

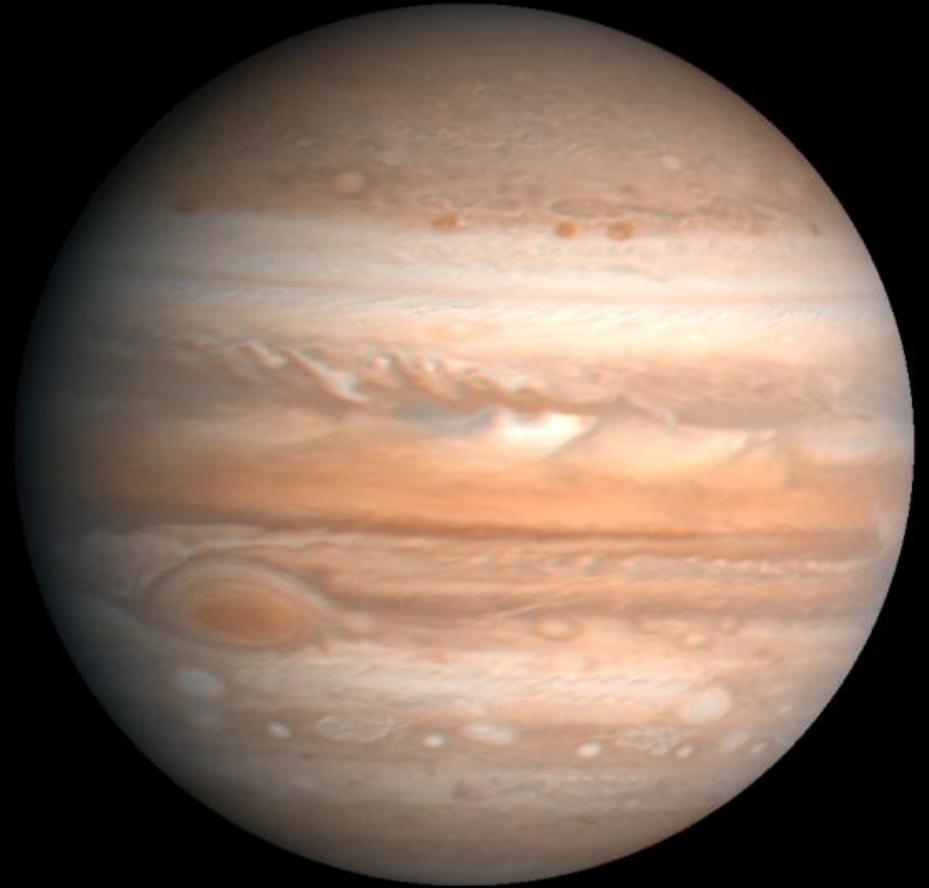
Jupiter & its Galilean Satellites

Melissa A. McGrath
NASA Marshall Space Flight Center

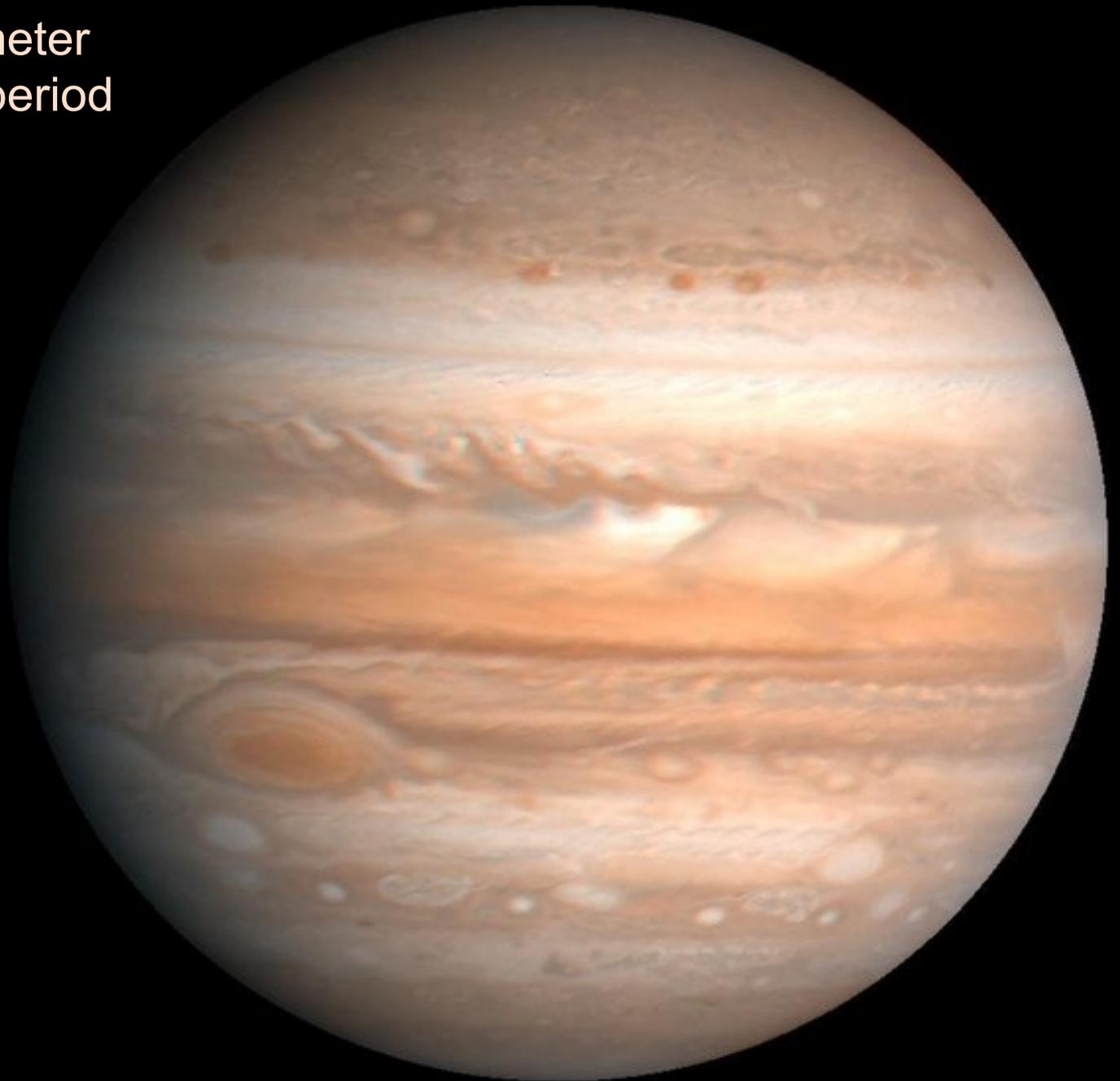


Jupiter - Giant of Planets

Largest, most
rapidly rotating planet



13x Earth diameter
10 hr rotation period



Earth

Venus

Jupiter

Saturn

Sun

Ju

Sun
Jupiter is about 1 pixel
Earth is invisible at this

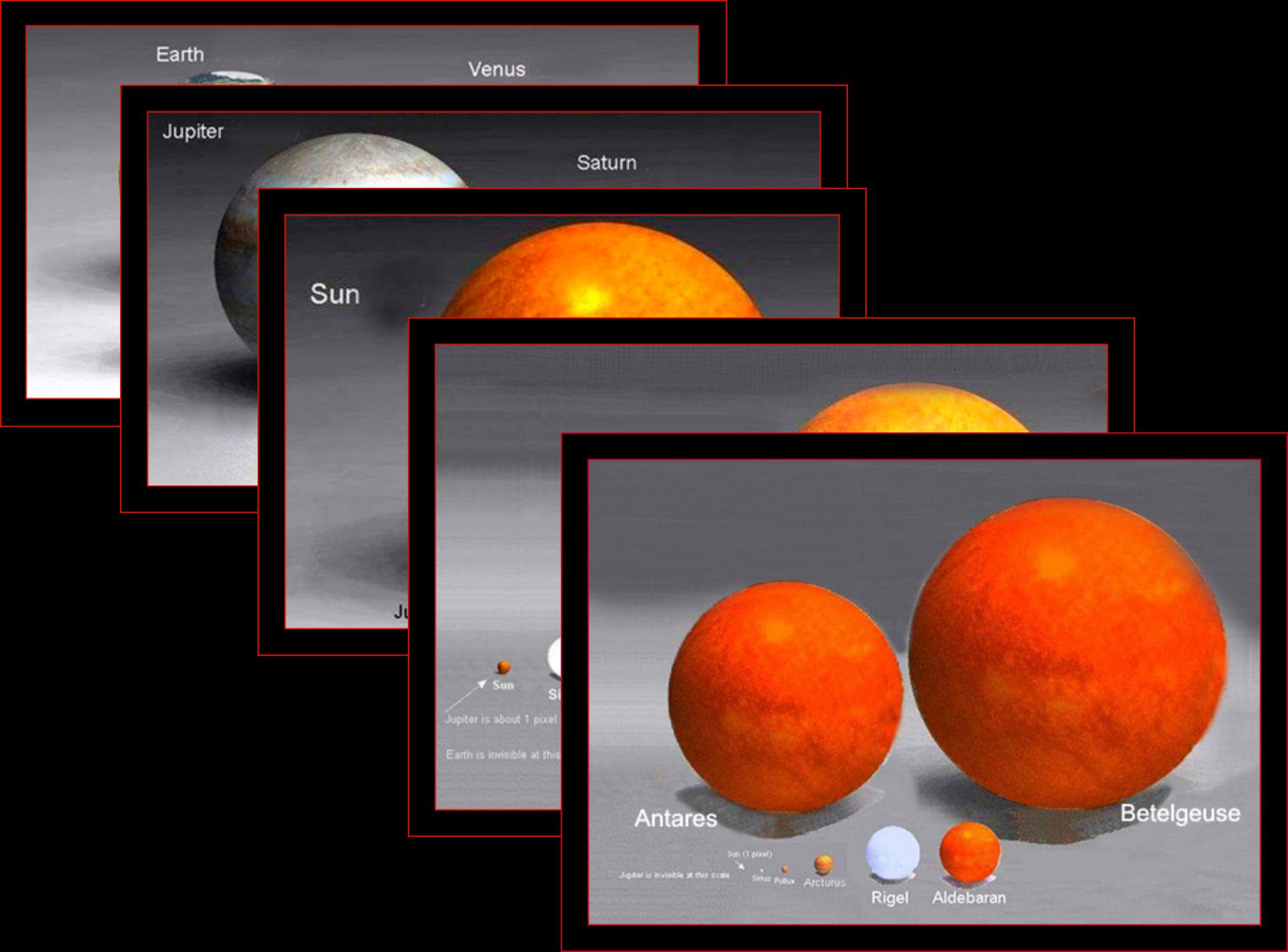
Antares

Betelgeuse

Sun (1 pixel)
Jupiter is invisible at this scale
Sirius Polaris Arcturus

Rigel

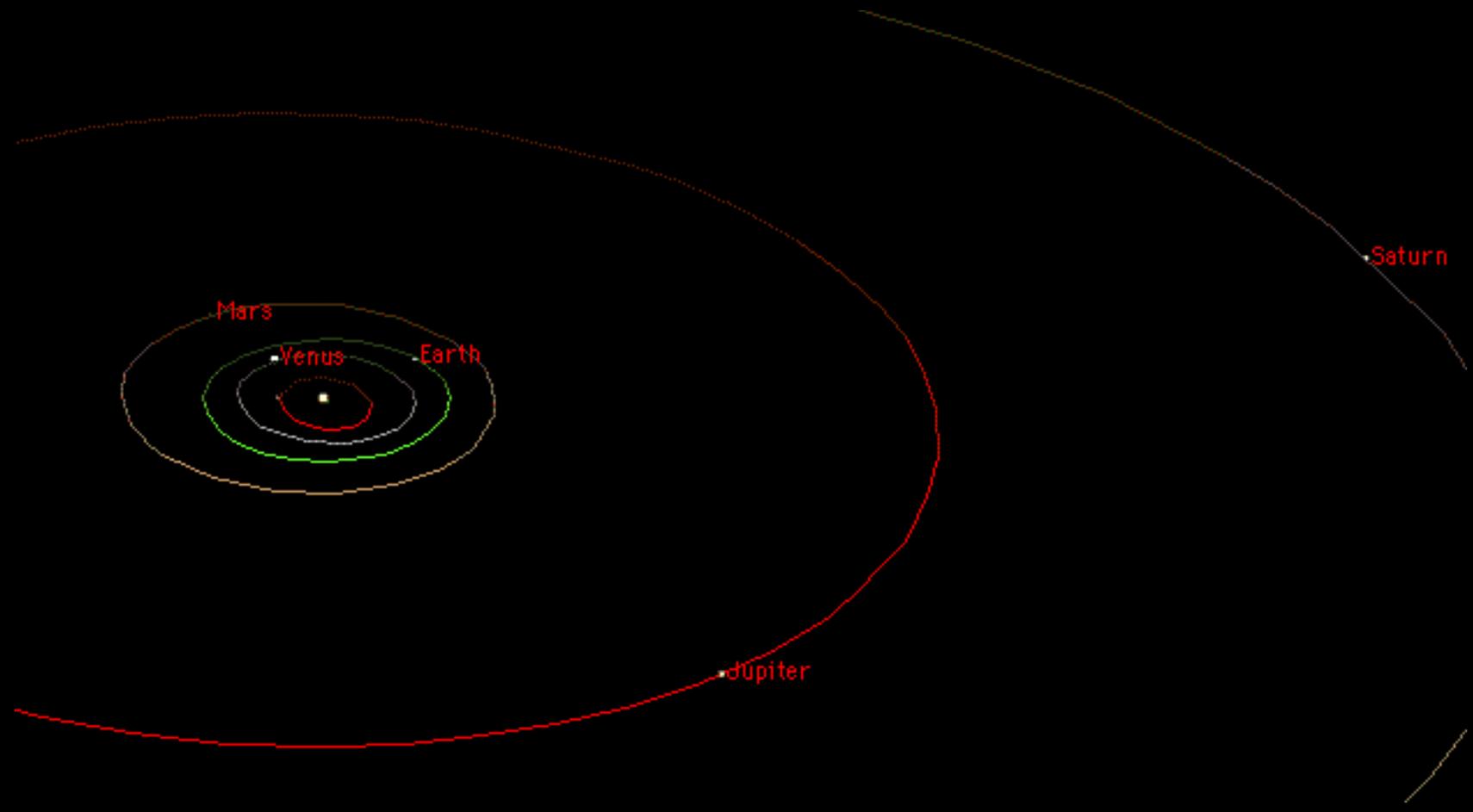
Aldebaran

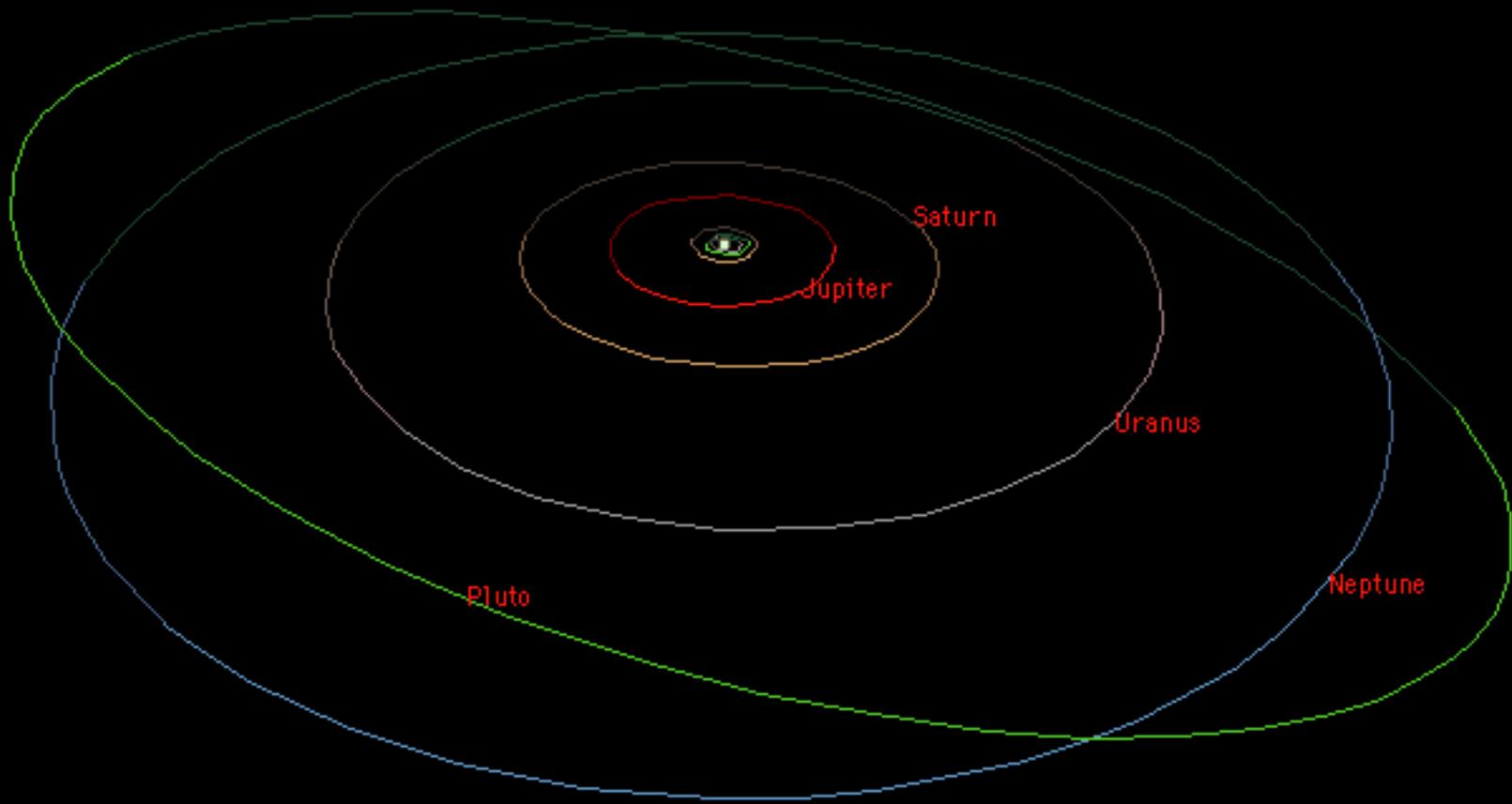




Jupiter

Saturn





Saturn

Jupiter

Uranus

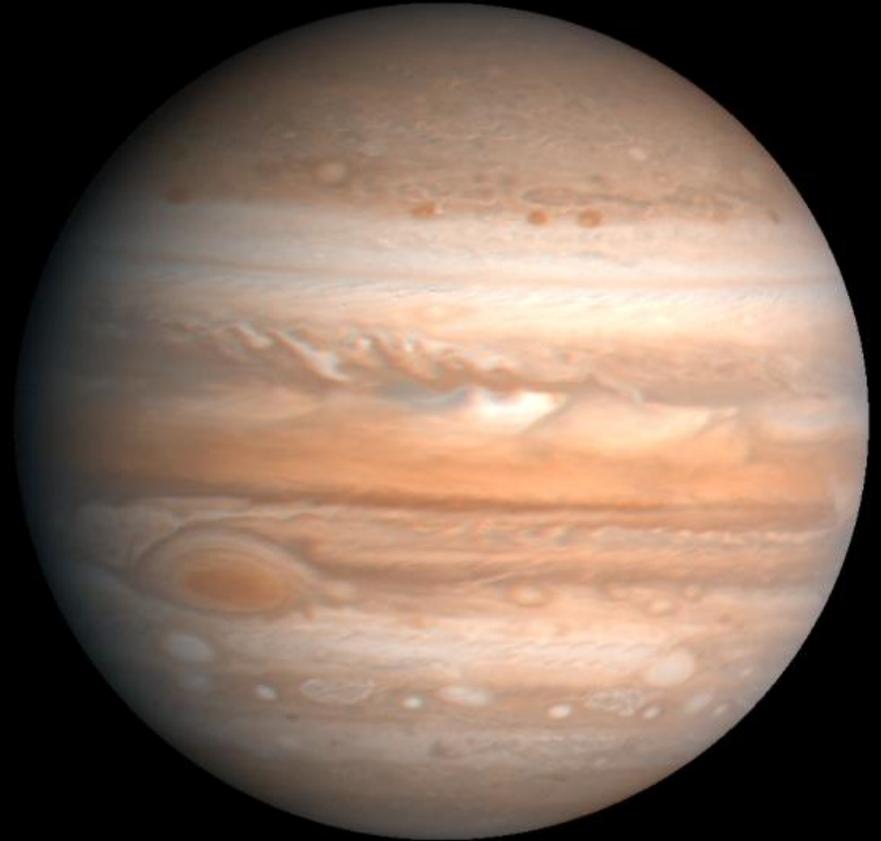
Pluto

Neptune

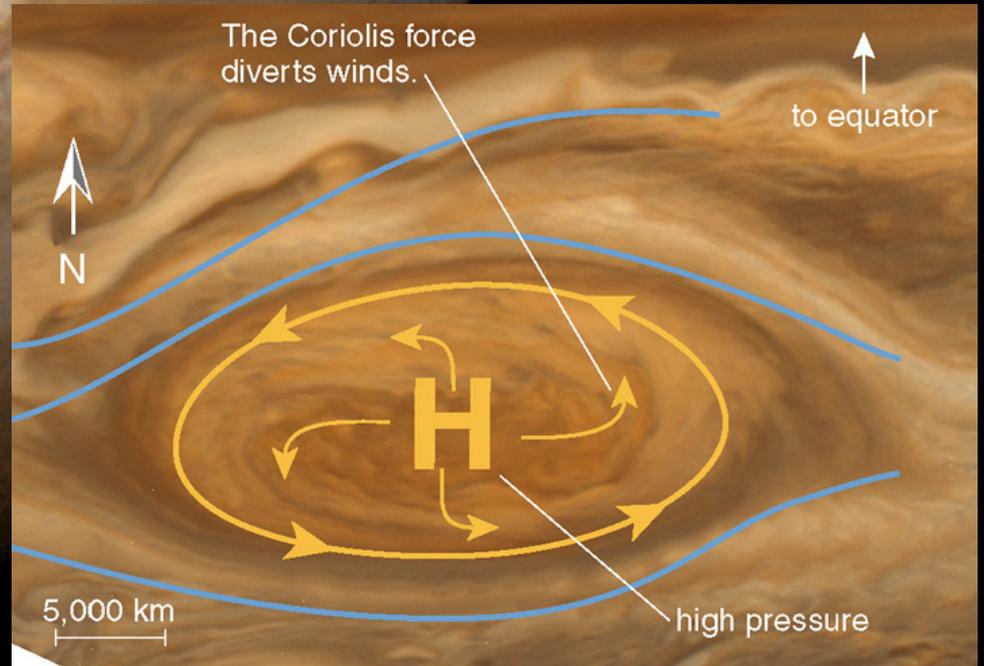
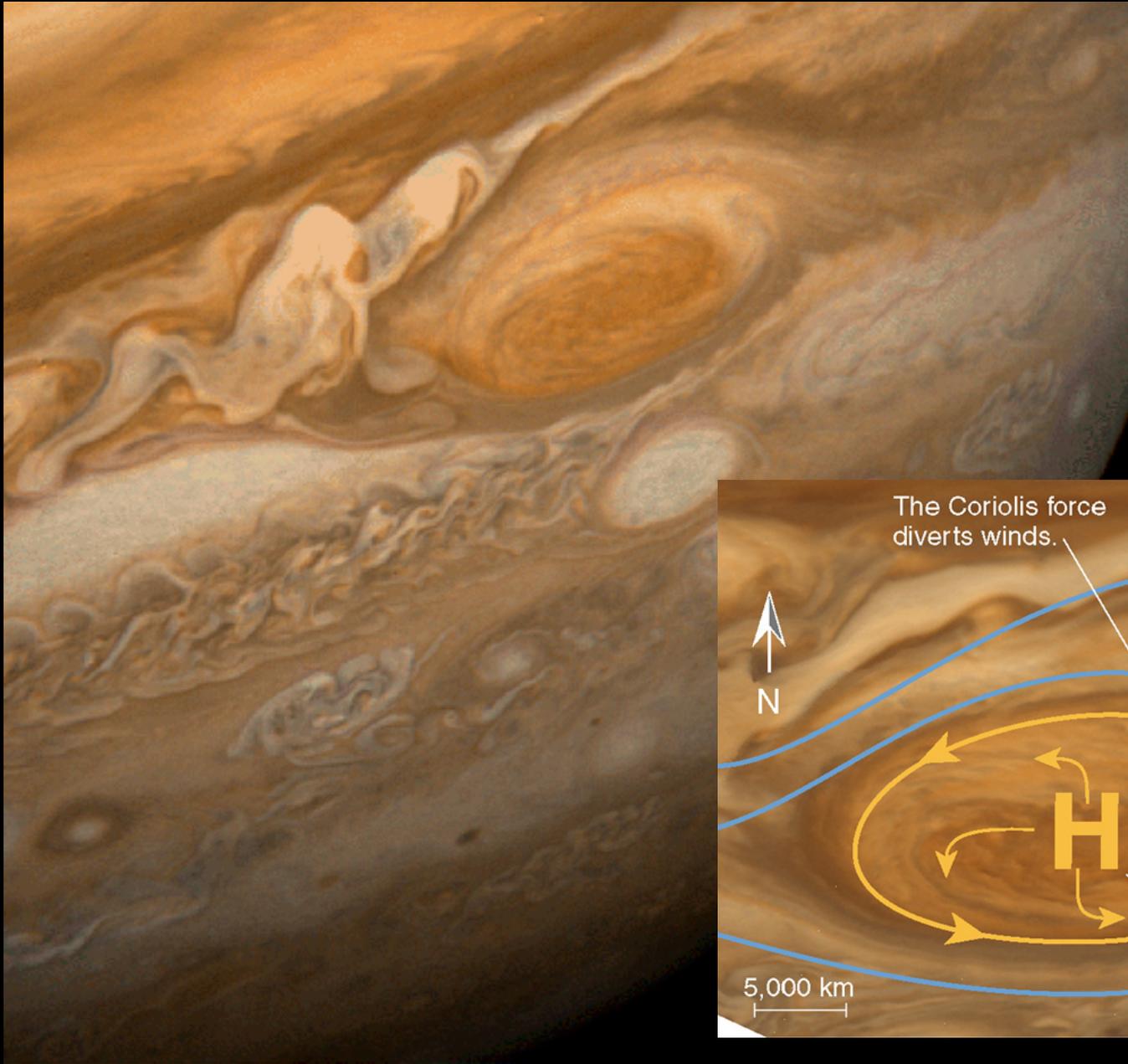
Jupiter - Giant of Planets

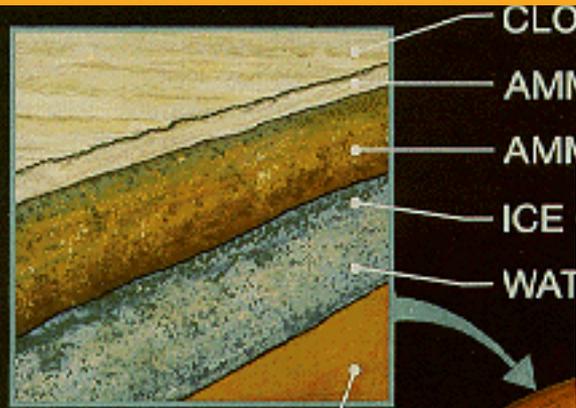
Largest, most
