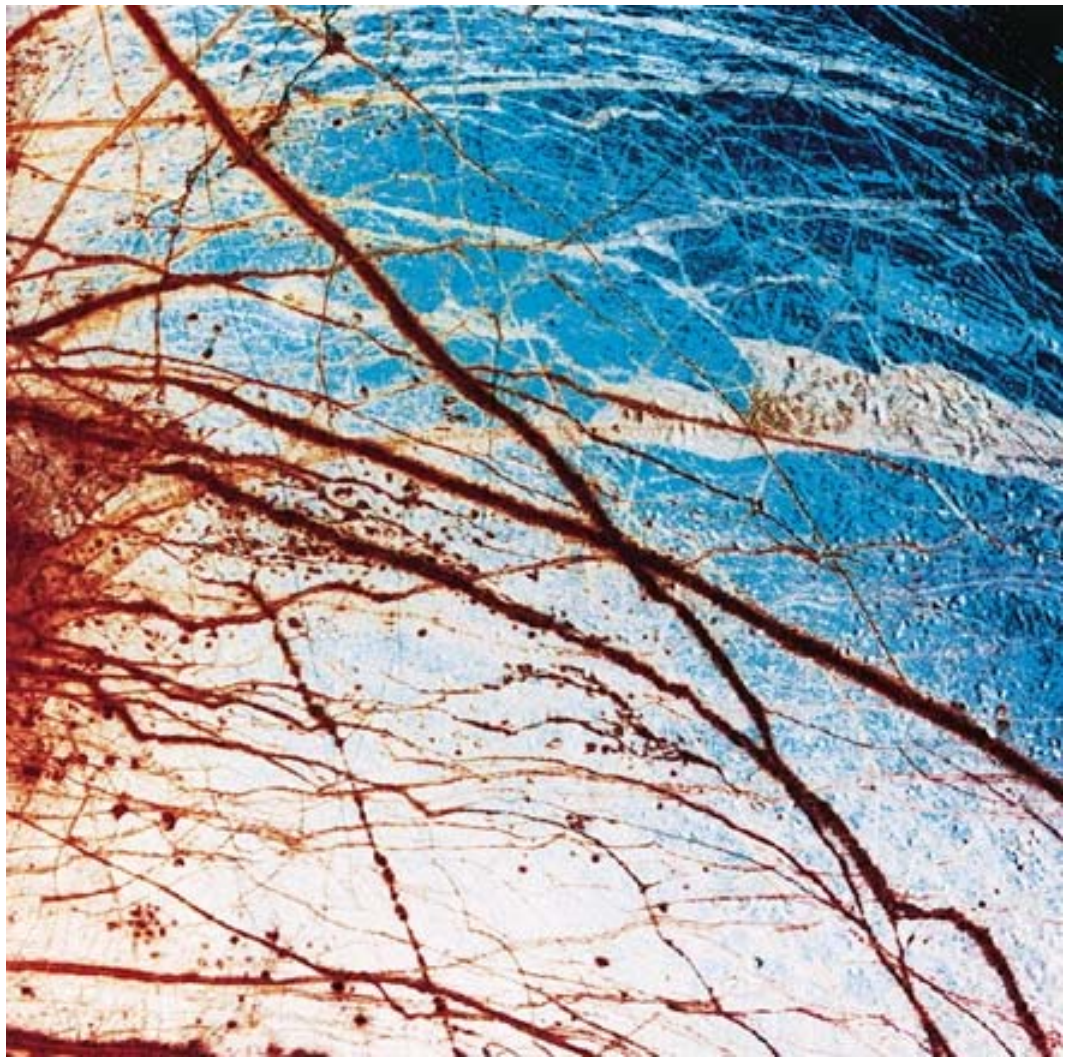



Europa

Fractures in Europa's Crust

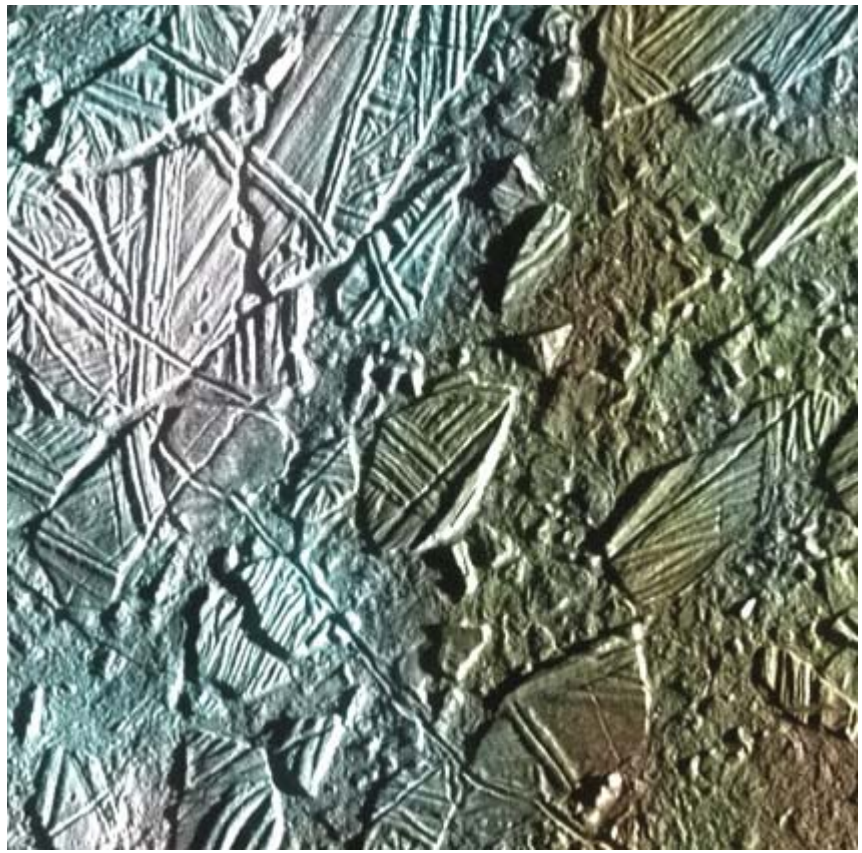
- **False colour IR / Visible image**
- **Blue ice plains**
- **Red fractures indicate presence of minerals in the ice.**

Area ~1260 *x* 1260km



Ocean of Liquid / Slushy Water

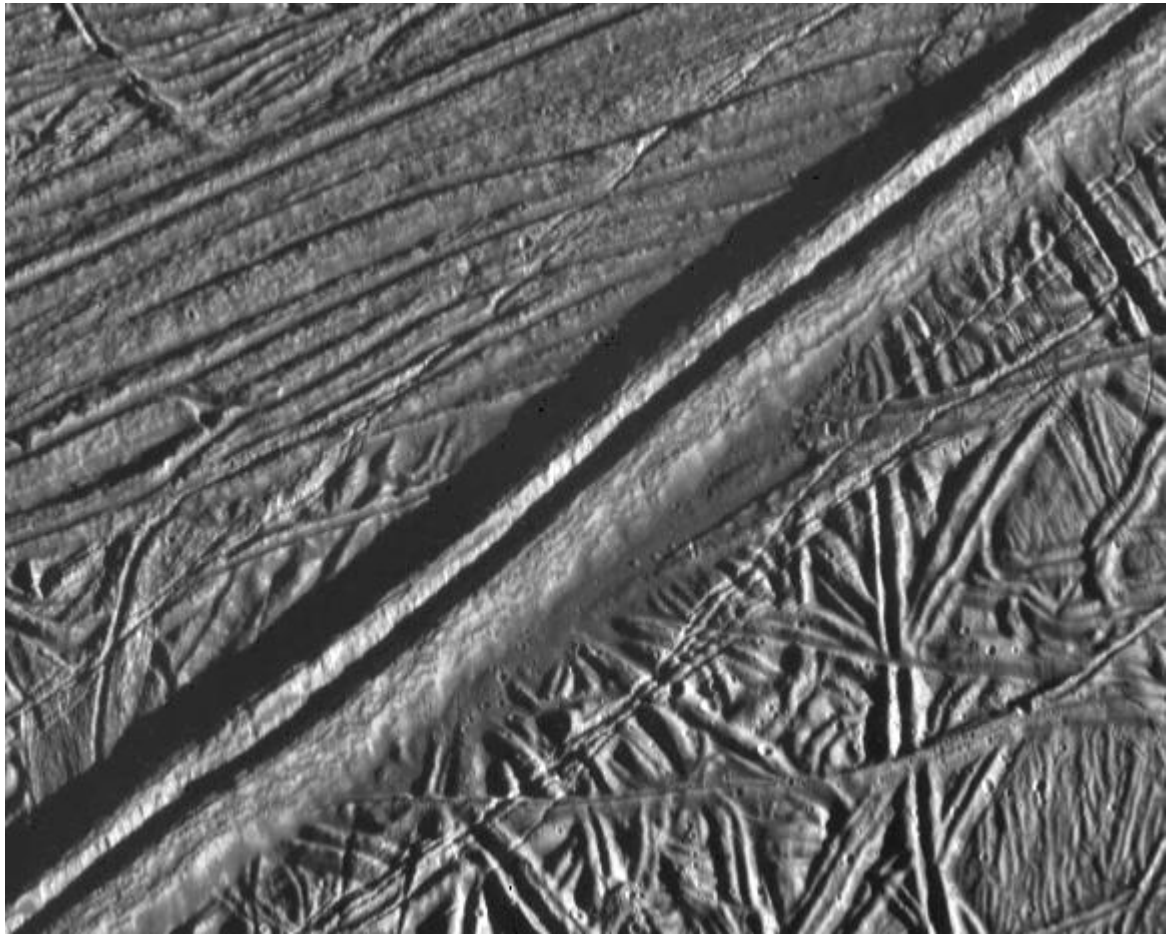
- ***Frozen surface*** **due to being so far from Sun.**
- **Cracks due to gravitational (tidal) pull from Jupiter and other Moons.**
- **~km deep ice rafts / bergs over ~100km deep ocean.**



