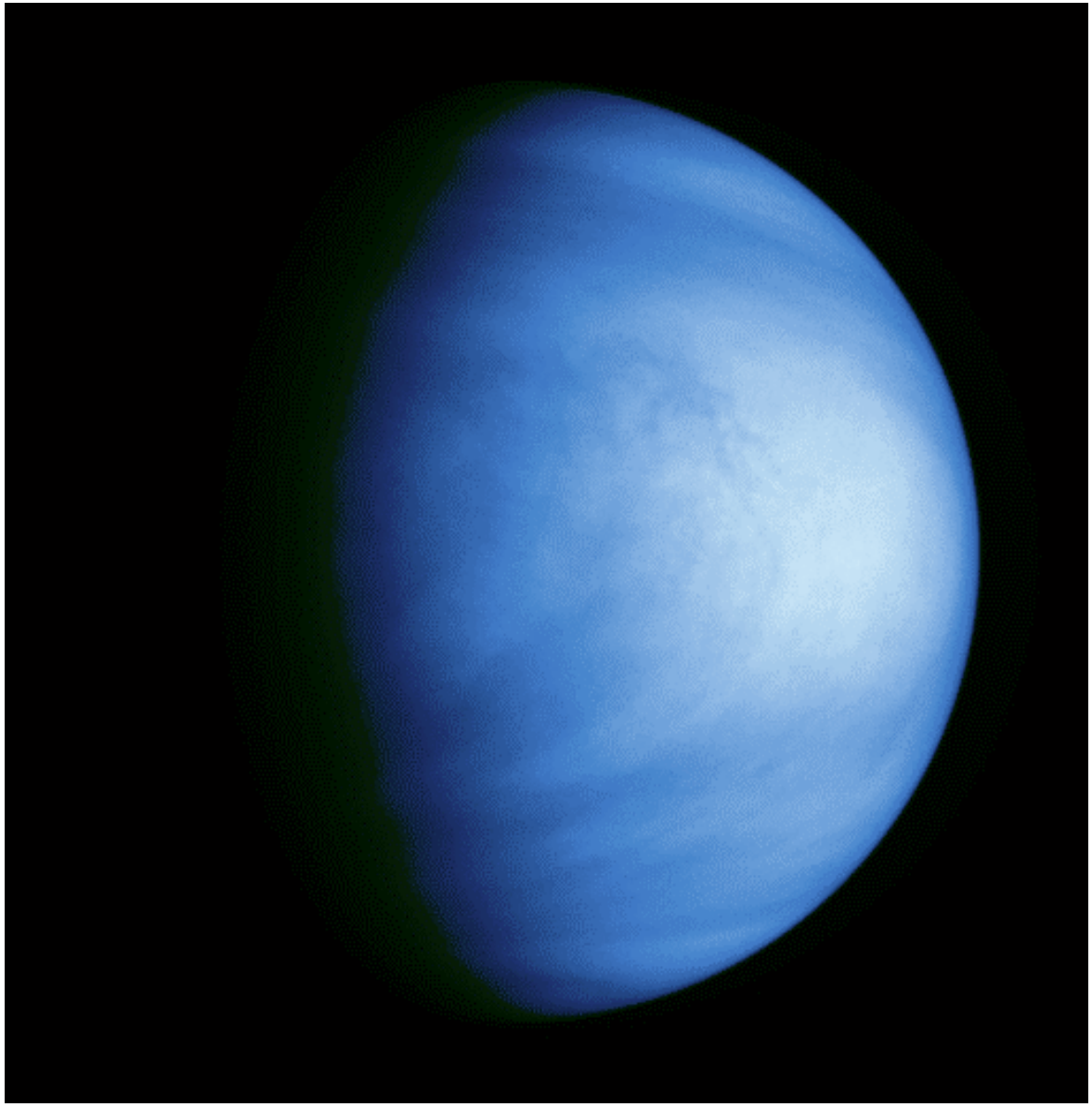
Venus: view of cloud tops



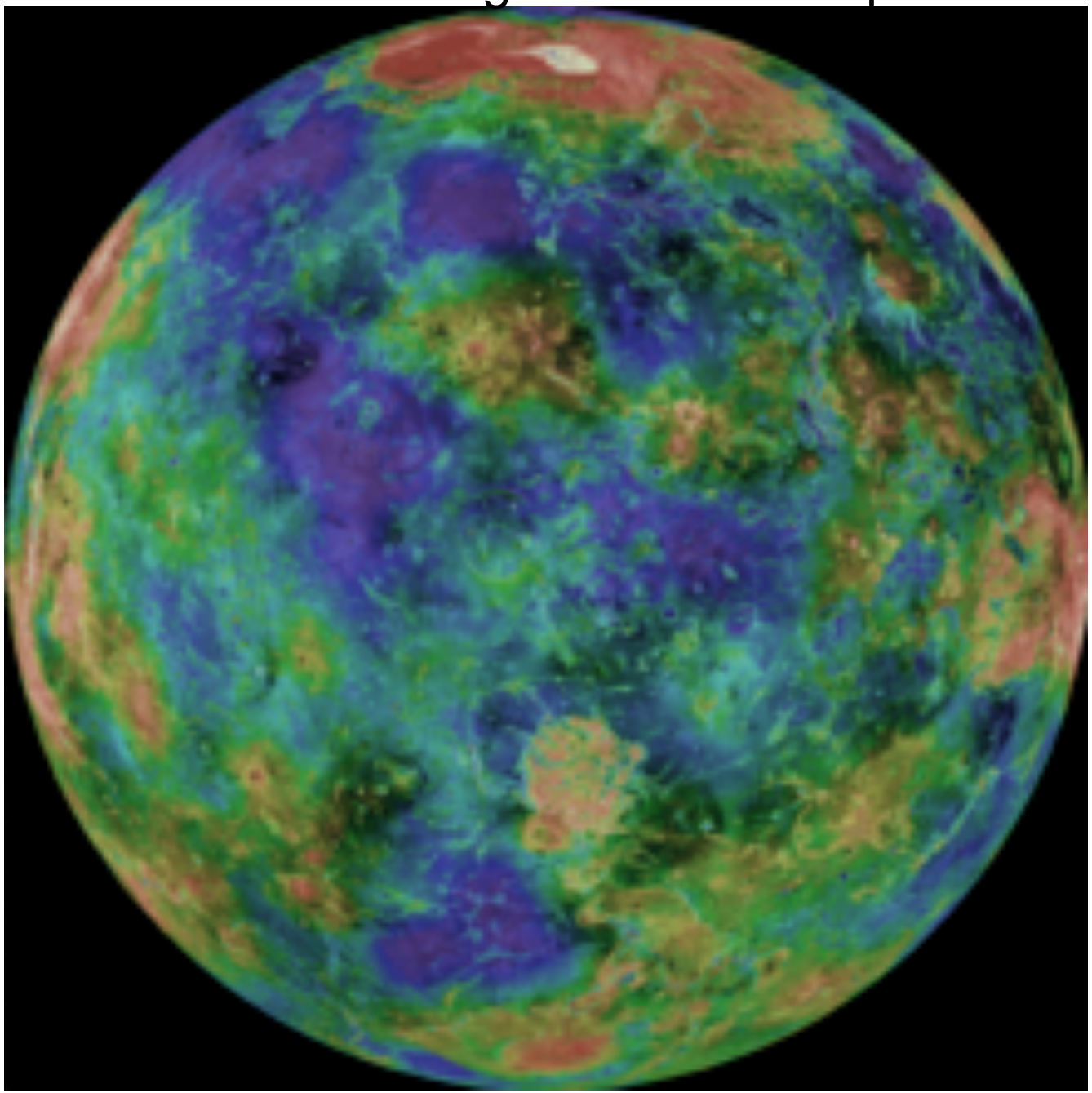
Venus: basic facts.

- Average distance from Sun = 0.72 AU
- Perihelion = 0.72 AU
- Aphelion = 0.73 AU – low e
- Orbital period = 0.62 years (225 days)
- Tilt of axis = 177 degrees (!)
- Rotation period = 243 days
- Temperature 745 K
- Size = 0.95 size of Earth
- Average density 4.2 g/cc (rocky)
- Geometric albedo ~ 0.84 ; Bond albedo ~ 0.75

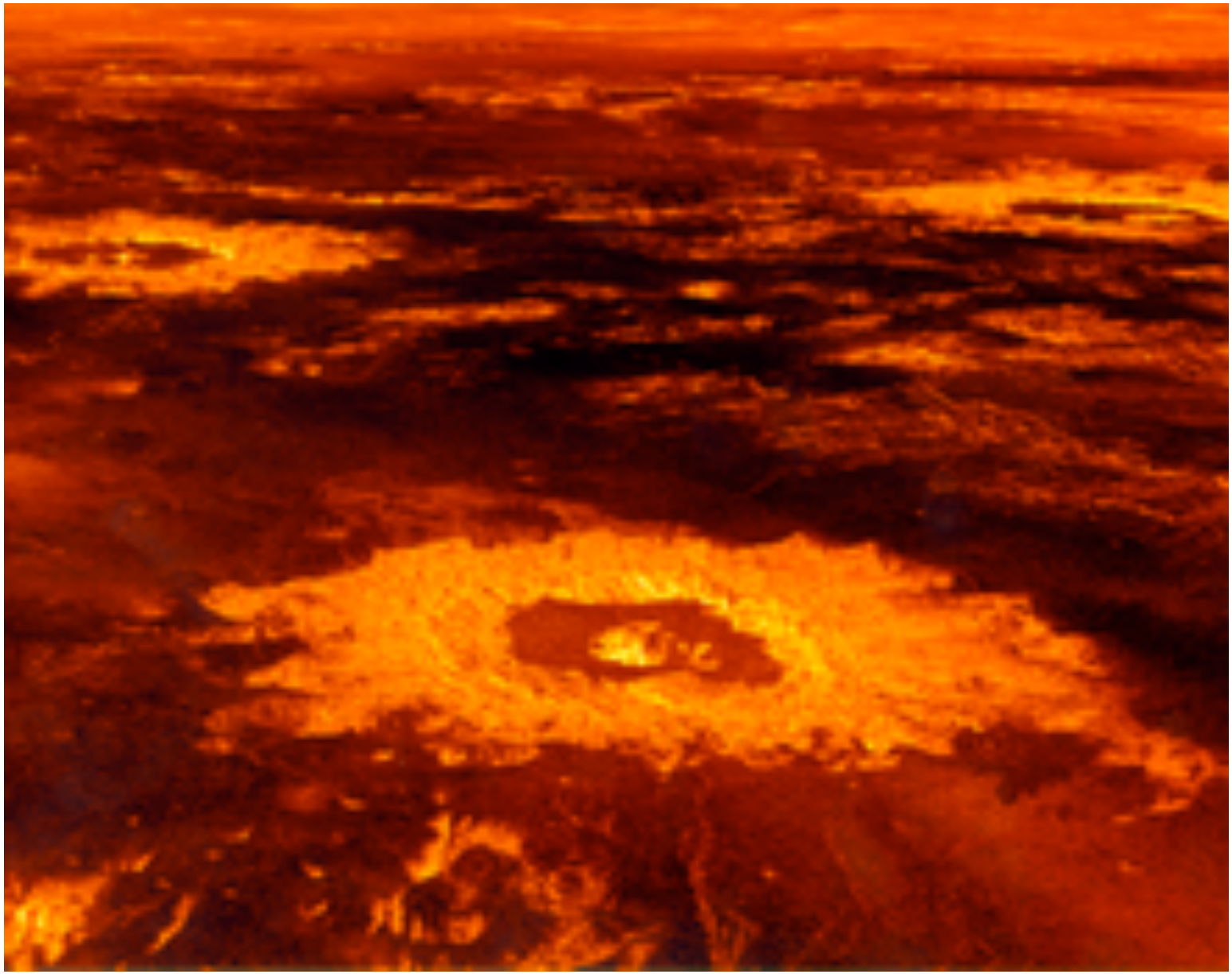
Venus: Radar view of surface

Bright = rough
Dark = smooth

Venus - Magellan Radar Map



Venus - Magellan SAR



Venera picture of surface

Venus

- Sometimes called Earth's twin
  - Similar diameter (95% that of Earth)
  - Similar mass (82% that of Earth)
  - Similar density

Venus

- Some differences from Earth:
  - No moon
  - No magnetic field
    - Due to slow rotation (day=243 earth days)?
  - Rotates backward
    - Due to *large impact*?
  - Completely cloud covered
  - Surface dry (no water)
  - Hot Hot Hot!   745 K   (880 F)

