AST 309L

The Moons of Jupiter

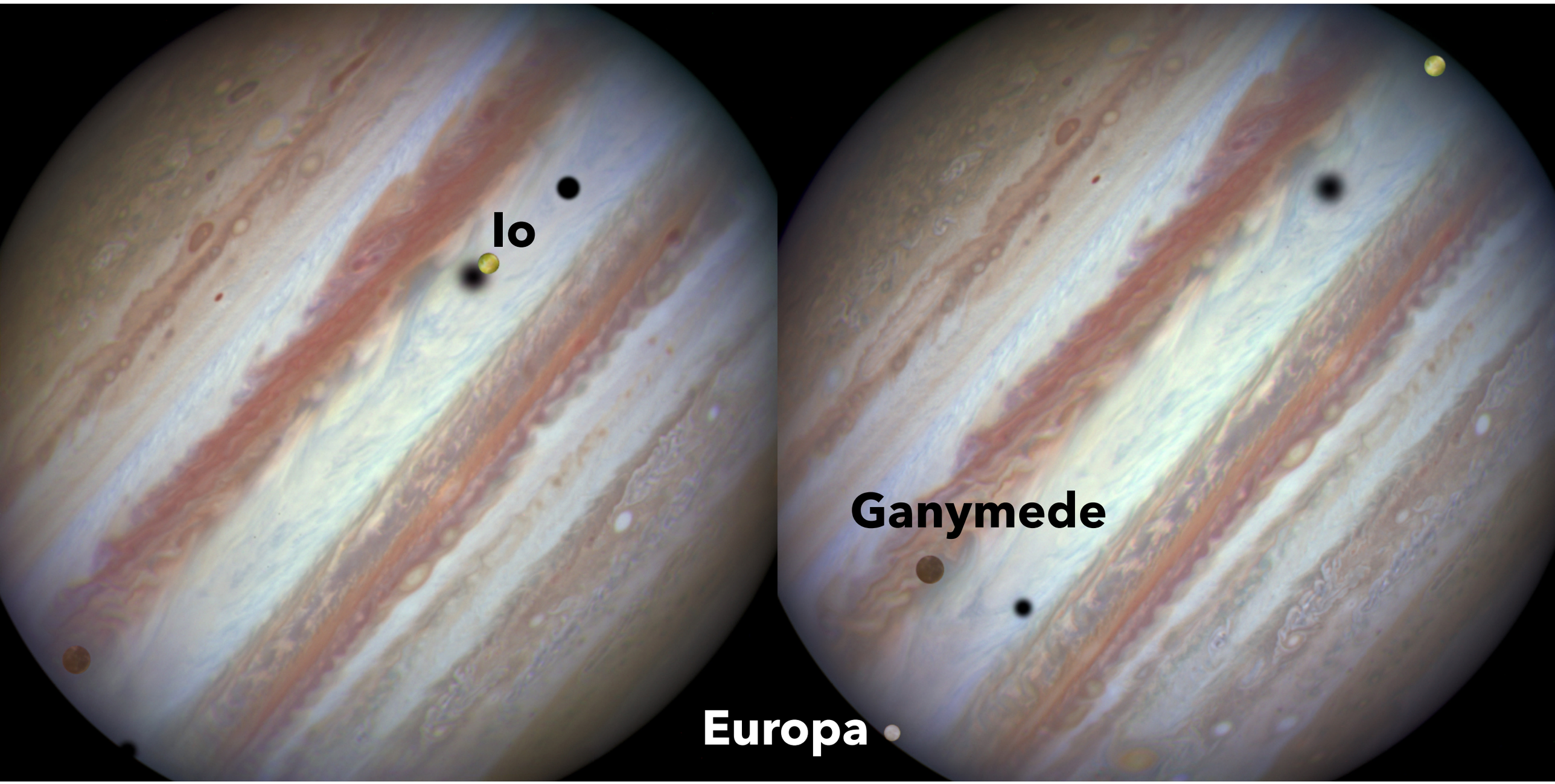
A few weeks ago, many of you listed Jovian moons as the #1 or 2 place to search for life in our solar system

Why?

Why Jovian moons?

