

Terrestrial Planets

Week 10

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Earth and Planetary Sciences
FD Adams 131C



Geological Activity

How would we recognize current and ancient geological activity on other planets and moons? Evidence?

With Earth as a model, we look for:

- **Plate tectonic topography (deep basins and high continents)**
- **Volcanism (active and ancient; magma and geysers)**
- **Isostatic violations**
- **Recent and ancient plate tectonic movements**
- **Thrust faulting and ridge spreading**
- **Seismic activity**



Searching our Solar System

A series of space missions has searched the planets and moons of our Solar System looking for active geology and climate and for life. In the following slides and videos, I show some discoveries resulting from the following missions:

- [Mariner 1 - 10](#): Venus, Mars and Mercury
- [Viking](#): Mars
- [Venera 1 – 16](#): USSR to Venus
- [Pioneer 10 – 11](#) first deep space mission through Solar system
- [Voyager 1 – 2](#): Jupiter, Saturn, Uranus, Neptune and their moons
- [Magellan](#): Venus
- [Galileo](#): Jupiter and its moons
- [Cassini/Huygens](#): Saturn, Titan and Enceladus
- [Mercury Messenger](#): Mercury
- [New Horizons](#): Pluto
- [InSight](#): Mars



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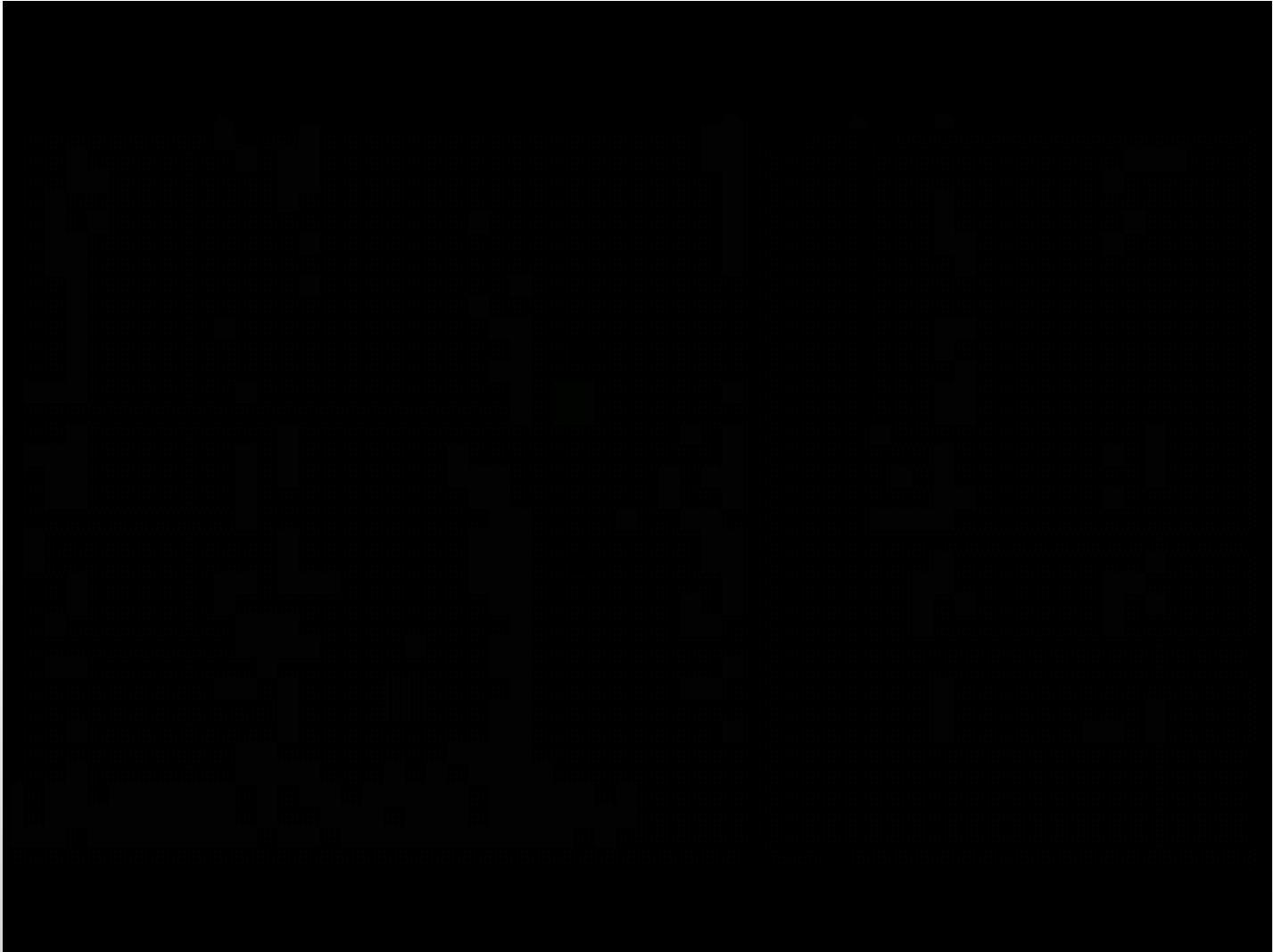
[Terra Firma from BBC Horizon](#)