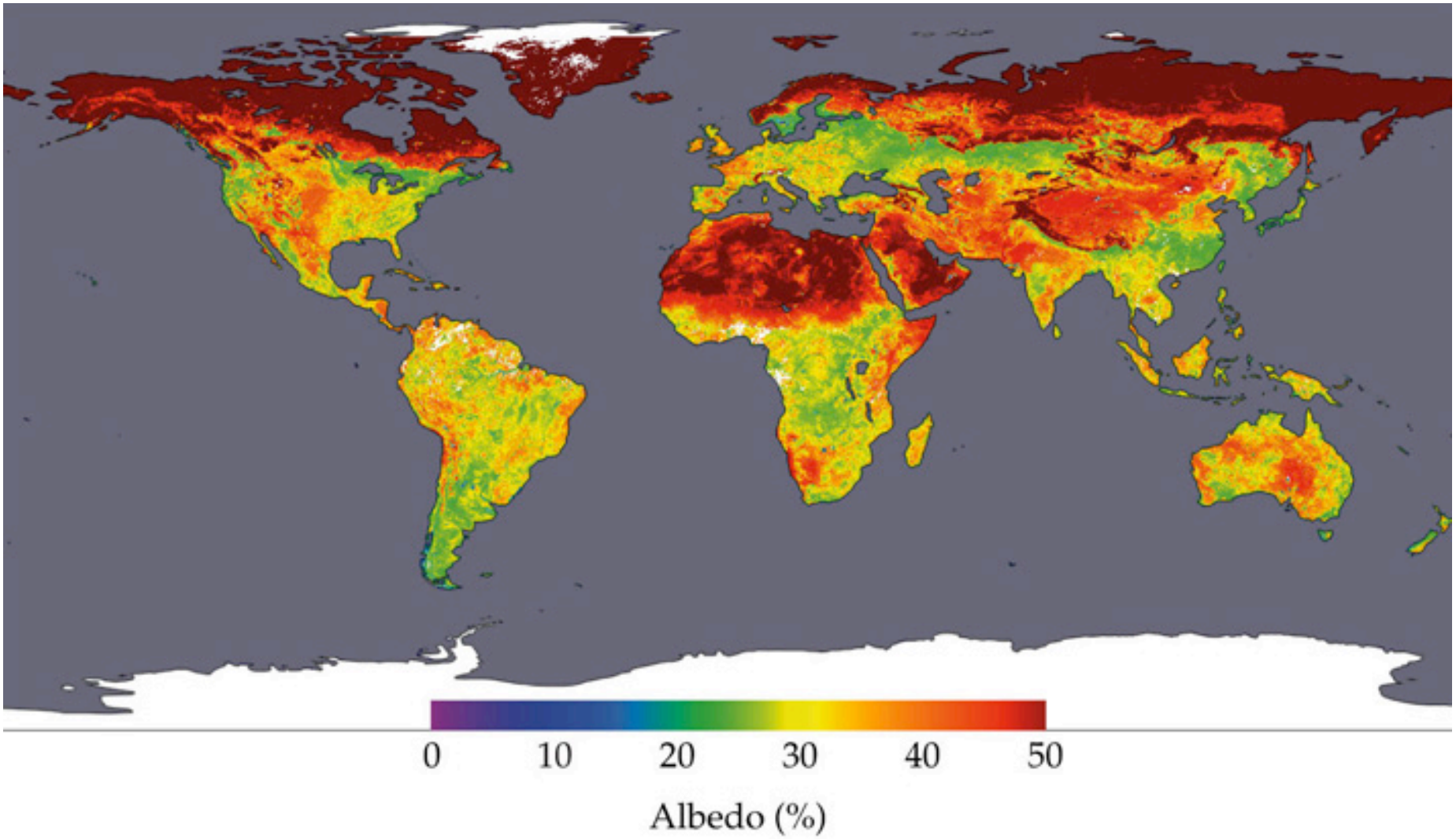
Atmosphere of Venus

- Composition
  - 96 % CO_2
  - 3.5% N_2
  - Trace H_2O, sulfuric acid, other compounds
- Pressure
  - 90 times greater than Earth!
- Temperature
  - 745 K at surface

Earth vs. Venus: why so different?

- *Venus*: too hot for water to condense into oceans
  - Water vapor split by solar UV into H and O
  - H lost from atmosphere, water effectively lost forever
  - Without oceans, CO_2 can't be cleansed from air
  - So now, CO_2 produce strong greenhouse effect
- *Earth*: further from sun, so somewhat cooler
  - Cool enough so most of water vapor rained into oceans
  - Oceans (and plants) cleanse CO_2 from air, most now trapped in rocks (limestone, CaCO_3)

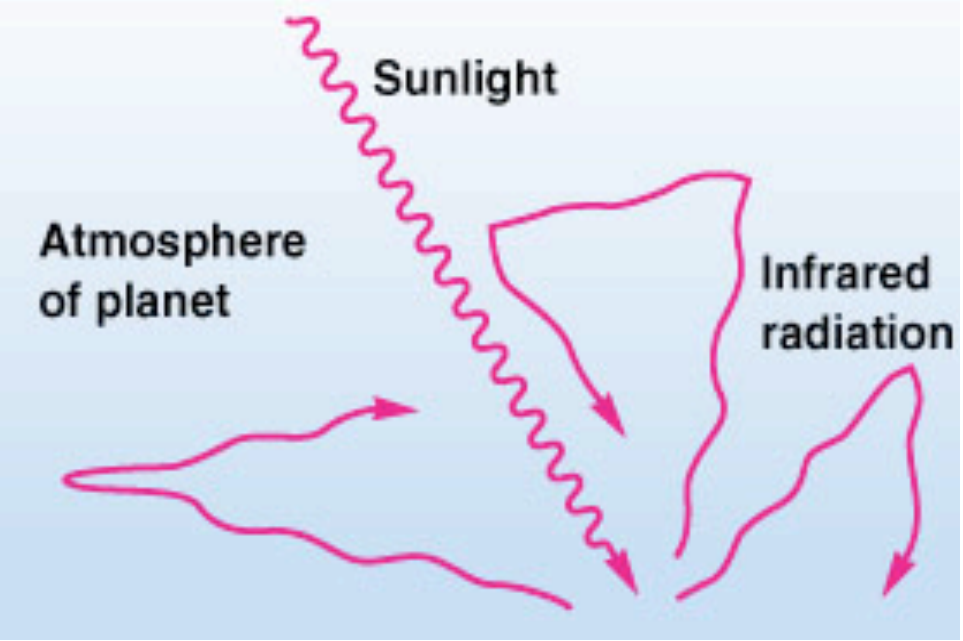
Earth Reflectivity/Albedo Map



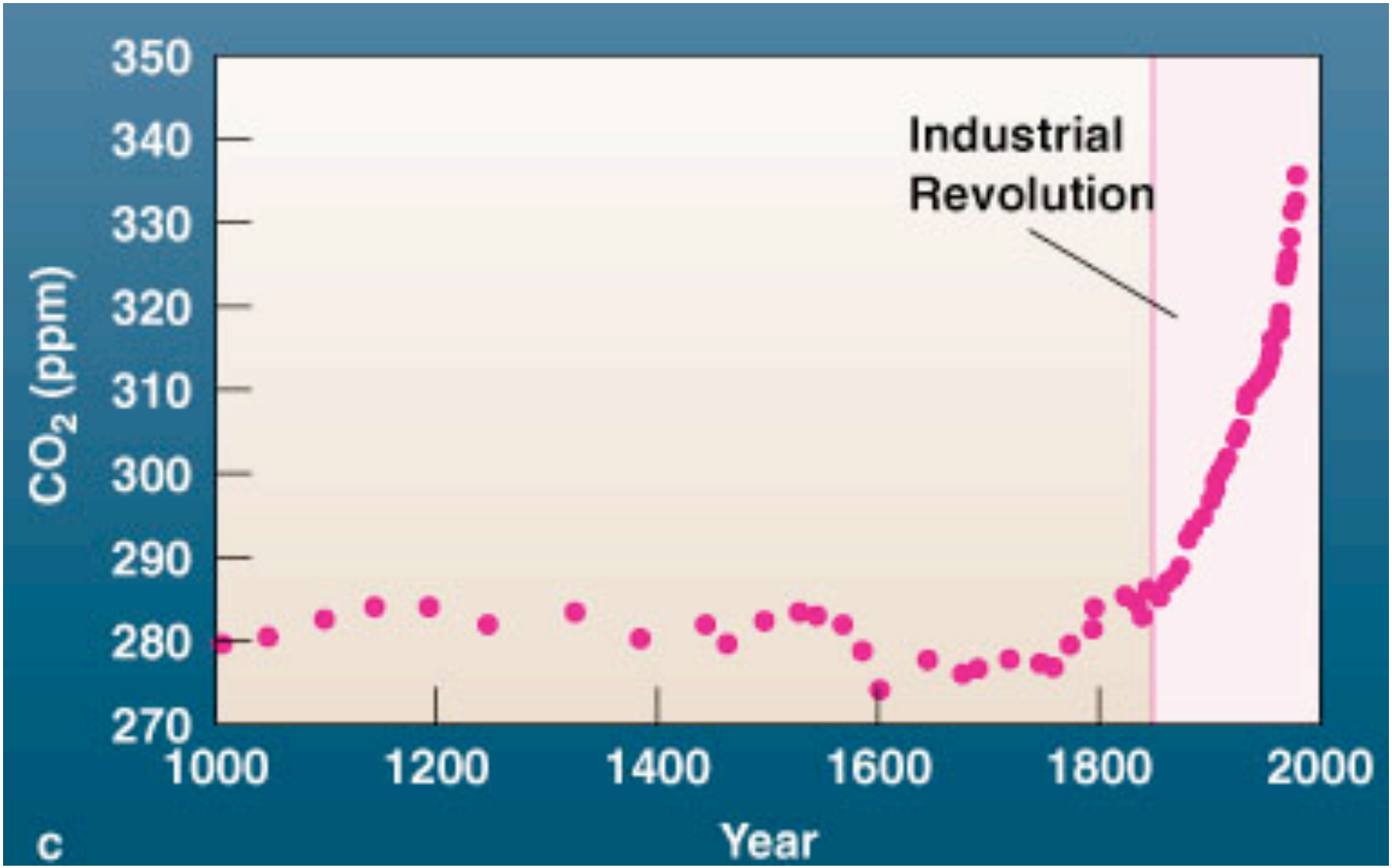
Atmospheric Greenhouse Effect

1. Visible light from sun absorbed by surface
2. Reradiated as infrared radiation
3. Water vapor (H_2O) , carbon dioxide (CO_2) and other greenhouse gases trap infrared

- Without greenhouse, surface of Earth would be *frozen*
- Venus has *huge* greenhouse effect