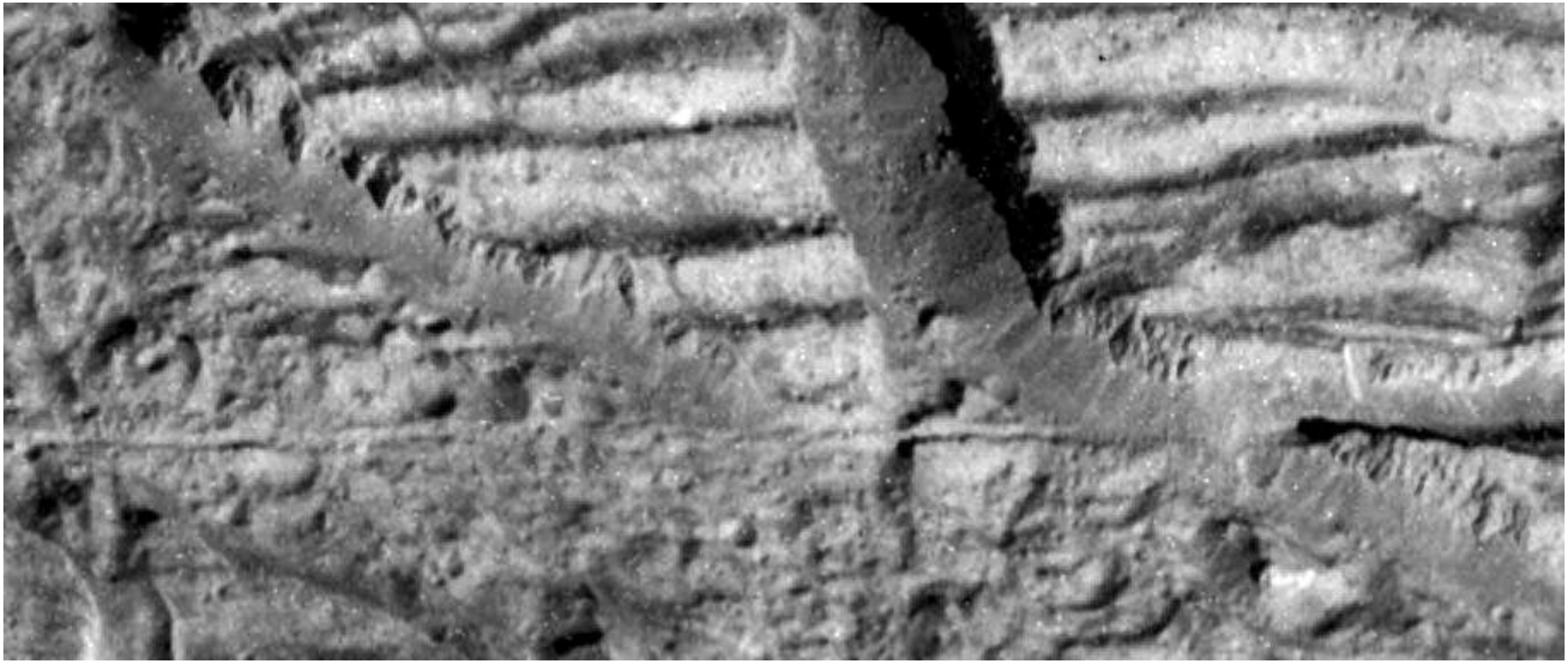
Colours are mineral contaminants.

Europa Surface Detail

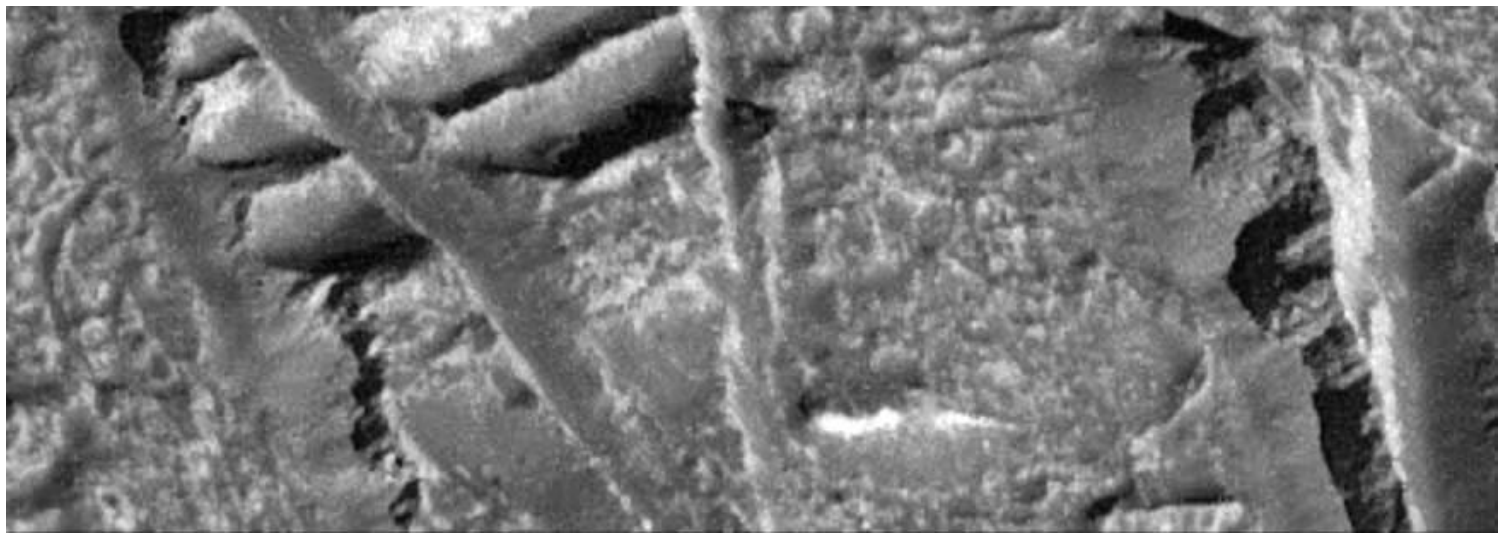
Pulled apart terrain with up-welling material filling in the gaps of the separating ice sheets.

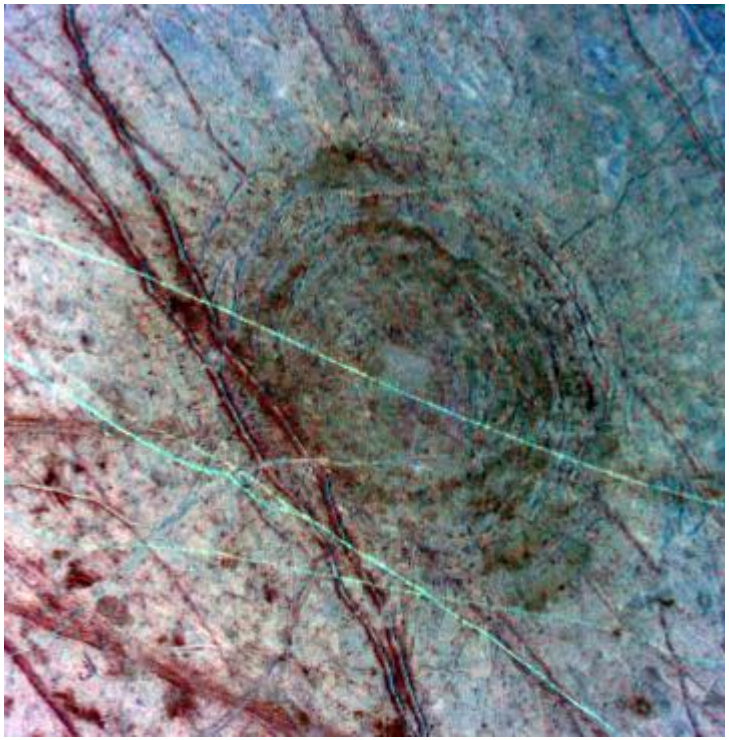


More… Europa Surface Detail



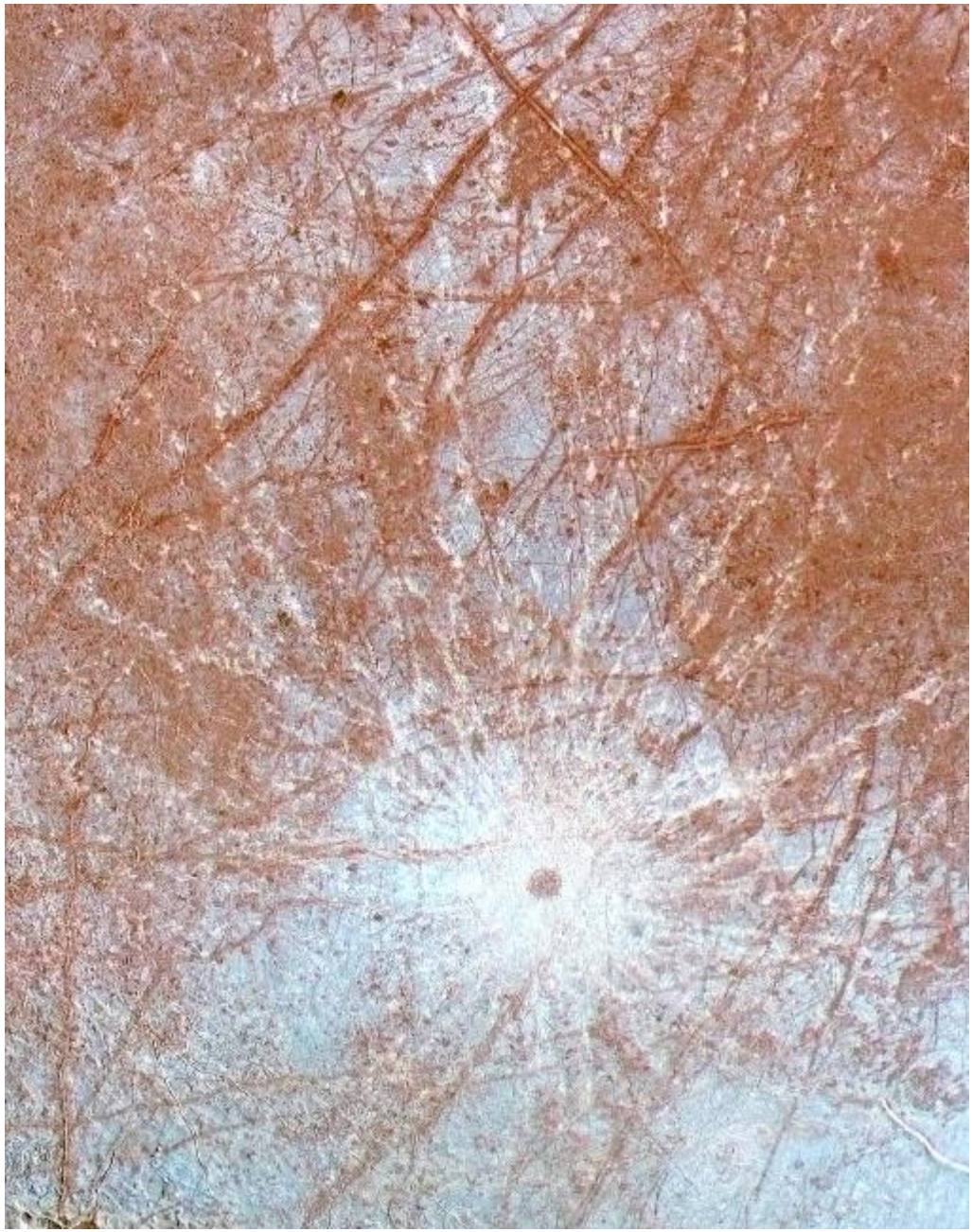
Icy ‘Cliffs’