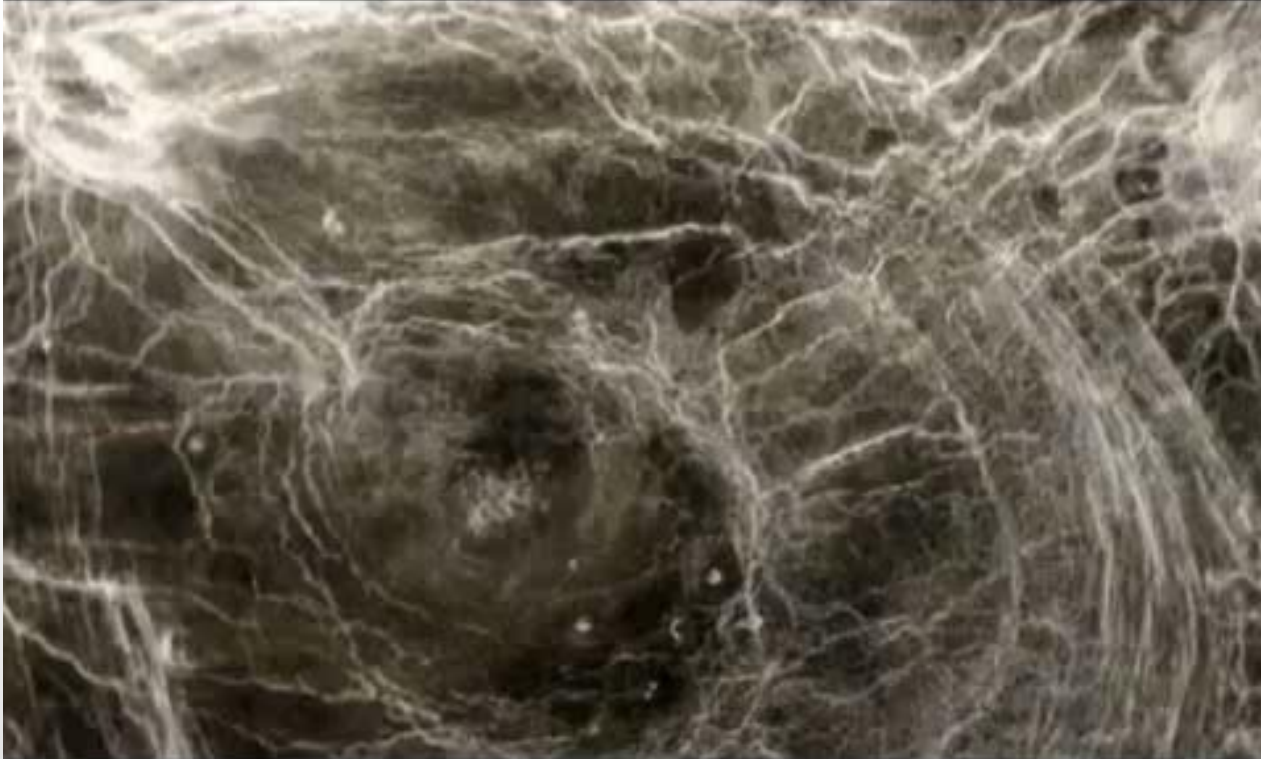
Mars



Venus



More of Venus & Io



Jupiter's moons to Triton



But Io wasn't the only surprise

Jupiter's Galilean Moons

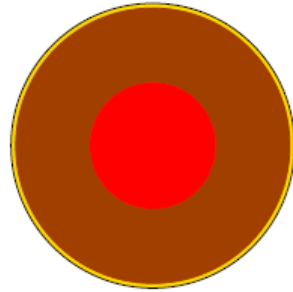
[Jupiter](#) probably has a small core of rocky silicate-composition material and a deeper iron core just like Earth and perhaps of about the same size as Earth. Overlying this Earth-like centre we believe there is an ocean of exotic liquid metallic atomic hydrogen more than 40000km deep and which is again overlain by an ocean of liquid molecular H₂-hydrogen 25 000km deep. Above that, there is a thick atmosphere of methane, CH₄, H₂ with possibly some water and CO₂. More than 70% of the mass of the planet is hydrogen (90%+ by atom count). 25% of the mass of the planet is probably He like the Sun with the heavier elements contributing well less than another 5%.

It is circled by more than 60 known moons; the 4 large inner moons are known as the [Galilean Moons](#) as they were first noted by Galileo in 1610. When Jupiter is close to Earth in our orbit, it is almost possible to see these moons with the naked eye and easily with binoculars.

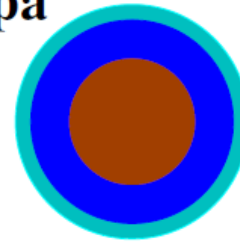


Jupiter's Galilean Moons

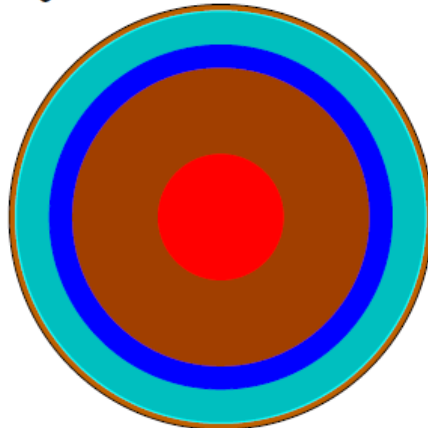
Io



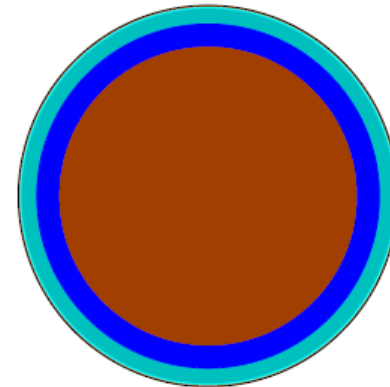
Europa



Ganymede



Callisto



Sulphur rich
regolith and
volcanoes



Silicate
regolith



Water ice



Water liquid



Silicate or
silicate/ice
mixture



Iron, possibly
molten



Jupiter's Galilean Moons

The Galilean moons of Jupiter ([Io](#), [Europa](#), [Ganymede](#) and [Callisto](#)) are very much like terrestrial planets in that they are hard-bodied and relatively dense suggesting that they comprise silicates and possibly iron.