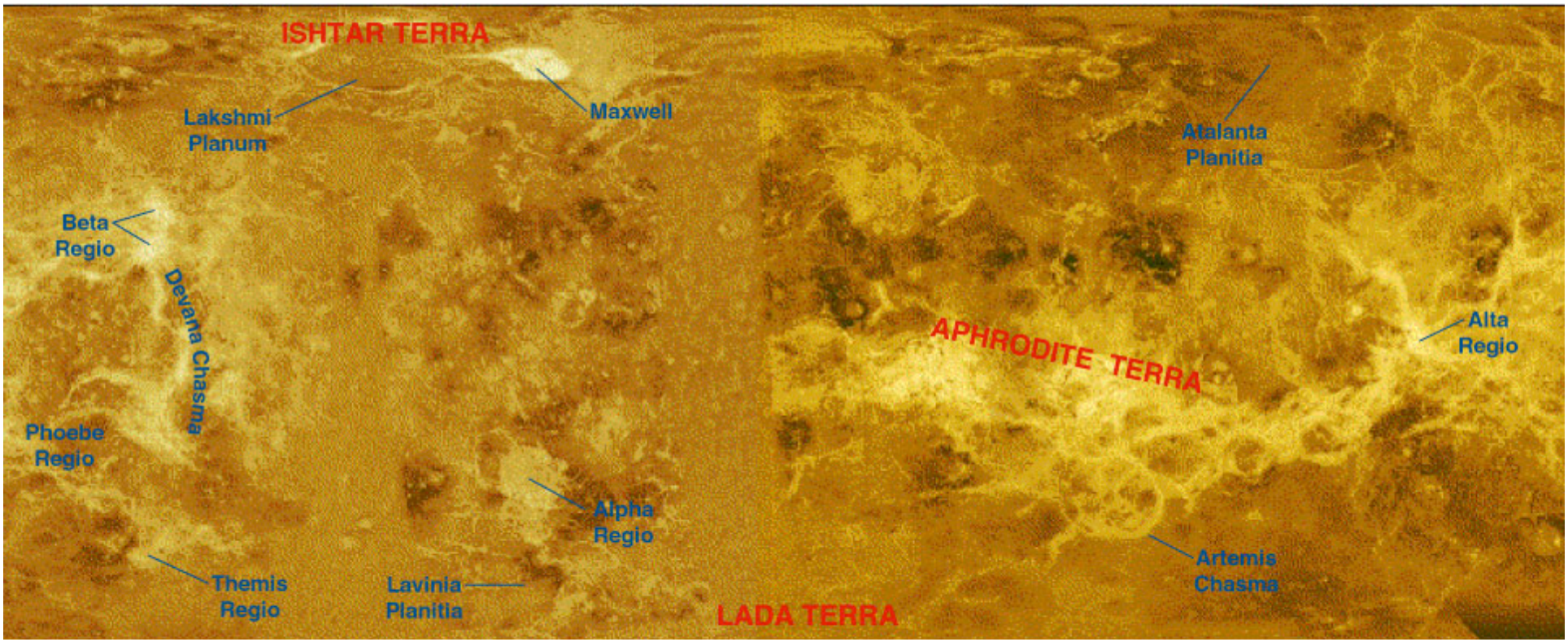


Since industrial revolution, atmospheric CO_2 has increased

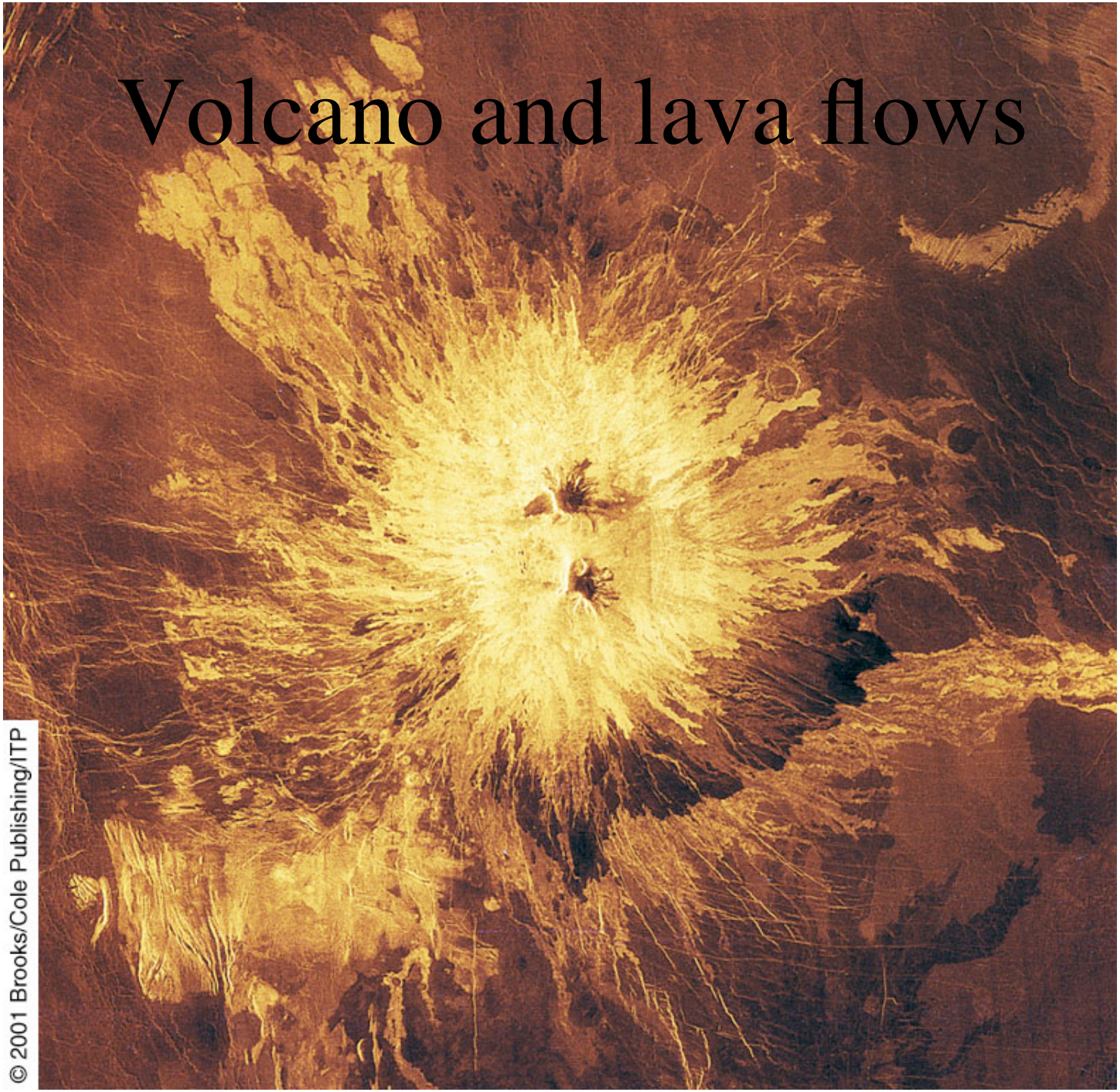


Radar images of Venus surface

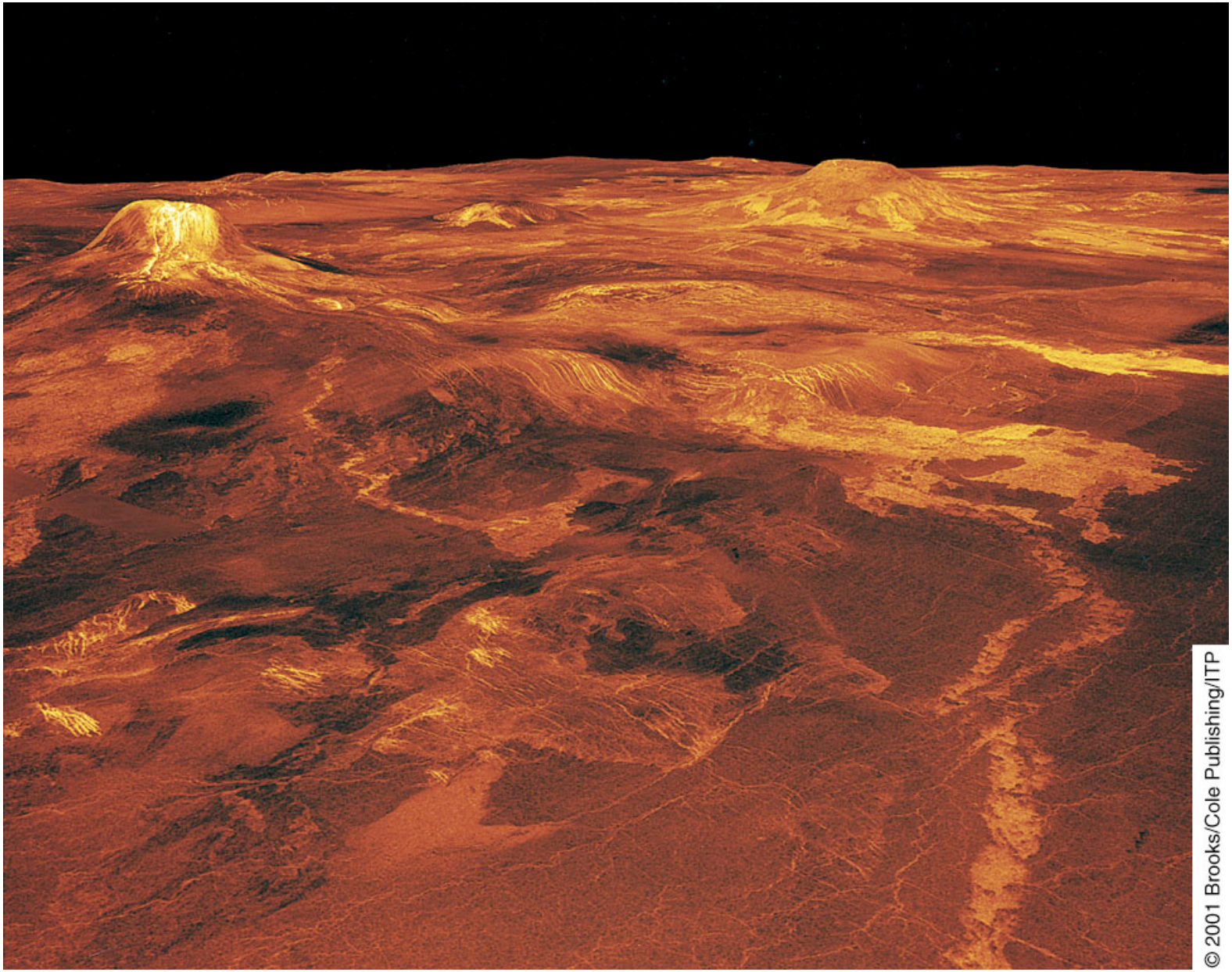
- 60% rolling plains 24% highlands
- 16% volcanic peaks