rapidly rotating planet

Most active atmosphere



Great Red Spot - at least 400 years old





CLOUD TOPS — AEROSOLS
 AMMONIA CRYSTALS
 AMMONIUM HYDROSULFIDE CLOUDS
 ICE
 WATER

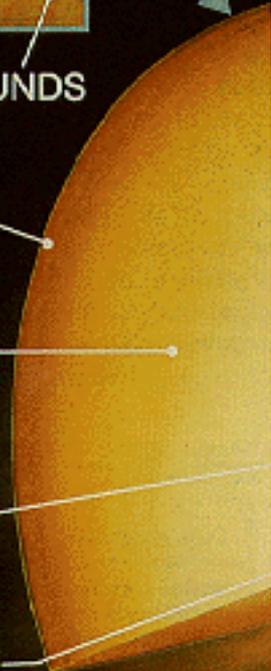
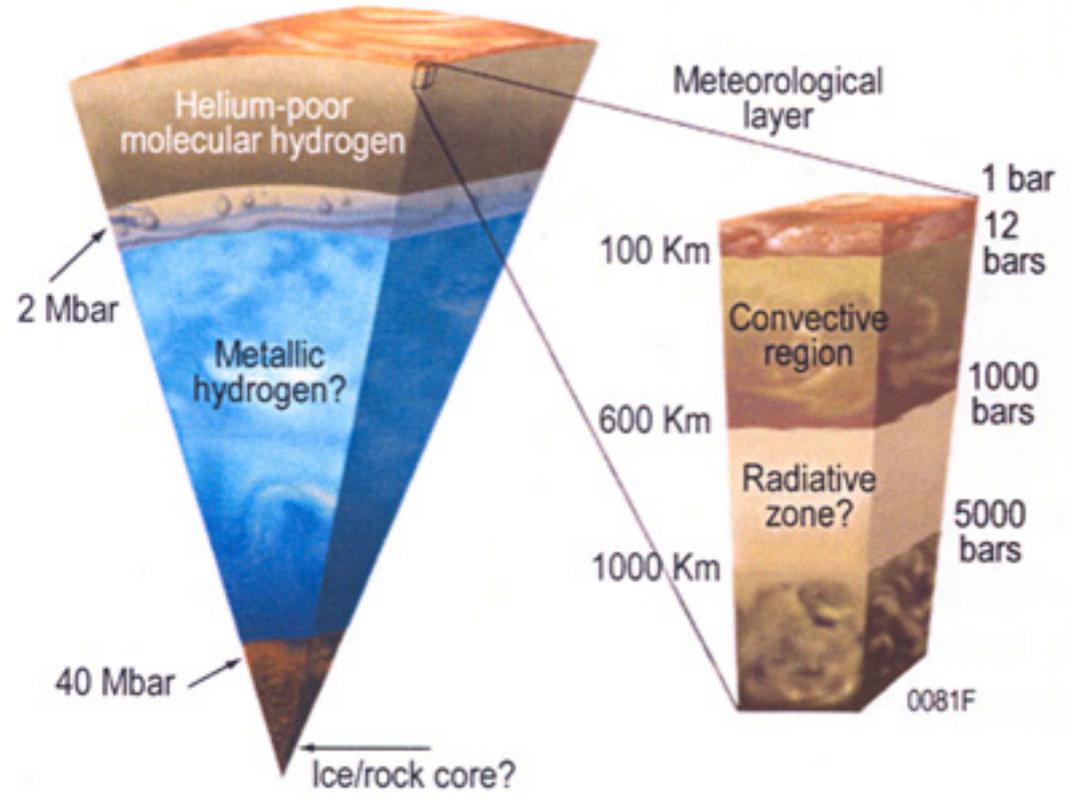
TRACE COMPOUNDS

FLUID MOLECULAR HYDROGEN

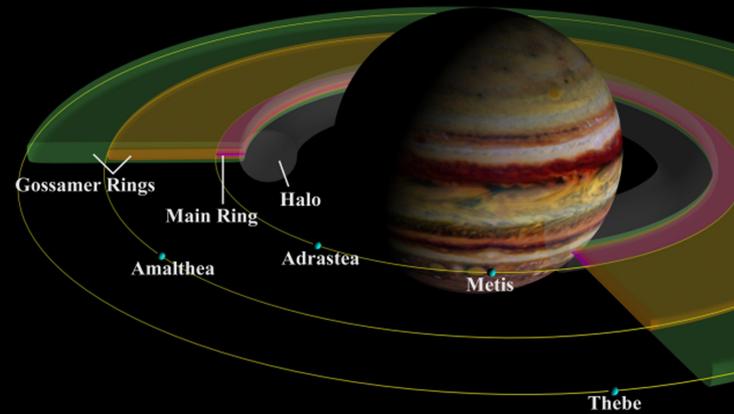
TRANSITION ZONE

FLUID METALLIC HYDROGEN

POSSIBLE CORE



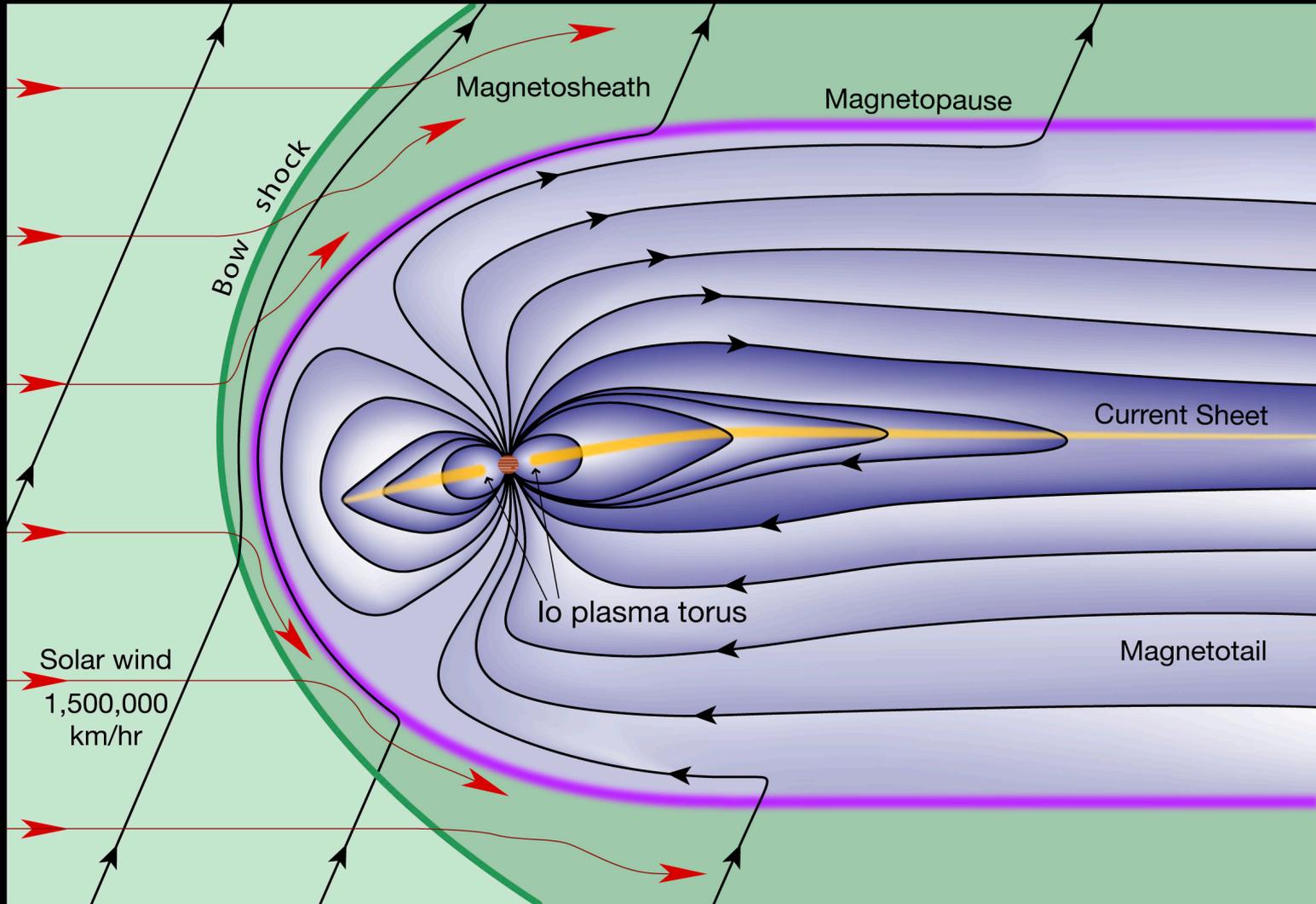
It also has rings

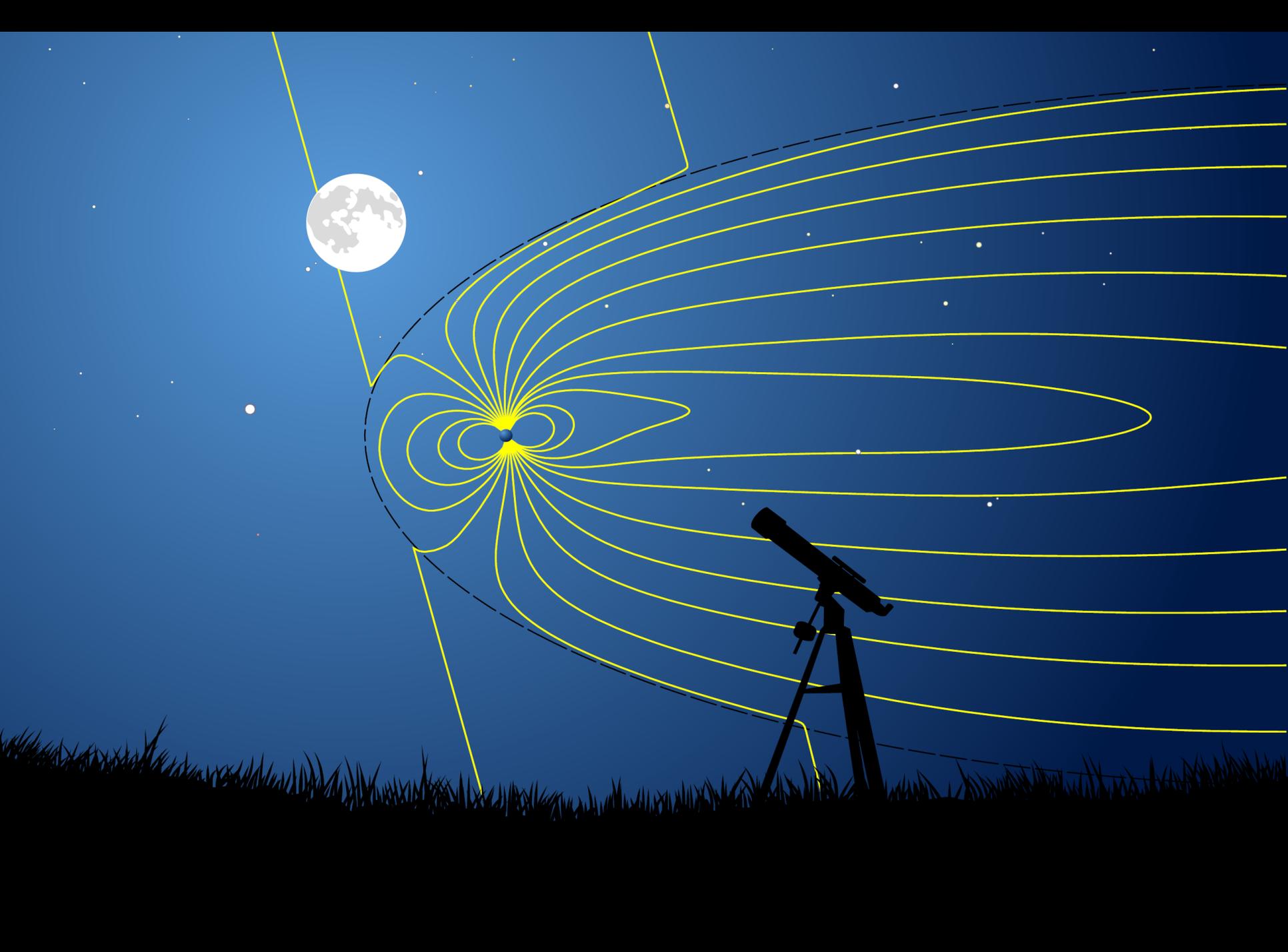


Strongest magnetic field and largest magnetosphere

$B_{\text{Jupiter}} \sim 10 \times B_{\text{Earth}}$

Magnetosphere $\sim 10^7$ km



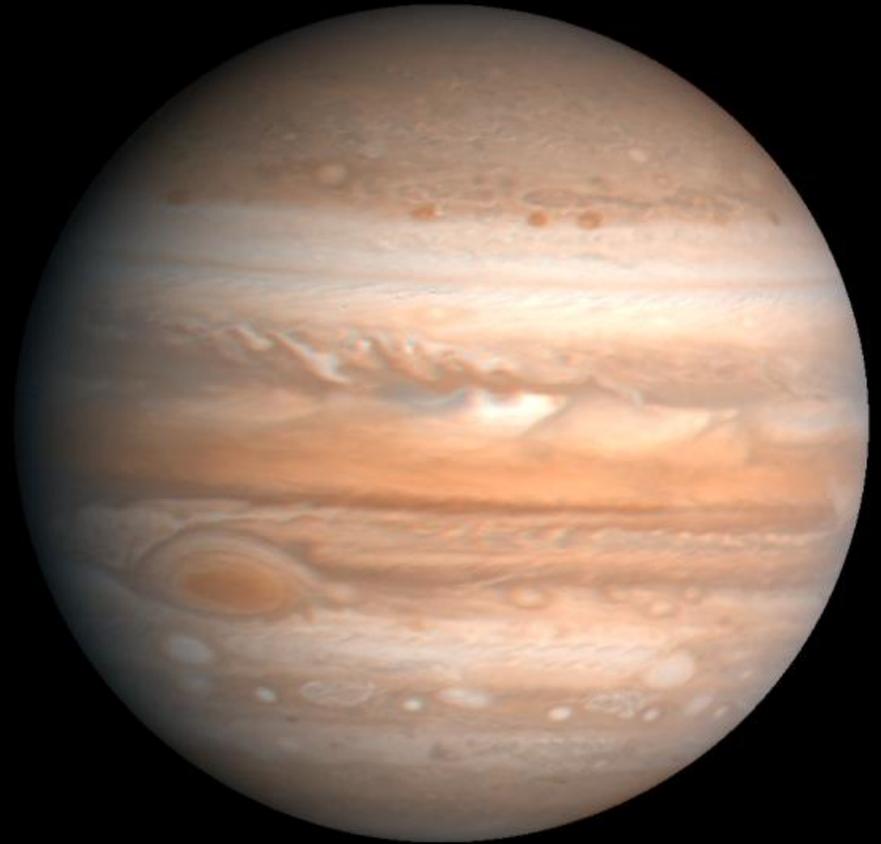


Introduction: The diverse Jupiter System

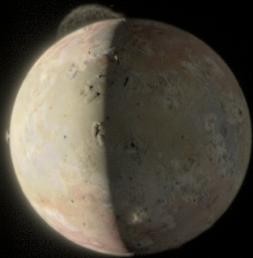
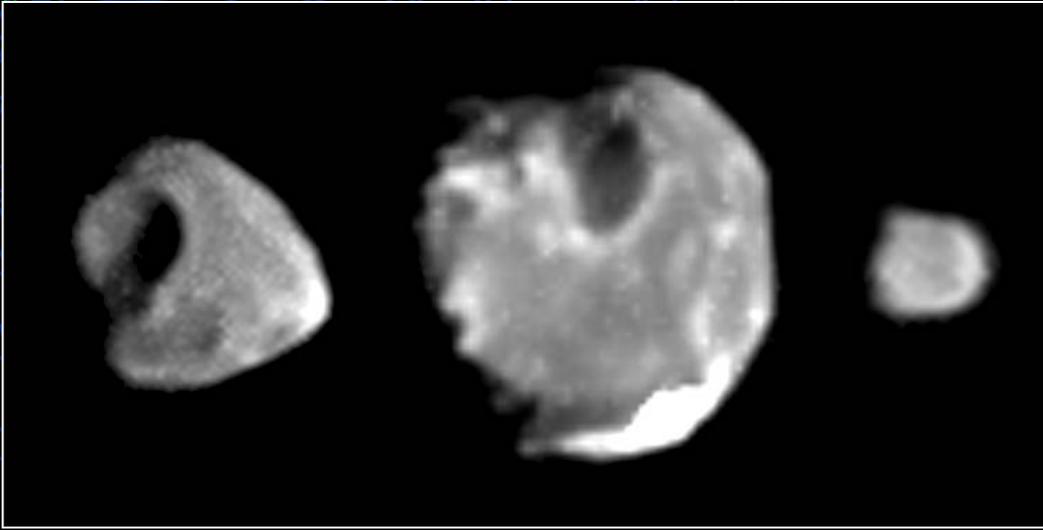
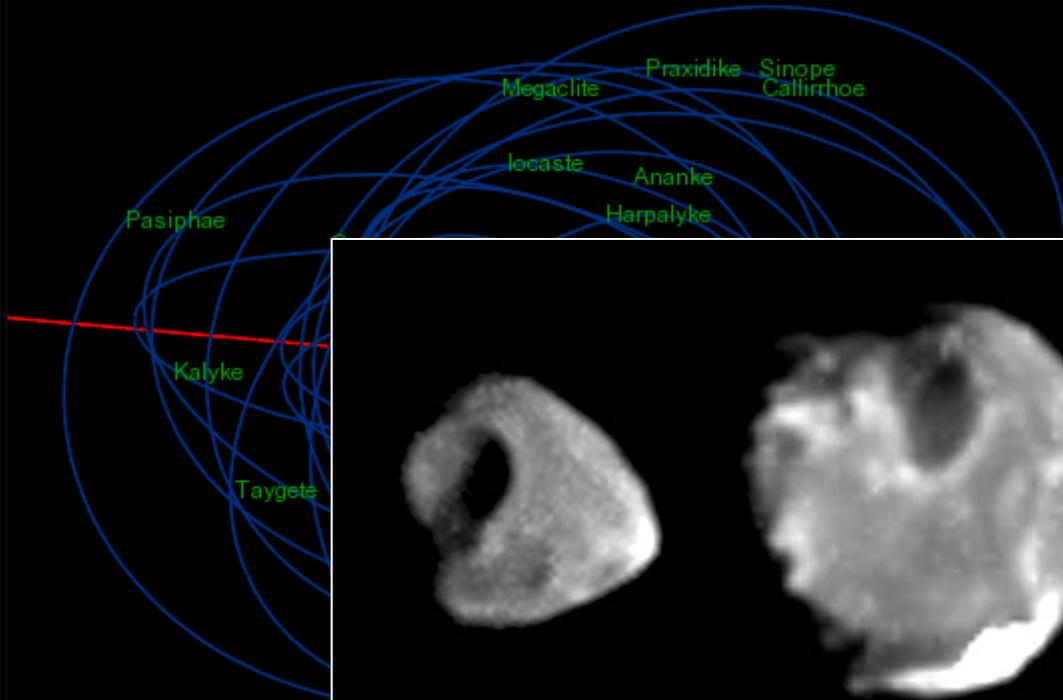
Largest, most
rapidly rotating planet