These moons all maintain one face toward Jupiter; they are “**spin-orbit**” coupled with one axial rotation per orbit.

Moreover the inner three are “**orbit-orbit**” coupled. Each time Ganymede orbits Jupiter, Europa orbits 2 times and Io 4 times. They are harmonically coupled in 1:2:4 ratios. Callisto is not.

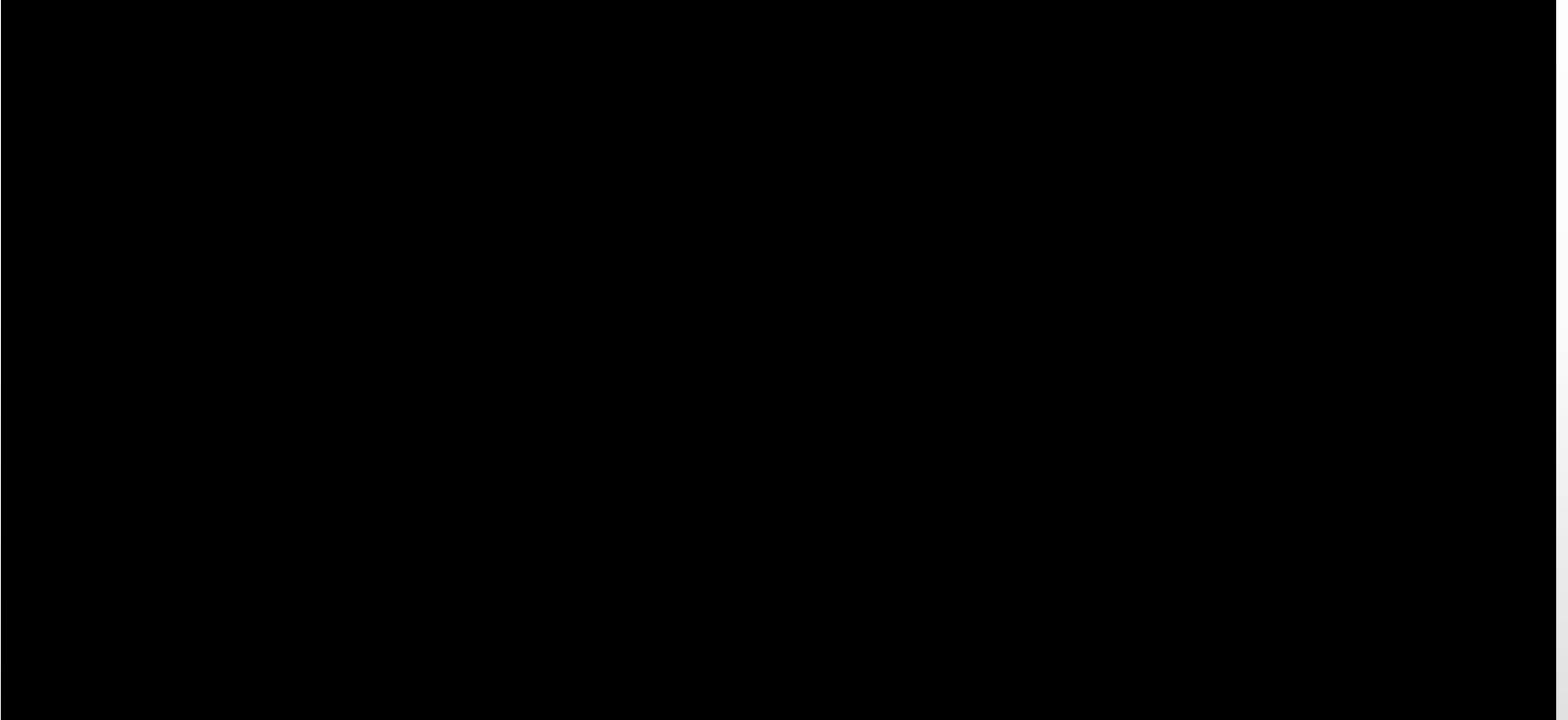
Ganymede and possibly Io have molten iron cores as they have internally generated magnetic fields.