- There's a lot of them! And they are extremely varied in size, composition, structure.
- We've sent missions to them before, so we know we can study them in detail.
- As we'll see, some have the ingredients necessary for life!

The Jupiter system

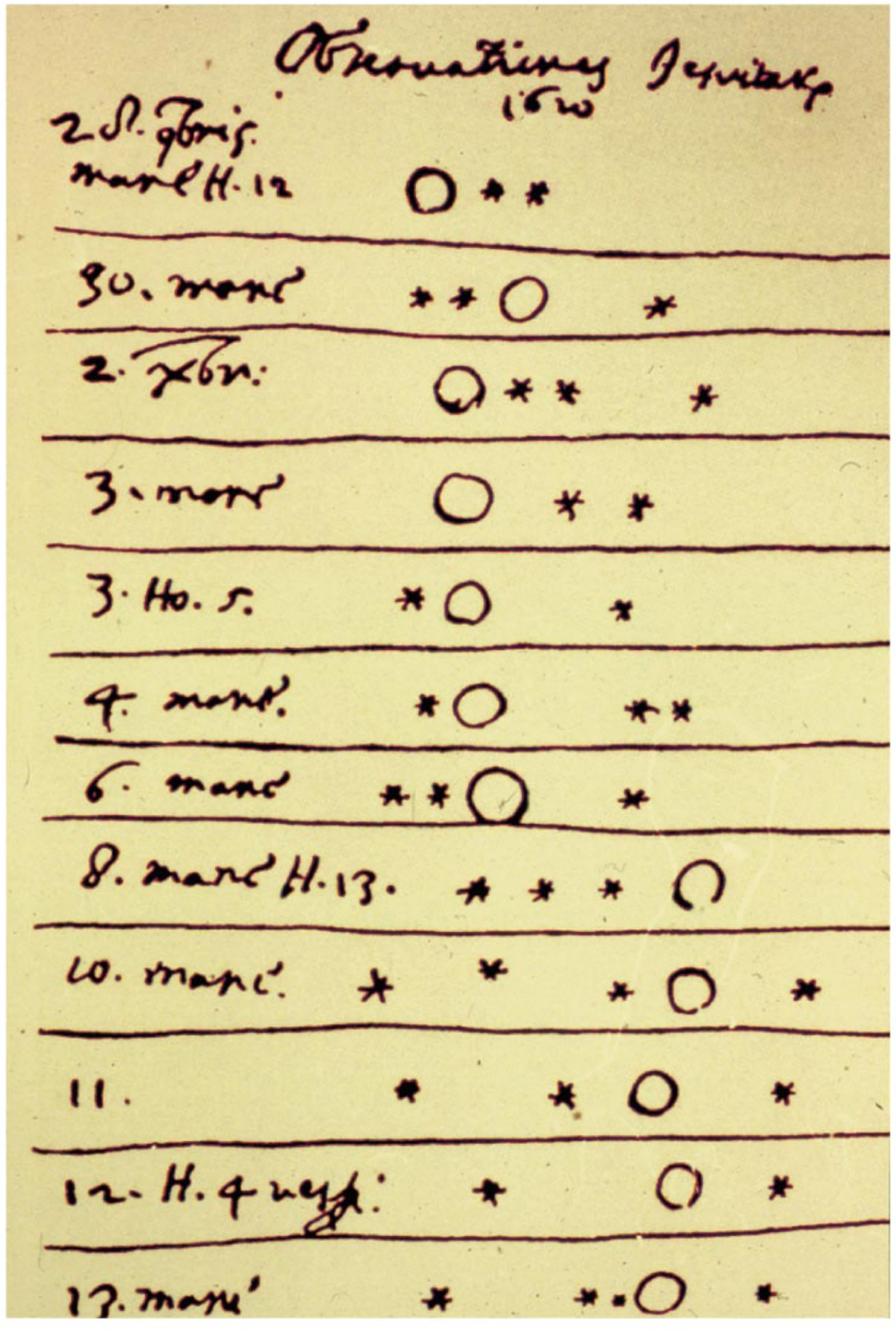


The Galilean moons

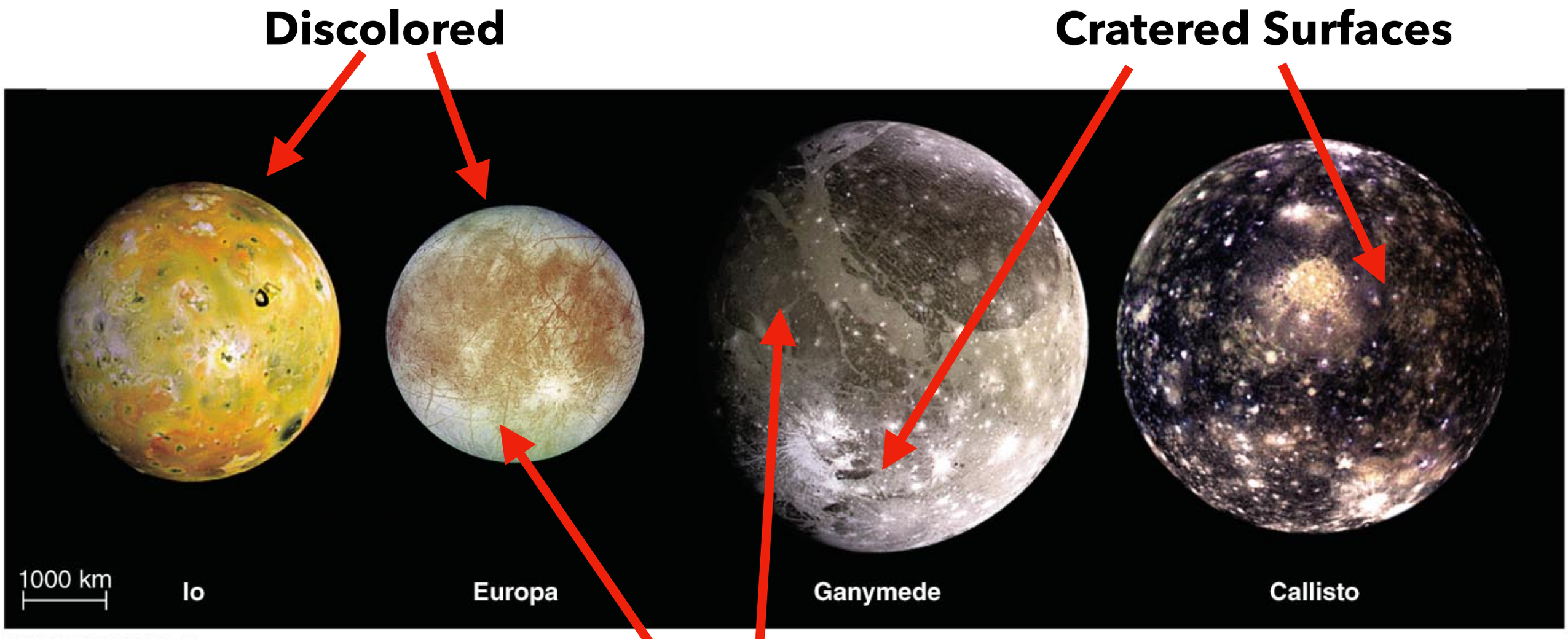
- The first moons discovered around another planet – by Galileo in 1610.

- Noticed 4 “stars” in a line around Jupiter that did not move like background stars.

- Claimed they orbited Jupiter – Heresy! What about geocentrism?



Modern view of the Galilean moons



General characteristics of the Galilean moons

- **They are relatively big!** All larger than Pluto, all but Europa larger than our Moon, and Ganymede is larger than Mercury! **Still much smaller than Earth/Venus.**

- They are **much less dense though!** Io is 60% the density of Mercury, and Callisto is 30% the density of Mercury.

- They **orbit Jupiter closely**, in roughly a few to 20 days.

- They all **lie in a plane and orbit in the same direction**, much like the planets in the solar system.

Activity – Moon-Planet Comparisons

- We'll be doing **Part A** right now, focusing on the differences between Jovian moons and rocky planets
- Raise your hand if you have any questions!

Activity Review

- Big difference? Size!