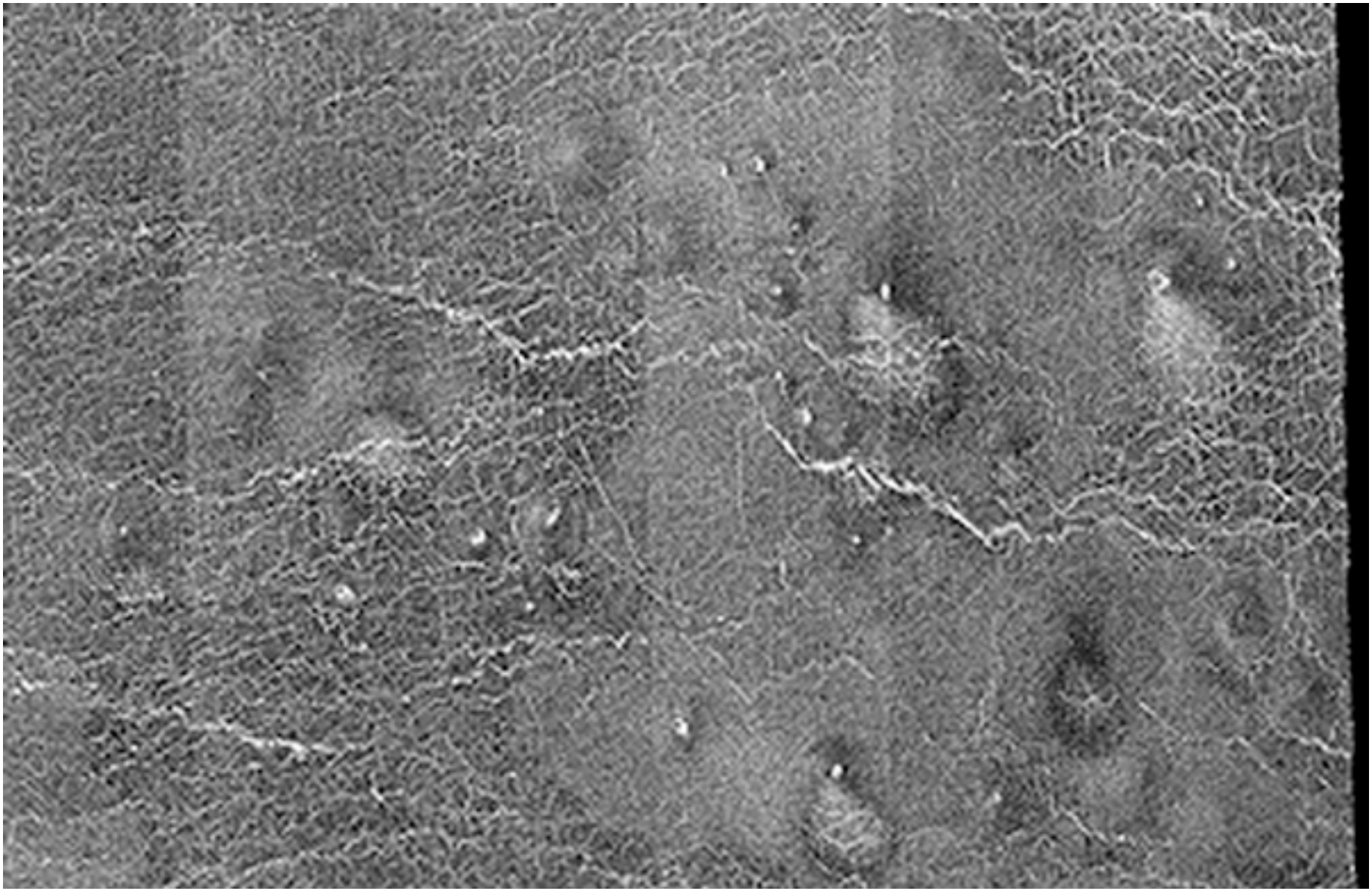
Volcano and lava flows



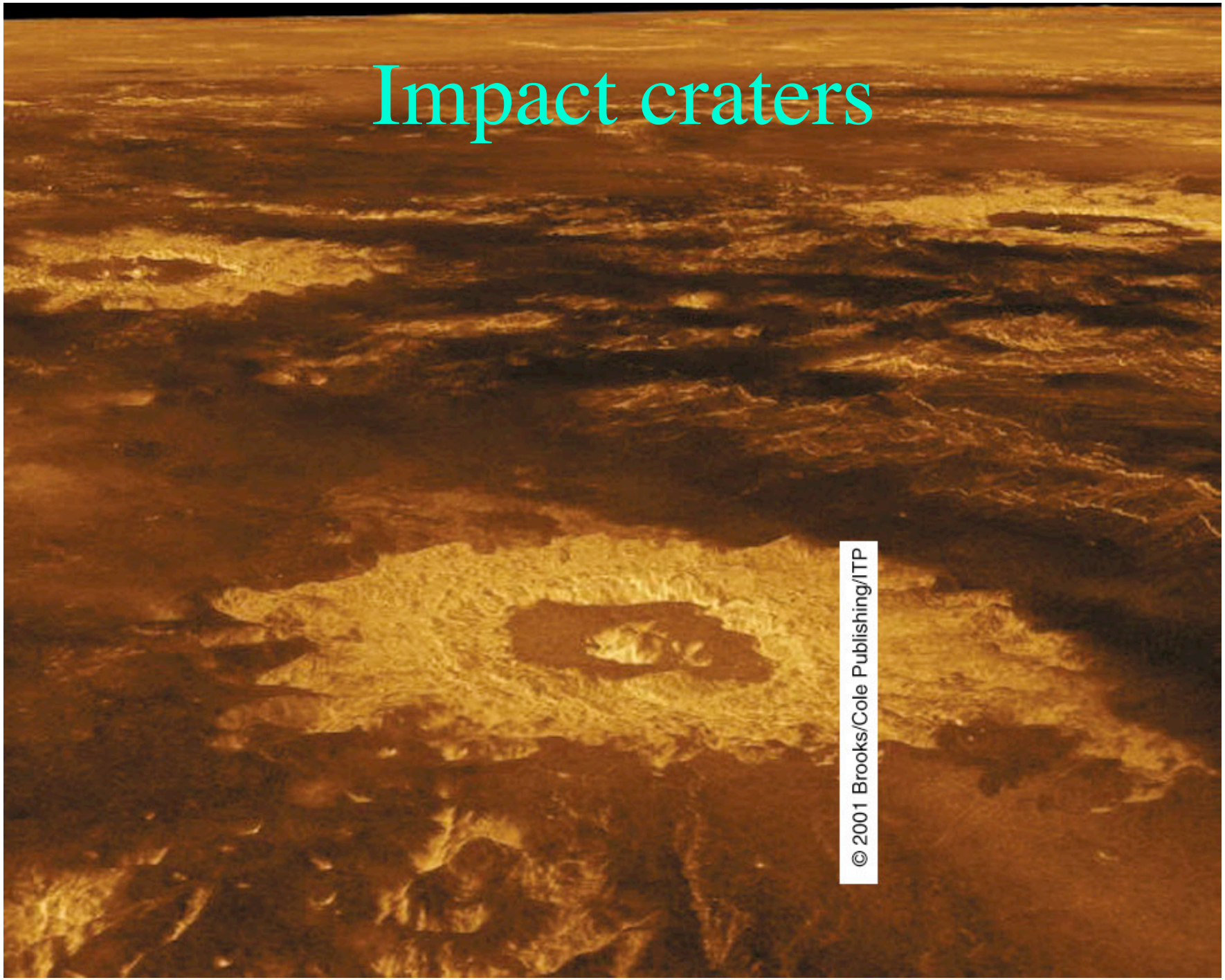
Volcanoes, lava flows, rift valley



Wind streaks



Impact craters



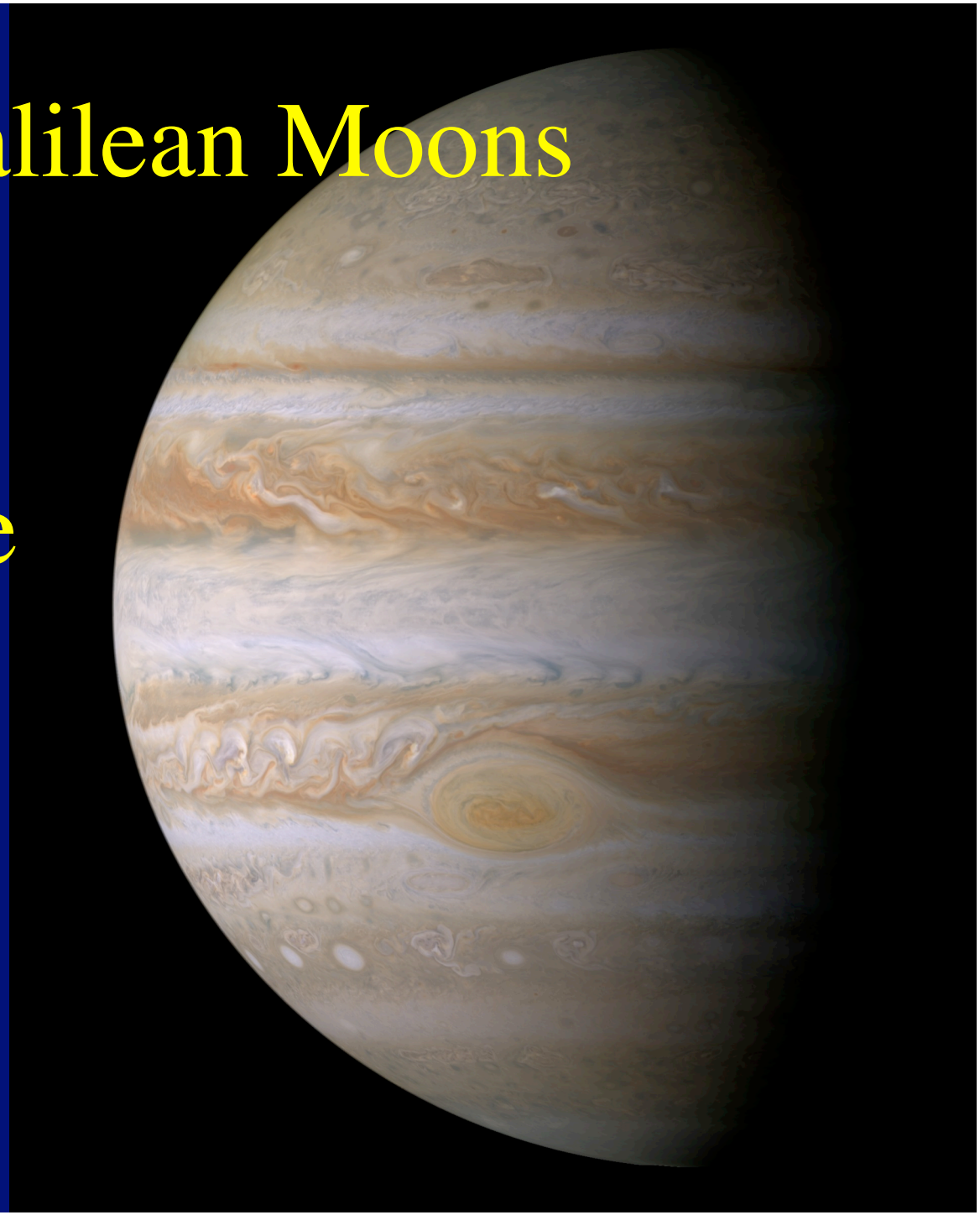
Reworking the surface

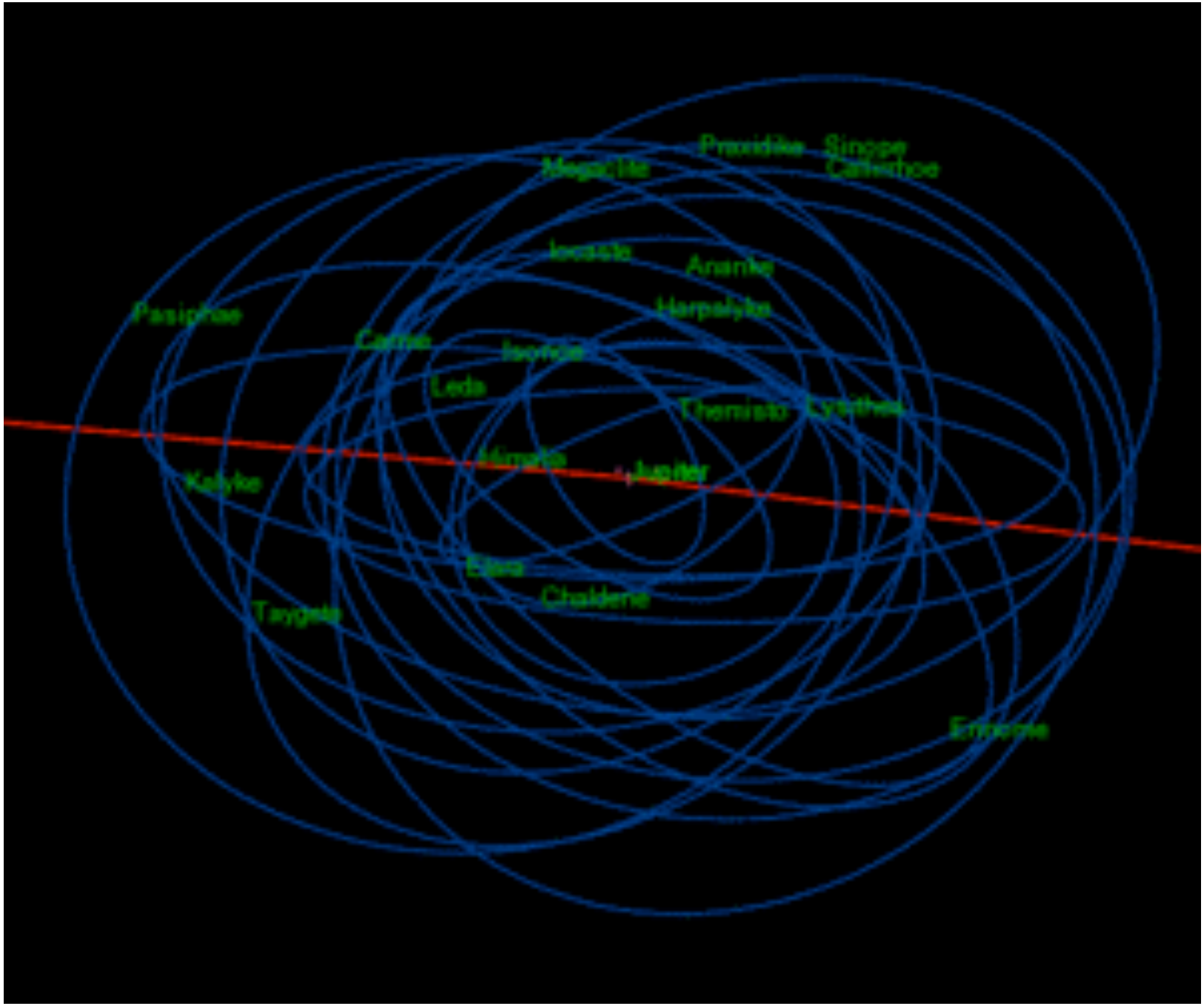
- No water, very little erosion
- Only large impact craters (small meteors do not make it through thick atmosphere)
- Extensive lava flows, but…
- No obvious plate tectonics
- Impact crater density suggest surface < 800my old

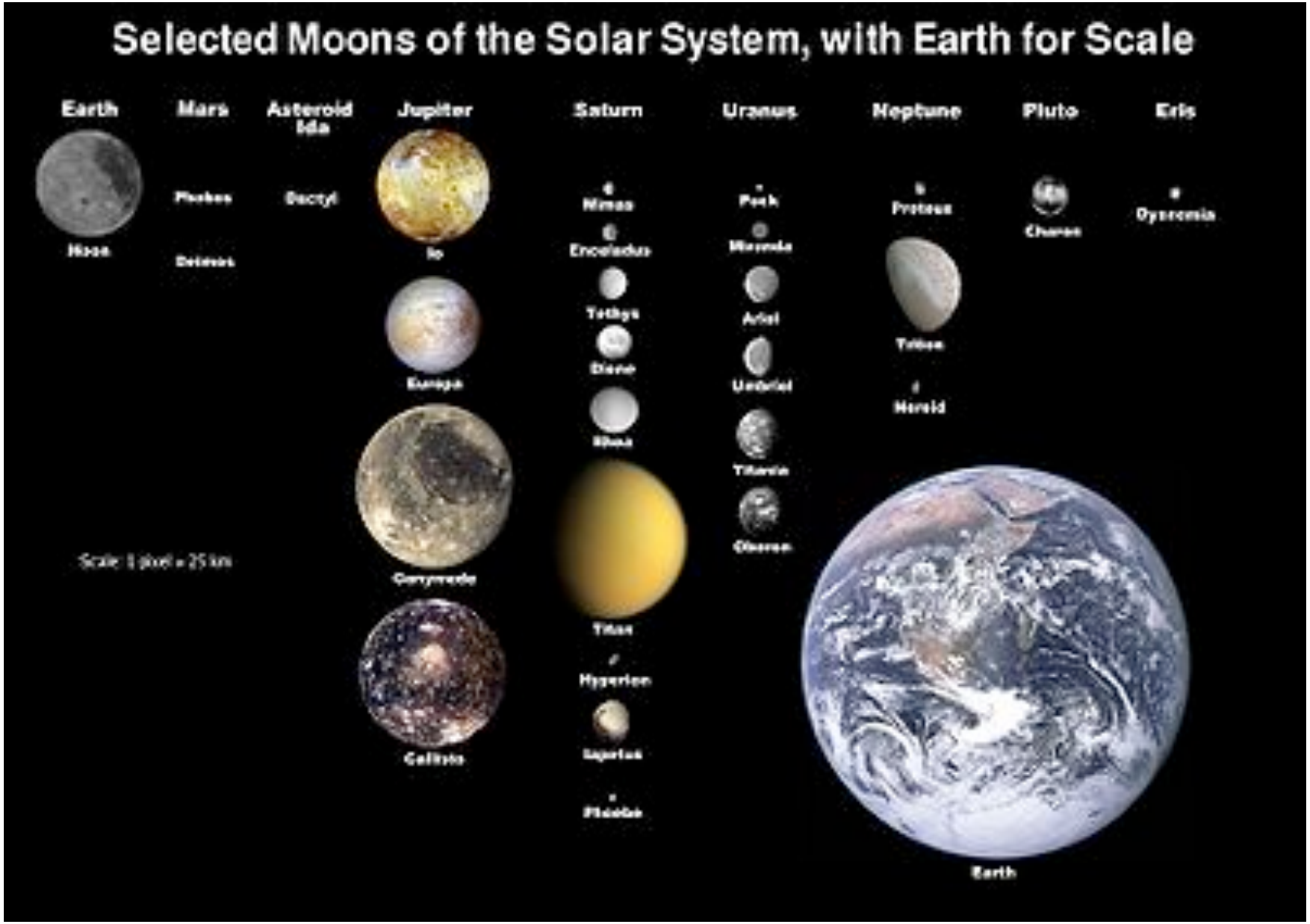
It has been suggested that variations in chemical abundances in atmosphere imply active volcanoes, but this is controversial

Jupiter's Galilean Moons

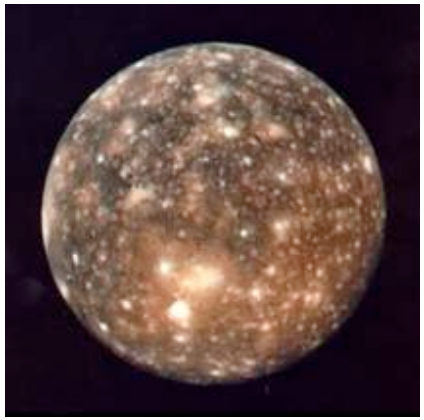
- Io
- Ganymede
- Callisto
- Europa



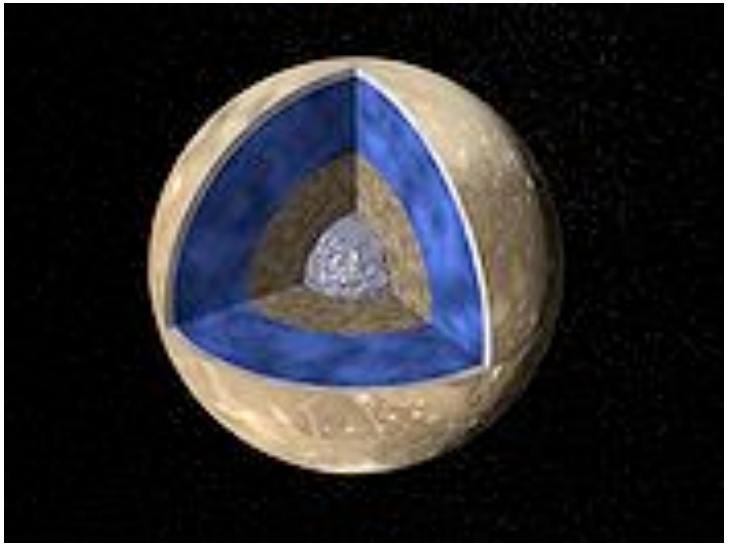

Pasiphae
Kalyke
Jupiter


Selected Moons of the Solar System, with Earth for Scale
Earth
Mars
Asteroid Ida
Jupiter
Saturn
Uranus
Neptune
Pluto
Eris
Moon
Phobos
Deimos
Dactyl
Io
Europa
Ganymede
Callisto
Mimas
Enceladus
Tethys
Dione
Rhea
Titan
Hyperion
Iapetus
Phoebe
Puck
Miranda
Ariel
Umbriel
Titania
Oberon
Proteus
Triton
Nereid
Charon
Dysnomia
Scale: 1 pixel = 25 km
Earth