Old Impact site (above)

Pwyll Crater (right)



Europa's Mysteries….

- **Weak variable magnetic field.**

  …Induced by induced currents in 'salty' water from motion in Jupiter's magnetosphere.

- **Very tenuous oxygen atmosphere!**

  …Photodissociation of H_20 vapour, H escapes to space.

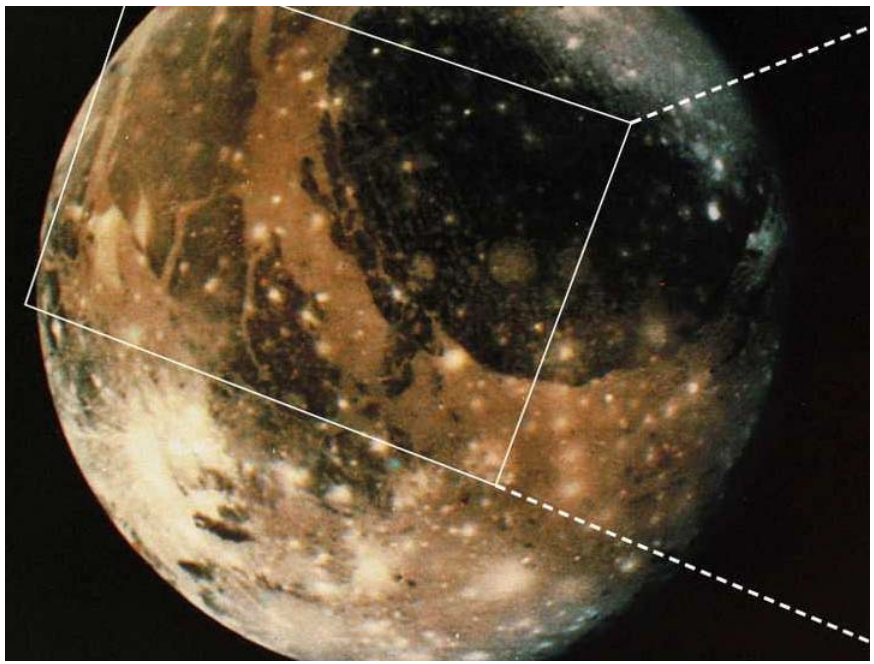
- **Life in water? ……. *future space missions!***

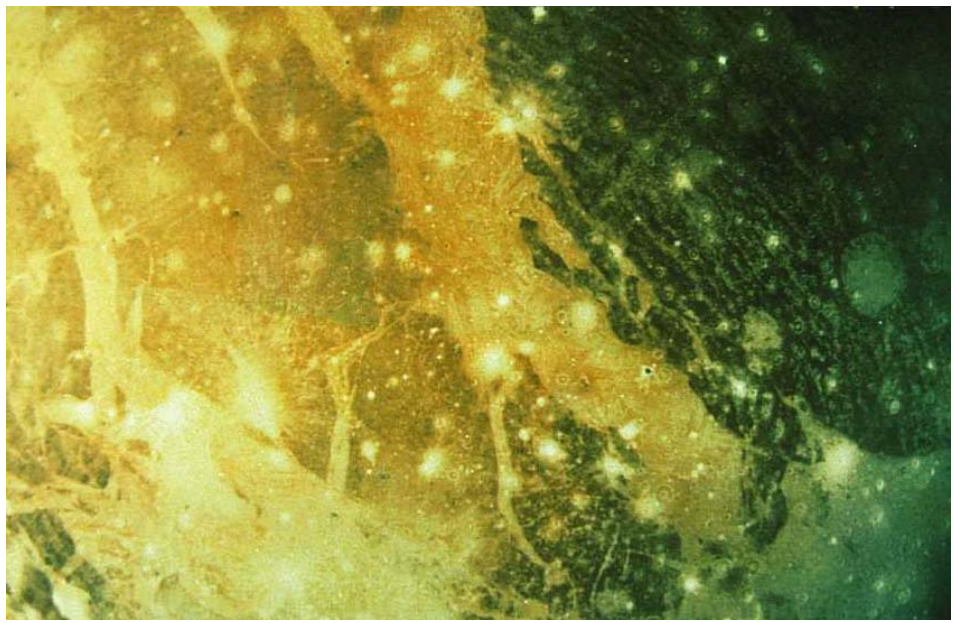
Ganymede

- **Cratered surfaces (unlike Io and Europa) but of *ice* not rock.**
- **Larger than Mercury!**
- **Tenuous atmosphere of O_2 and O_3 *ozone***

Dark and Light Terrain

- **Unlike our Moon, *dark* areas are older – more craters - than *light* regions.**
- **Dark due to micro-meteoritic dust.**





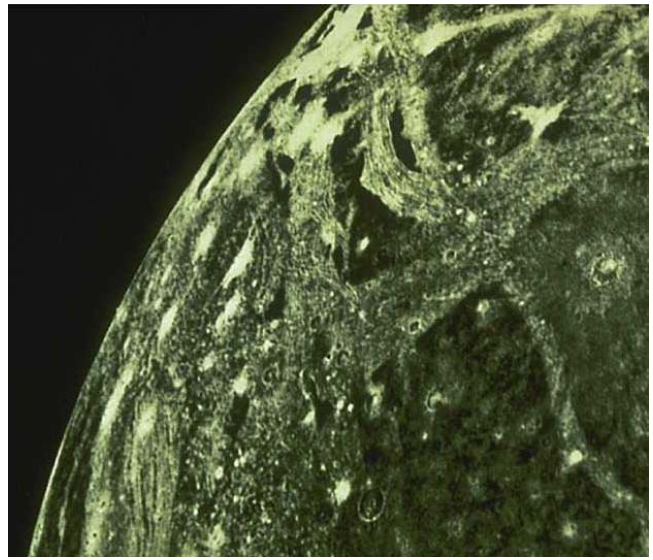
Ganymede

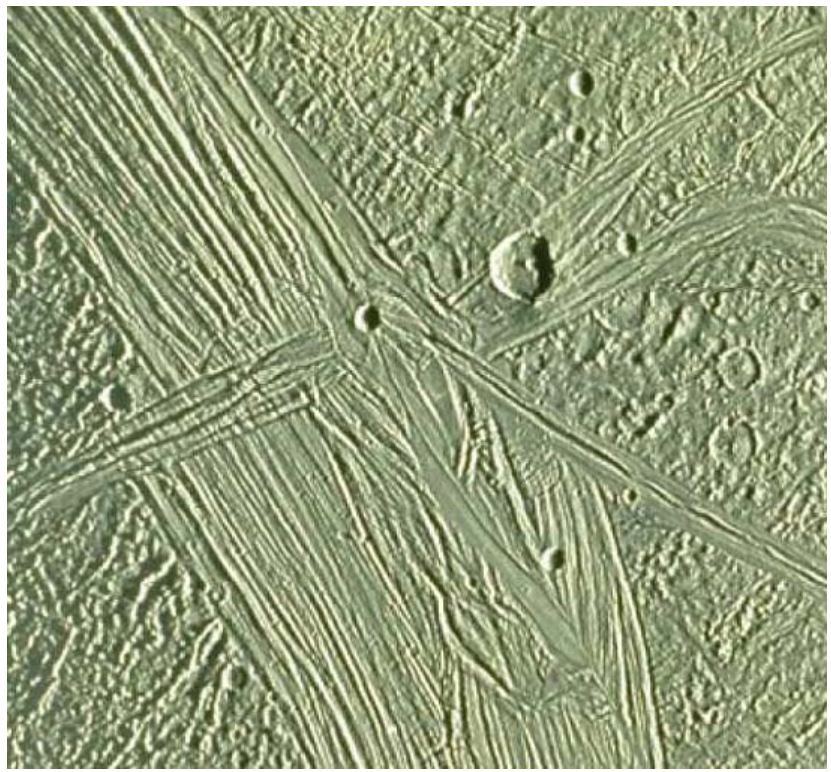
Light recent craters on surface of different colours/ages.