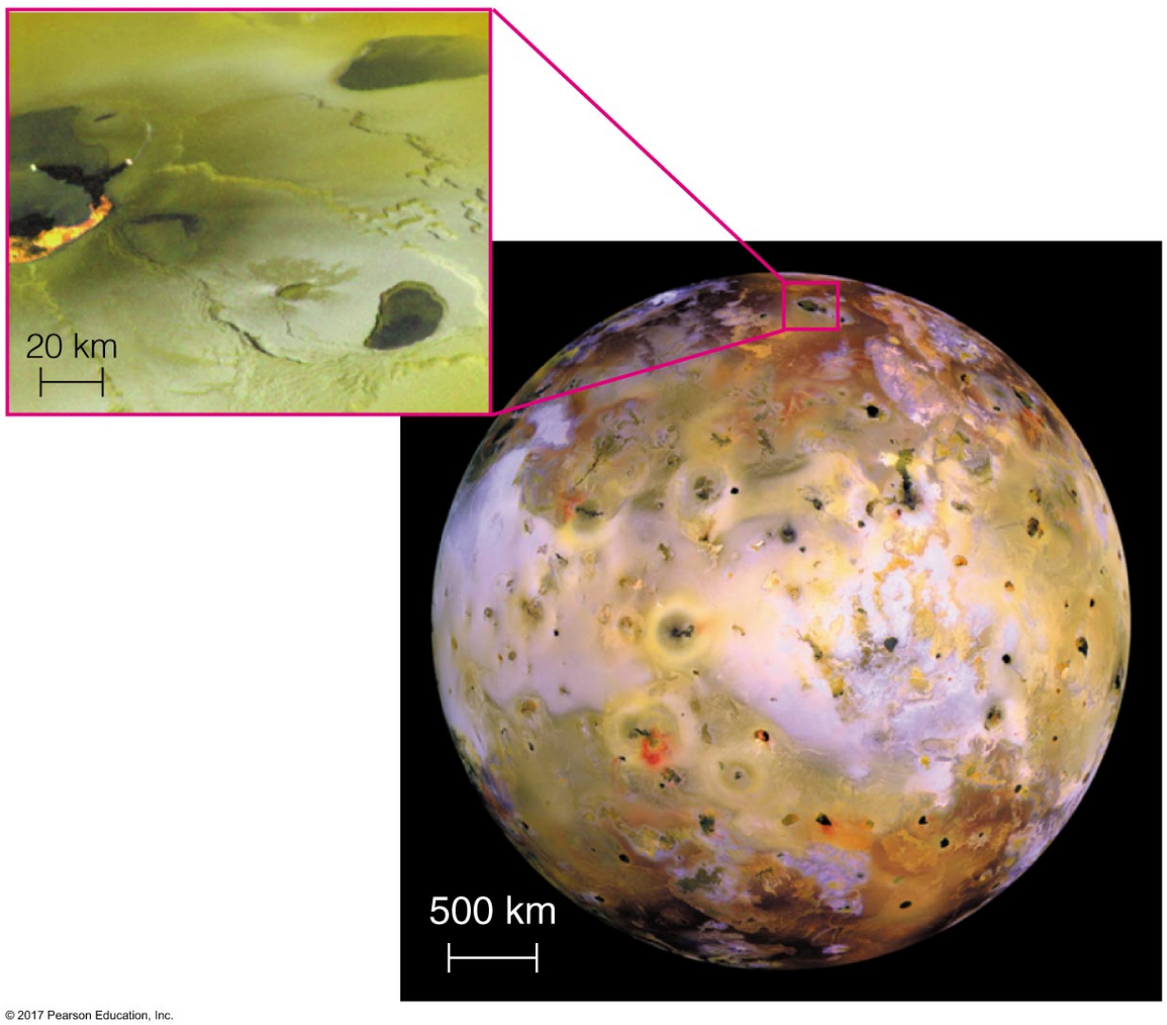
- Earth's internal heat is from **formation and radioactivity**, there wouldn't be nearly as much of this for moons (like Mercury and Mars).

- Earth's magnetic field is from its **liquid core**, need internal heat!

- What do you think this says about the habitability of Jovian moons?

But Io… has volcanic activity!

Has many volcanoes!