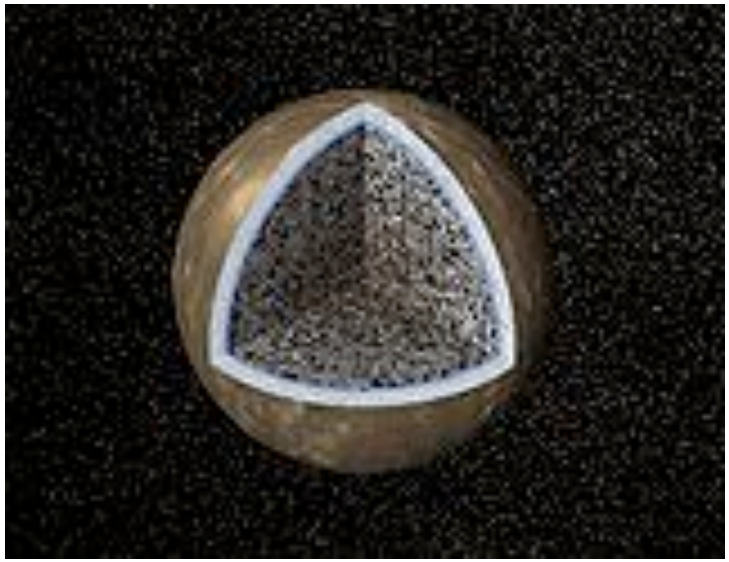
Jupiter's Galilean Moons



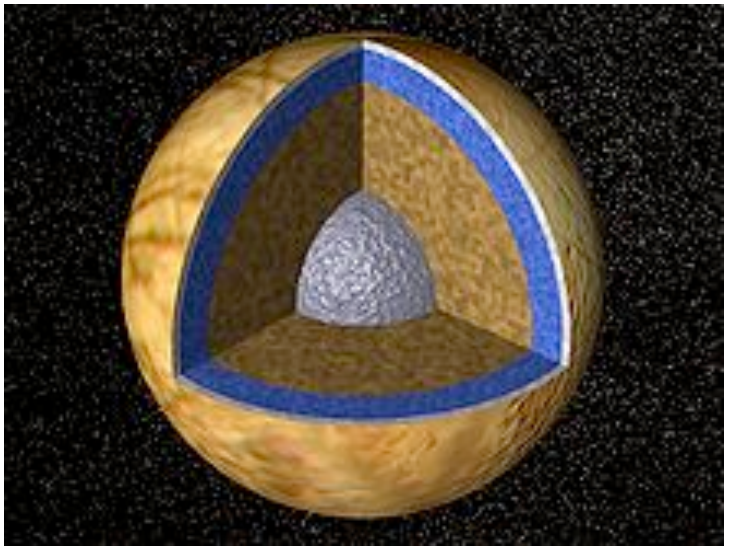
Ganymede



Callisto



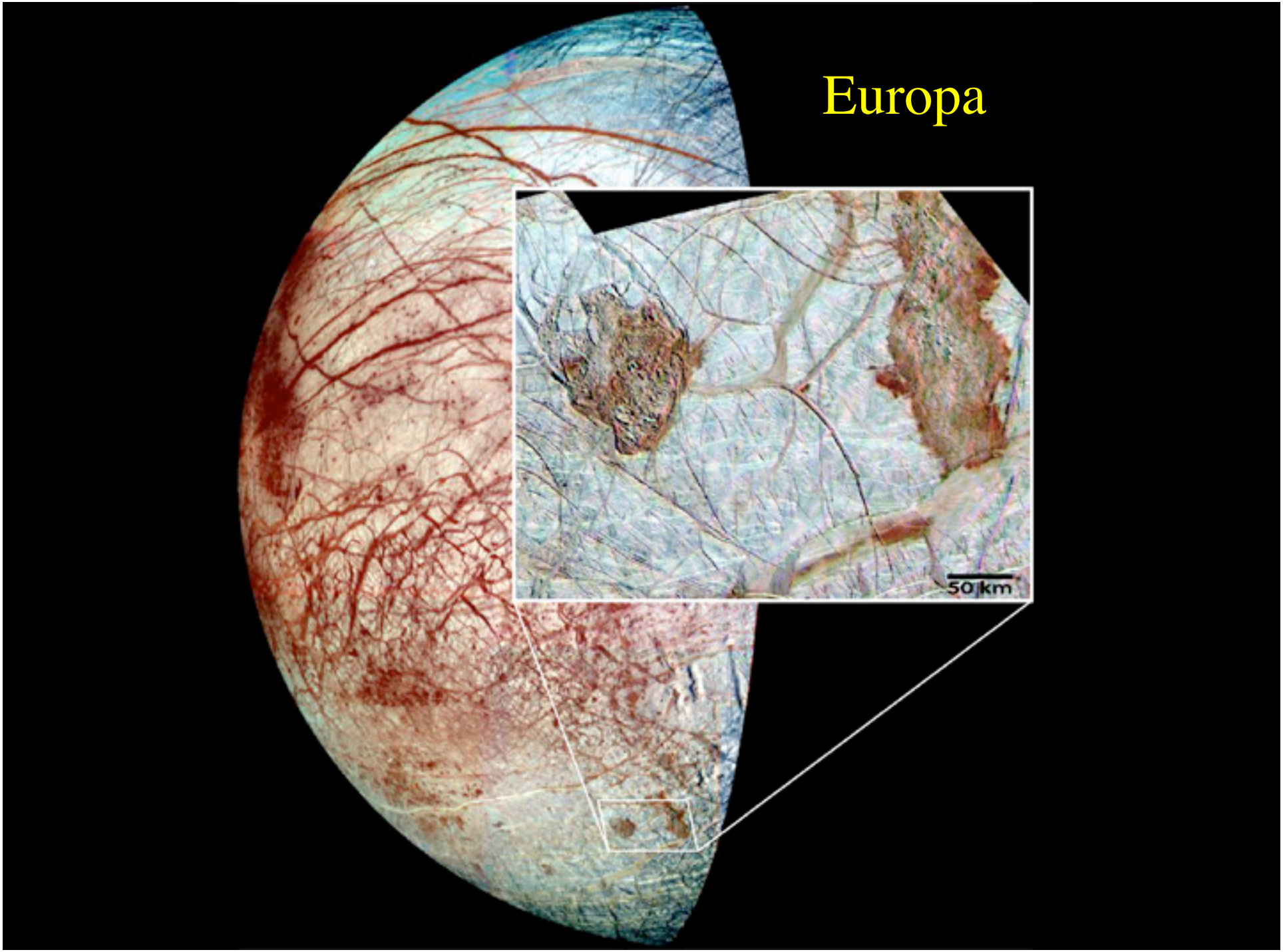
Europa



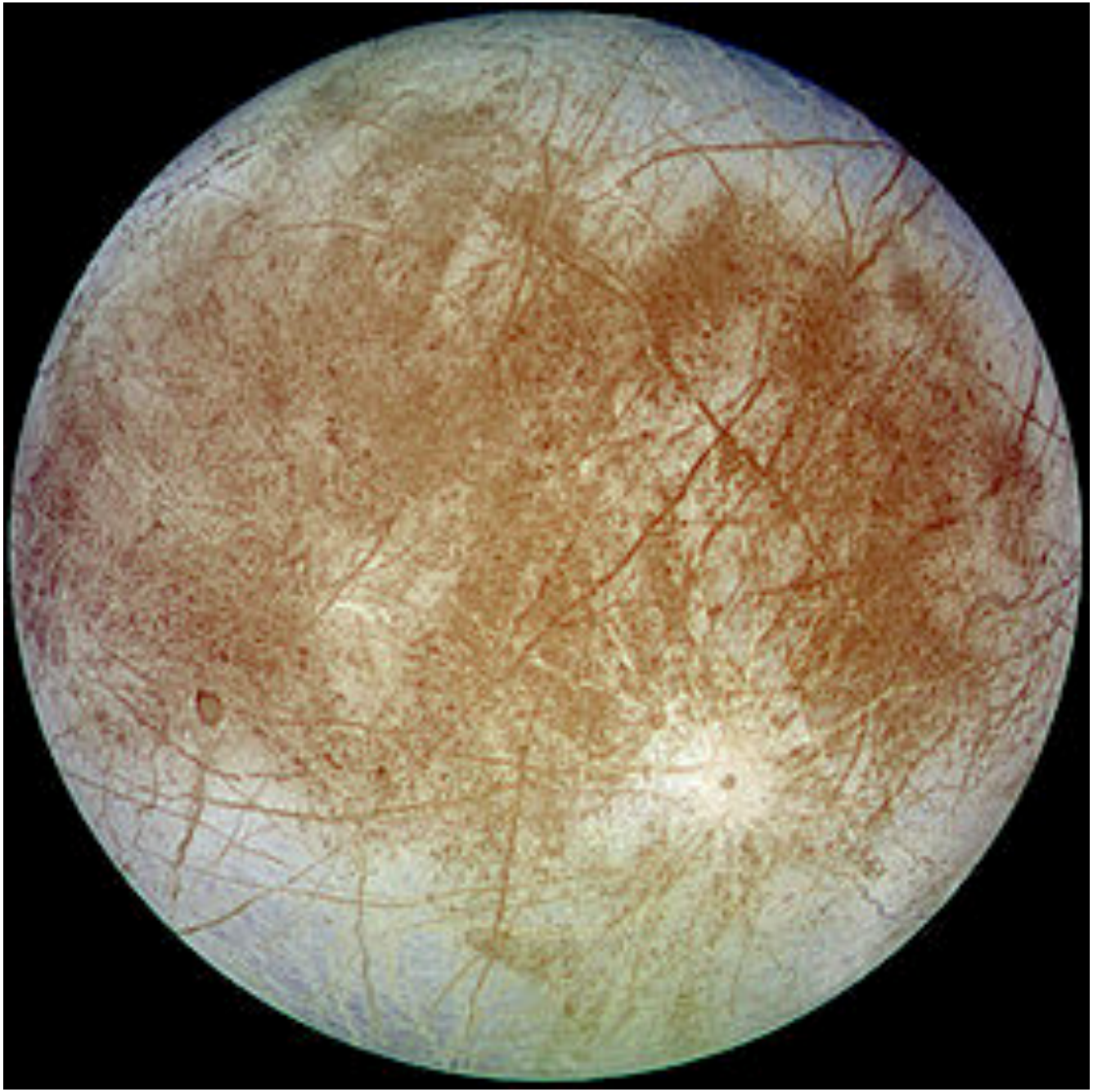
Io

Ganymede

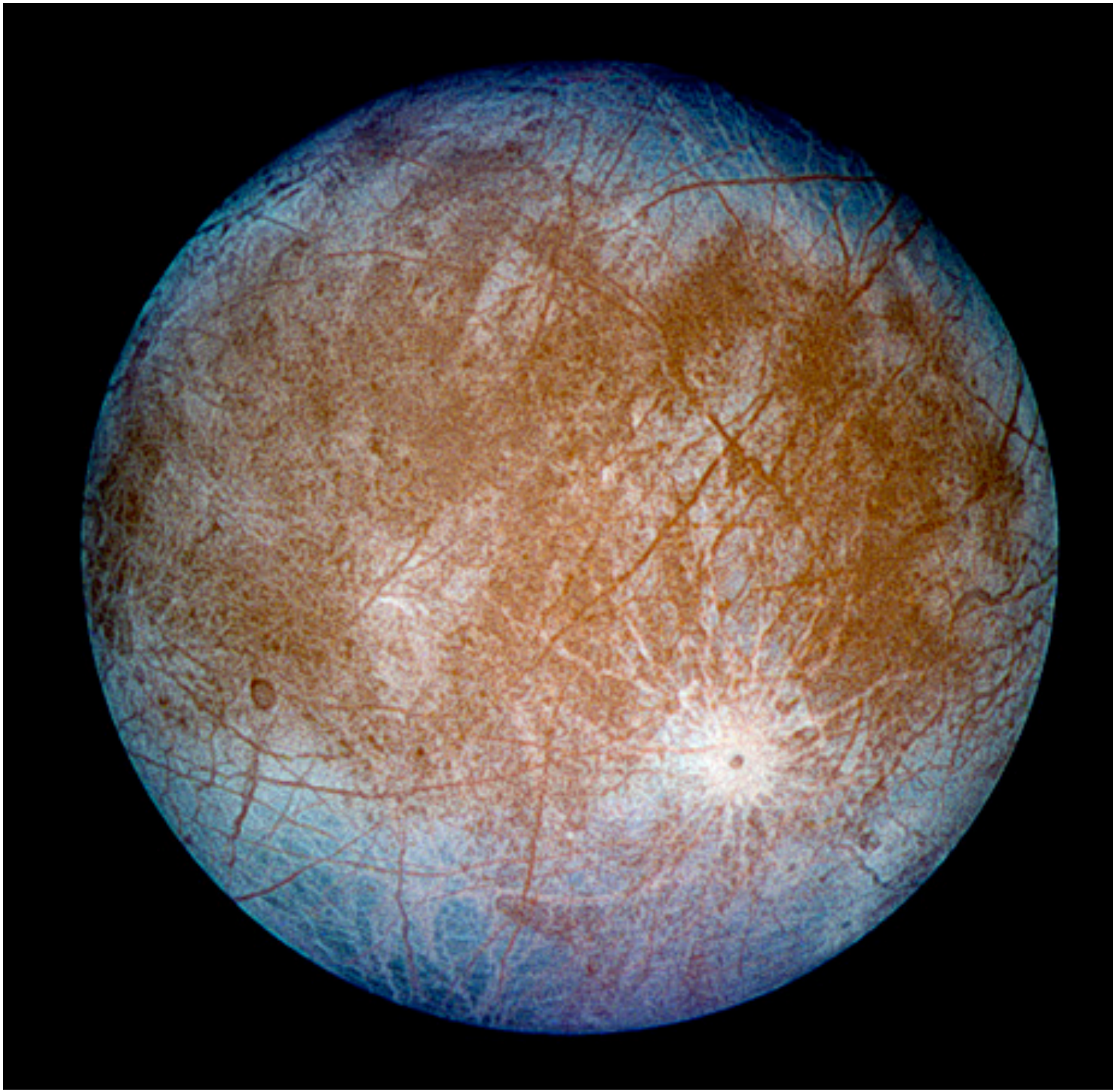
Callisto


Europa
50 km

Europa



Europa



Europa: geologically active

- Density 3 g/cc
  - Mostly rock with thin icy crust
- Surface:
  - Clean ice, very few craters
    - Less than 10 million years old
- Jumbled ice blocks
  - Pack ice, perhaps floating on ocean below