Most active atmosphere

Solar system in miniature

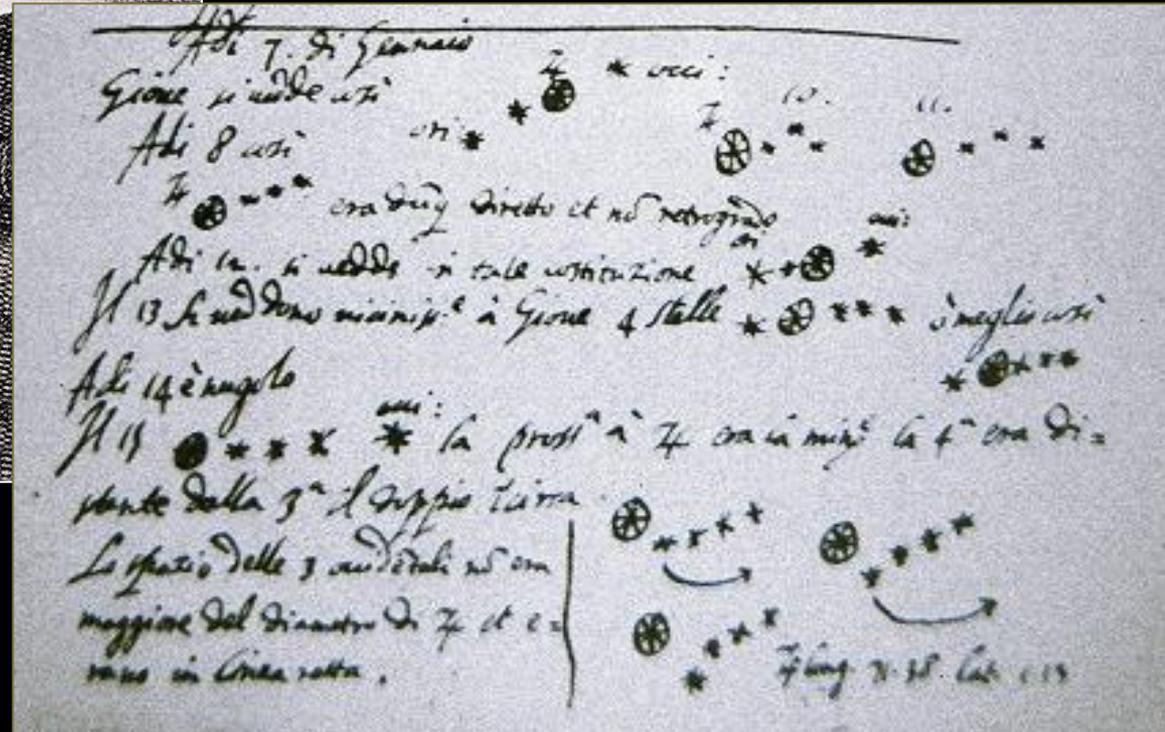


The most moons (63),
4 large Galilean moons



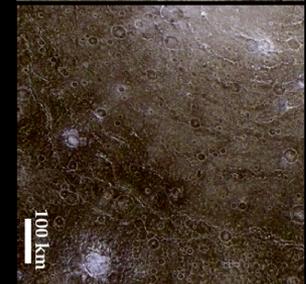
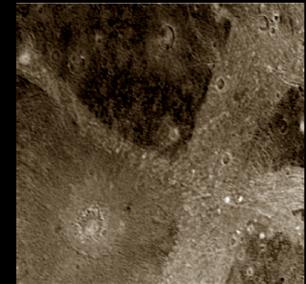
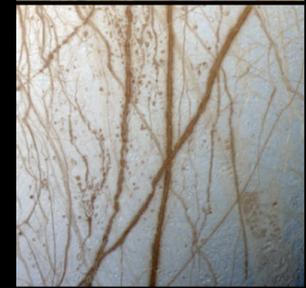
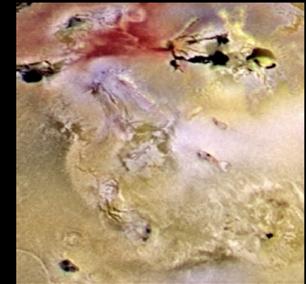
Galileo (1564-1642)

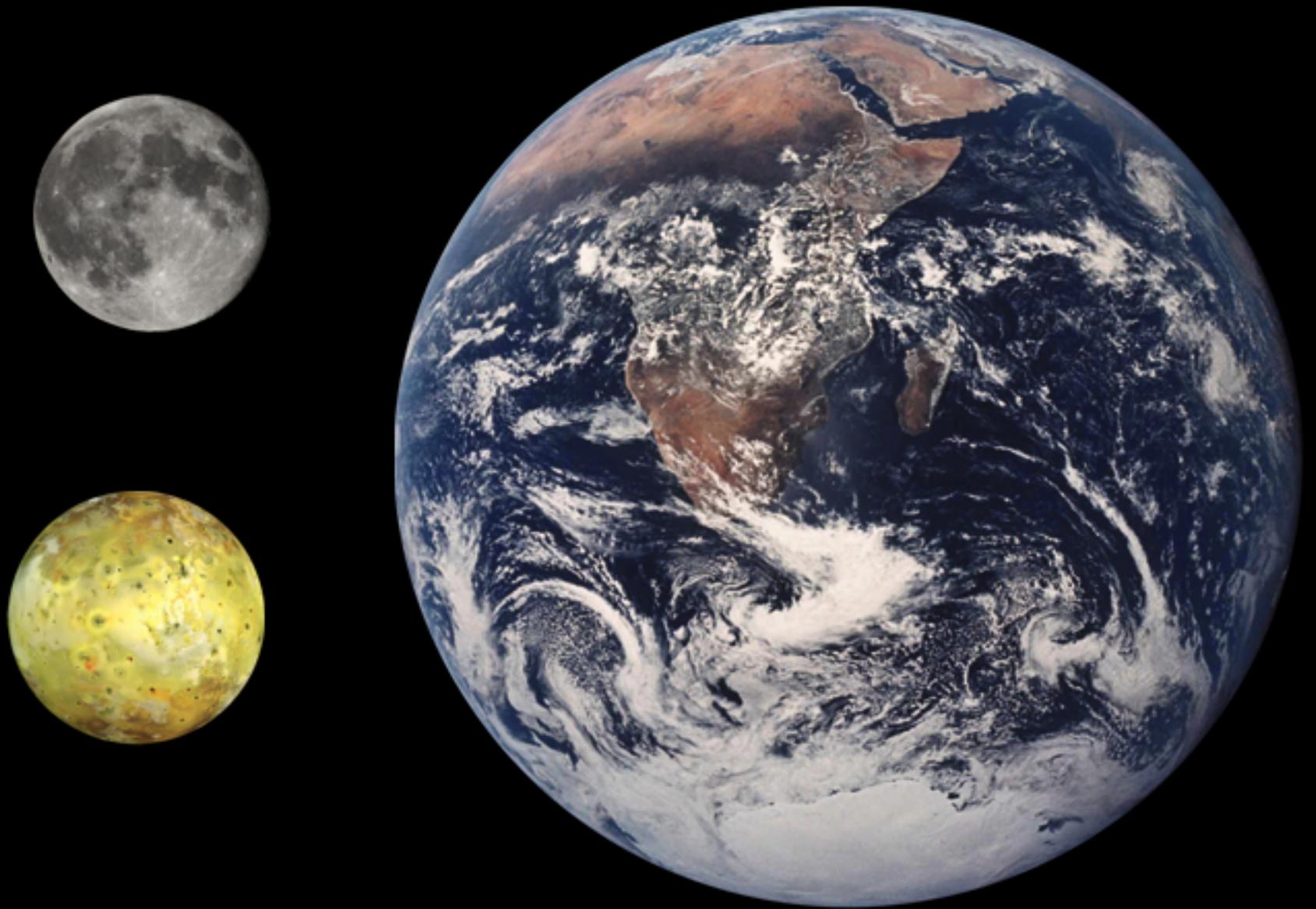
- Telescope: 1609
- Jupiter's satellites: 1610
- *Sidereus Nuncius*: March 1610

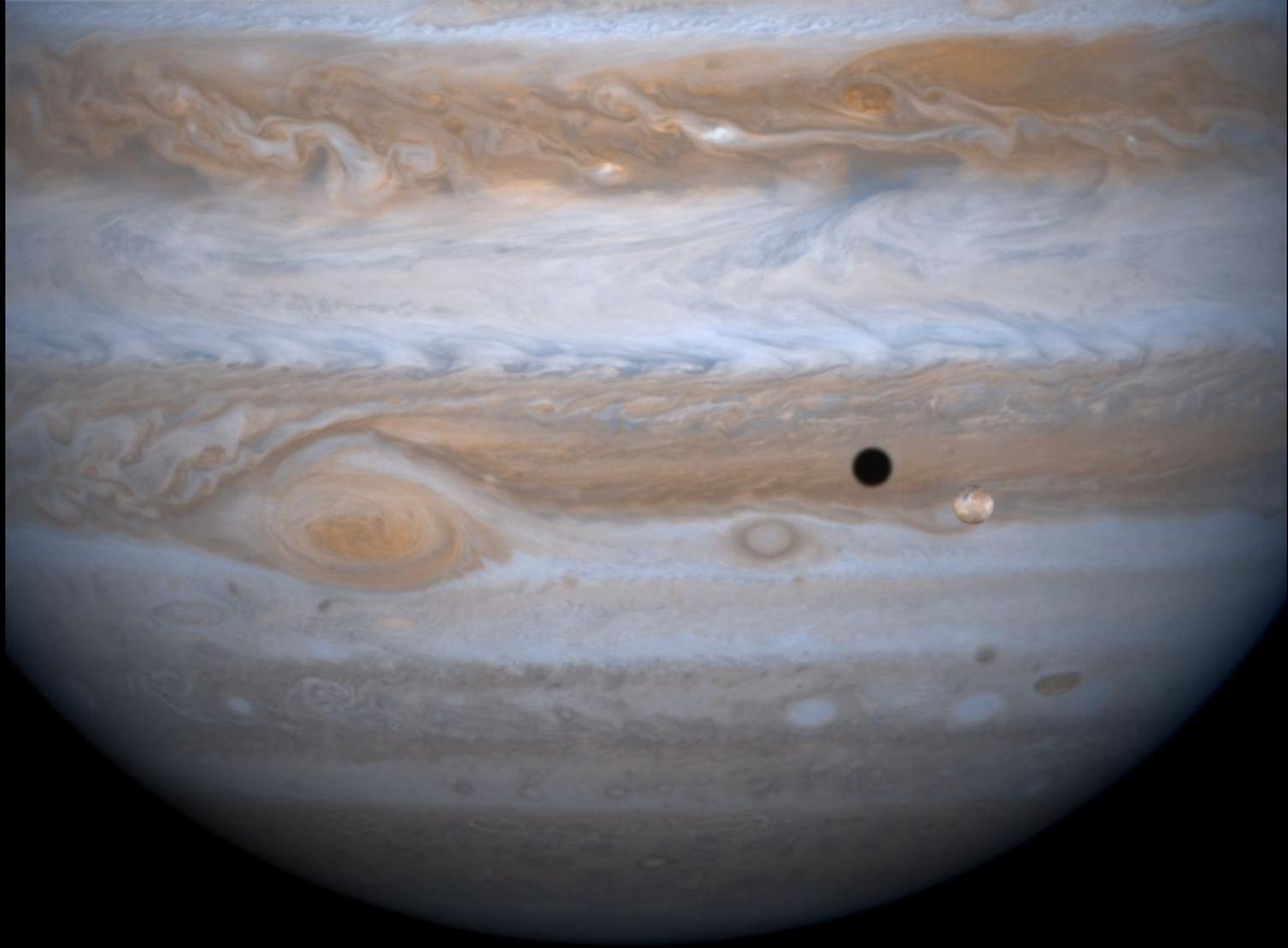


Galilean Satellites

| | D_{sat} (km) | $d_{\text{sat-Jup}}$ $10^5 \text{ km } [R_j]$ | Density |
|-------------|--------------------------|--|------------|
| Io | 3630 | 4.2 [5.9] | 3.6 |
| Europa | 3140 | 6.7 [9.4] | 3.0 |
| Ganymede | 5260 | 10.7 [15.0] | 1.9 |
| Callisto | 4800 | 18.8 [26.3] | 1.9 |
| Moon | 3474 | 3.8 | 3.3 |

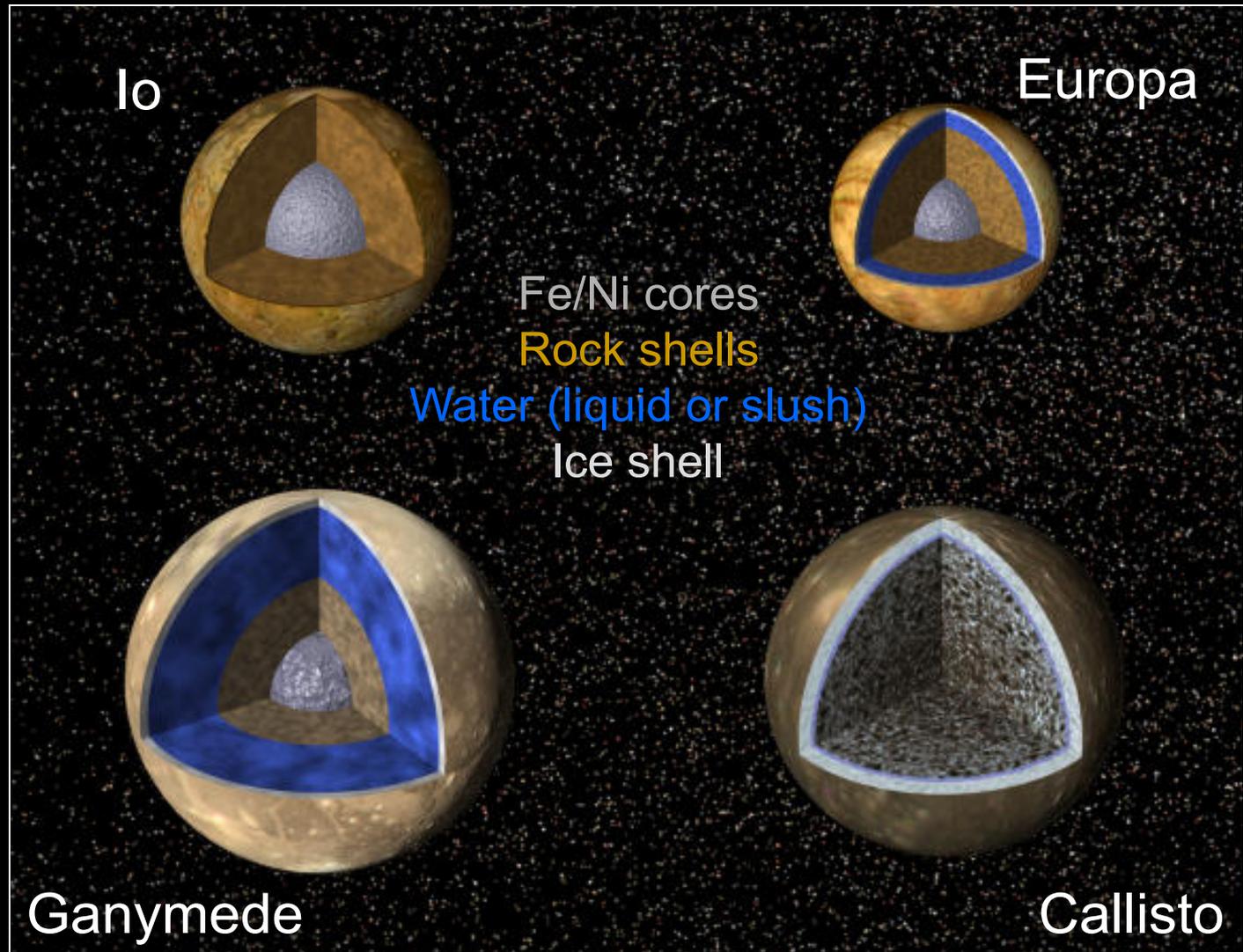






- Strong tides
- Phase locked orbits
- Leading-trailing asymmetries

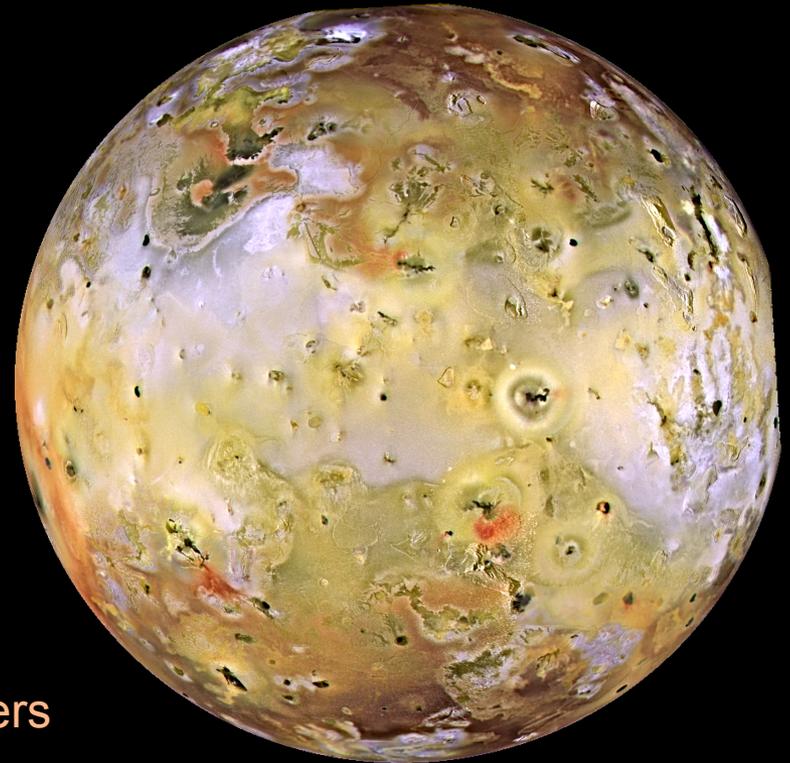
Interior structures greatly clarified by Galileo close flybys