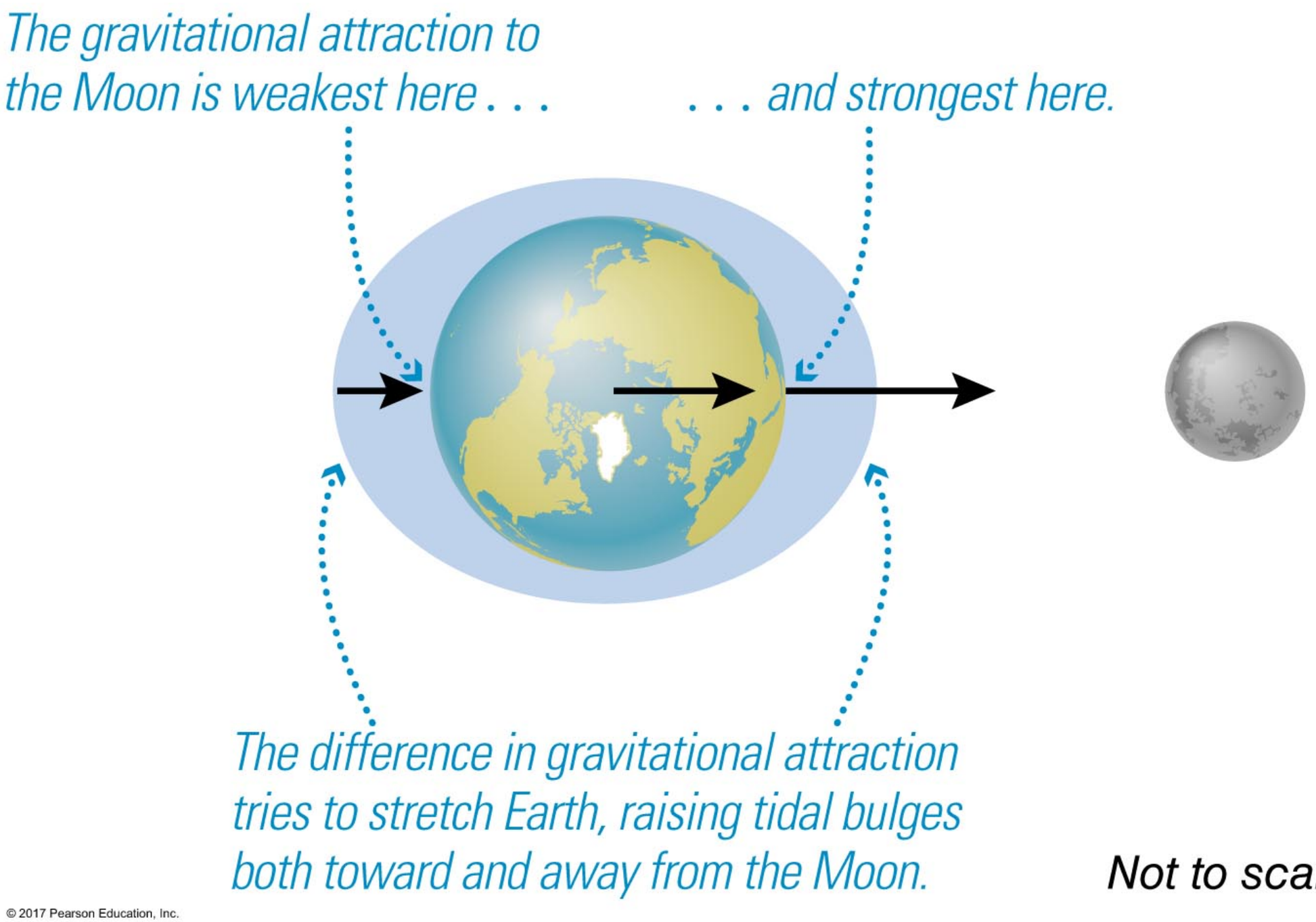
Covered with volcanic deposits

What is the source of Io's internal energy?