Surface Detail

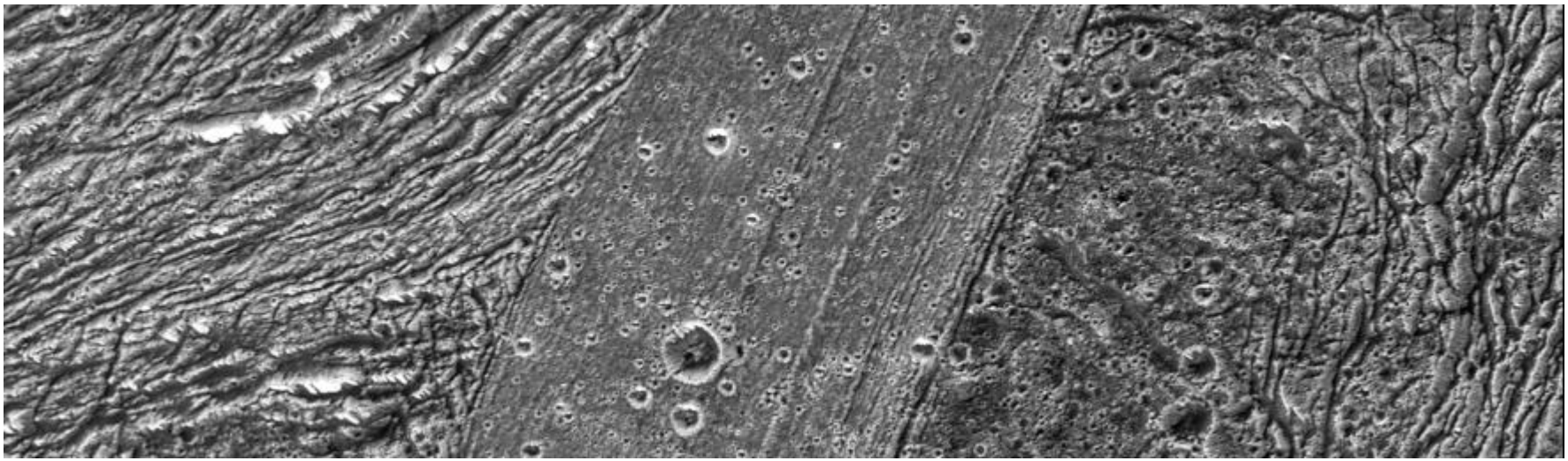
- **Grooved terrain..**
- **Possibly signs of *old plate tectonics.***

  quit 3 billion years ago
- **Despite possibility of radioactive heating, now too cold for activity.**

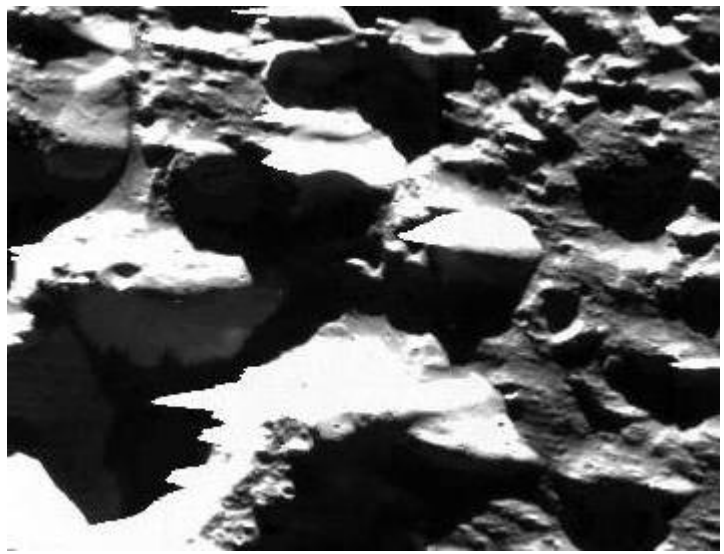




Strange Mixed Terrains – of different ages

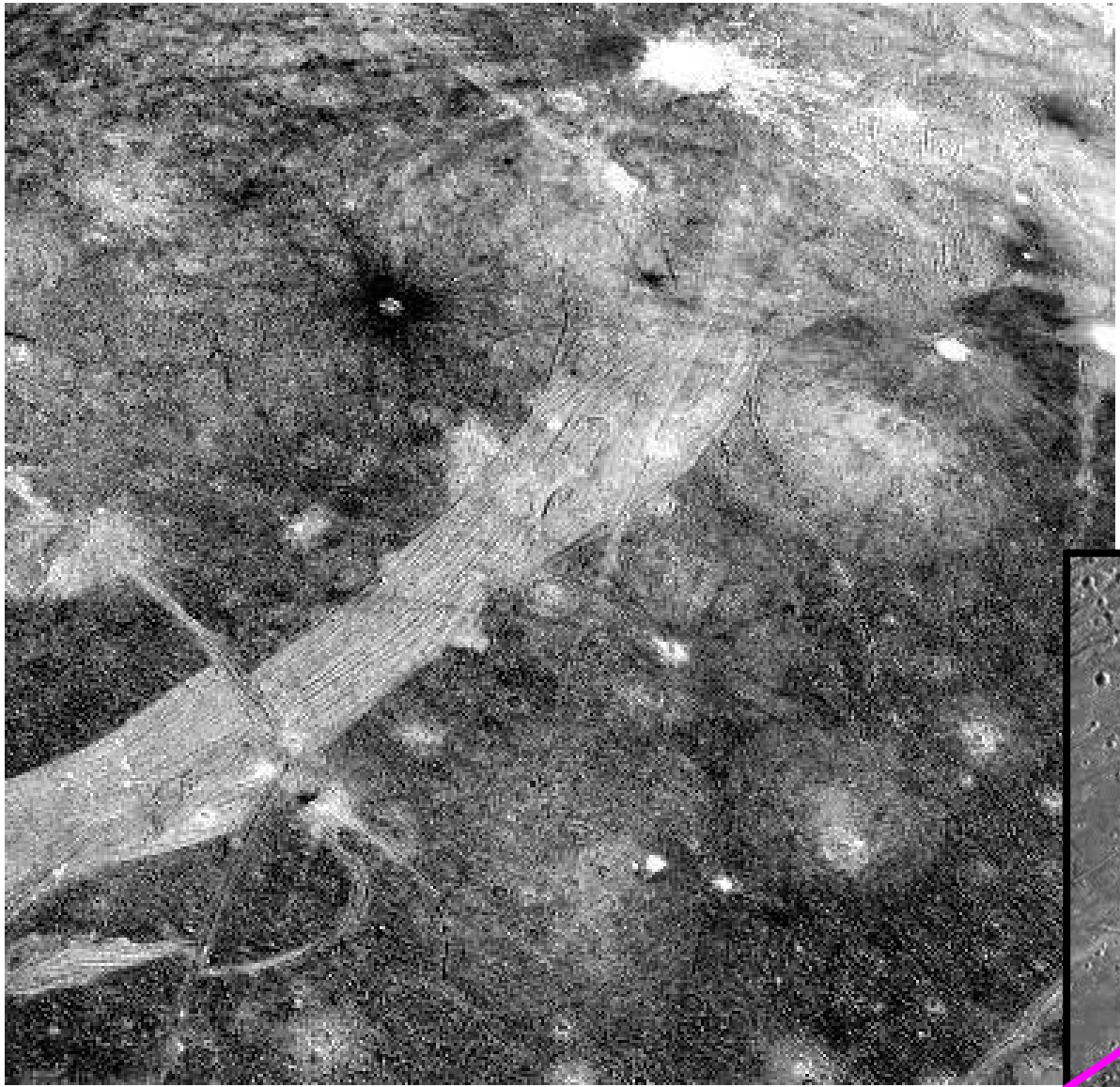


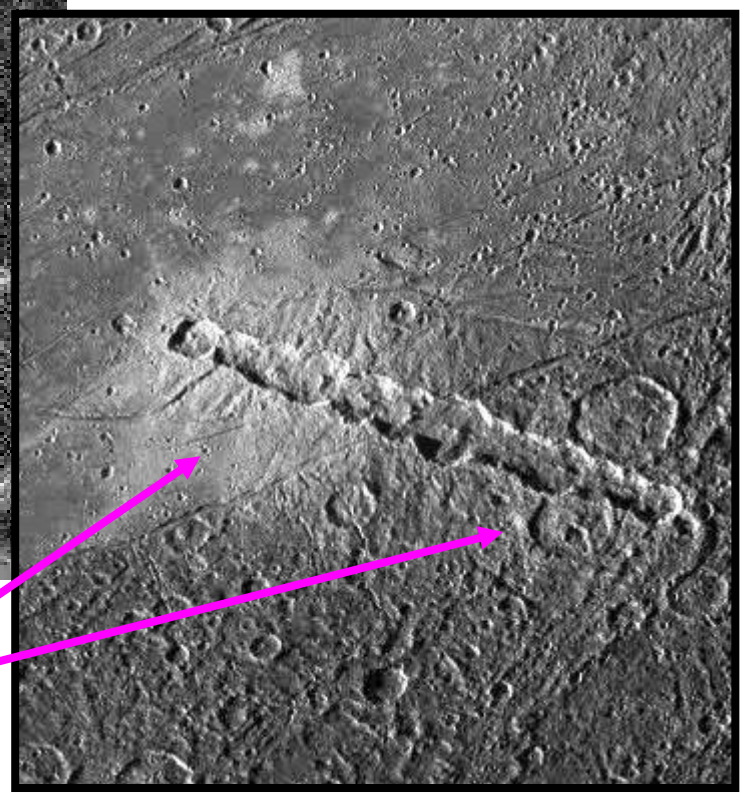
Zoom in at ice cliffs ~15m high!