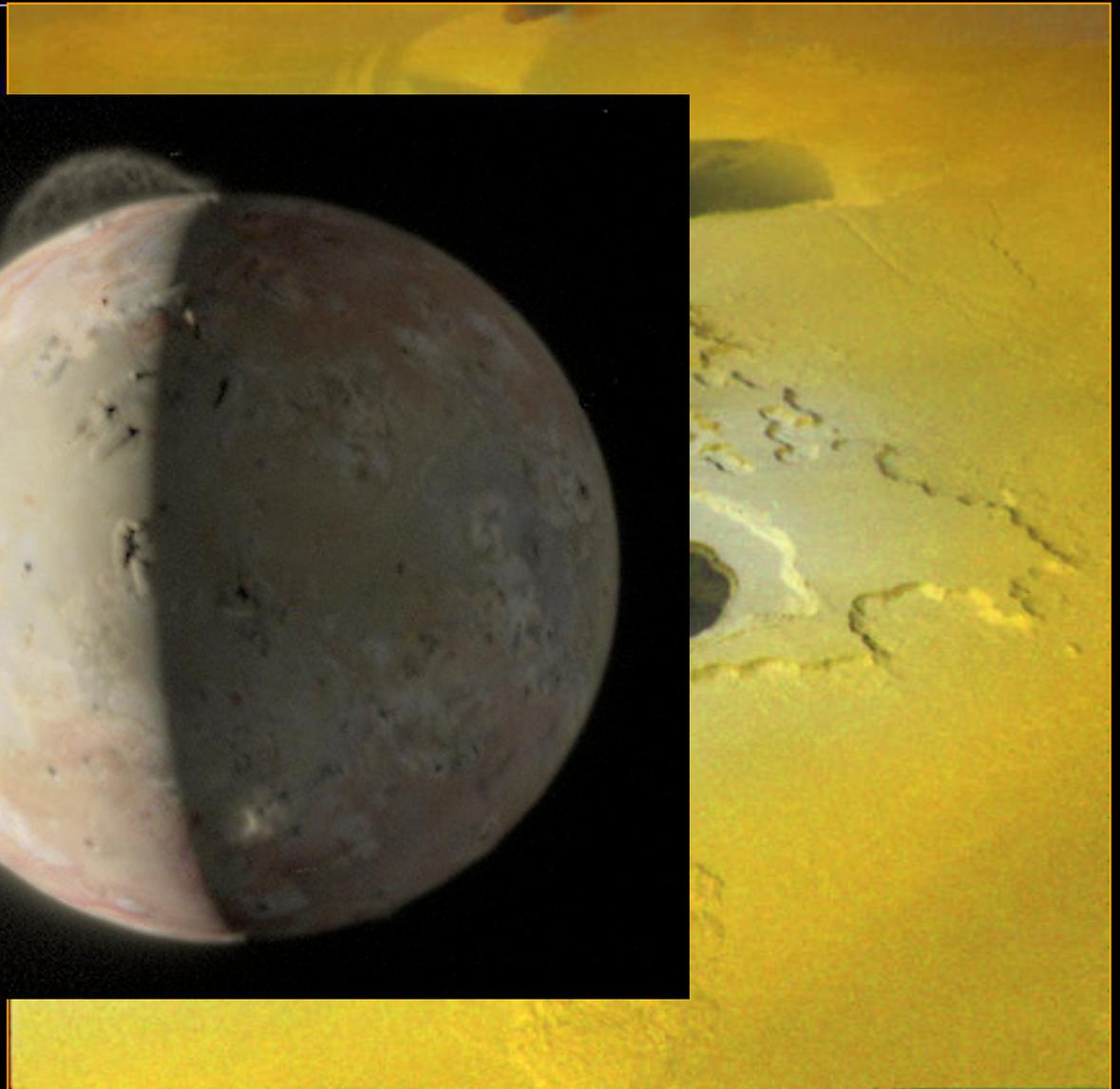
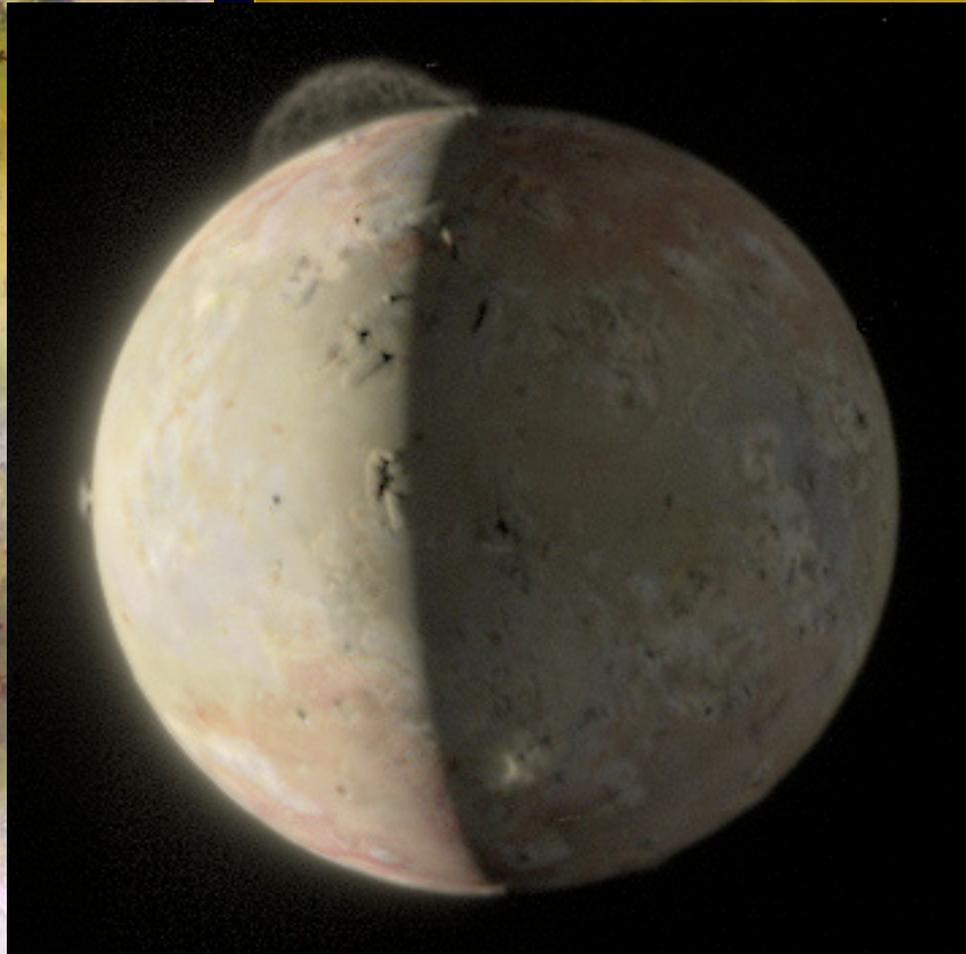
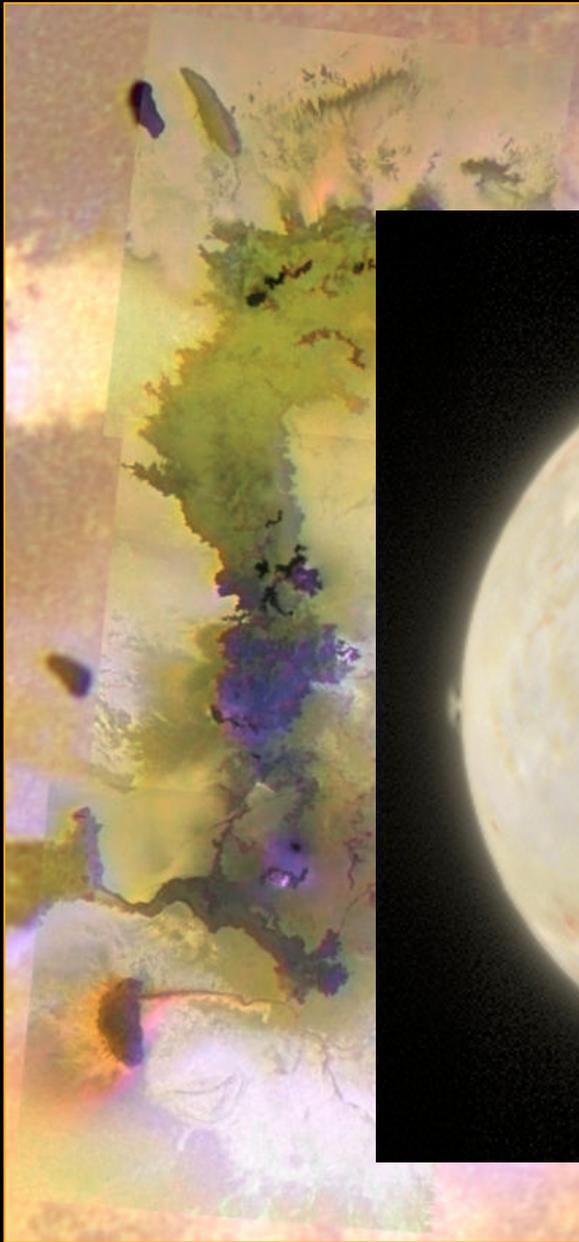
Io

Located deep within the gravitational well and magnetic cavity, it has a tremendous impact on the Jovian system because of its active volcanism.

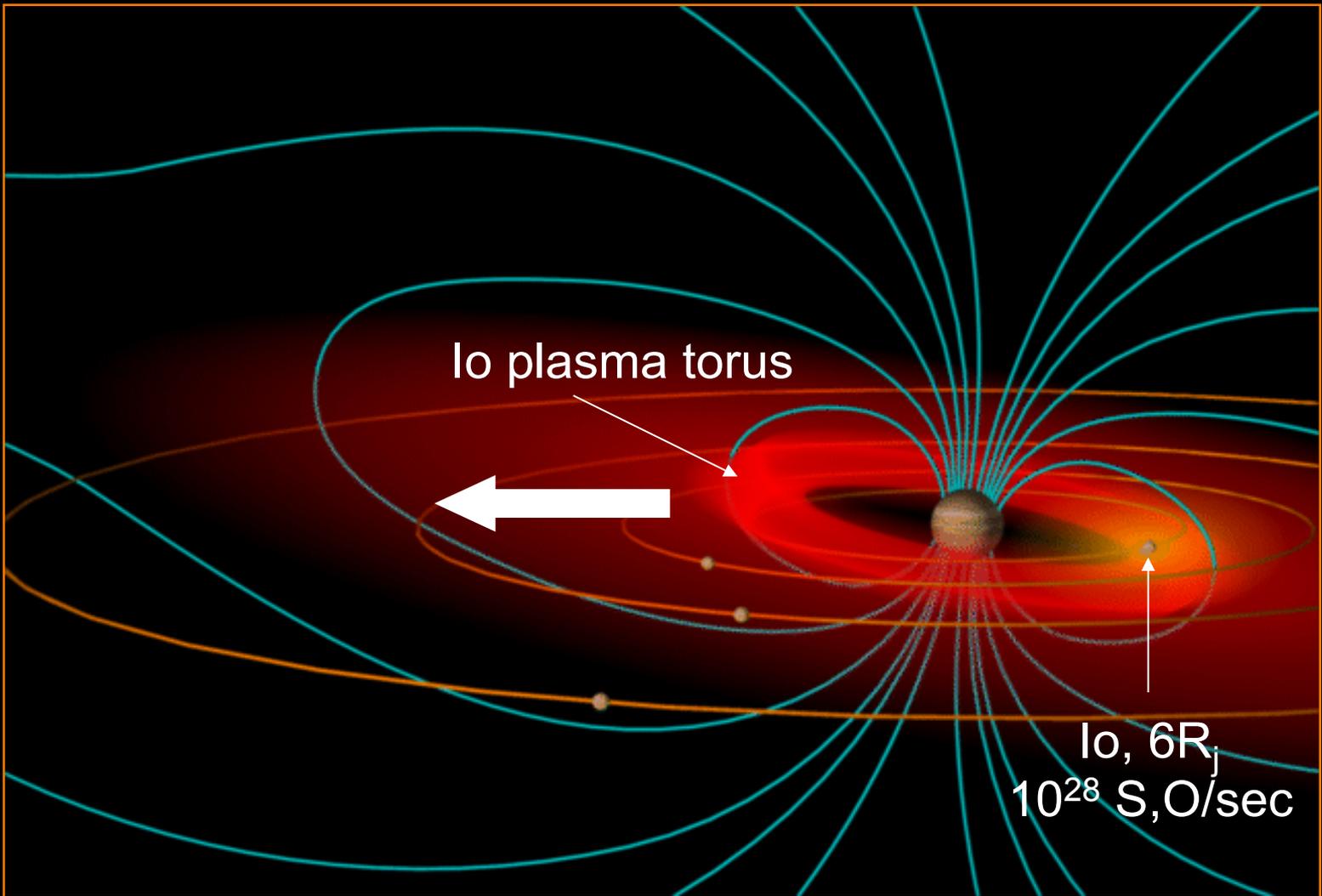
- 166 confirmed active hot spots and plumes
 - 541 features classified as volcanic centers
 - 2 peaks in concentration:
 - 5°N, 170° (anti-Jovian)
 - 15°S, 345° (sub-Jovian)
 - None > 80° latitude
- (Lopes-Gautier et al. 2000, 2004; Kirchoff et al. 2005)*

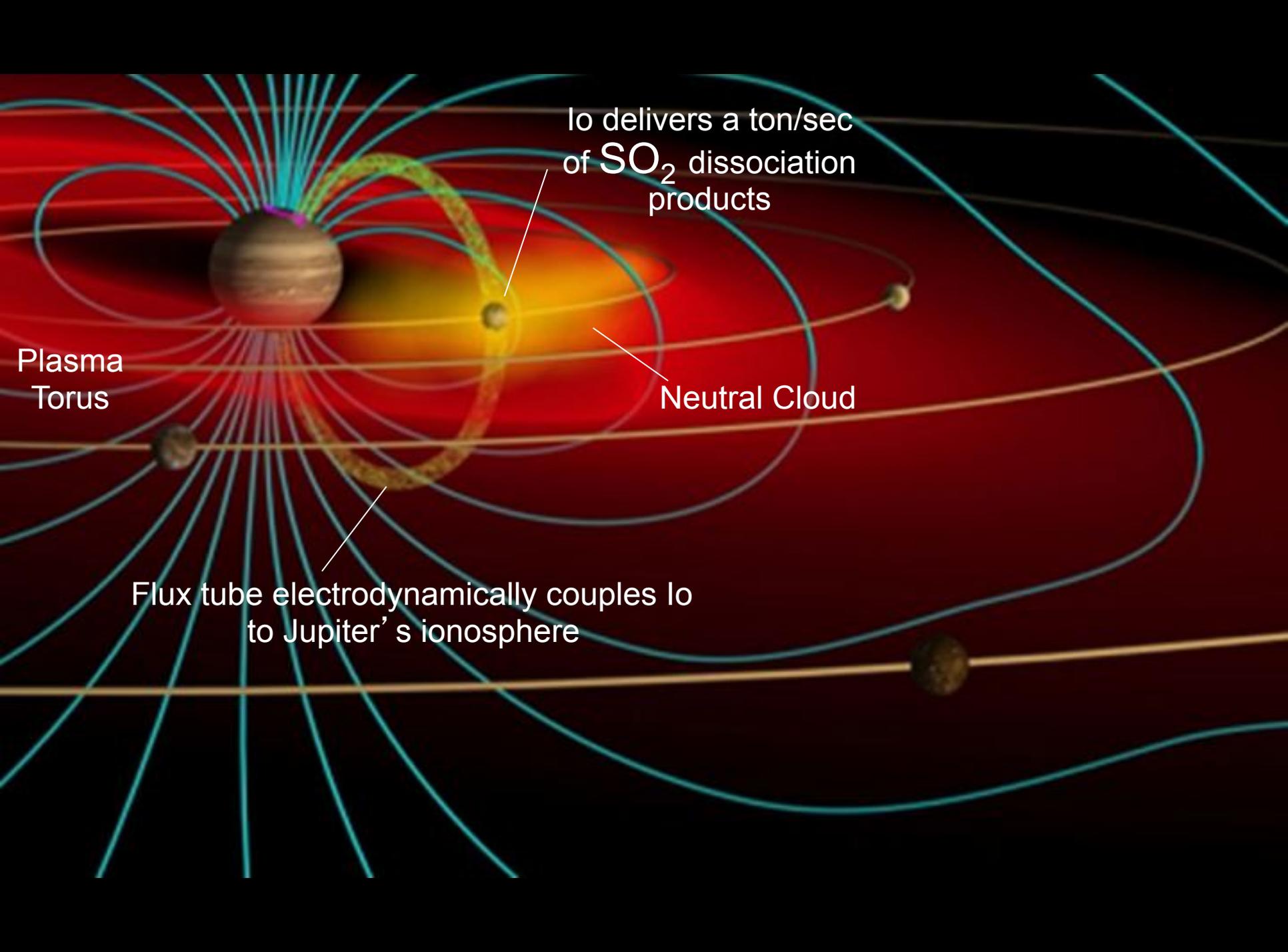


Io volcanism



Io & the Jovian magnetosphere





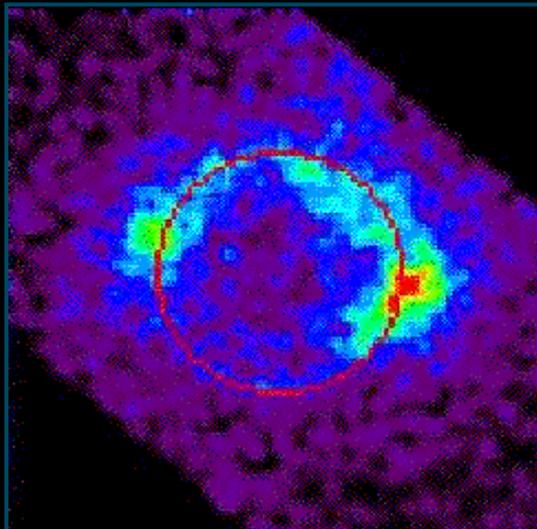
Io delivers a ton/sec
of SO_2 dissociation
products

Plasma
Torus

Neutral Cloud

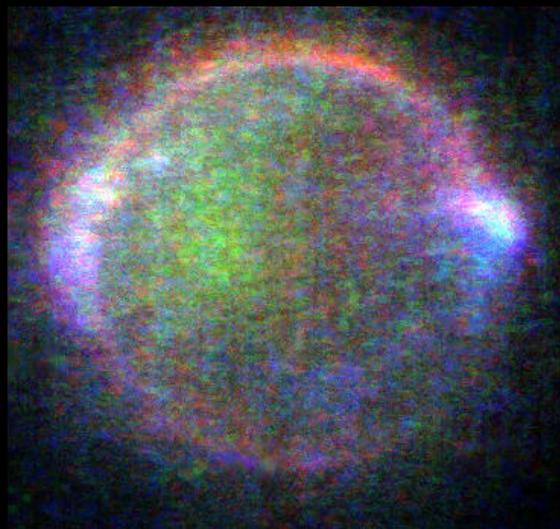
Flux tube electrodynamically couples Io
to Jupiter's ionosphere