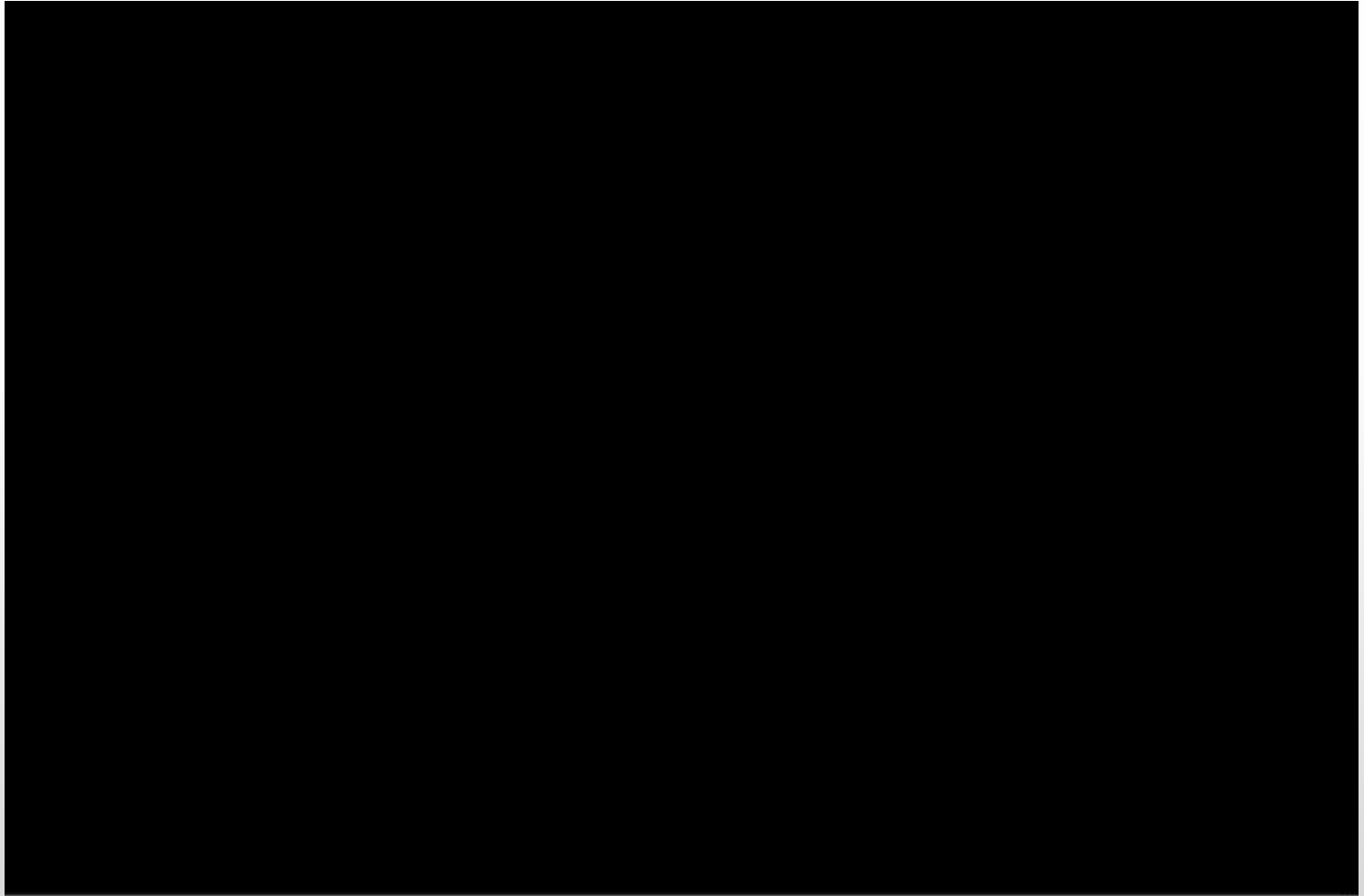
Jupiter's Galilean Moons

Galileo discovers Jupiter's large moons

Galileo: Europa, Io ...



Galileo: Europa, Io ...



Saturn: Titan and Enceladus

Saturn is similarly composed as Jupiter over an Earth-like core.

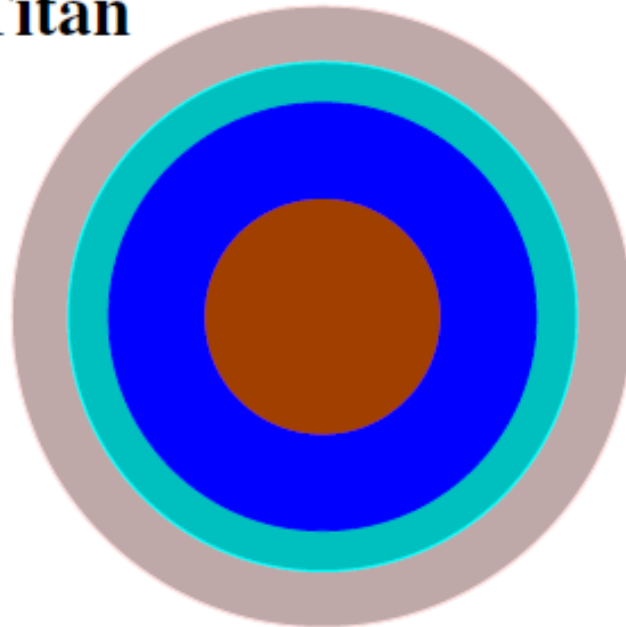
Saturn's largest moon, Titan, is interesting in that it has an extremely thick, thicker than Earth's, atmosphere composed mostly of CH₄ and N₂. It is thought that this atmosphere is like that of the earliest stages of Earth's evolution.

Enceladus is a very small moon that is surprisingly active. It is probably composed of a small silicate core overlain by a thick mantle of water ice. A hot spot in its "southern" hemisphere is melting ice, vapourizing water and spouting geysers.