Ice blocks on Europa

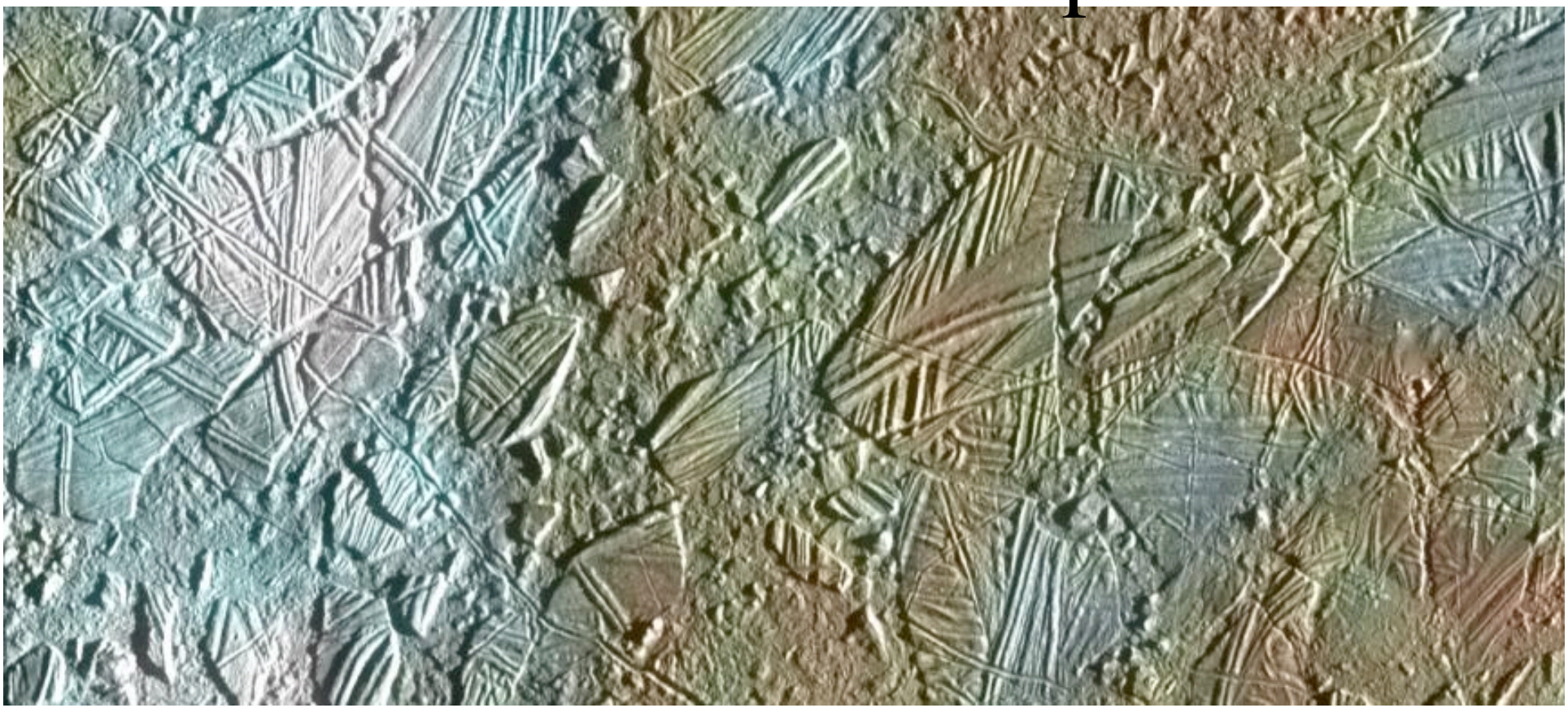
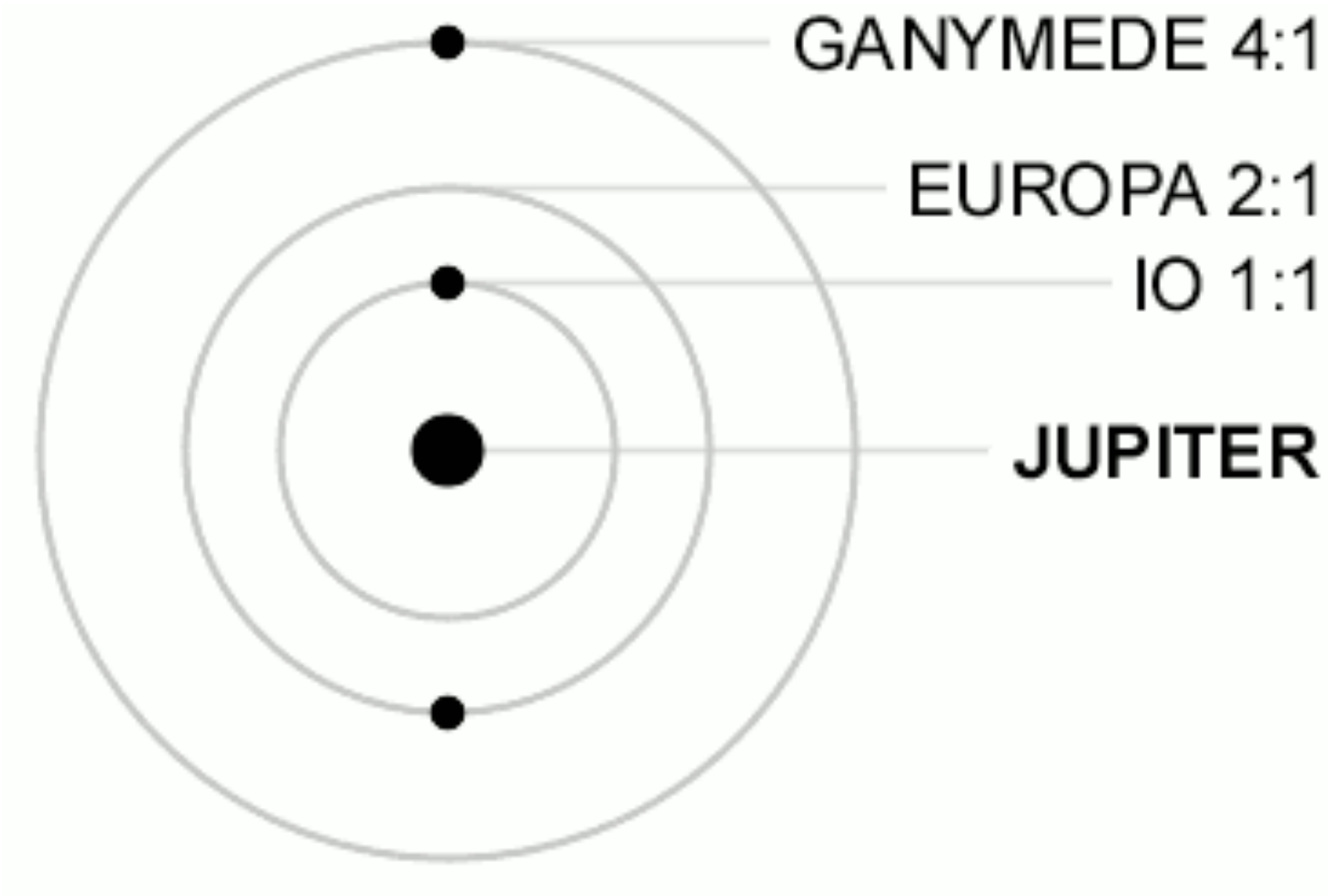
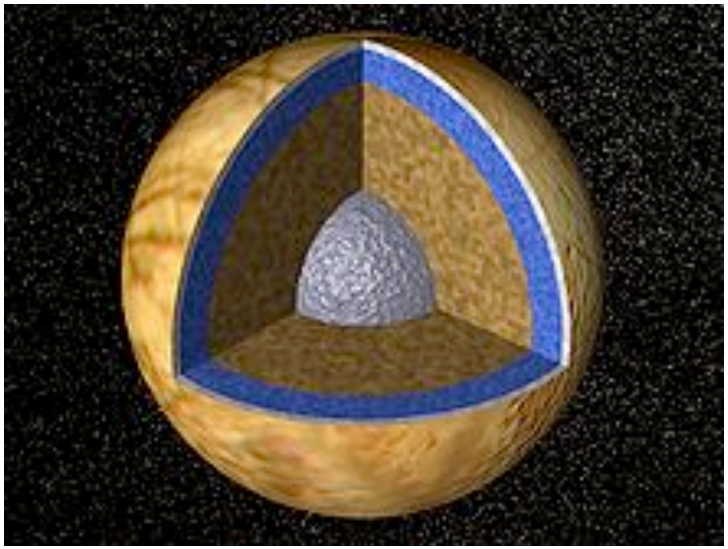
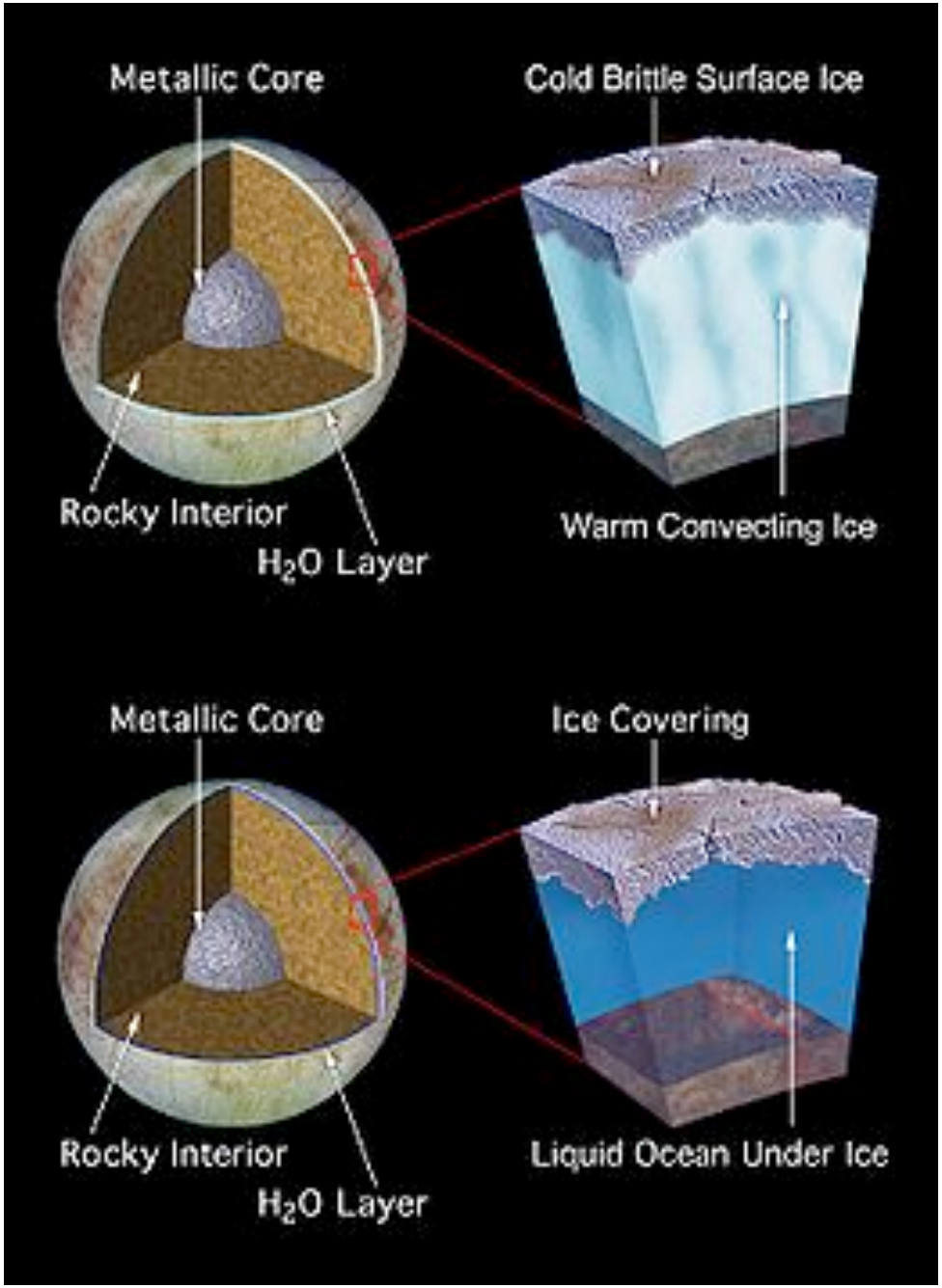