UV oxygen

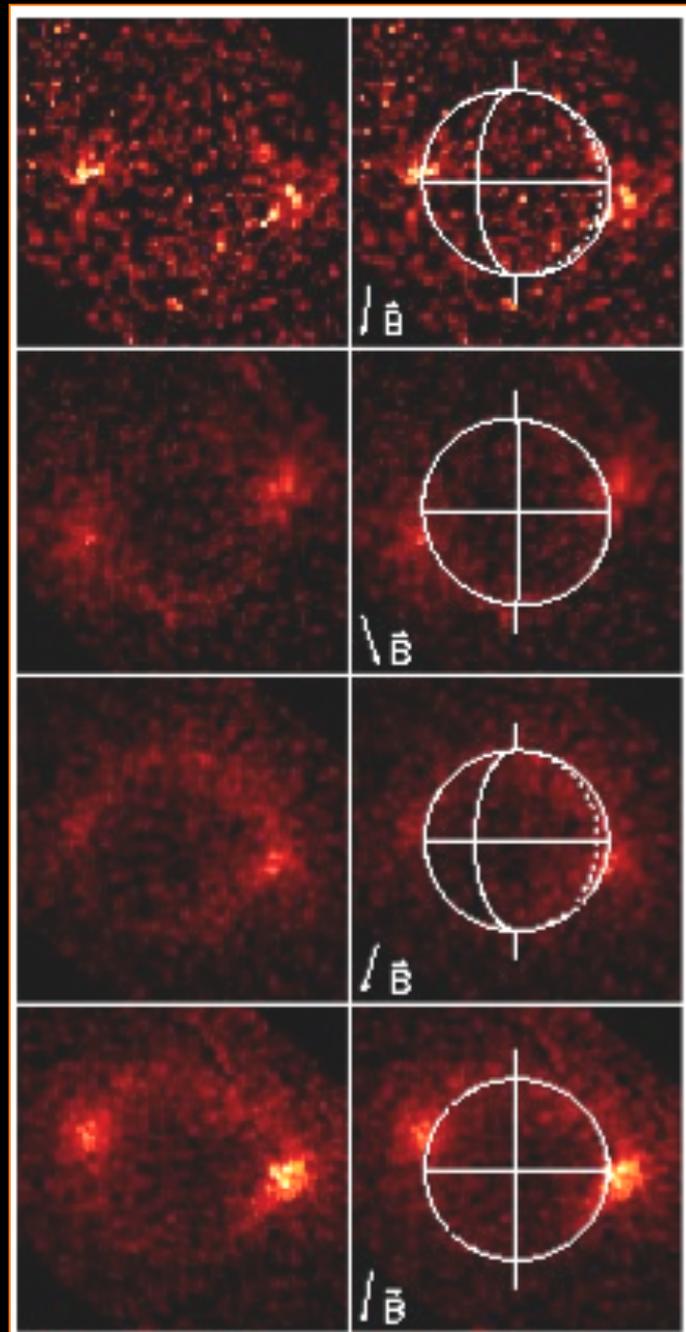


Roesler et al. 1999

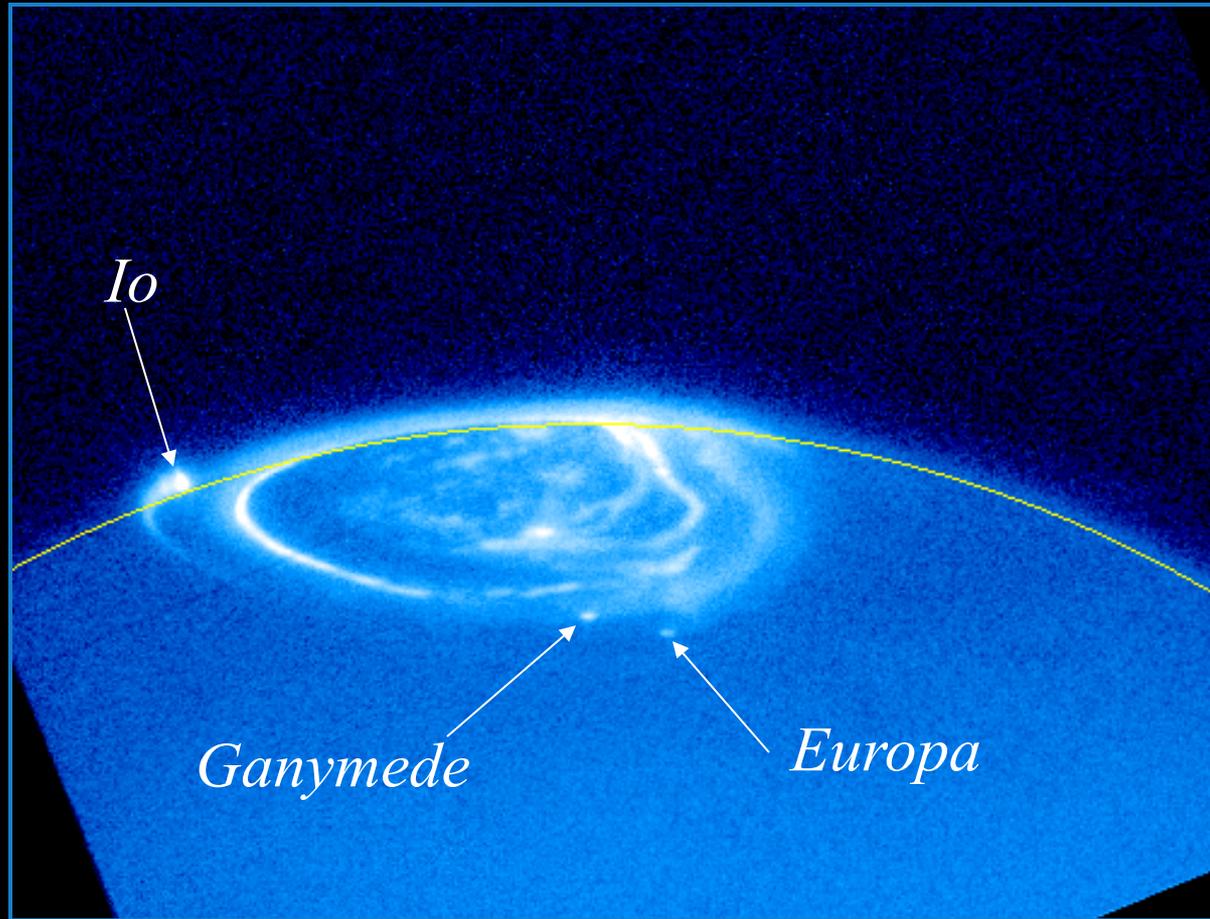
Visible,
Galileo



Spots rock with changing
Jupiter B field orientation

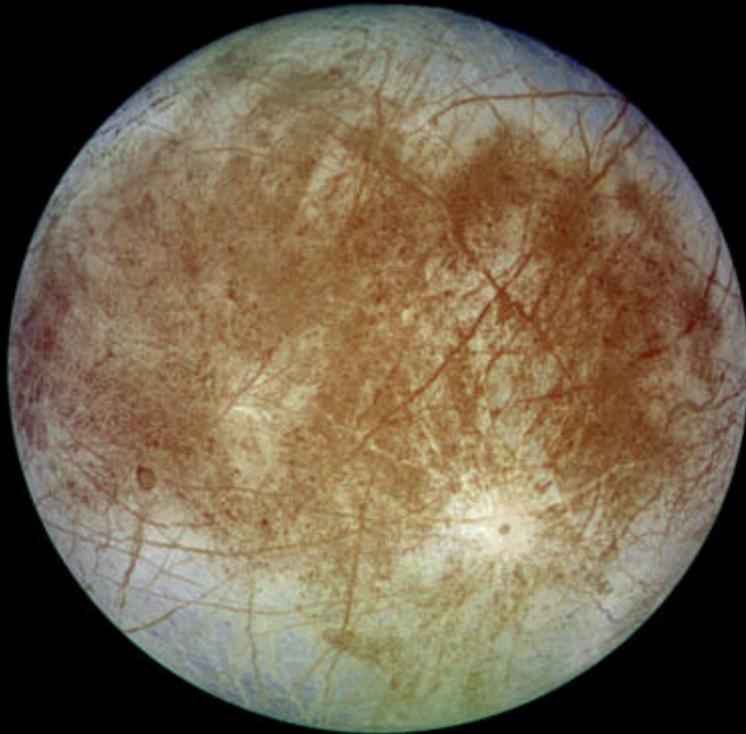


Satellite signatures in the Jovian aurora

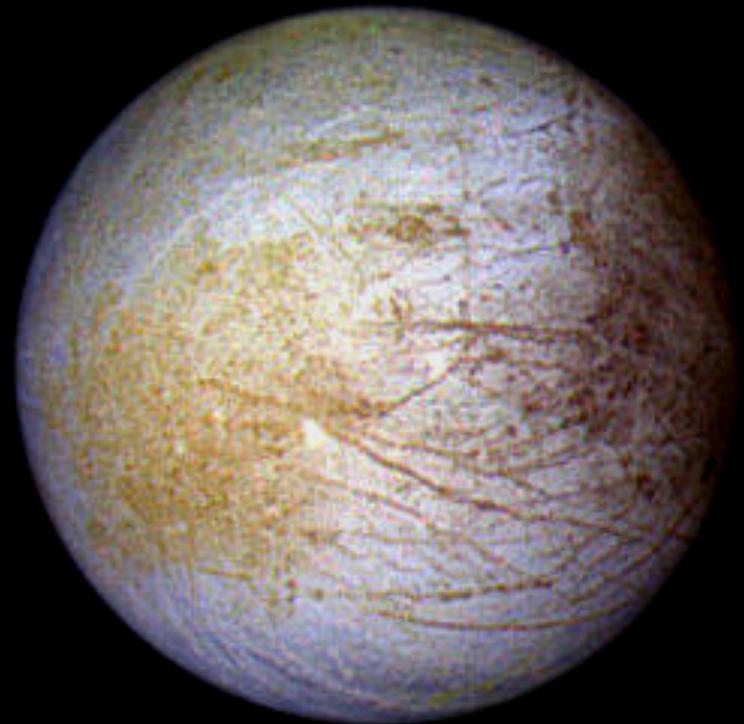


Clarke et al. 2004

Europa

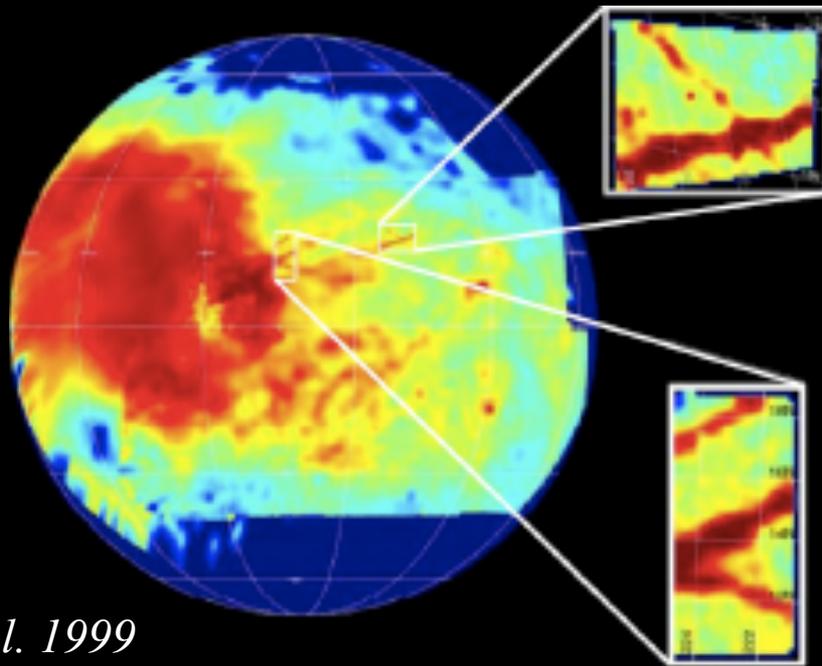


trailing hemisphere

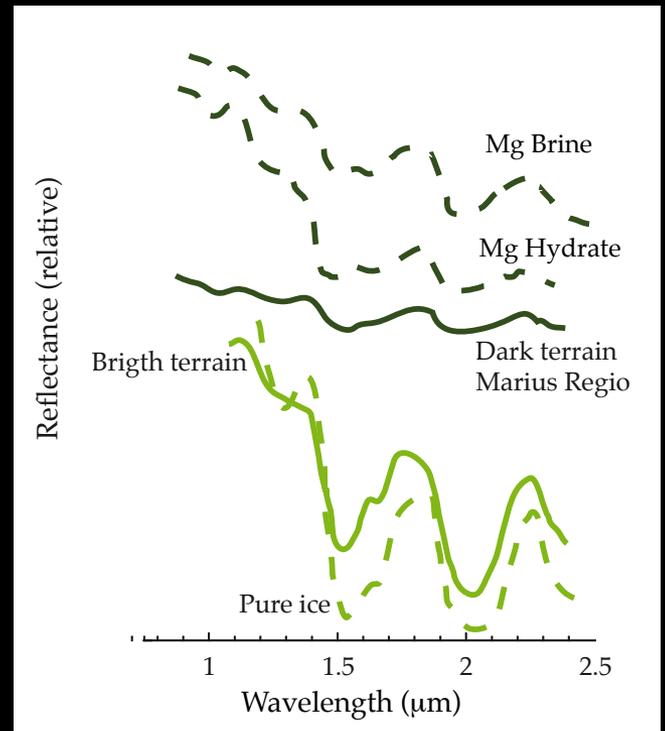


leading hemisphere

leading-trailing asymmetry due to radiolysis

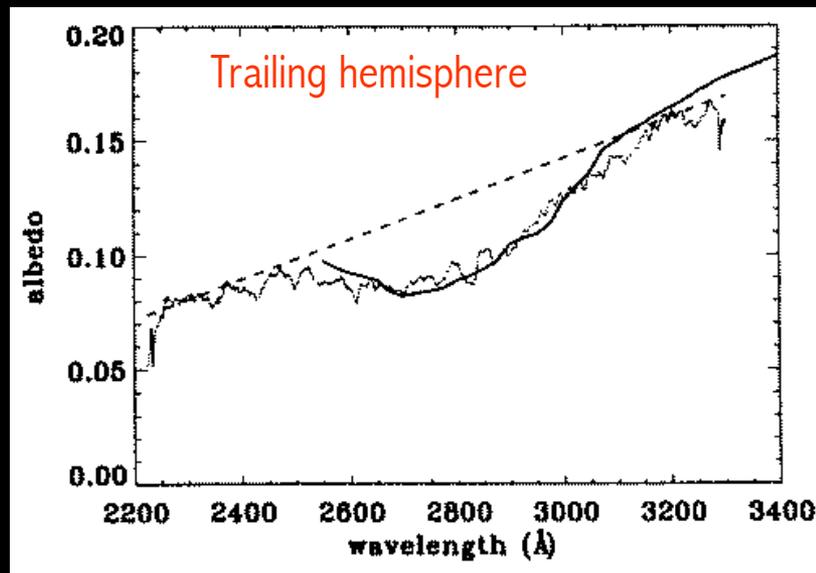


McCord et al. 1999



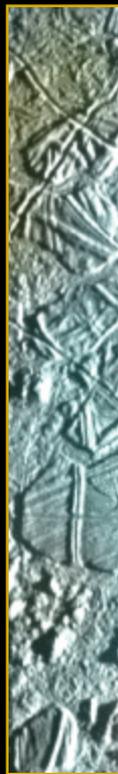
Frozen brines and hydrates ?

**How does the surface
relate to the subsurface ?**

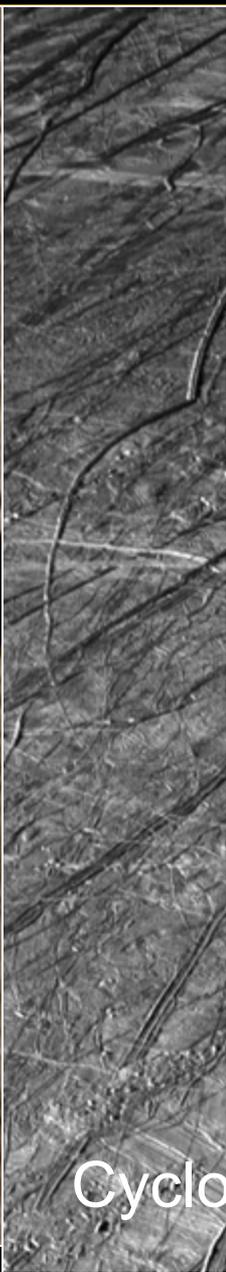


Detection of SO₂ in H₂O ice

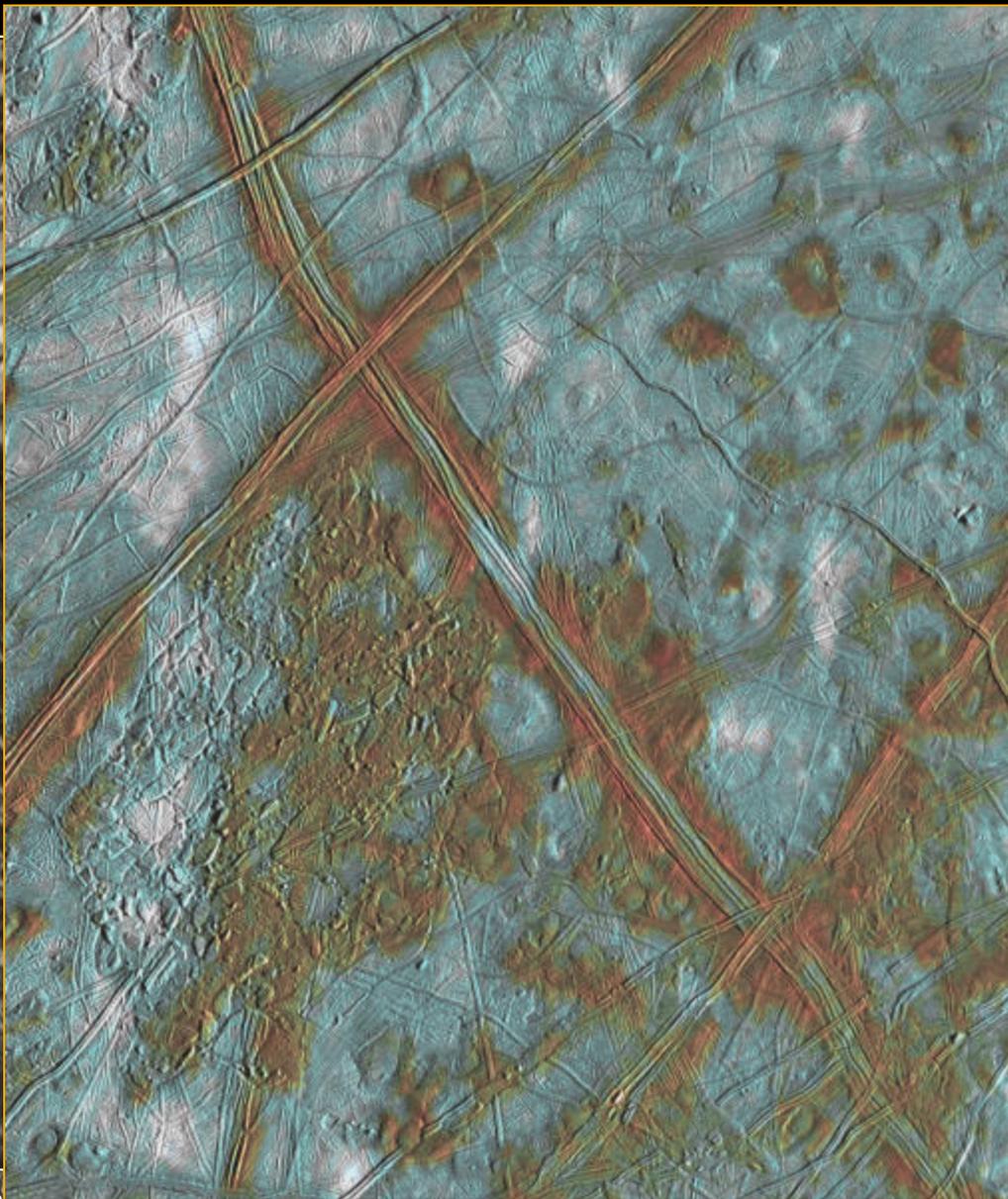
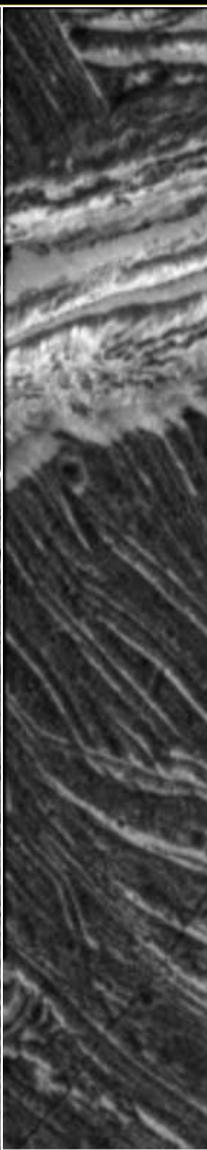
Noll et al. 1995



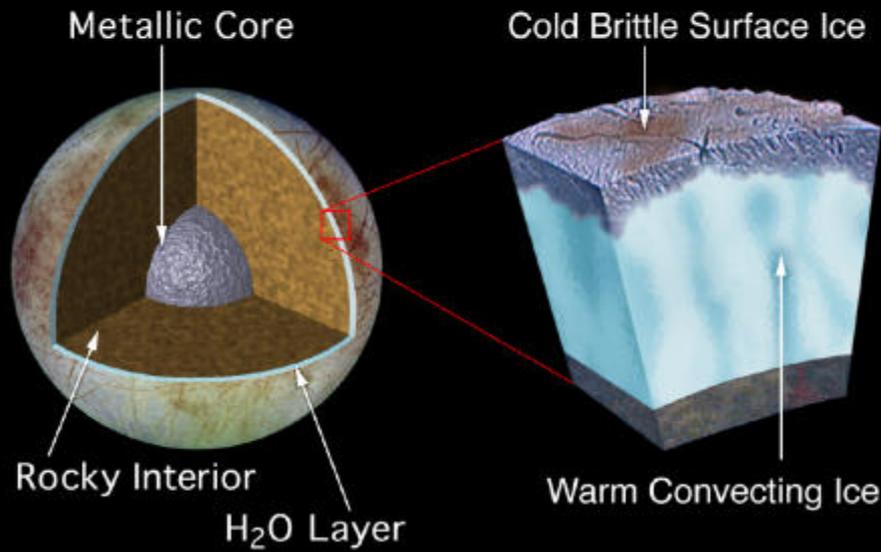
Ice ri



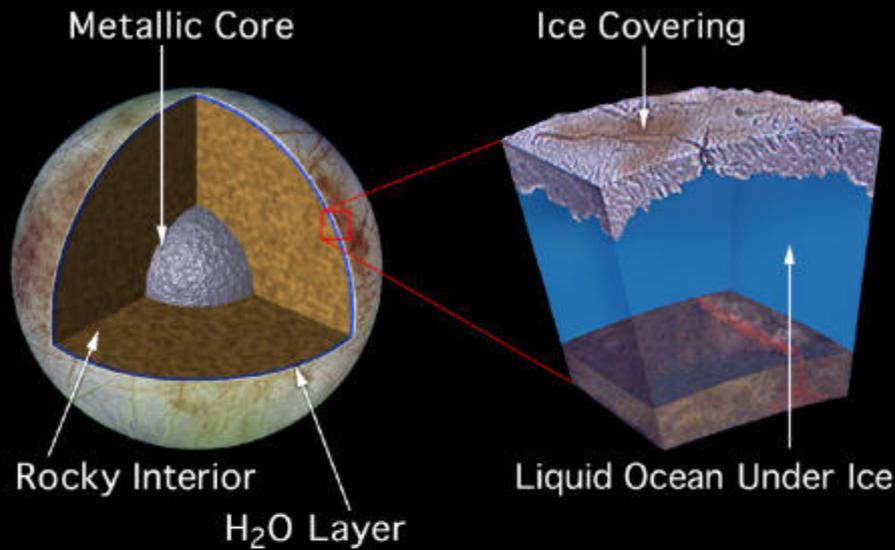
Cycloidal for



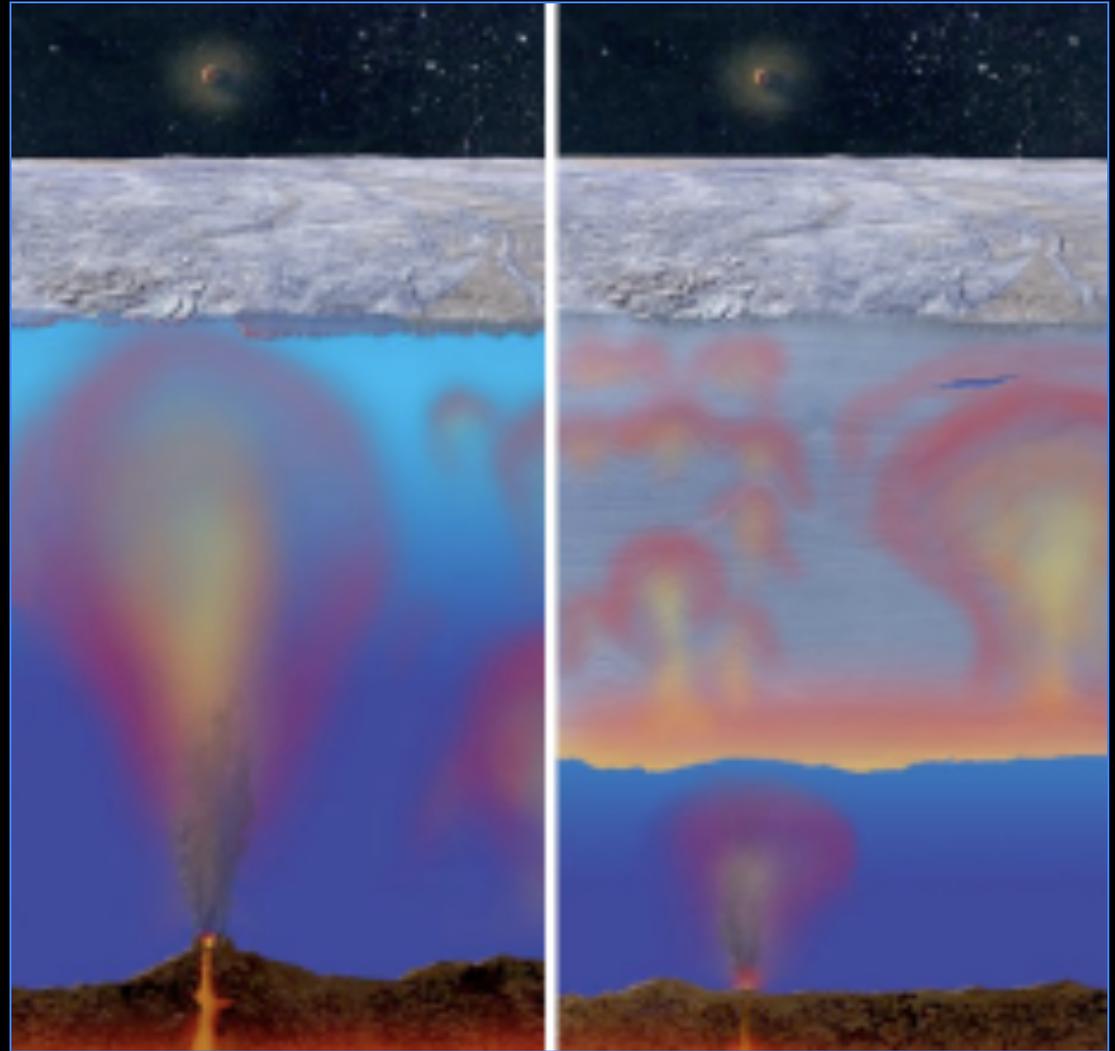
and induced magnetic field...