Saturn: Titan and Enceladus

Titan



Thick CH₄,
N₂ atmosphere



Water ice



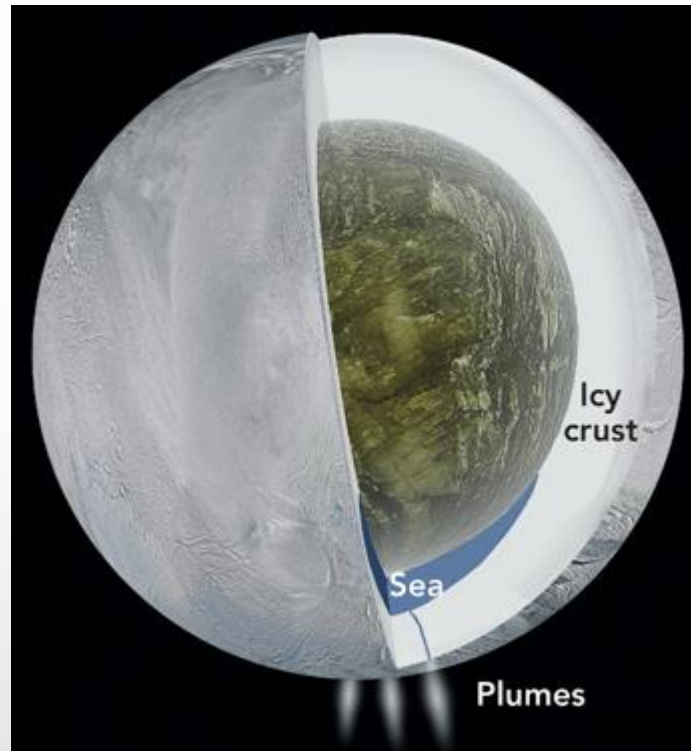
Water liquid



Silicates,
heavy elements



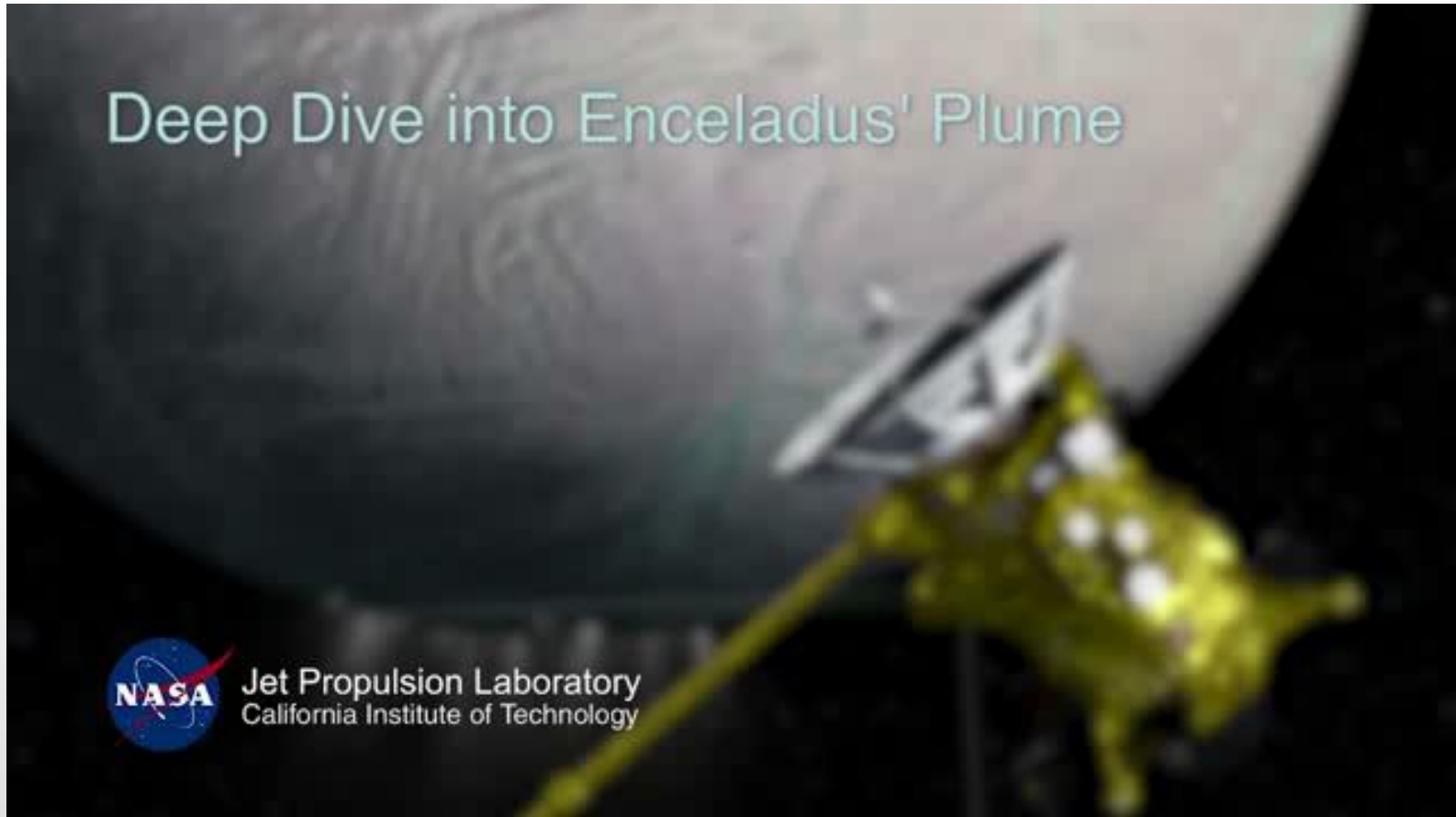
Saturn: Titan and Enceladus



Enceladus' geyser-plumes might contain organics