Ganymede

Surface Detail and Variation

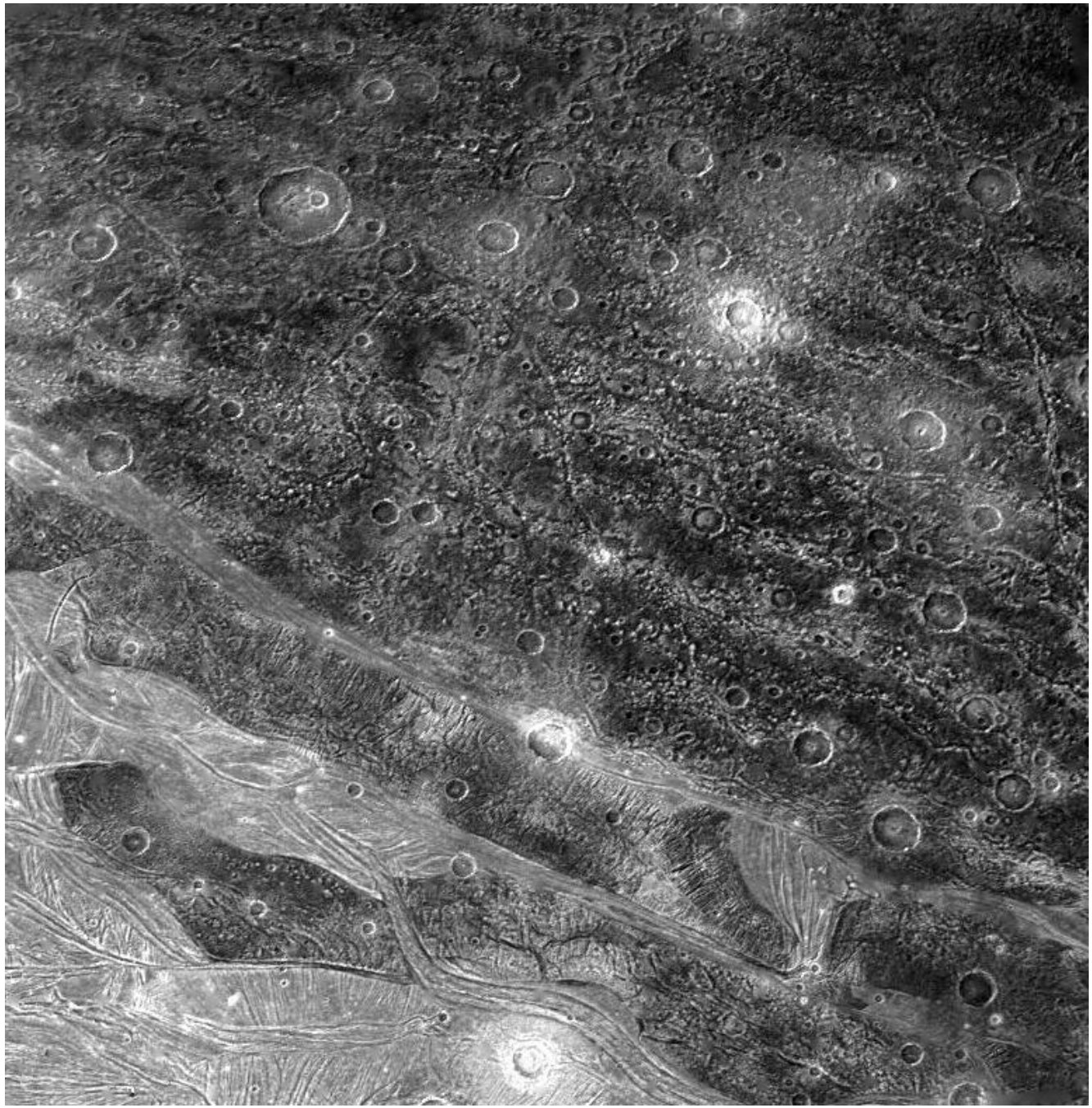




Comet fragments – *strange variation in the ejecta types*

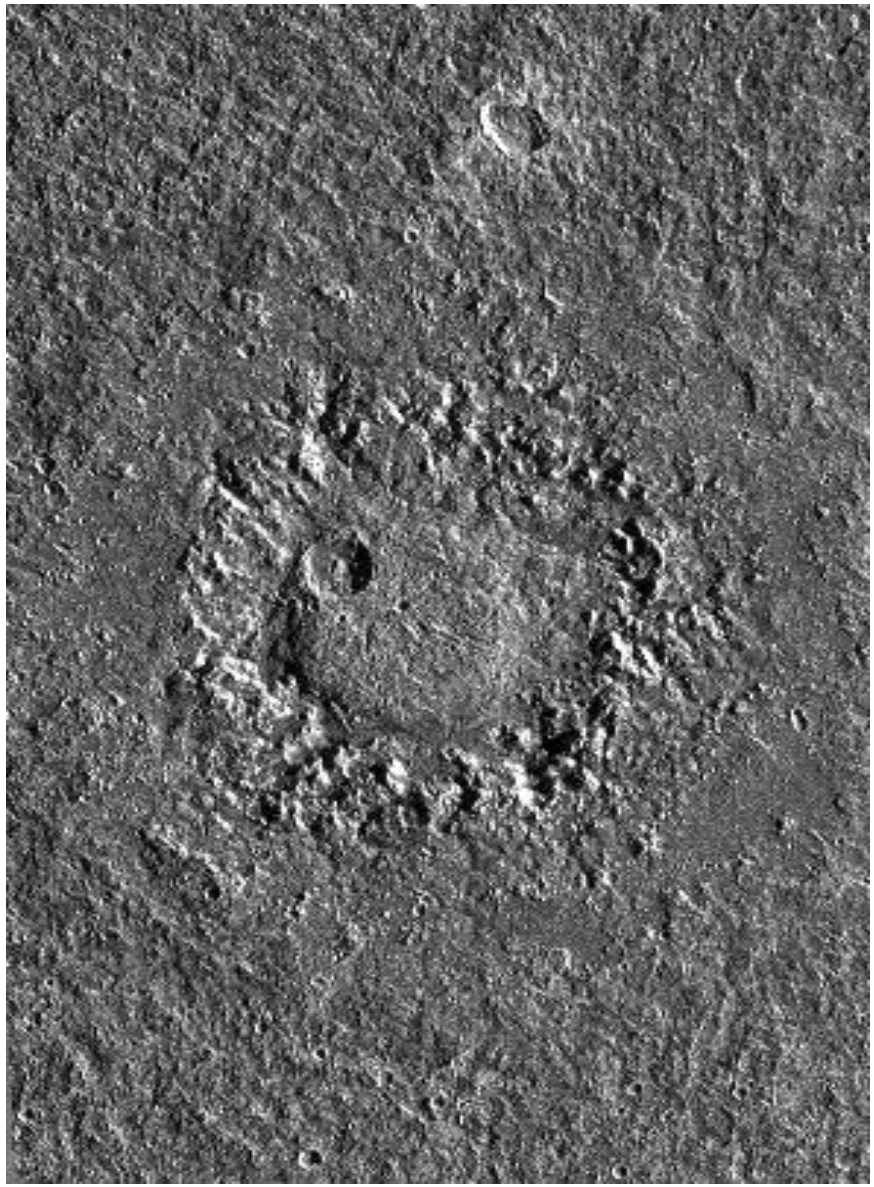
Ganymede

Surface Detail and Variation



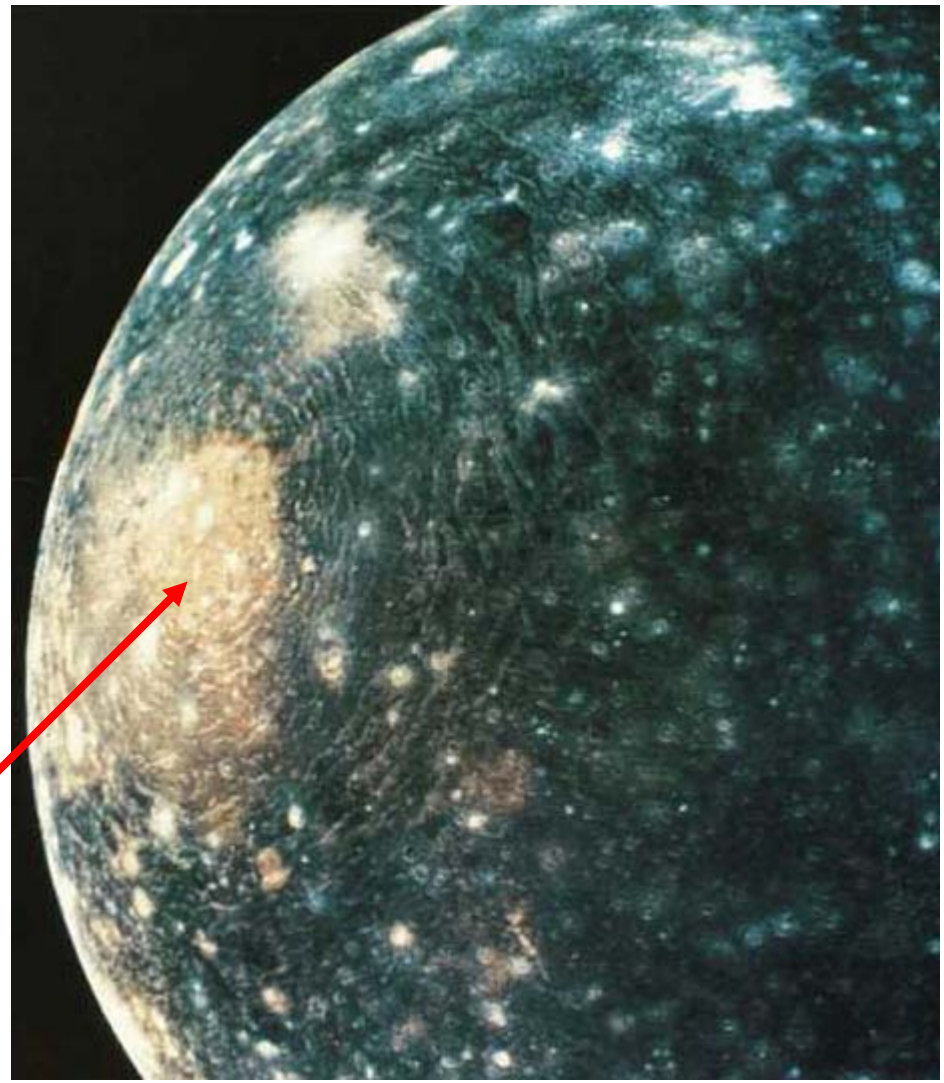
Craters Gula and Achelous

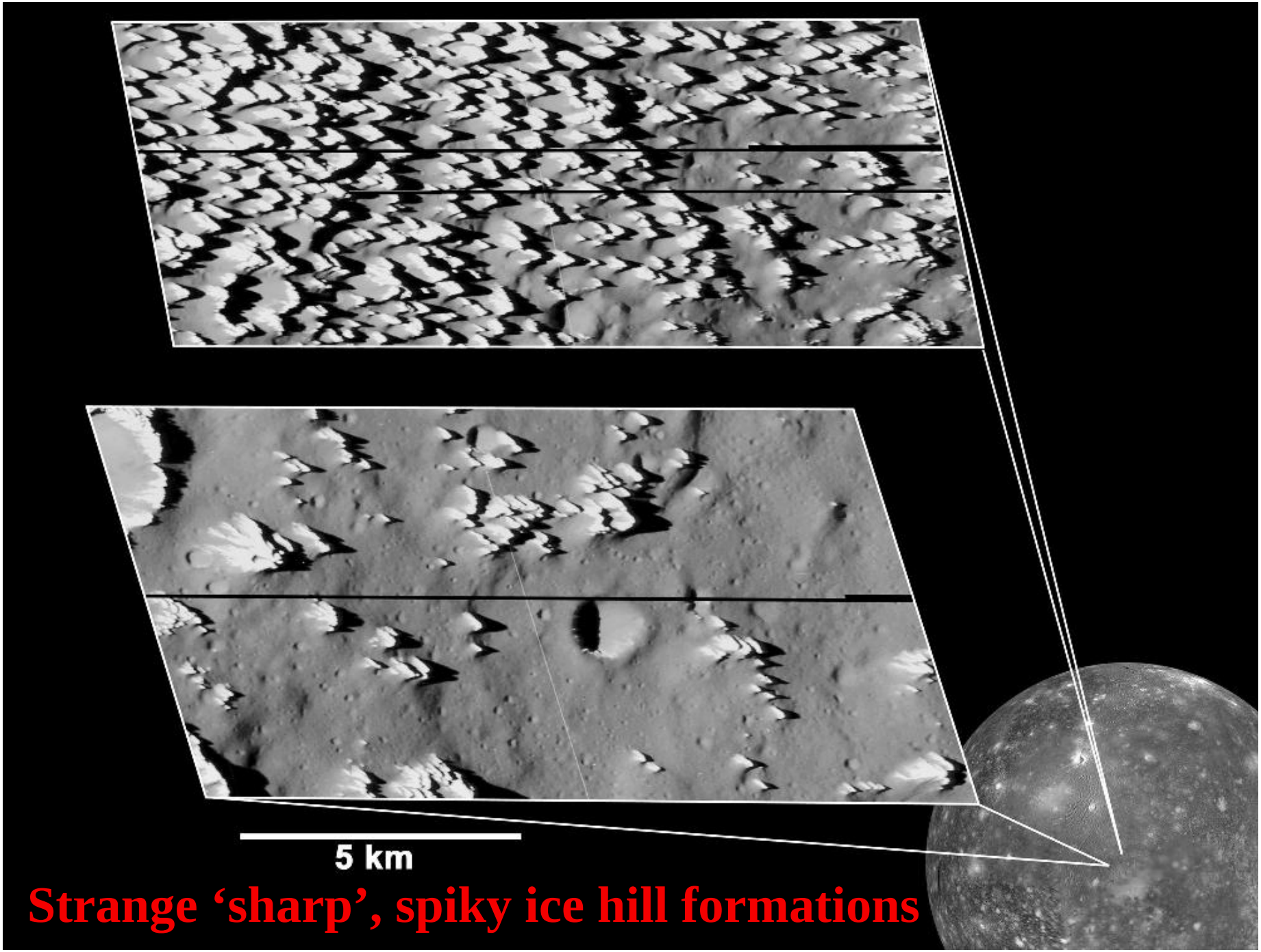
Old Dome Crater