...indicate the presence of a mobile, subsurface material, possibly liquid.



The most contentious issue is the thickness of the overlying ice.

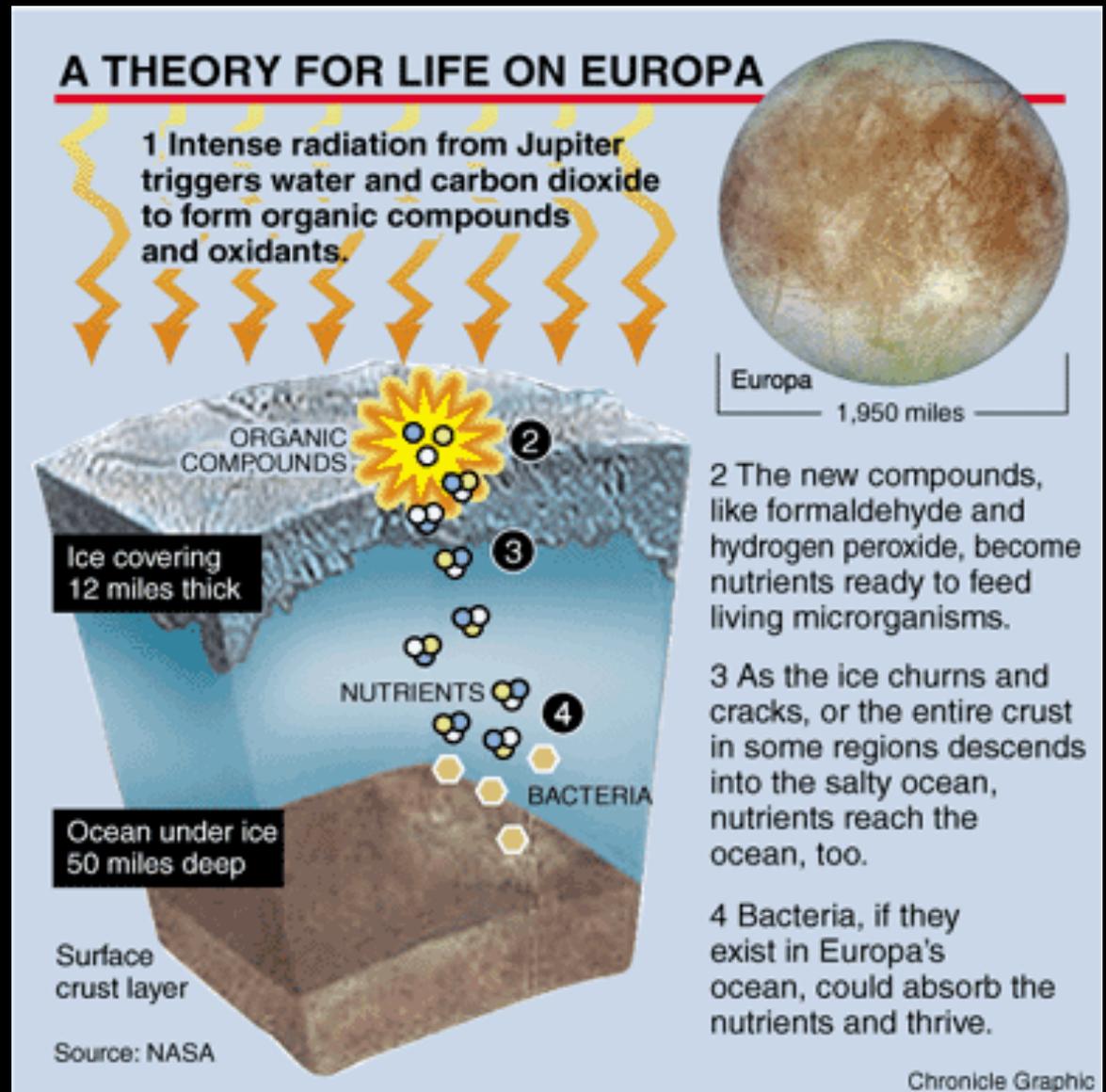


Life on Europa?

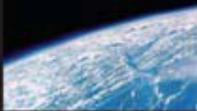
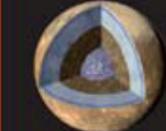
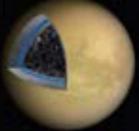
The search for life involves the search for life as we know it, primarily the search for liquid water.

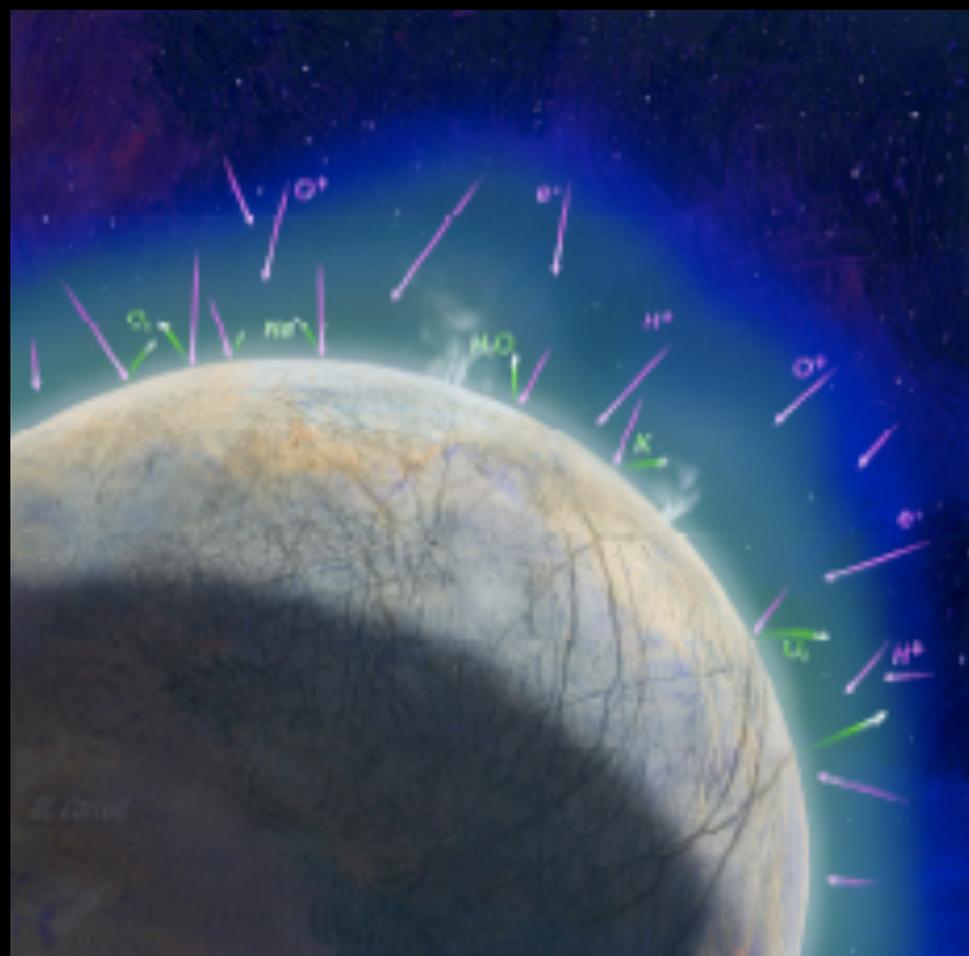
- ✓ Liquid water
- ✓ “Biogenic” elements (e.g., carbon as organics)
- ? Useful source of free energy (on Earth it’s primarily photosynthesis)

Deadly radiation powers life on Europa?



Chyba (2000)

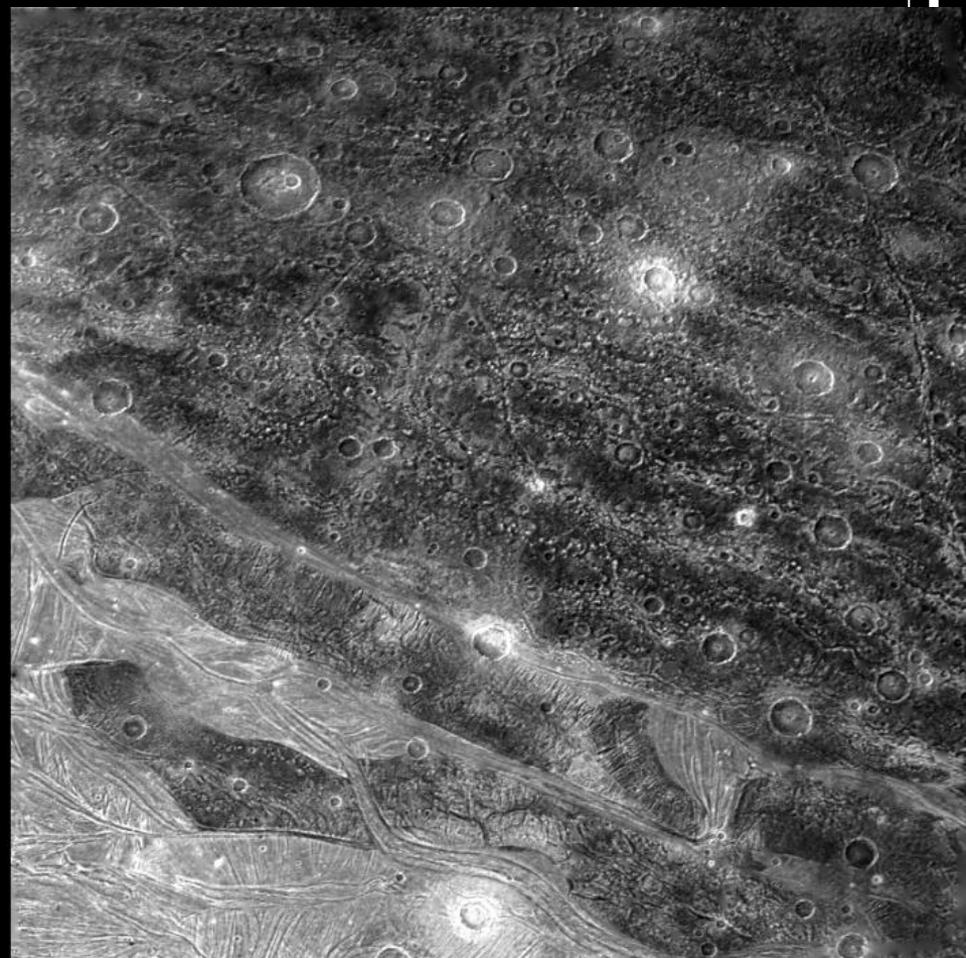
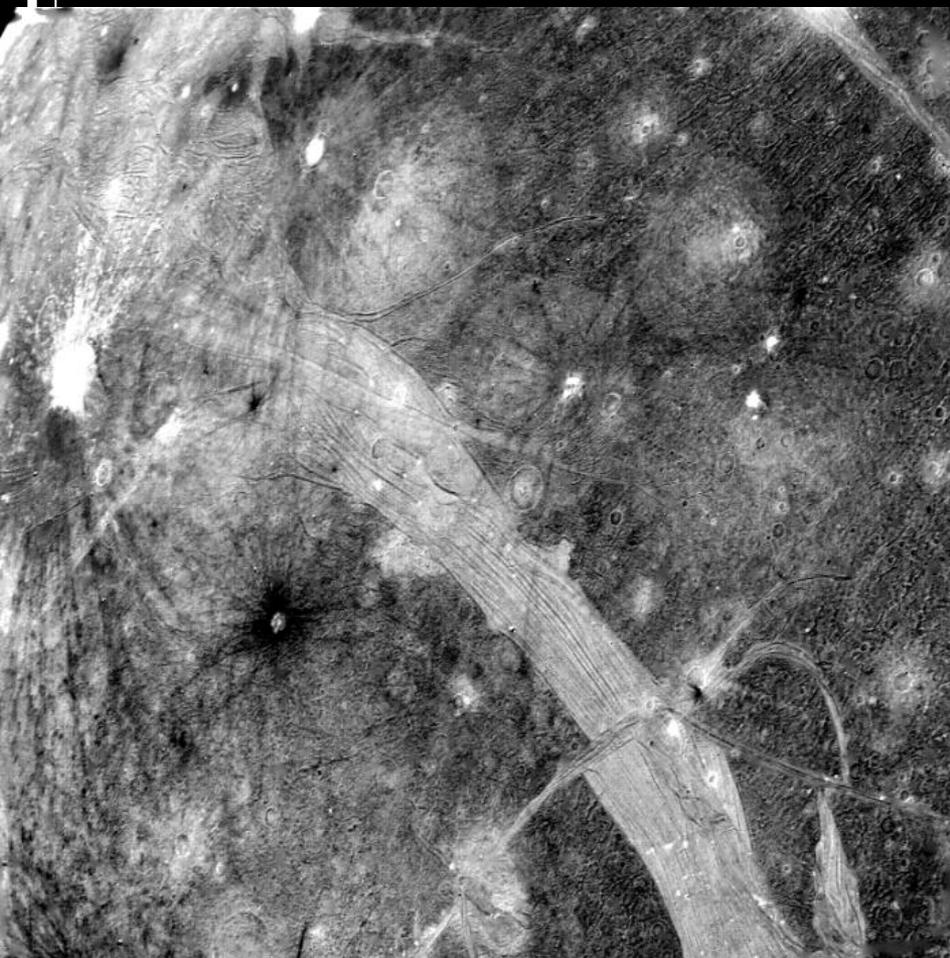
| | SURFACE HABITATS | | DEEP HABITATS | | | | |
|--------------------|--|--|--|--|--|--|--|
| | Shallow water | | Trapped oceans | | Top oceans | | |
| | The Earth | Mars | Ganymede | Callisto | Titan | Europa | Enceladus |
| |  |  |  |  |  |  |  |
| Liquid Water |  |  |  |  |  |  |  |
| Stable Environment |  |  |  |  |  |  |  |
| Essential elements |  |  |  |  |  |  |  |
| Chemical Energy |  |  |  |  |  |  |  |

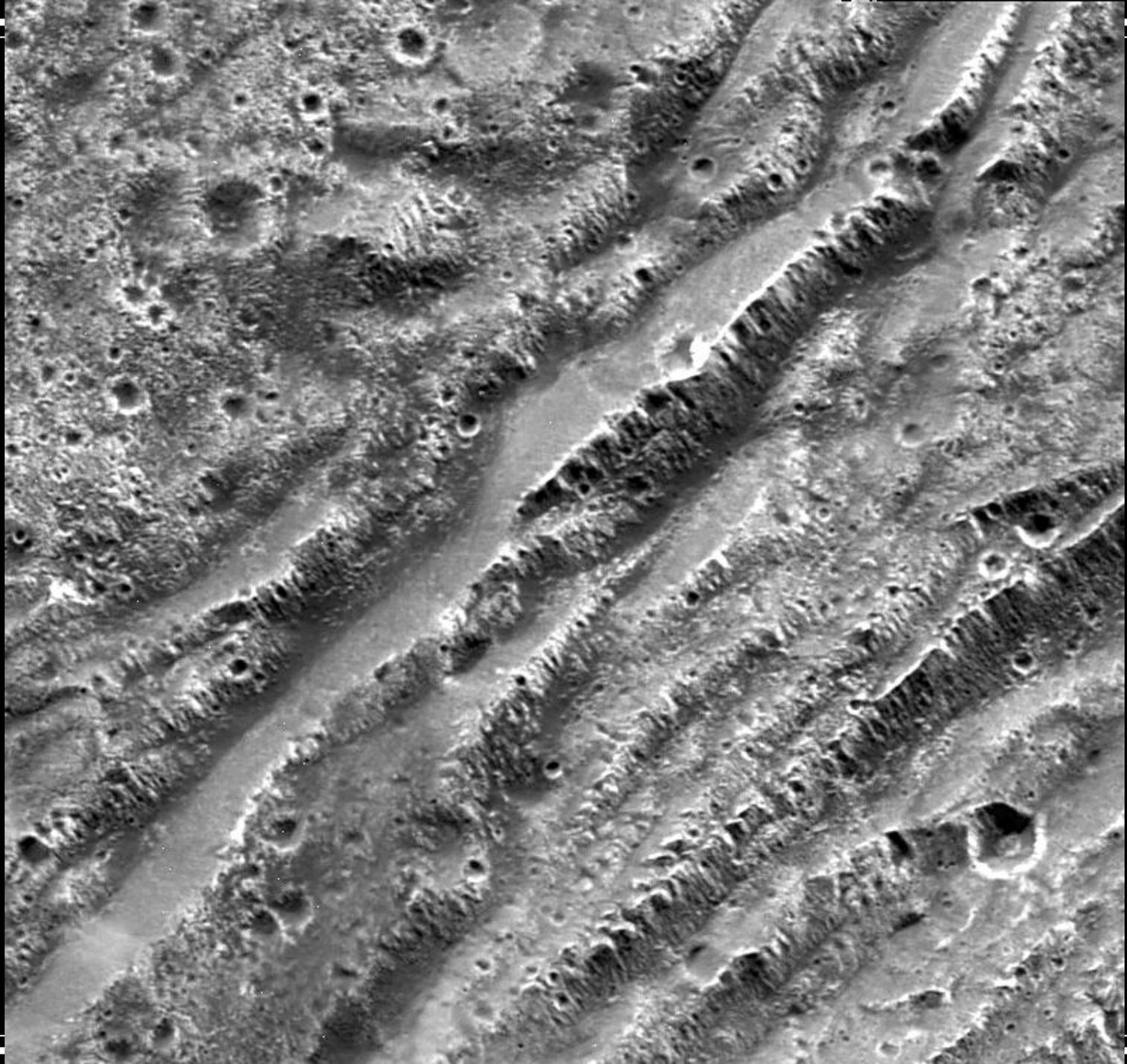


Ganymede

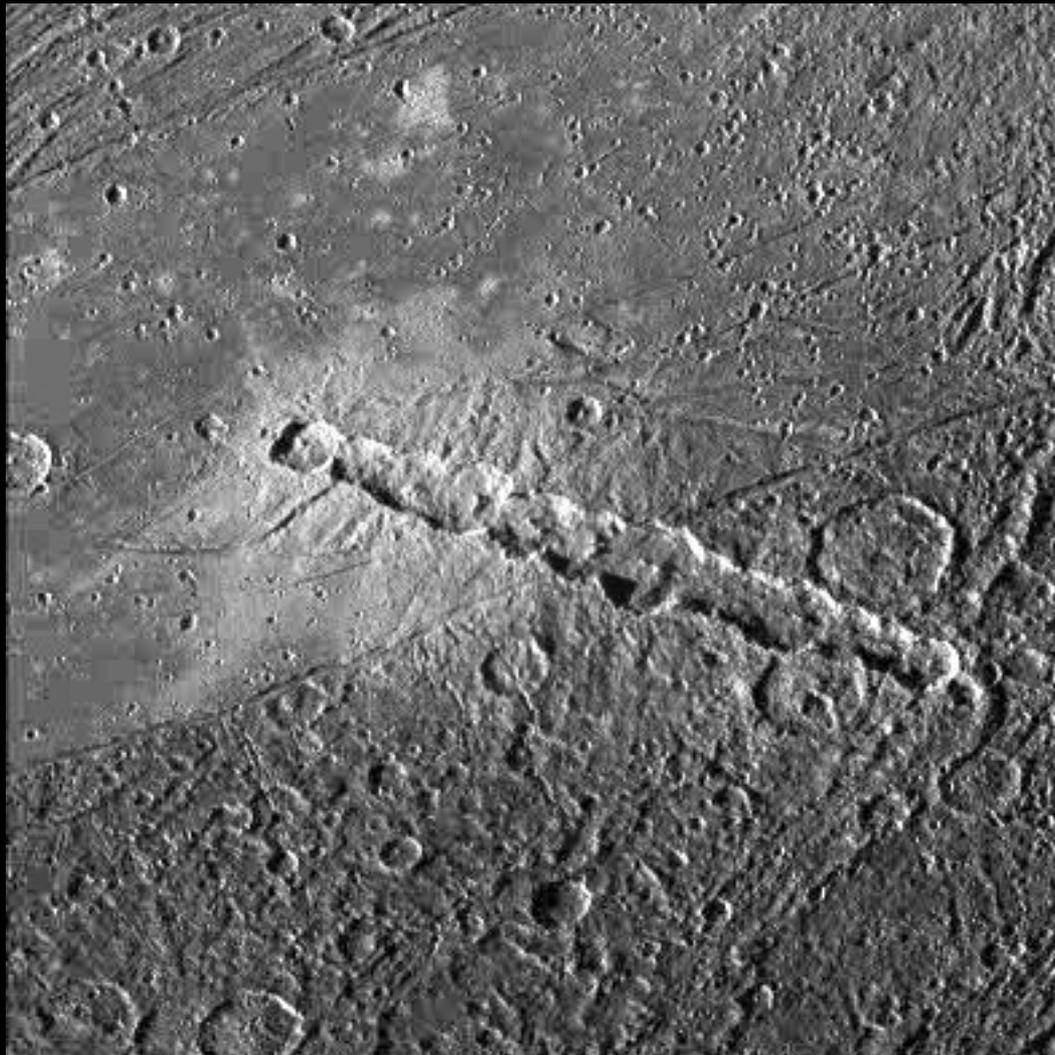
The largest satellite in the solar system,
larger than Mercury and Pluto, only
slightly smaller than Mars