Cassini at Saturn: Enceladus



Deep Dive into Enceladus' Plume



Jet Propulsion Laboratory
California Institute of Technology

Cassini at Saturn: Enceladus

ENCELADUS

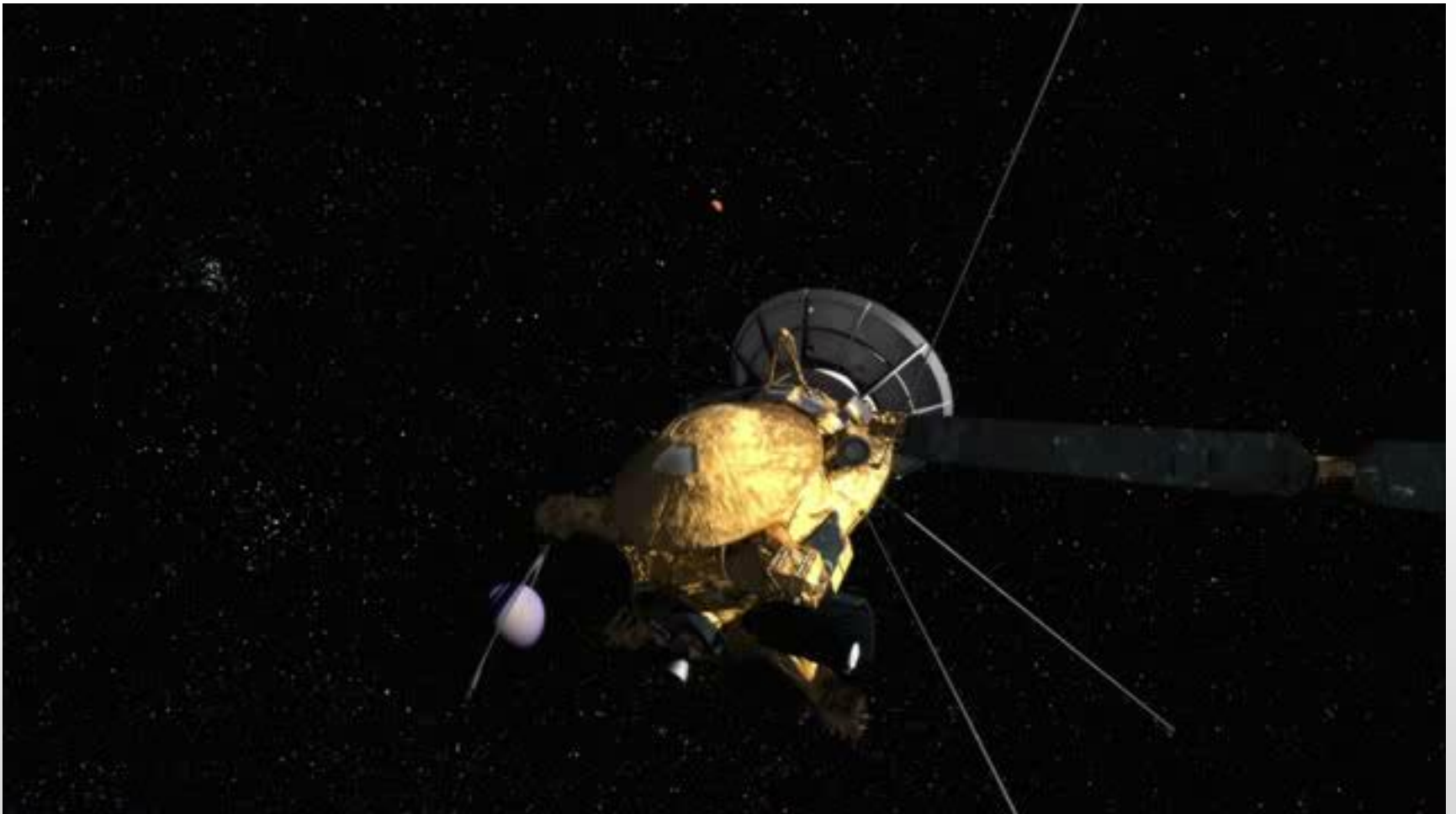
The Mystery of the Icy Moon



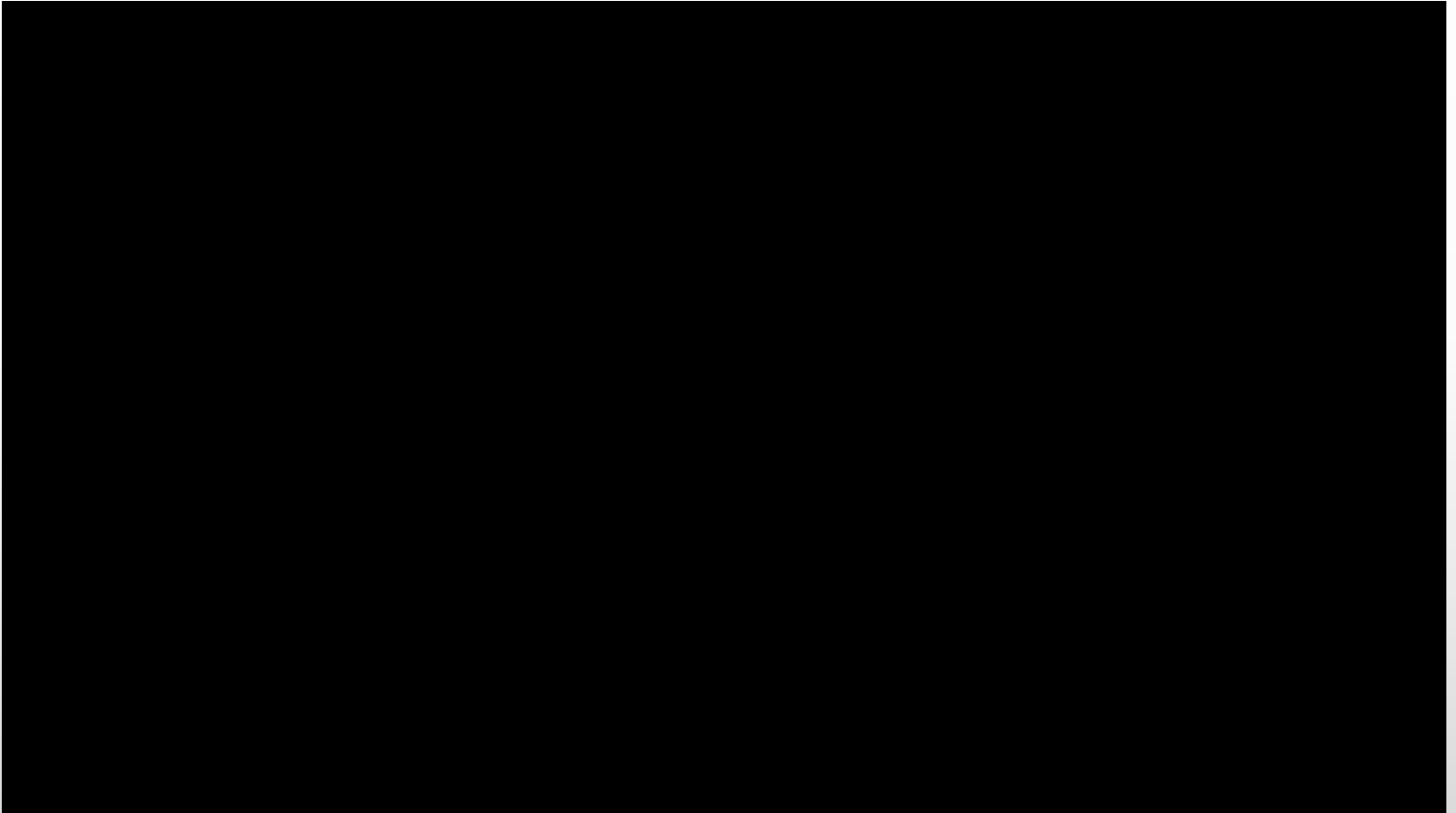
Jet Propulsion Laboratory