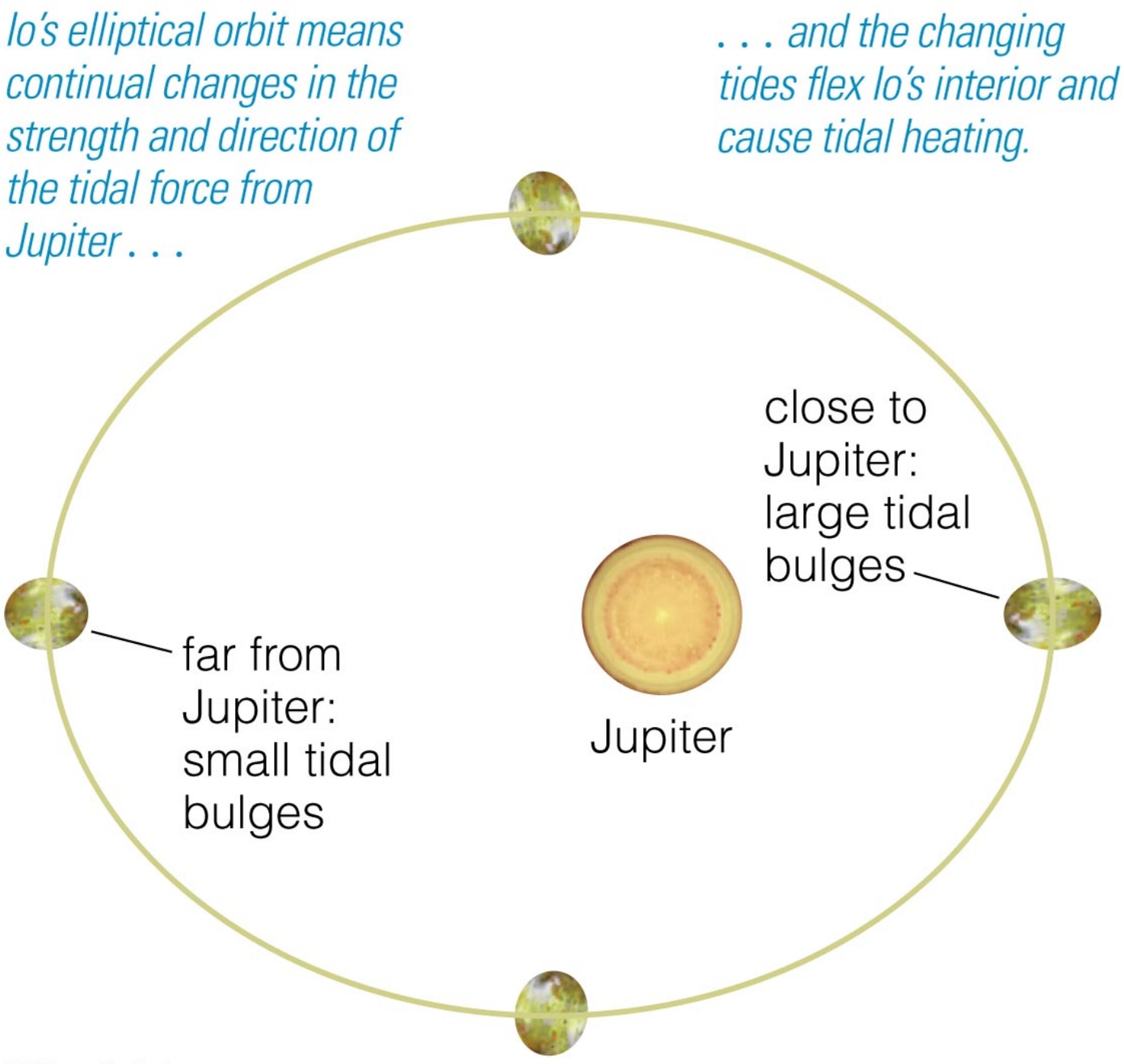
Can't be formation/gravitational (size)
Not enough radioactivity for geology

Tidal heating! What is it?