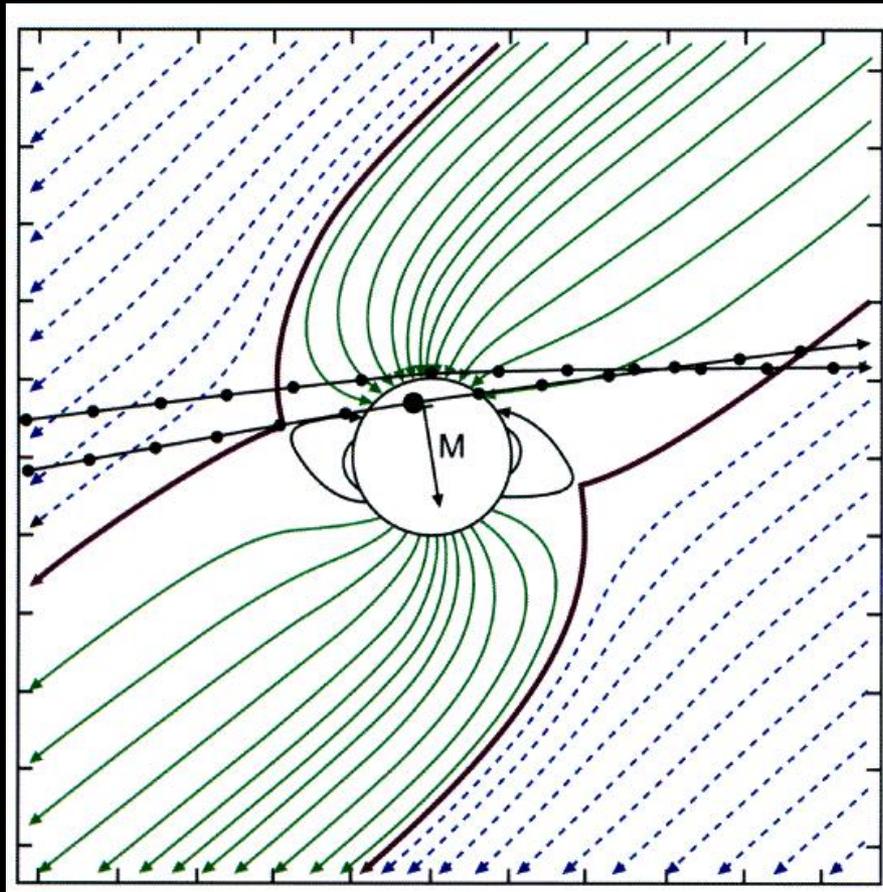




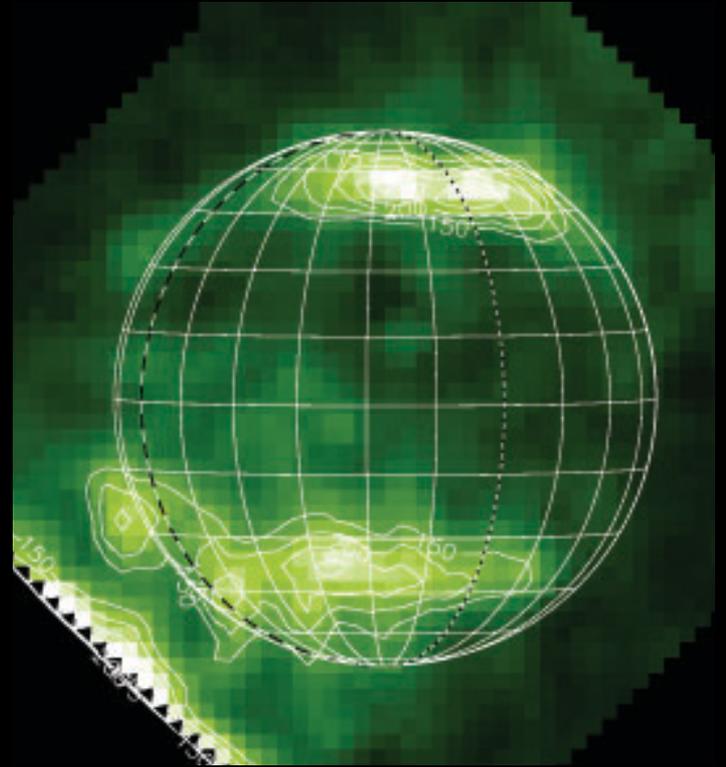






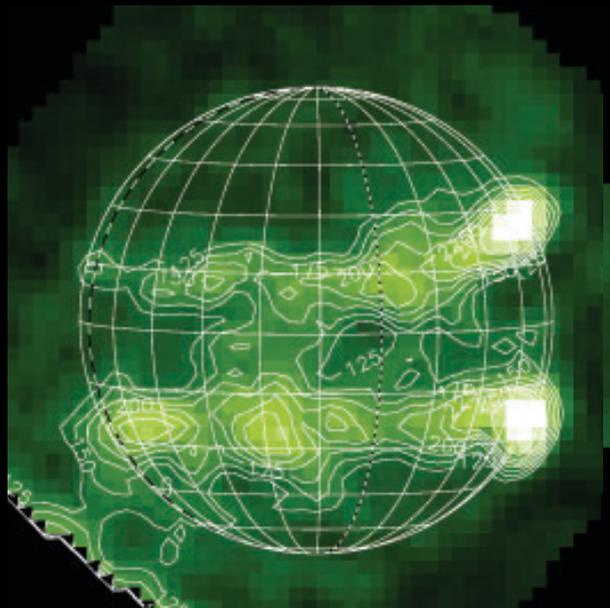


Gurnett et al. 1996
Kivelson et al. 1996

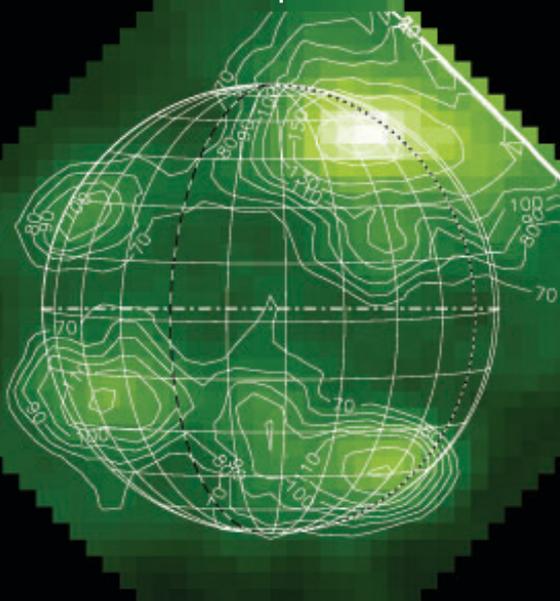


Feldman et al. 2000

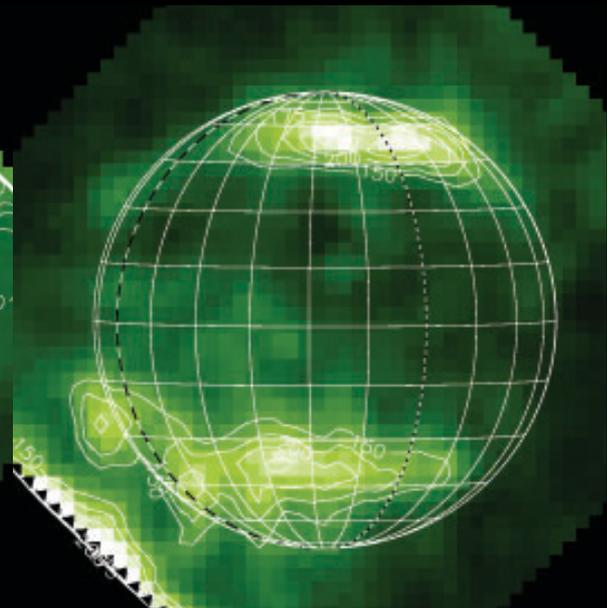
Leading hemisphere



~Jupiter facing hemisphere



Trailing hemisphere



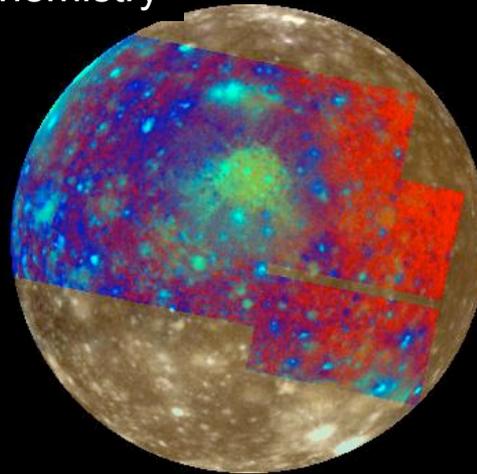
McGrath 2007

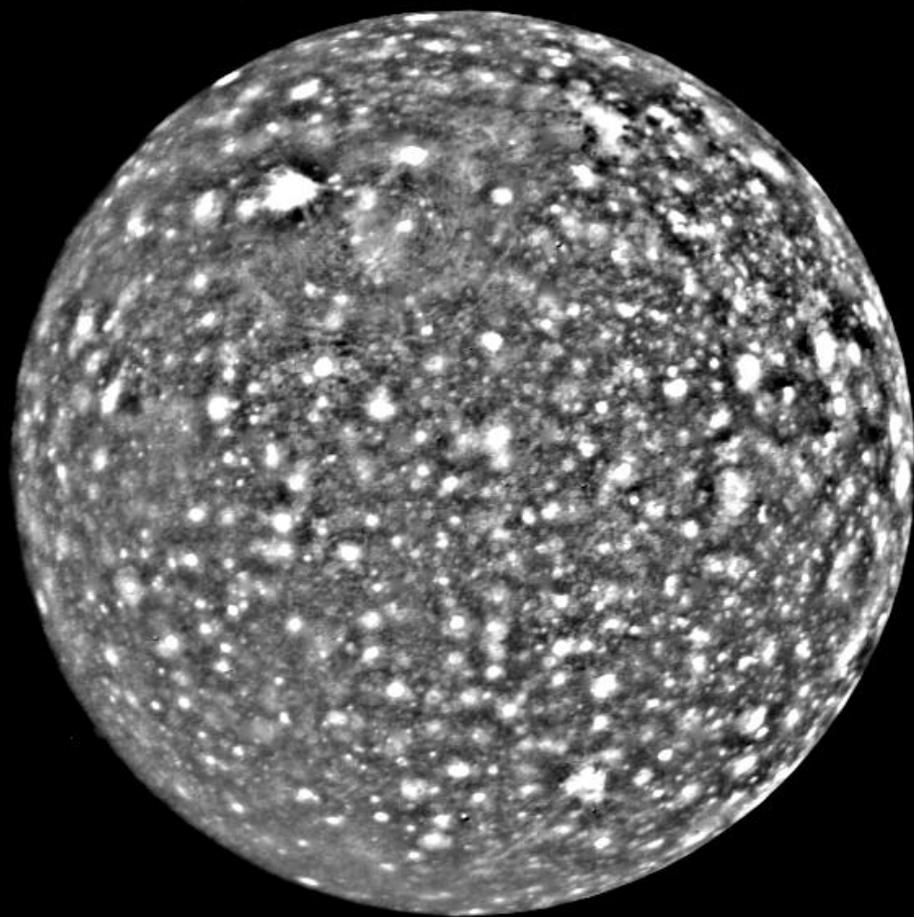
Callisto

Oldest surface of the Jupiter system —
a witness of early ages

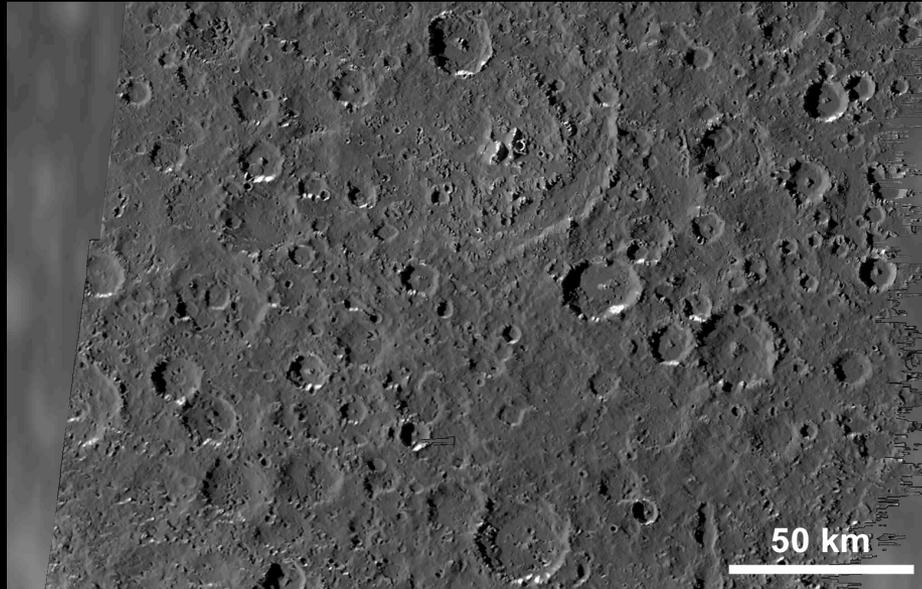


Complex chemistry

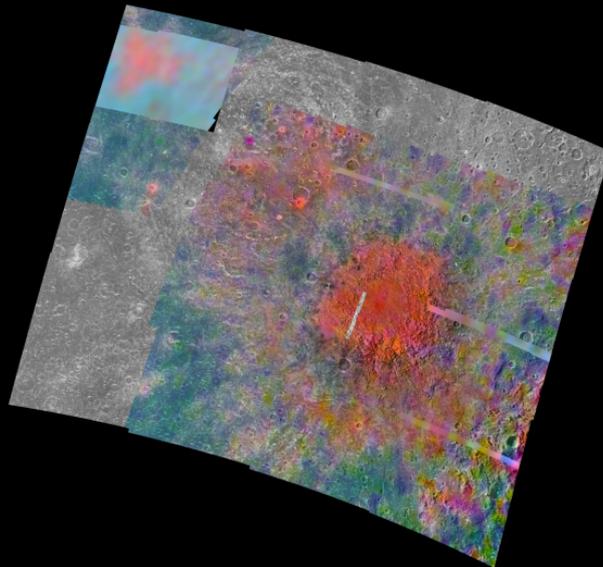
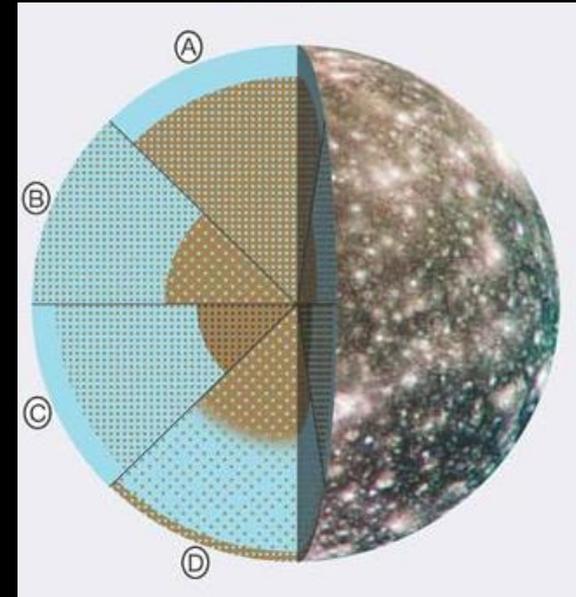




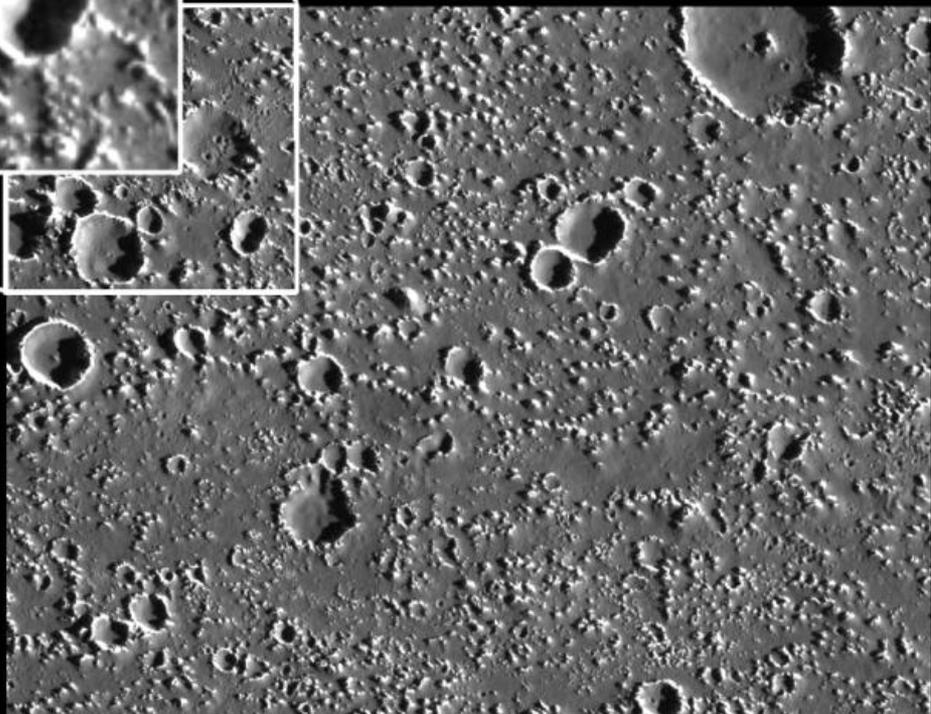
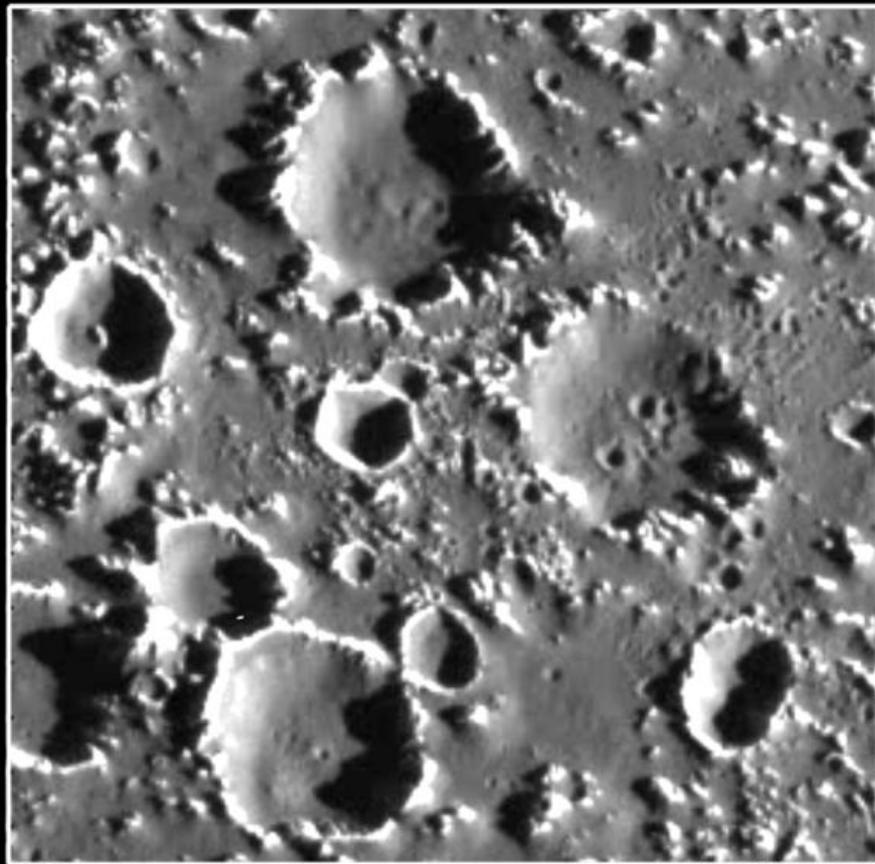
Cratering record and early geological history