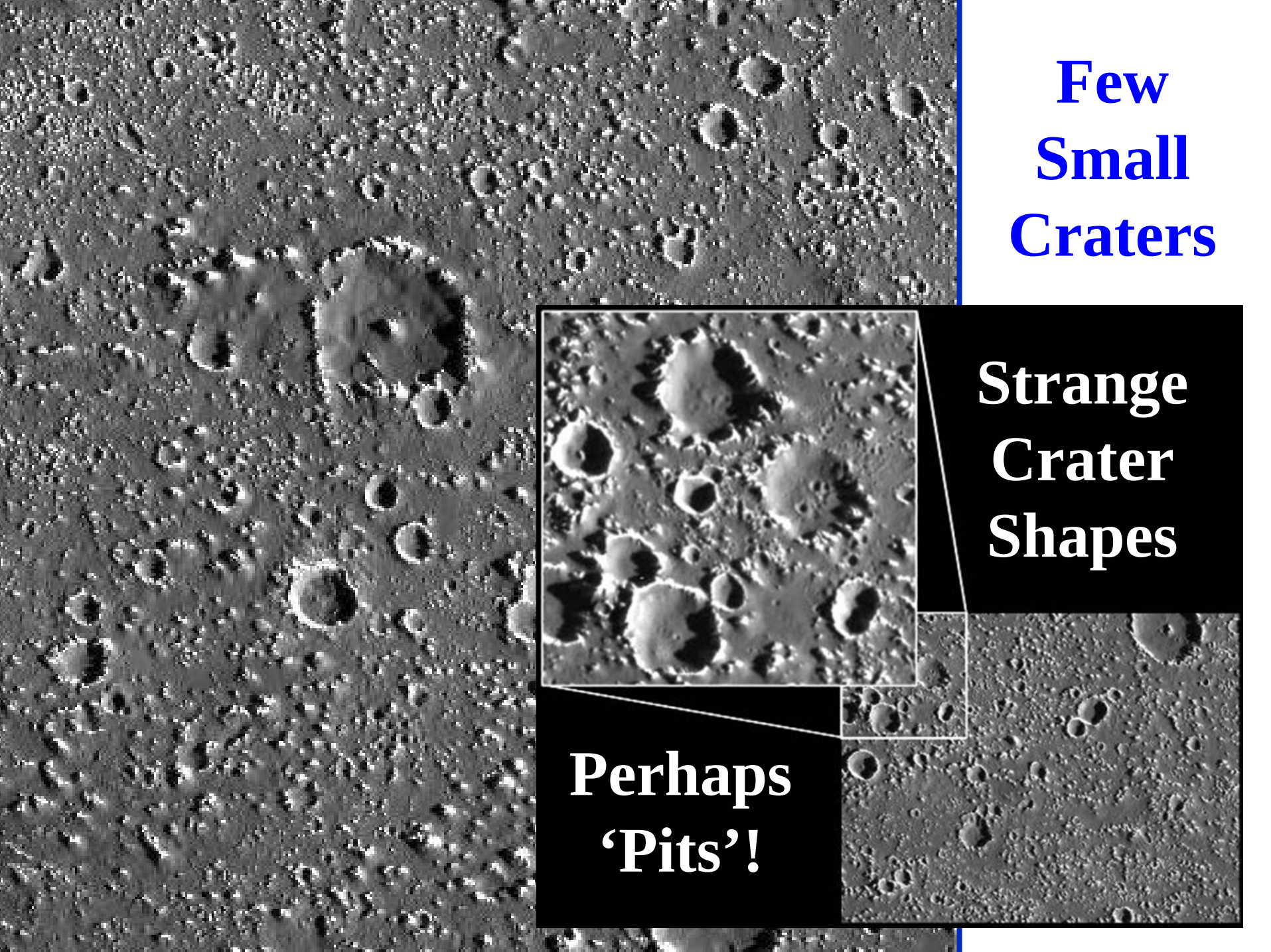
Callisto

- **Similar to Ganymede, but with *more craters* and fewer fault lines.**
- **Concentric frozen ice ridges around large meteor impact sites, such as *Valhalla* ~3000km diameter.**



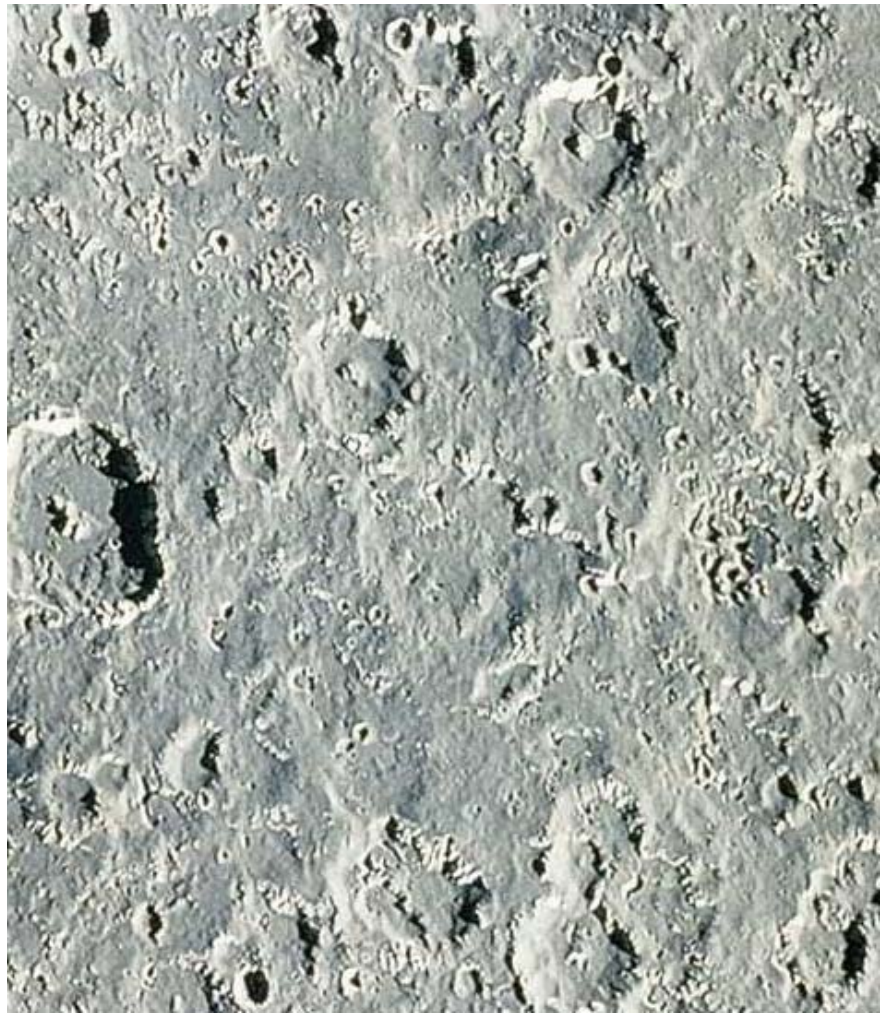


Strange ‘sharp’, spiky ice hill formations


Few
Small
Craters
Strange
Crater
Shapes
Perhaps
‘Pits’!