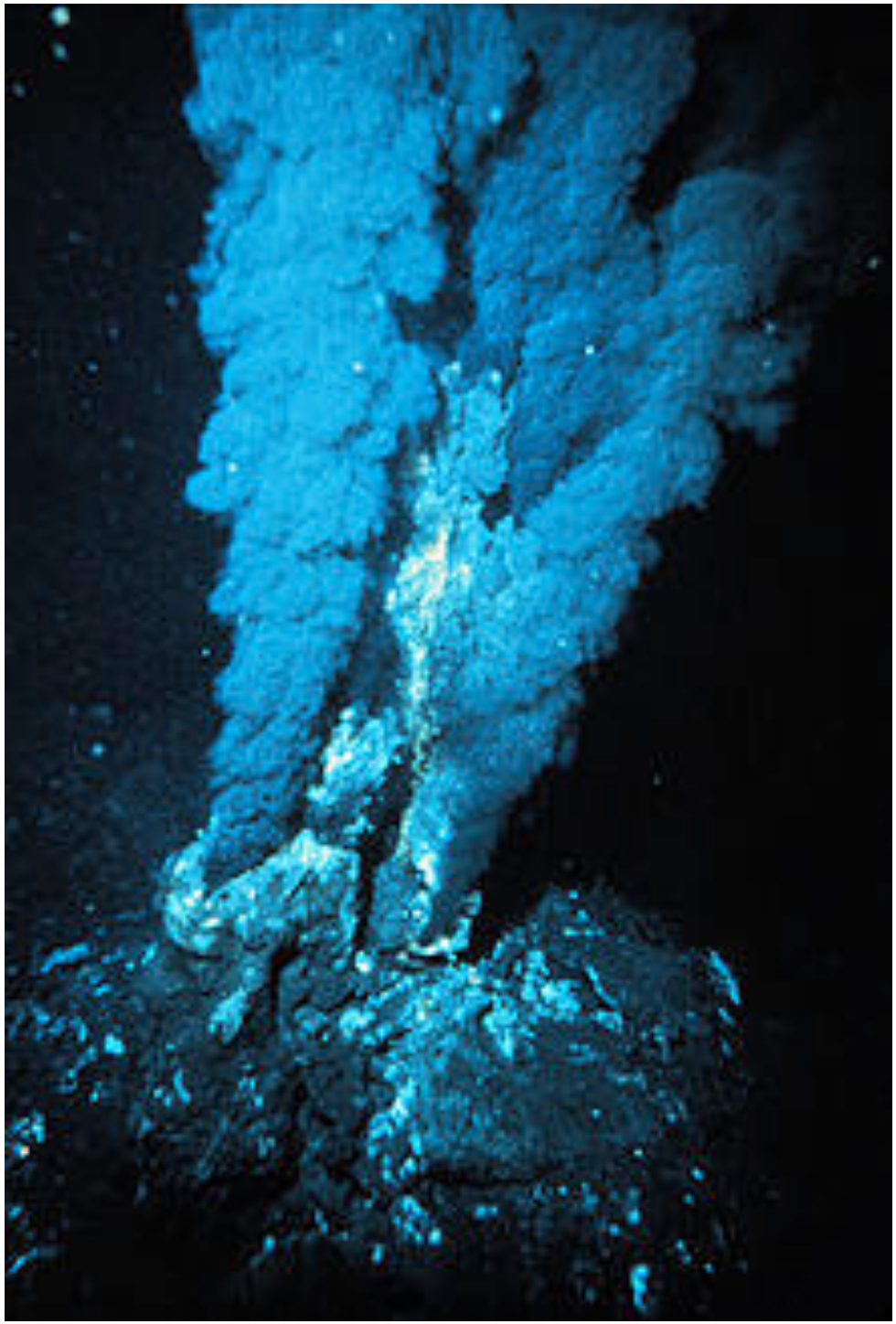
Image shows area 20x40 miles

Is there life in seas below pack ice? What is brown stuff?


GANYMEDE 4:1
EUROPA 2:1
IO 1:1
JUPITER



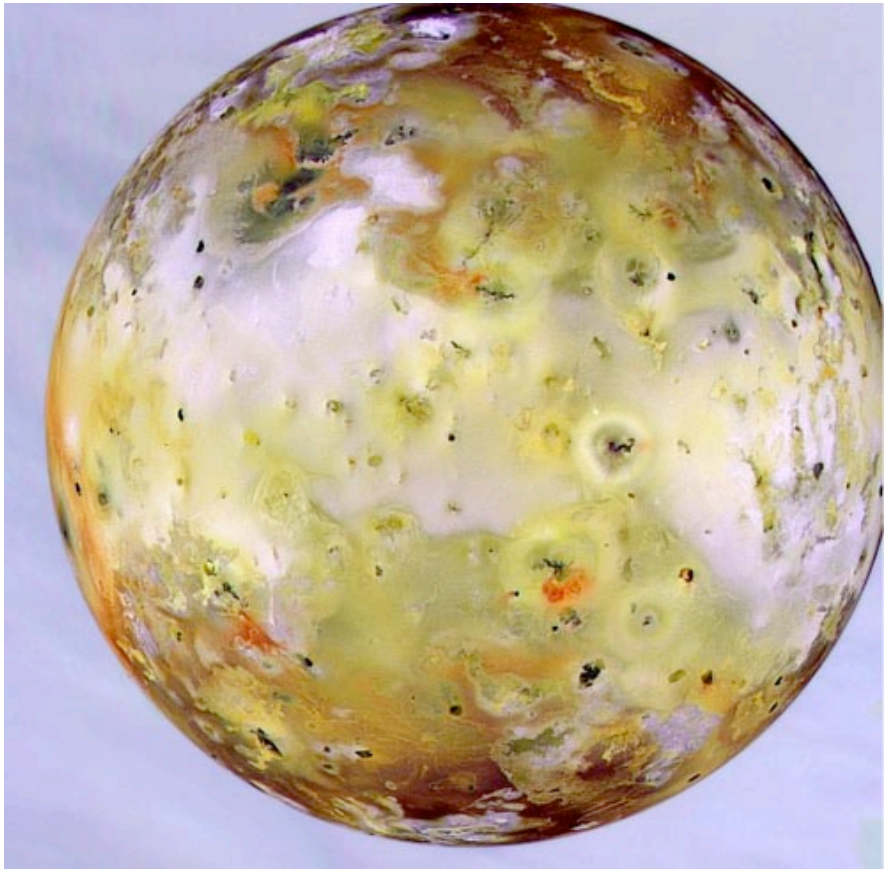

Metallic Core
Cold Brittle Surface Ice
Rocky Interior
H_2O Layer
Warm Convecting Ice
Metallic Core
Ice Covering
Rocky Interior
H_2O Layer
Liquid Ocean Under Ice

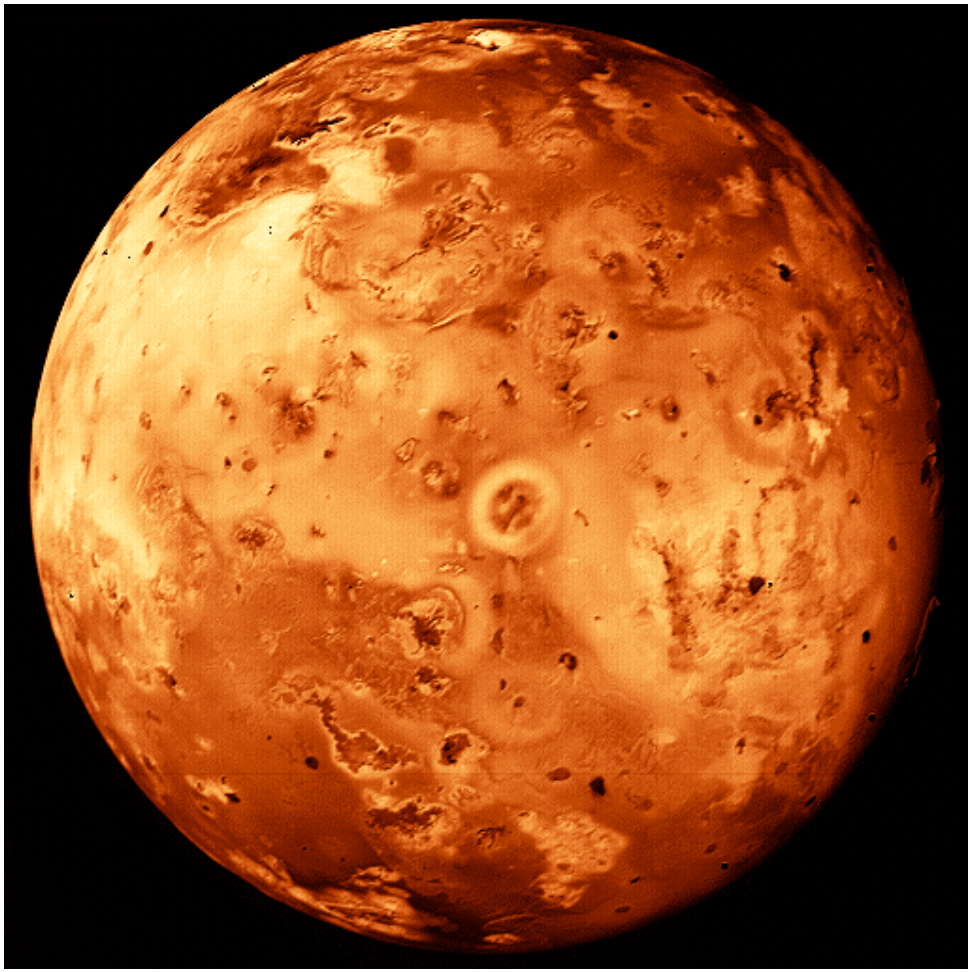


Volcanically active Io

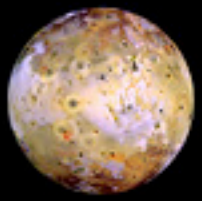
- Density of 3.5 g/cc and magnetic field
  - Metallic core
  - Rocky, sulfur-rich core
  - No evidence for water (ice)
  - No impact craters
- Many erupting volcanoes have been seen
- Surface changes dramatically in a few years