California Institute of Technology



Cassini: Huygens Touchdown



Cassini: Mapping Titan



Mercury

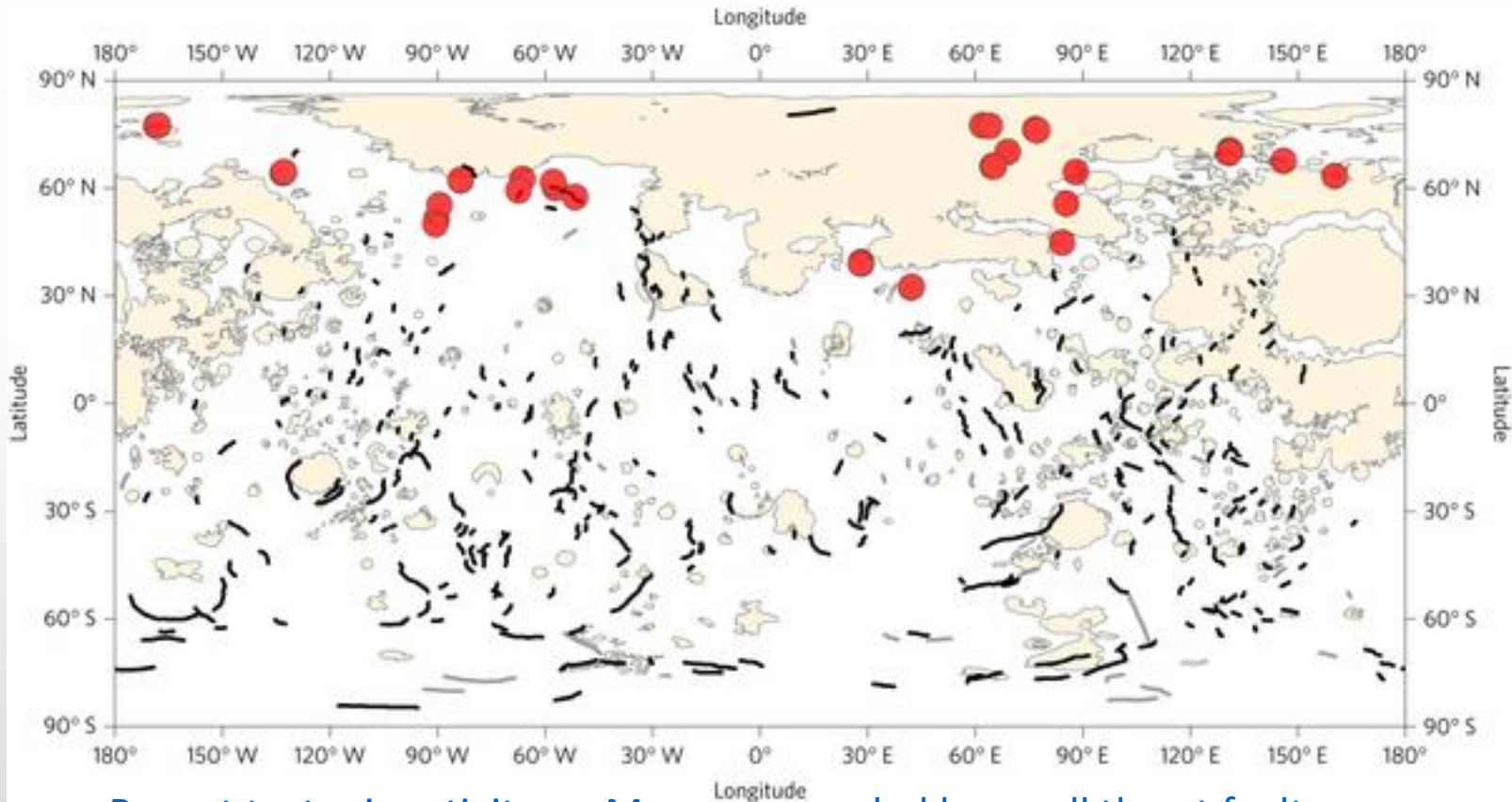
“It’s small, it’s hot, and it’s shrinking. New NASA-funded research suggests that Mercury is contracting even today, joining Earth as a tectonically active planet.