Surprising differences with Ganymede

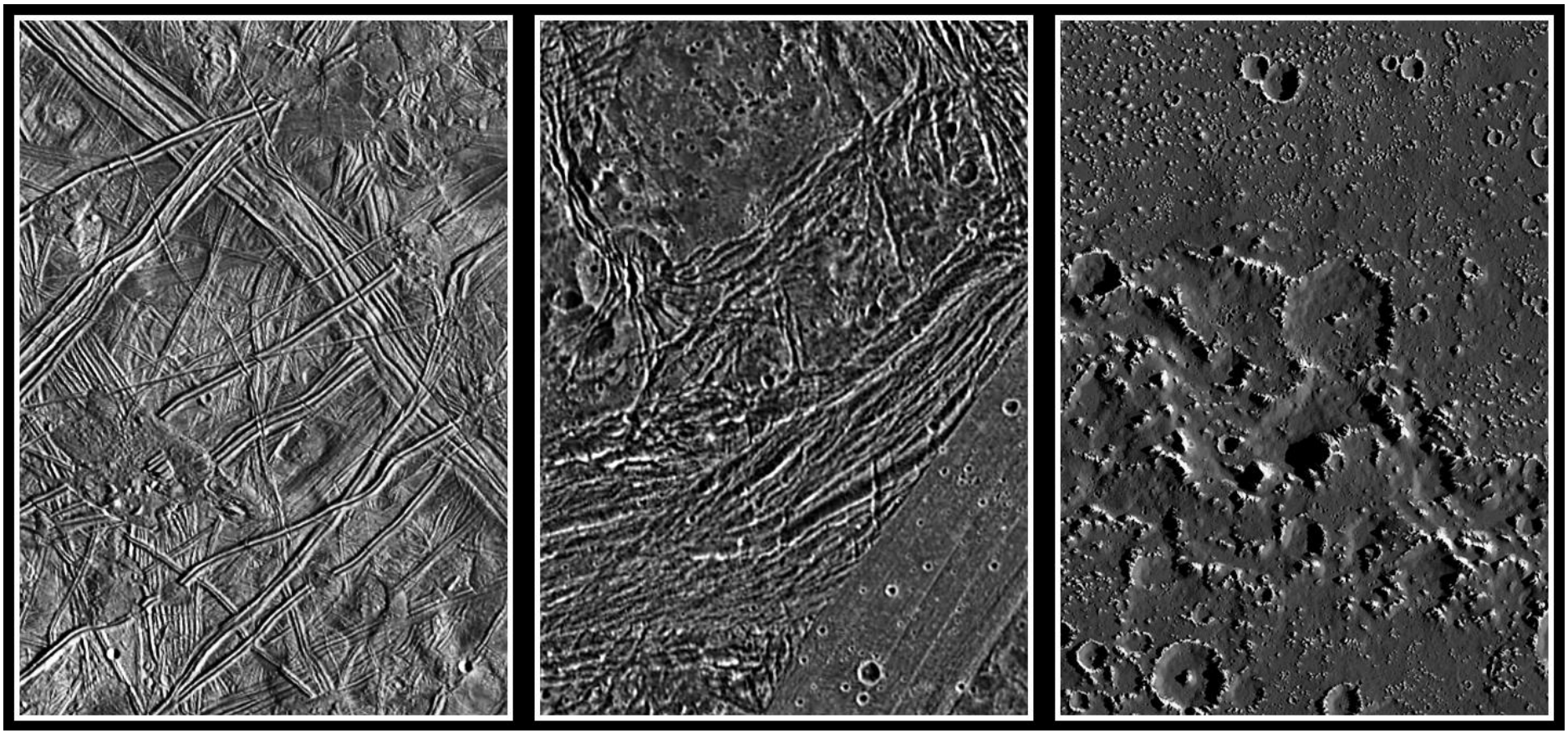
- **Heavier Cratering**
- **Weak CO_2 Atmosphere**
- **Under surface ocean ~10km deep, possibly with *ammonia* as anti-freeze!**
- ***Many unanswered questions…***



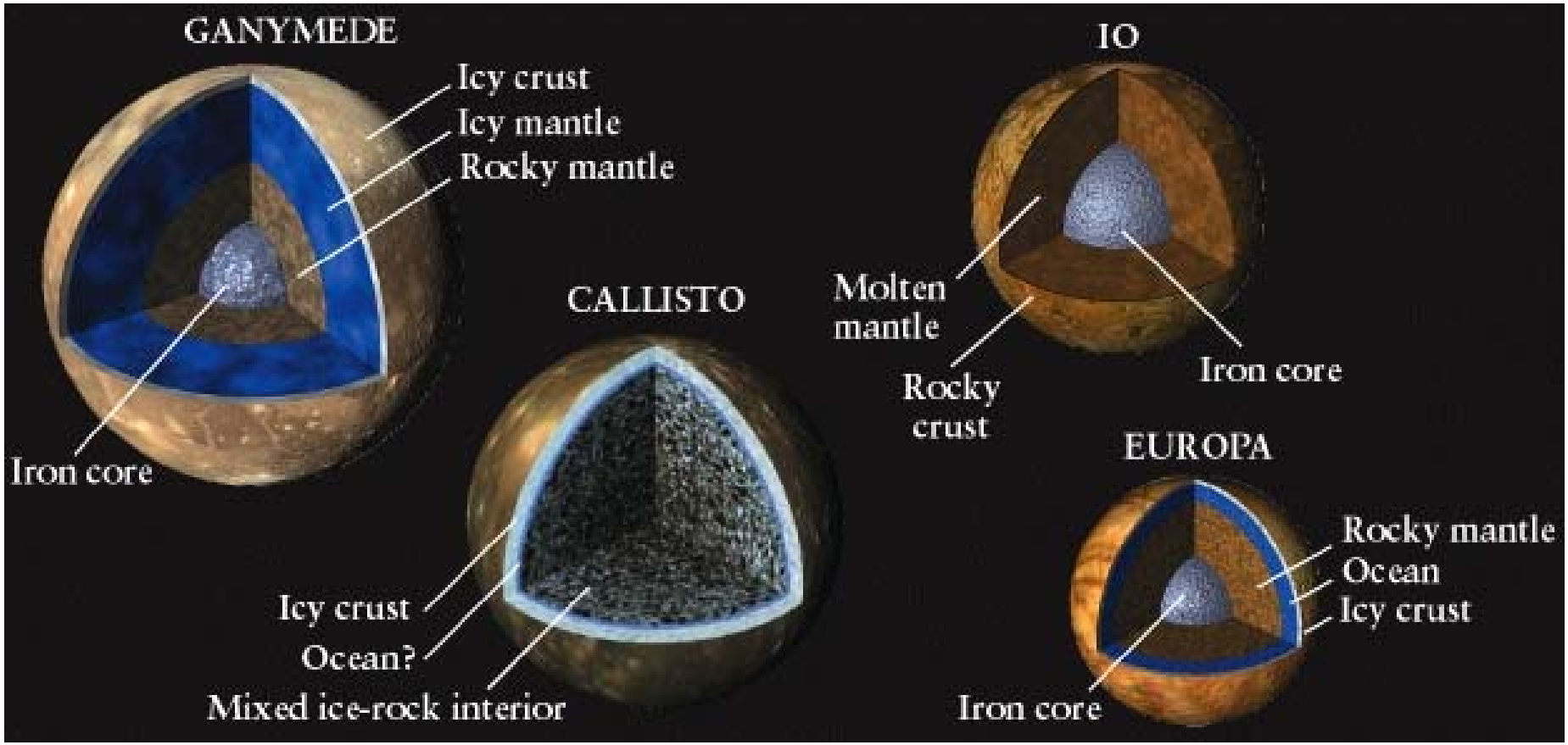
200 x 300km area

Europa, Ganymede, and Callisto:

Surface comparison at high spatial resolution

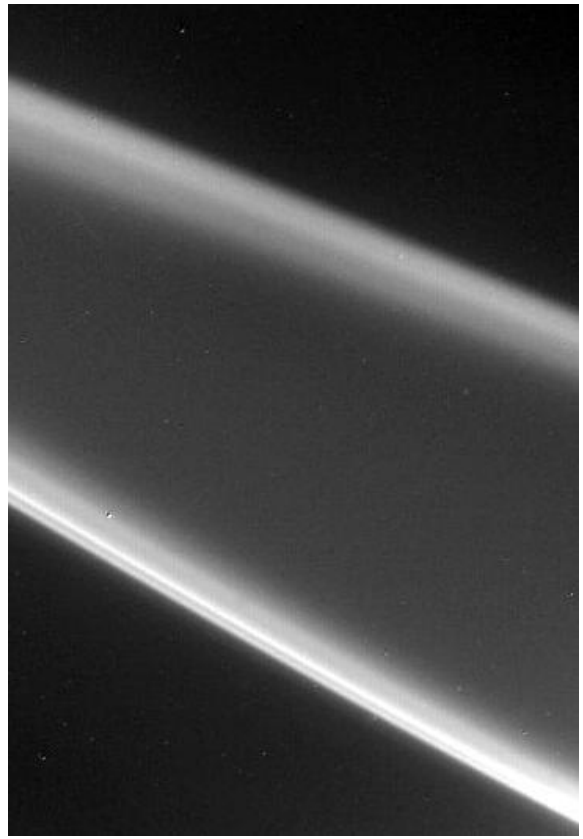


Varied Interiors of Moons

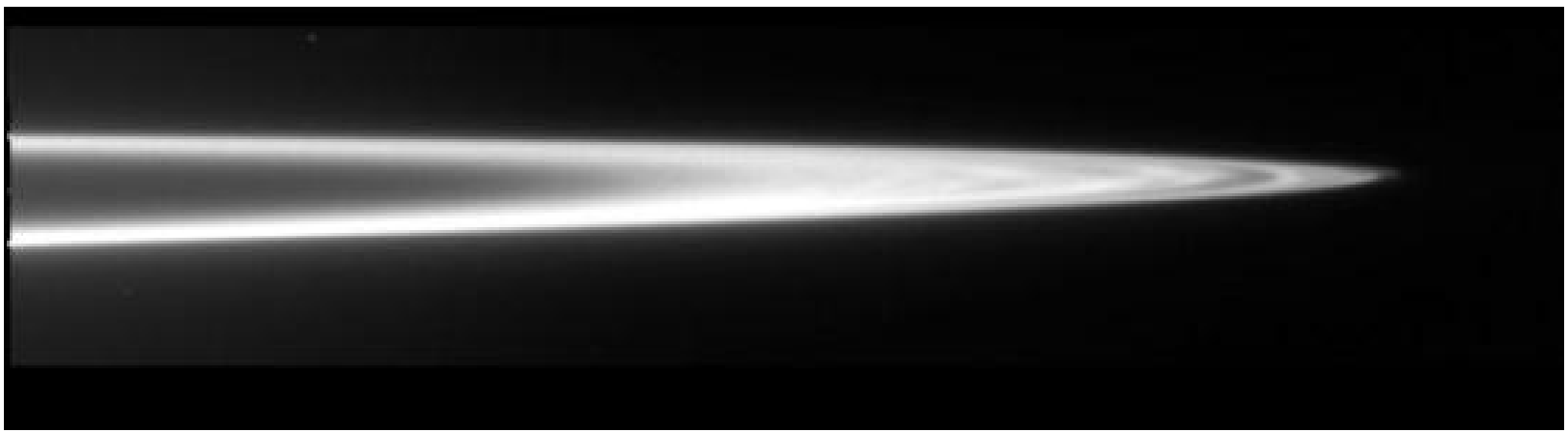


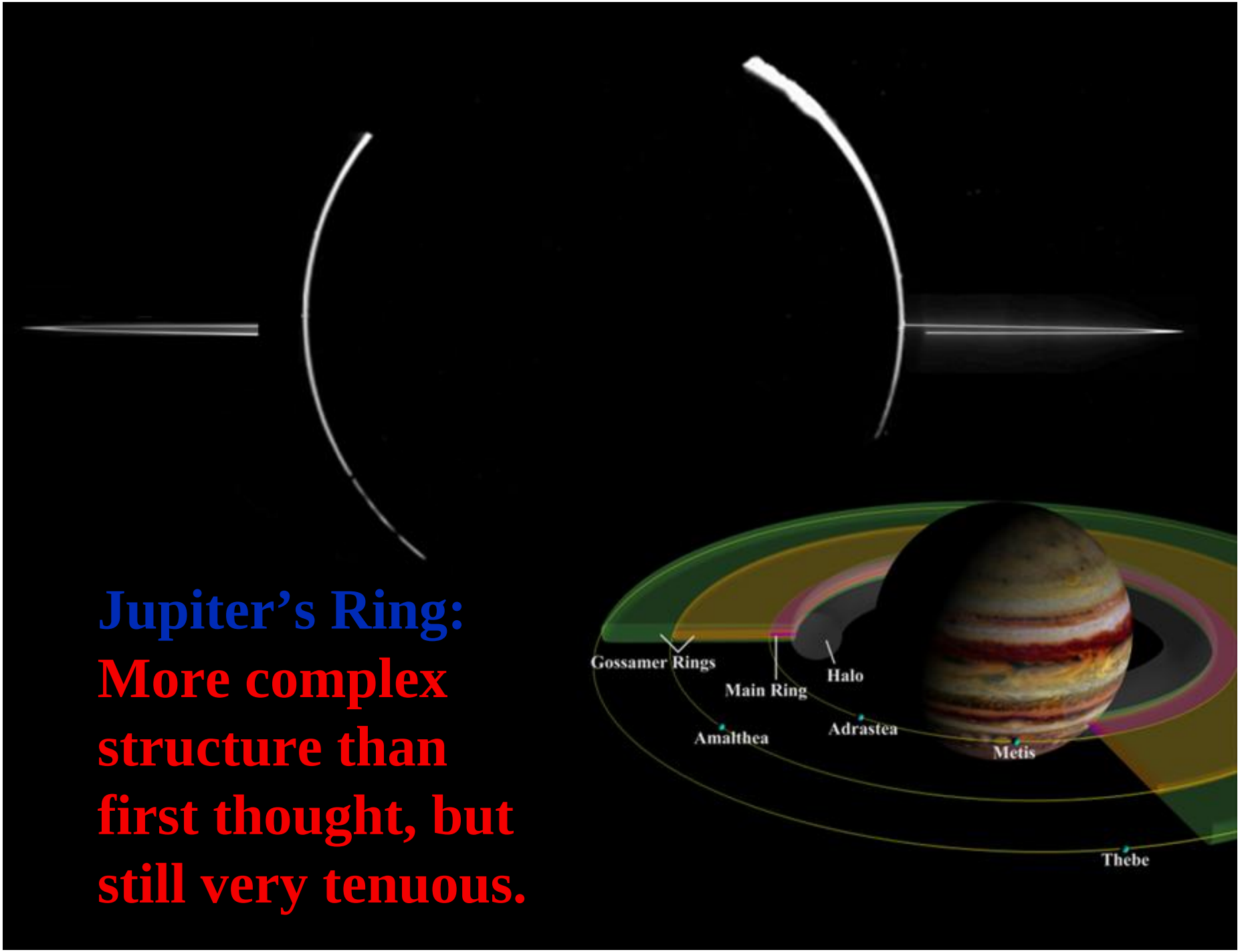
Possible interiors based on current data.

Jupiter's Ring

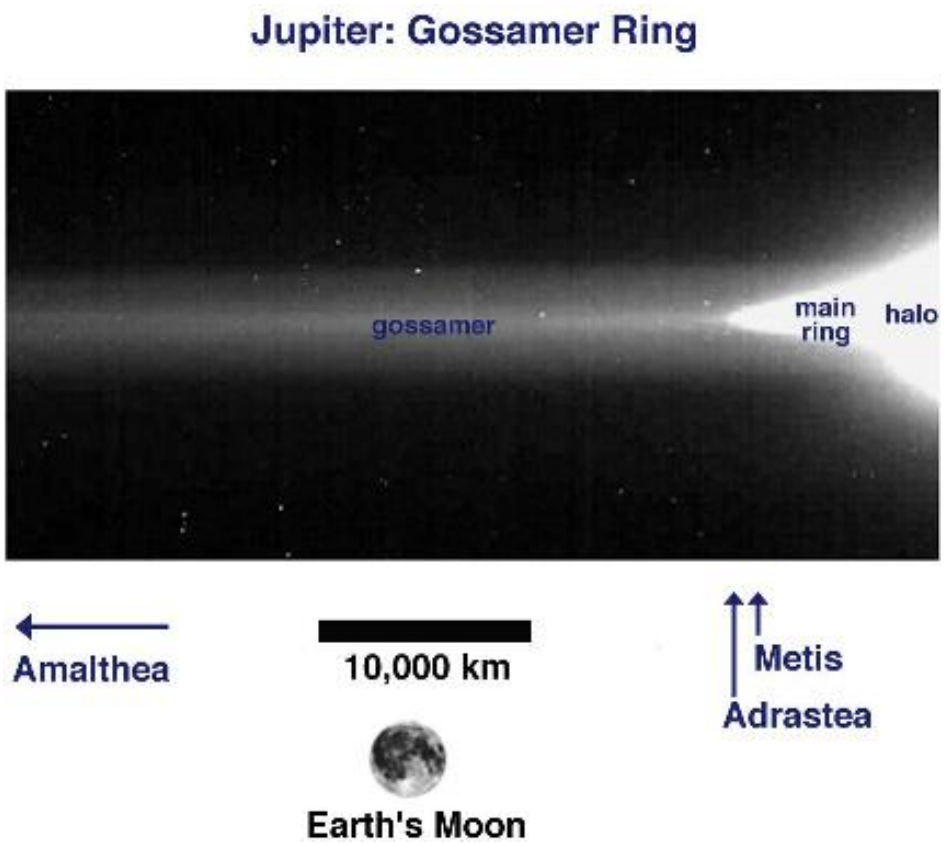


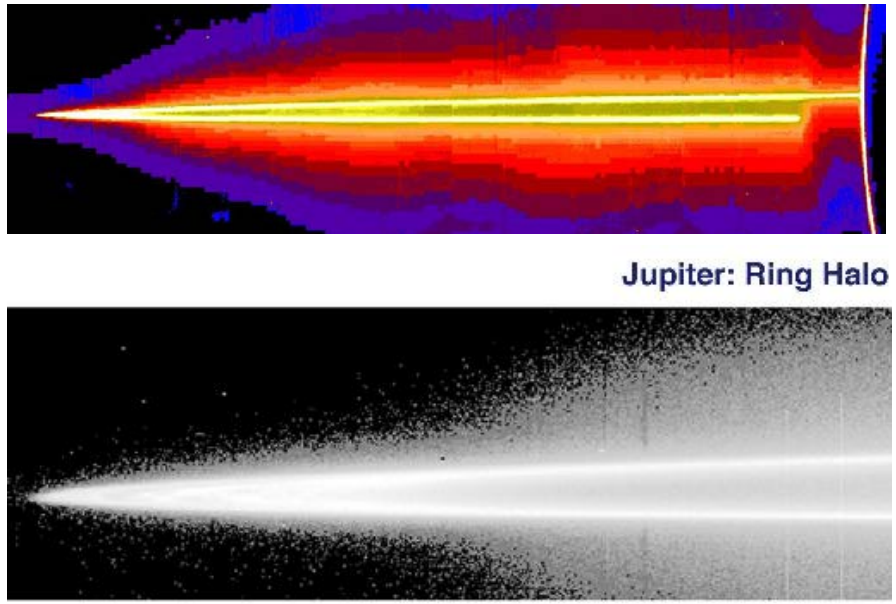
- **Discovered 1979 by Voyager.**
- **Just inside orbit of innermost moon, *close to Metis and Adrastea*, in equatorial plane.**
- **Thin ~10's km thick**





Jupiter's Ring:
More complex structure than first thought, but still very tenuous.





Faint Gossamer Ring

Extends to ~3 R_J

Unusual Halo

A faint mist of µm-sized *charged* particles can be seen above and below the main ring.