Io





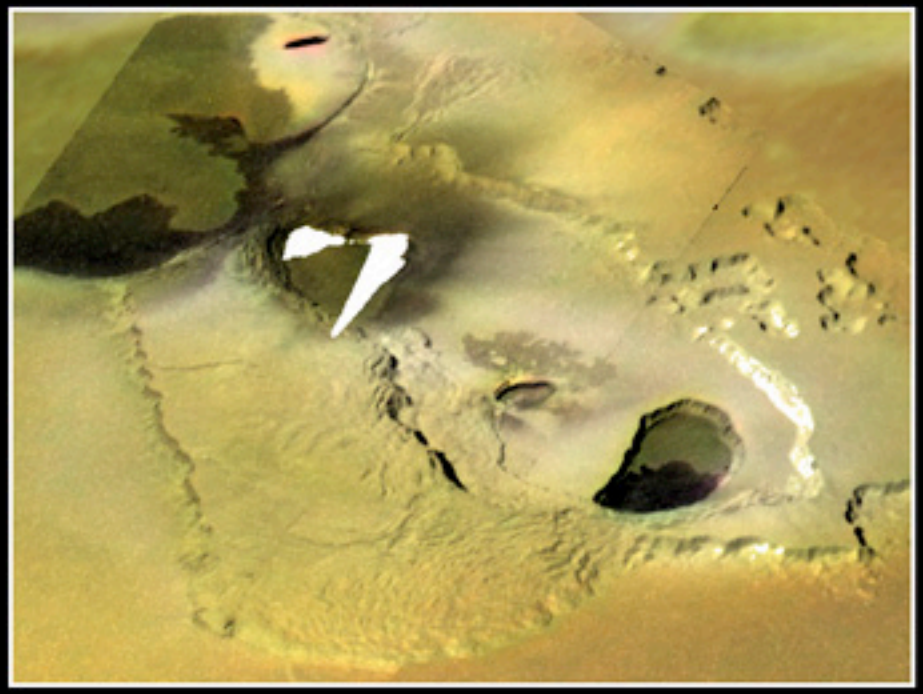
Volcano on Io as seen by Galileo

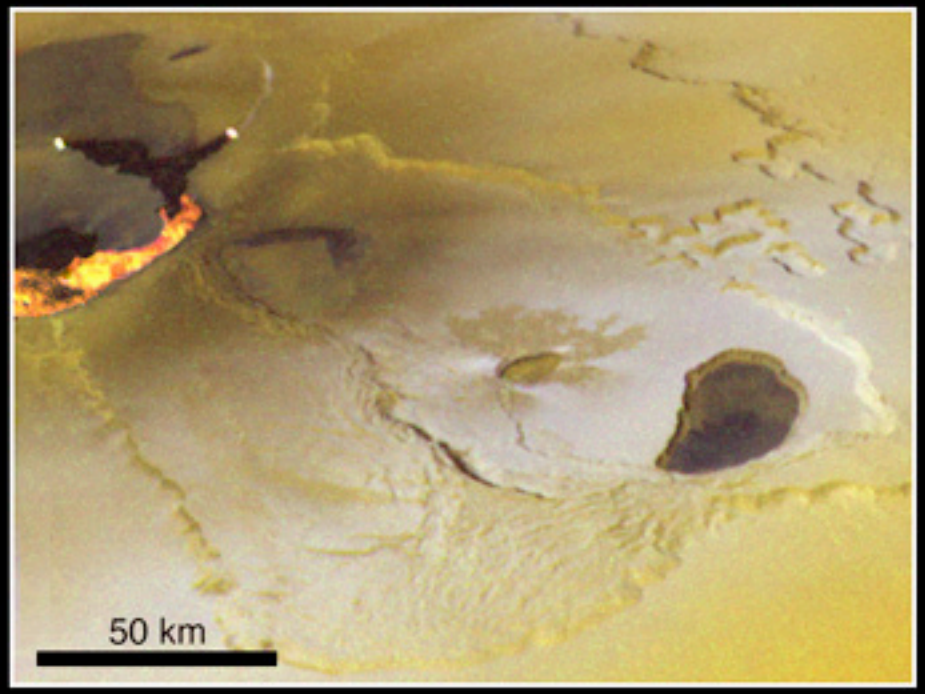


Io — Tvashtar Catena

I25 (26 Nov 1999)
+ C21 low-resolution color

I27 (22 Feb 2000)
visible wavelength data
+ IR data of active lava flow



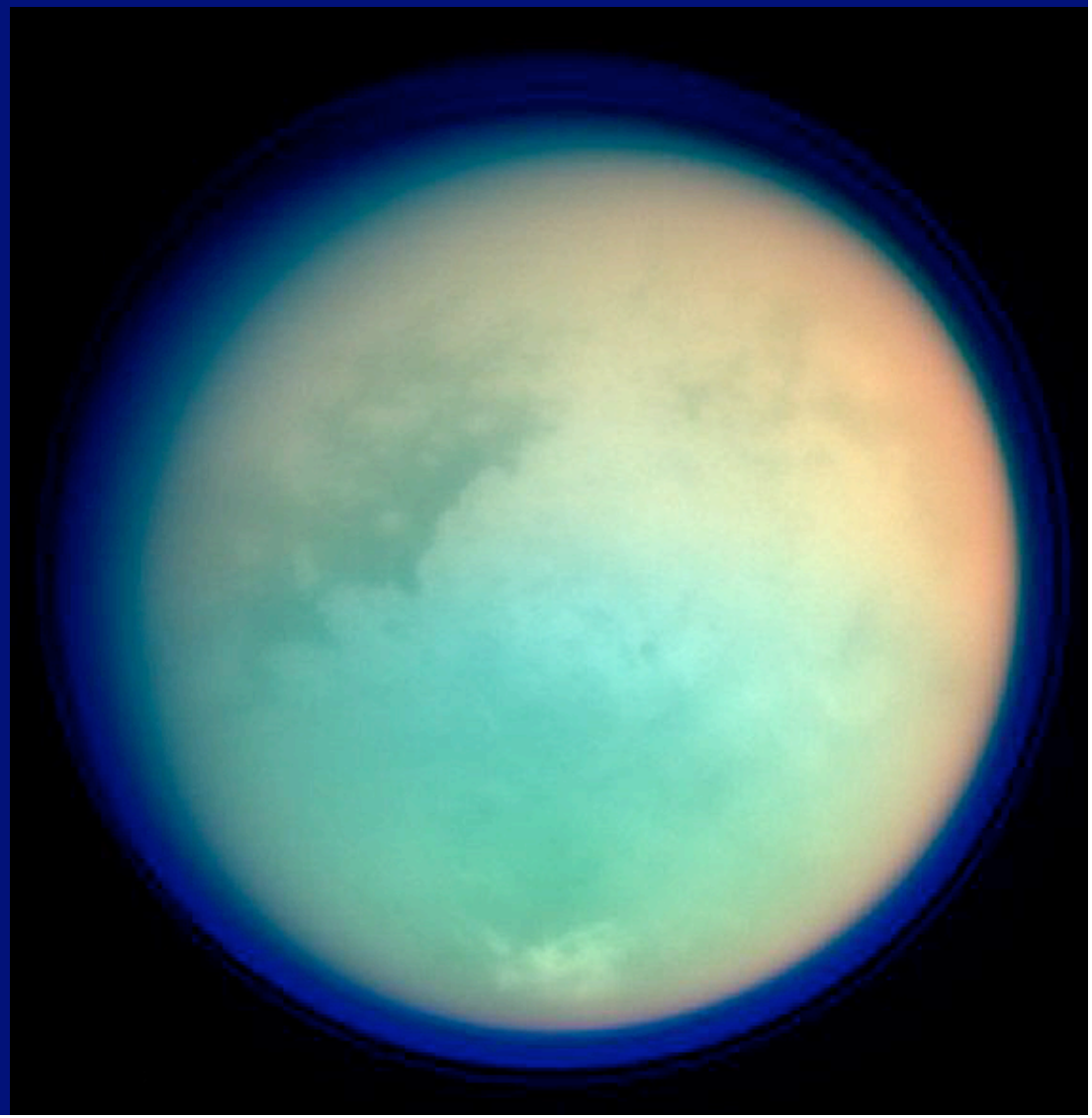


Why is Io most active object in solar system?

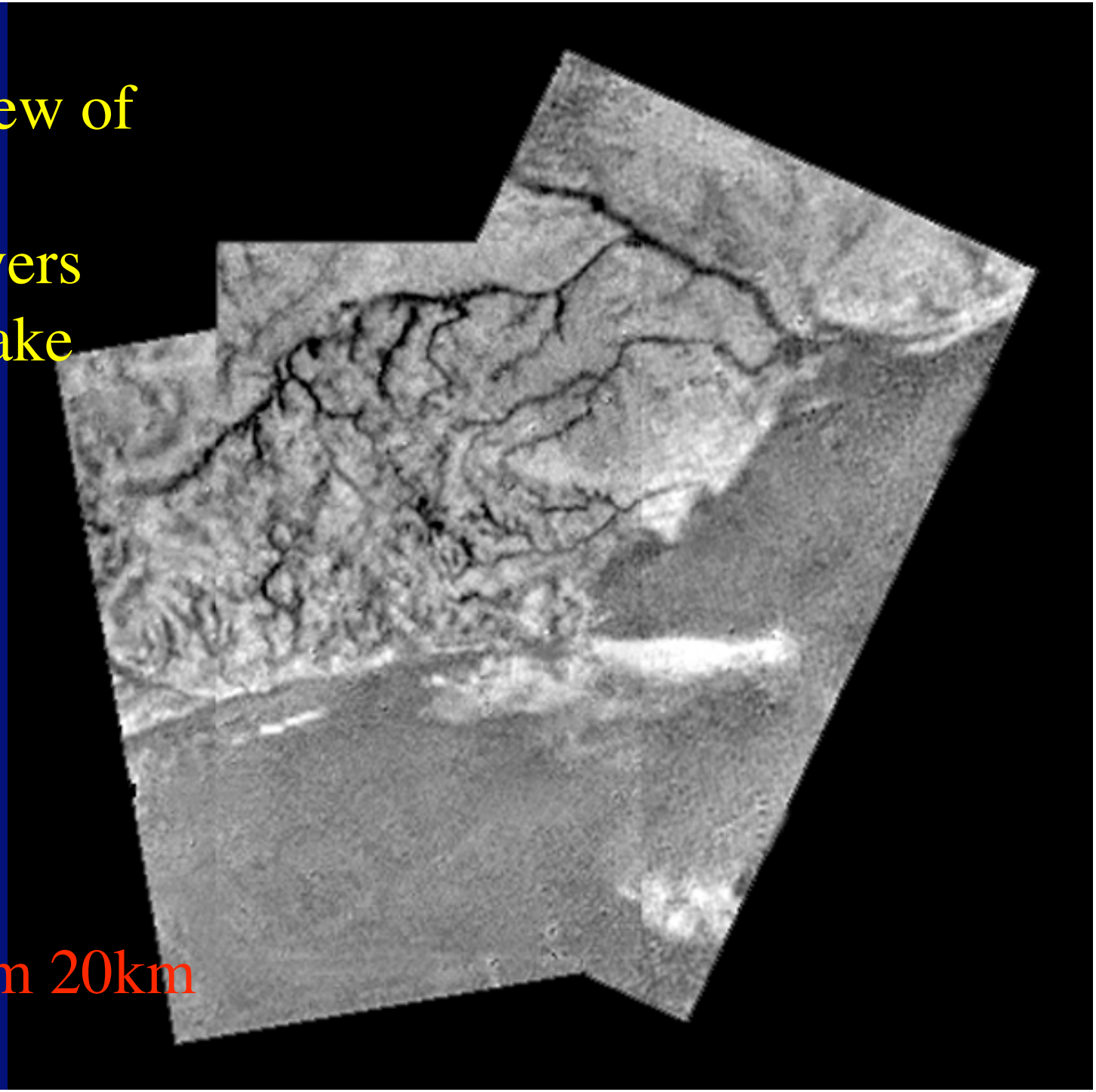
- Too small to have retained much heat from its formation epoch
- Reason: *Tidal heating*:
  - Elliptical orbit, relatively near to Jupiter
  - Tidal forces of Jupiter flex and stretch Io, causing tremendous heating
- Perturbations from other moons keep Io from circularizing orbit

Saturn's Moon Titan: organic haze

- Mercury-sized, but cold
  - Hangs on to atmosphere
  - Organic haze
  - Methane oceans



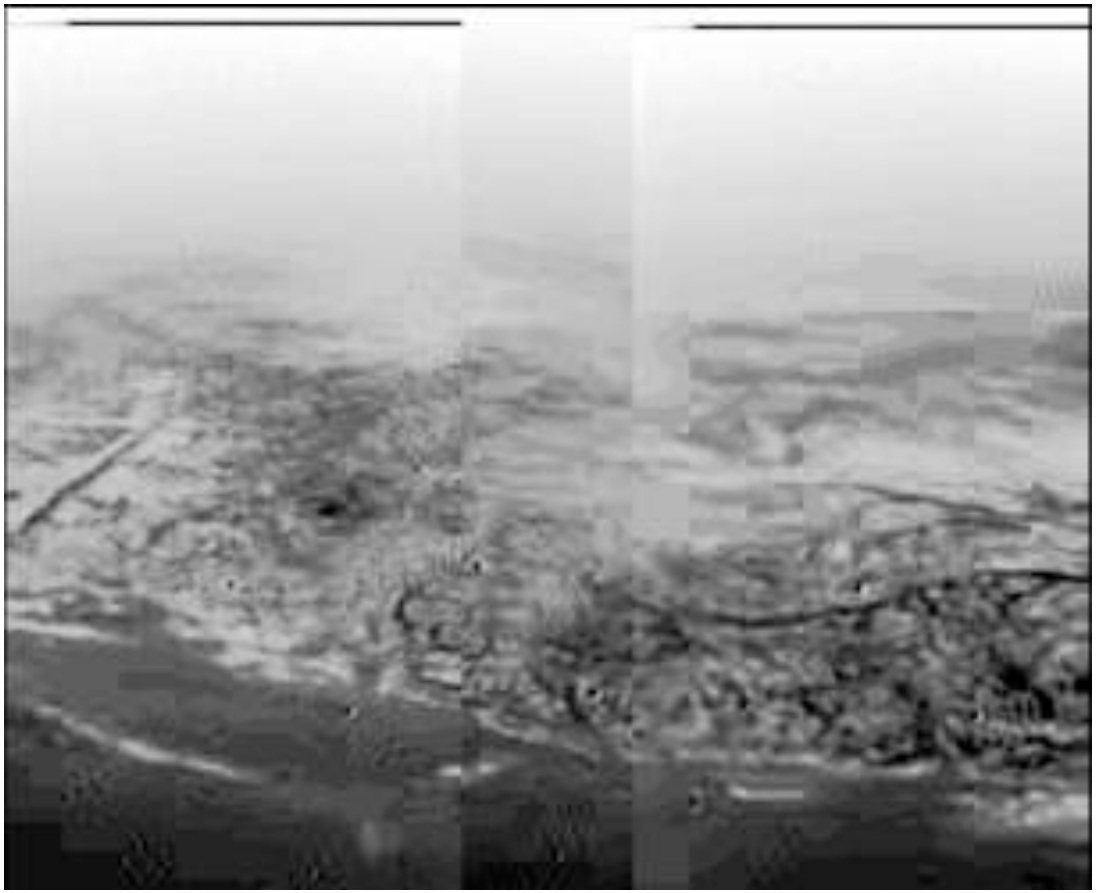
Huygens view of Titan:
Methane rivers leading to lake



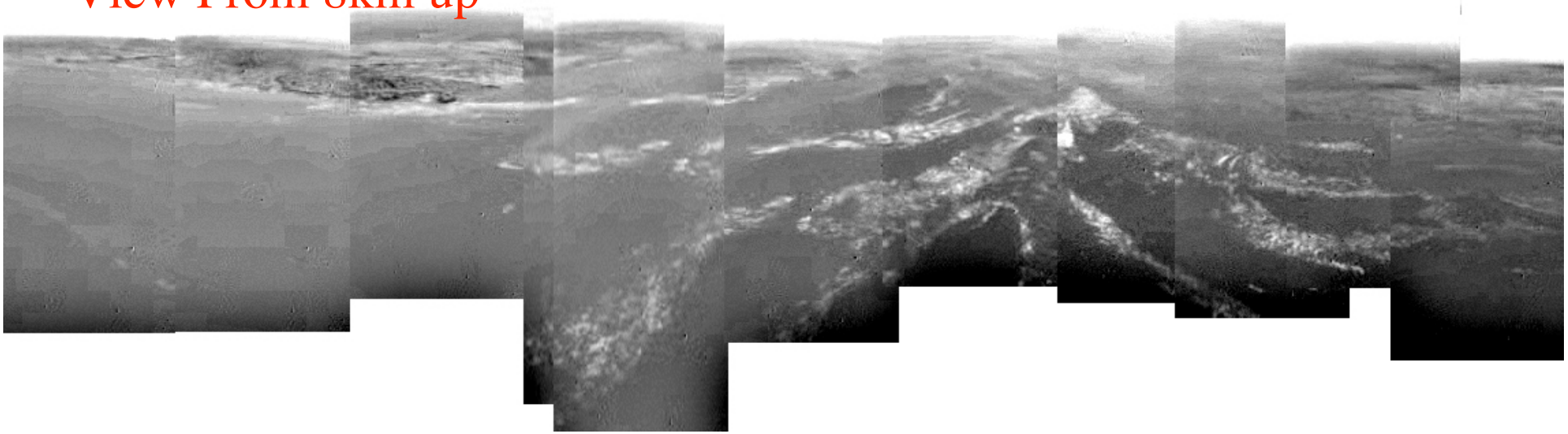
View from 20km

Images from descent of Huygens probe

Methane seas



View From 8km up



Huygens view from the surface
From force of impact, landed on slushy not solid ice
Not rocks, but ice chunks
Wind speed: 8km/hr