Images obtained by NASA’s MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft reveal previously undetected small fault scarps— cliff-like landforms that resemble stair steps. These scarps are small enough that scientists believe they must be geologically young, which means Mercury is still contracting and that ***Earth is not the only tectonically active planet in our solar system***, as previously thought.”

... quoted from: [The Incredible Shrinking Mercury is Active After All](#)



Mercury



[Recent tectonic activity on Mercury revealed by small thrust fault scarps](#)



Mercury

Ice on Mercury (north polar region)

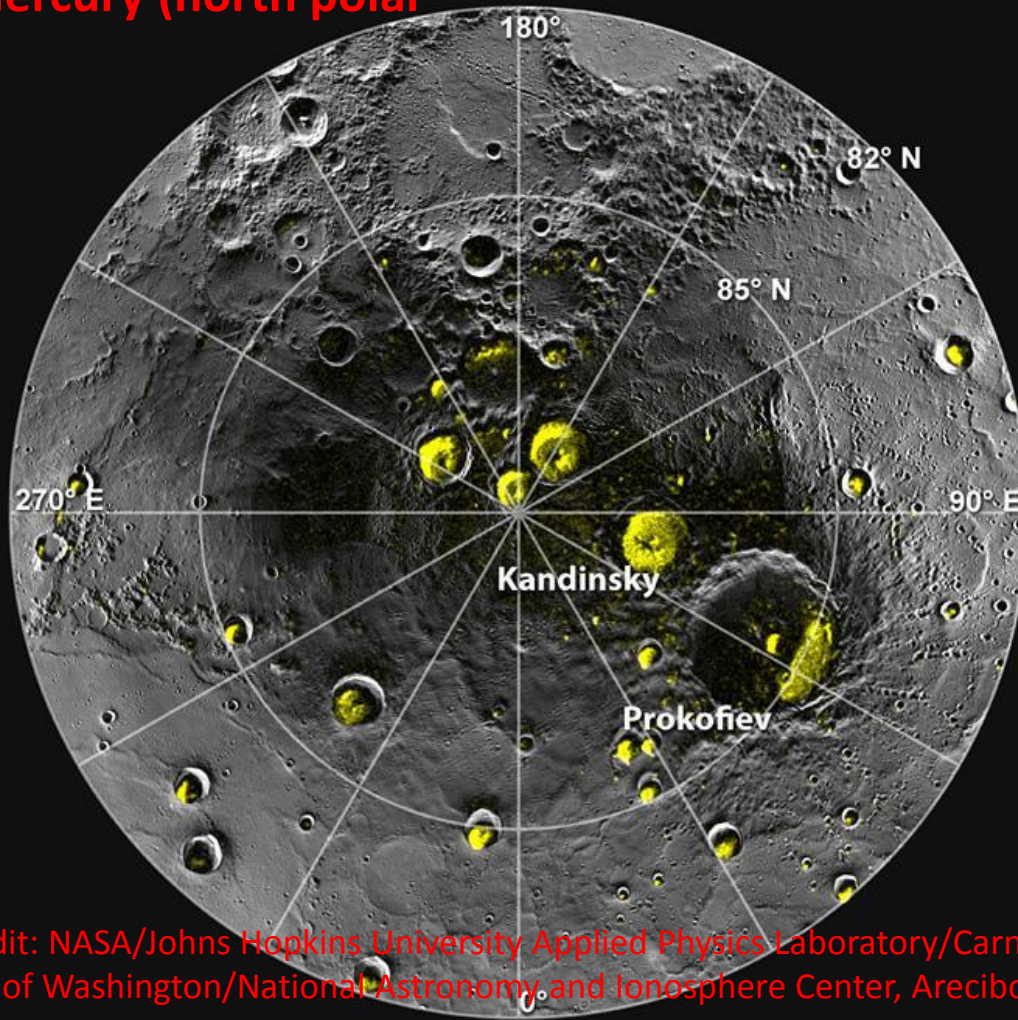


Image Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington/National Astronomy and Ionosphere Center, Arecibo Observatory



Pluto

On July 14, 2015, the [New Horizons](#) space probe passed close to Pluto following a 9-year mission from Earth.

Pluto surprised us!



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[*More of
Pluto in a
Minute...*](#)