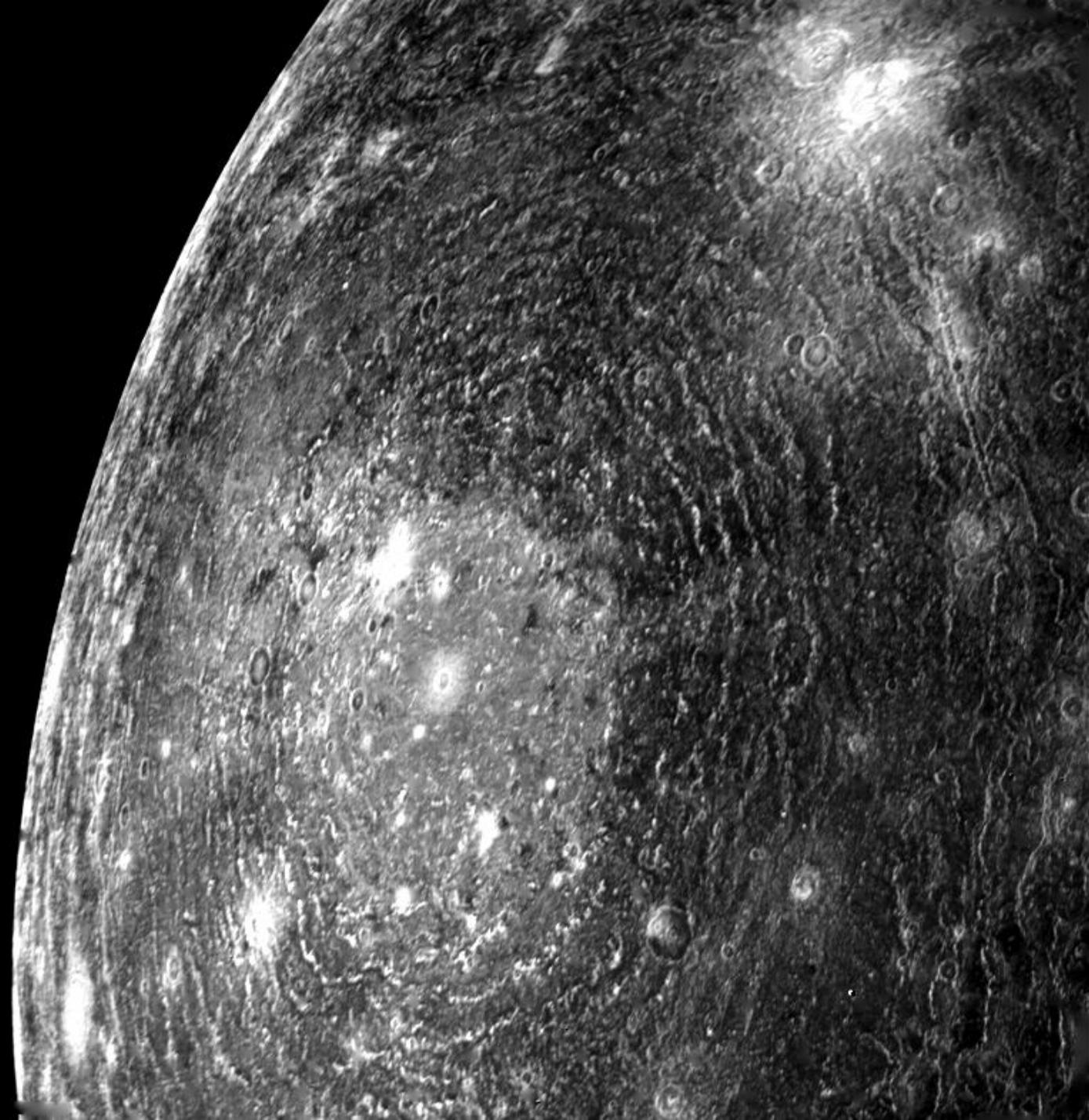


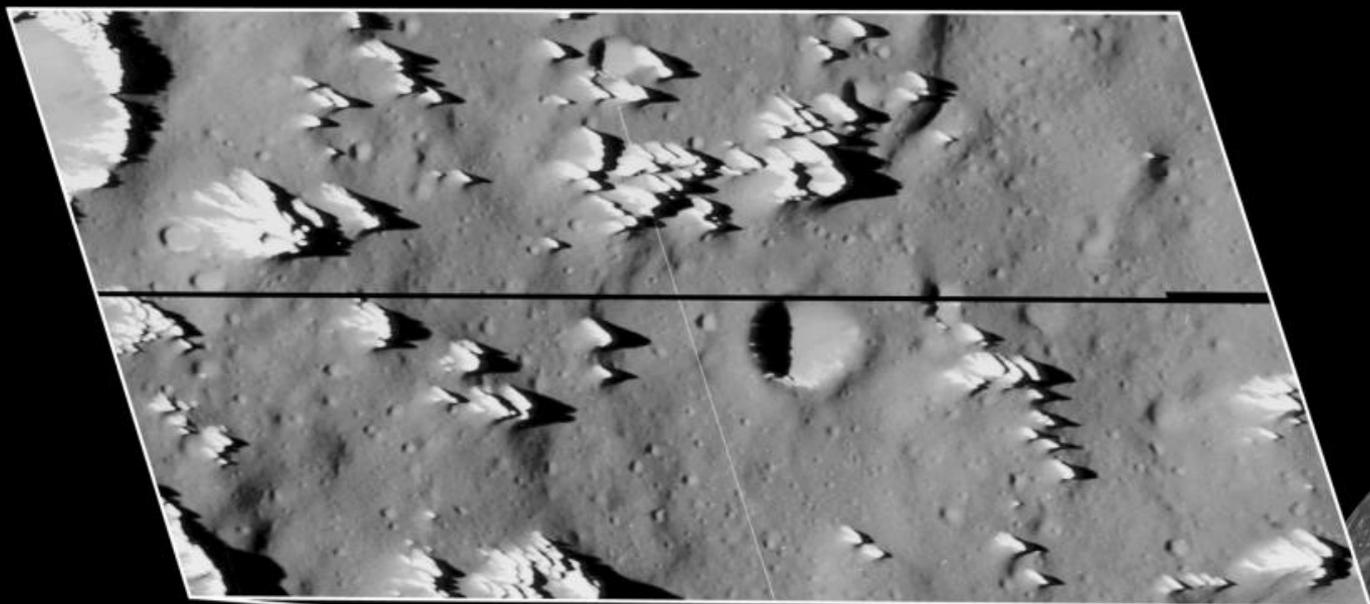
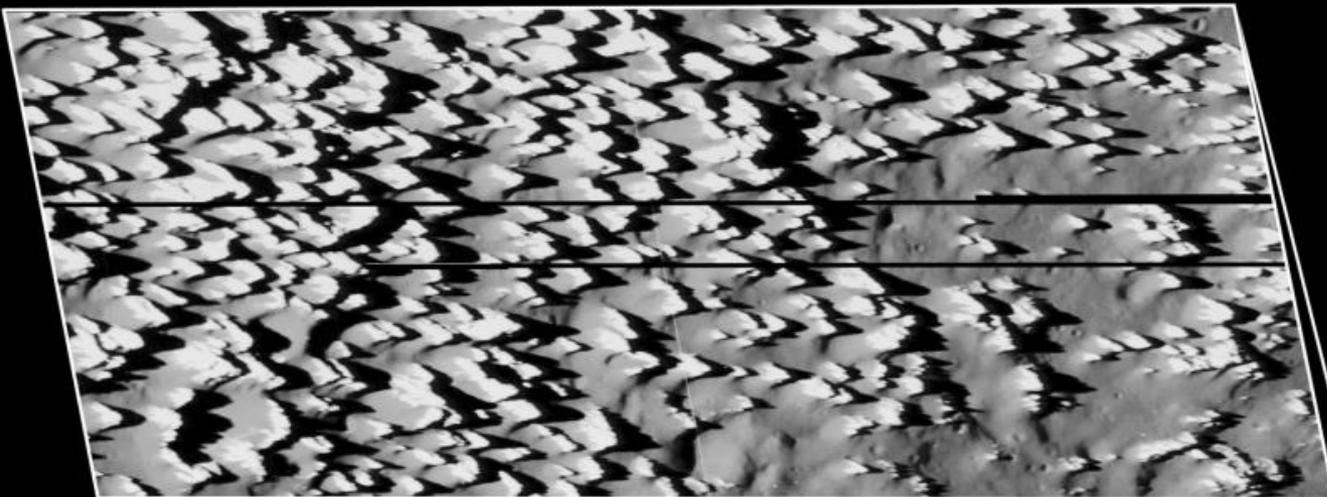
Structure and internal differentiation



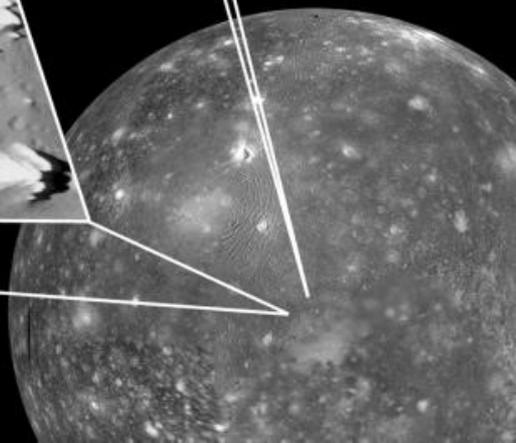
Surface composition and degradation processes

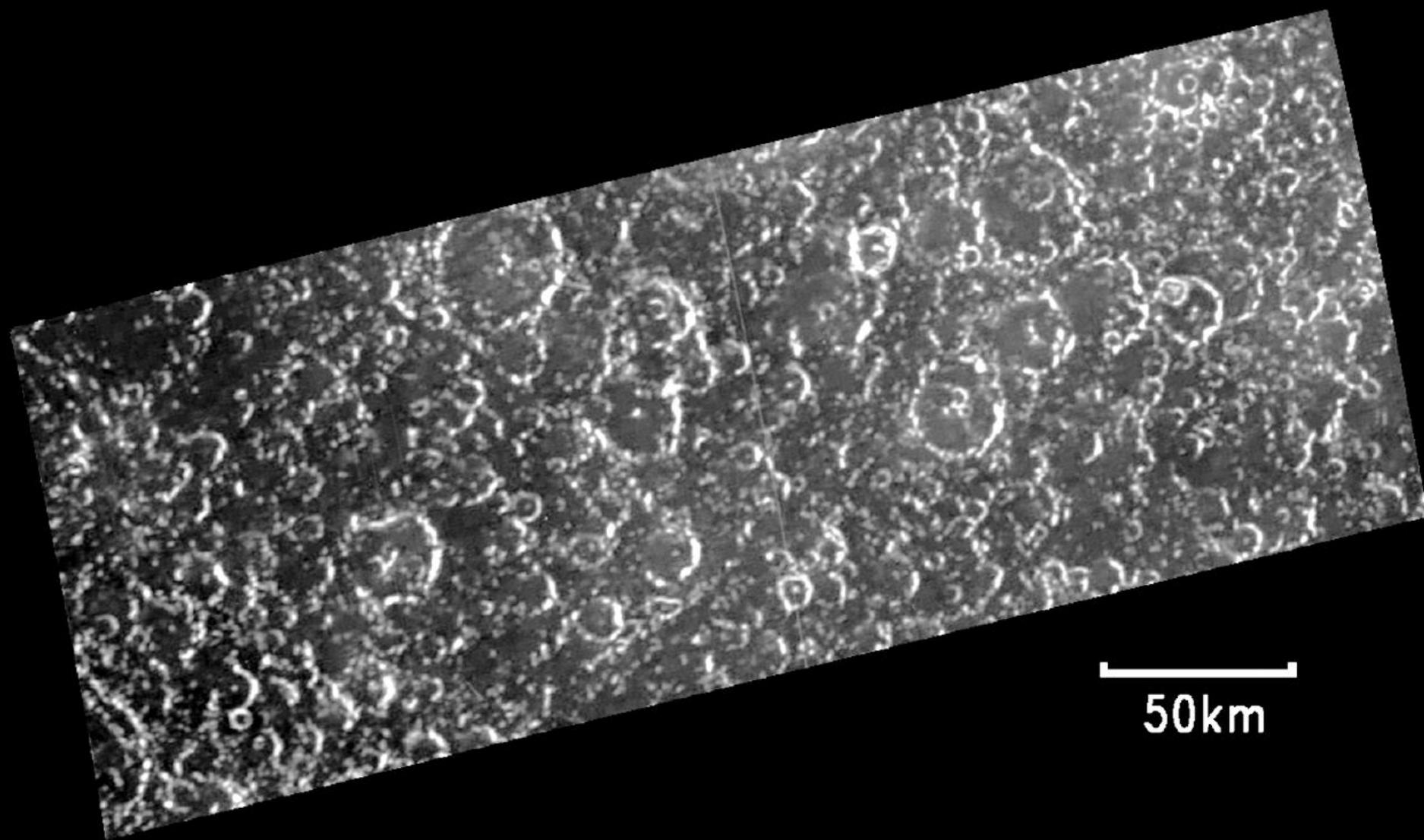




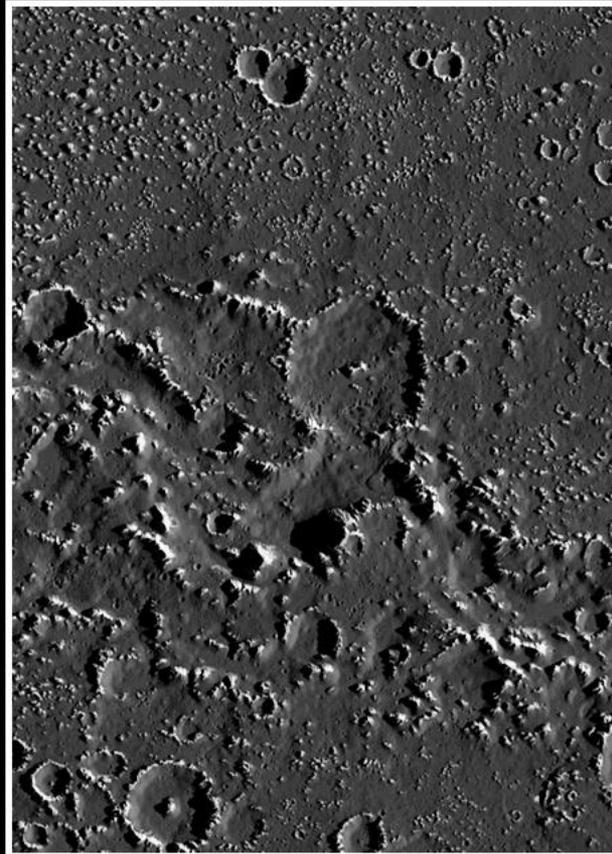
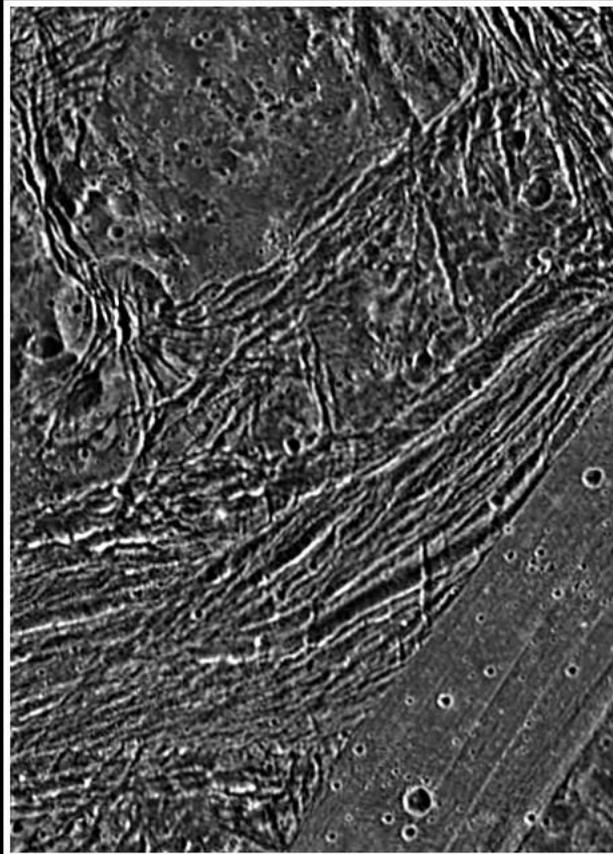


5 km

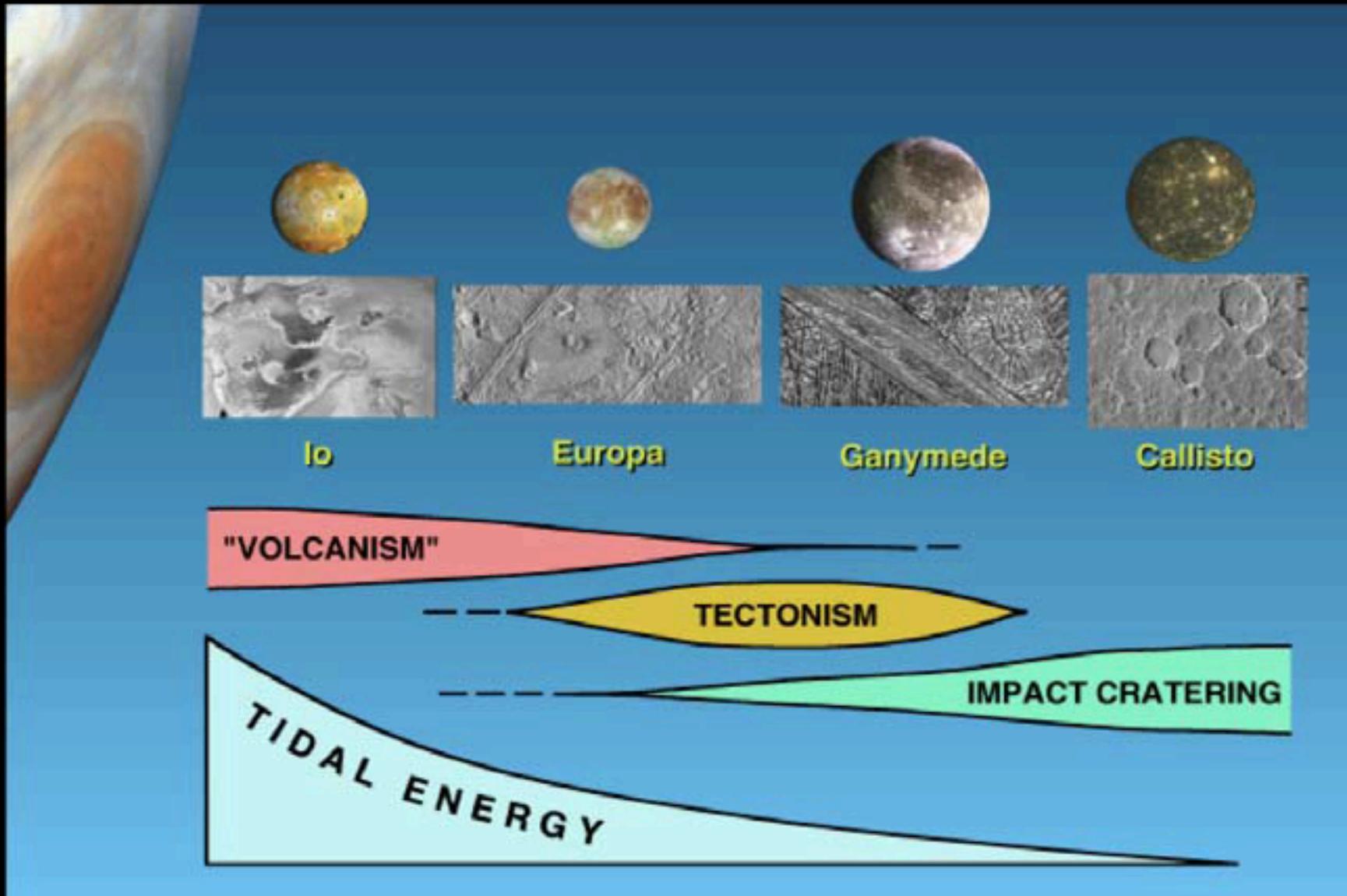




50km







Io

Europa

Ganymede

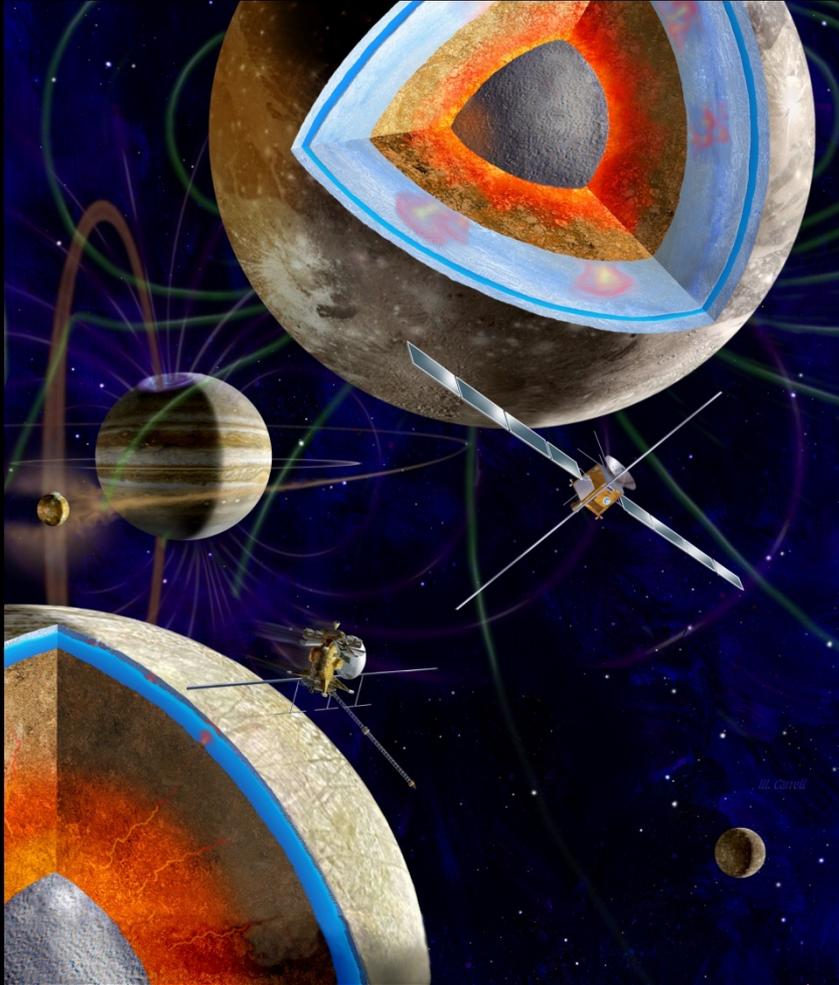
Callisto

"VOLCANISM"

TECTONISM

IMPACT CRATERING

TIDAL ENERGY



Key Questions:

- Does the Jupiter system harbor habitable worlds?
- What are the processes operating within the Jupiter system?

EJSM-Laplace mission:

- Jupiter Ganymede Orbiter (JGO)
- Jupiter Europa Orbiter (JEO)

The diverse Jupiter System