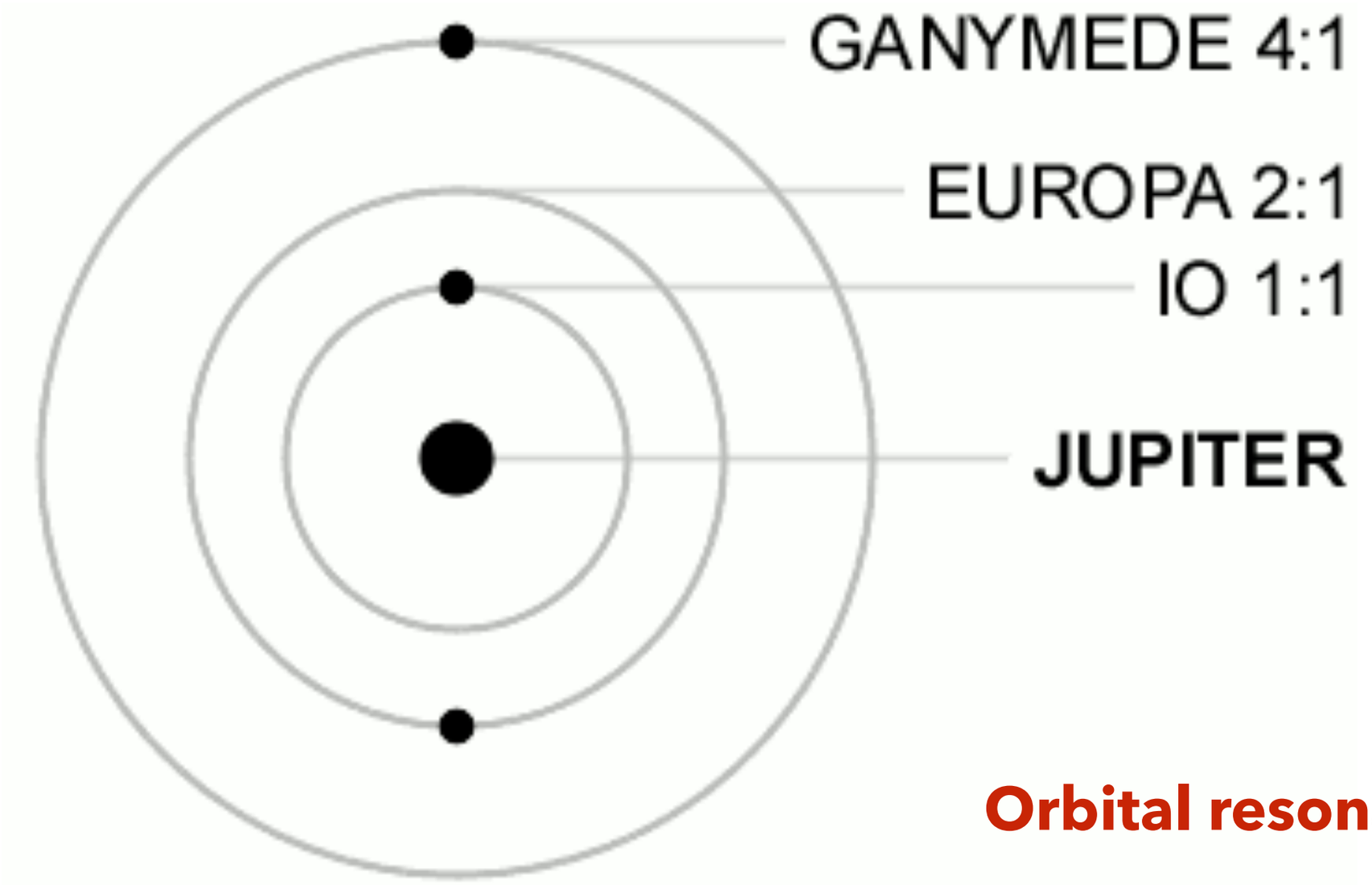
Tidal heating! What is it?



To increase tidal heating, you need an elliptical orbit



And you need something to keep elliptical orbit stable



Orbital resonance!

Instapoll #2:

Io experiences strong internal tidal heating because of:

A. large amounts of radioactive decay occurring inside the moon

B. the large amount of internal heat left over from its formation

C. the strong tidal forces exerted by the outer Galilean moons, Europa, Ganymede, and Callisto

D. the strong tidal force from the massive Jupiter combined with its elliptical orbit

Instapoll #3:

Why is Io's orbit about Jupiter slightly elliptical?

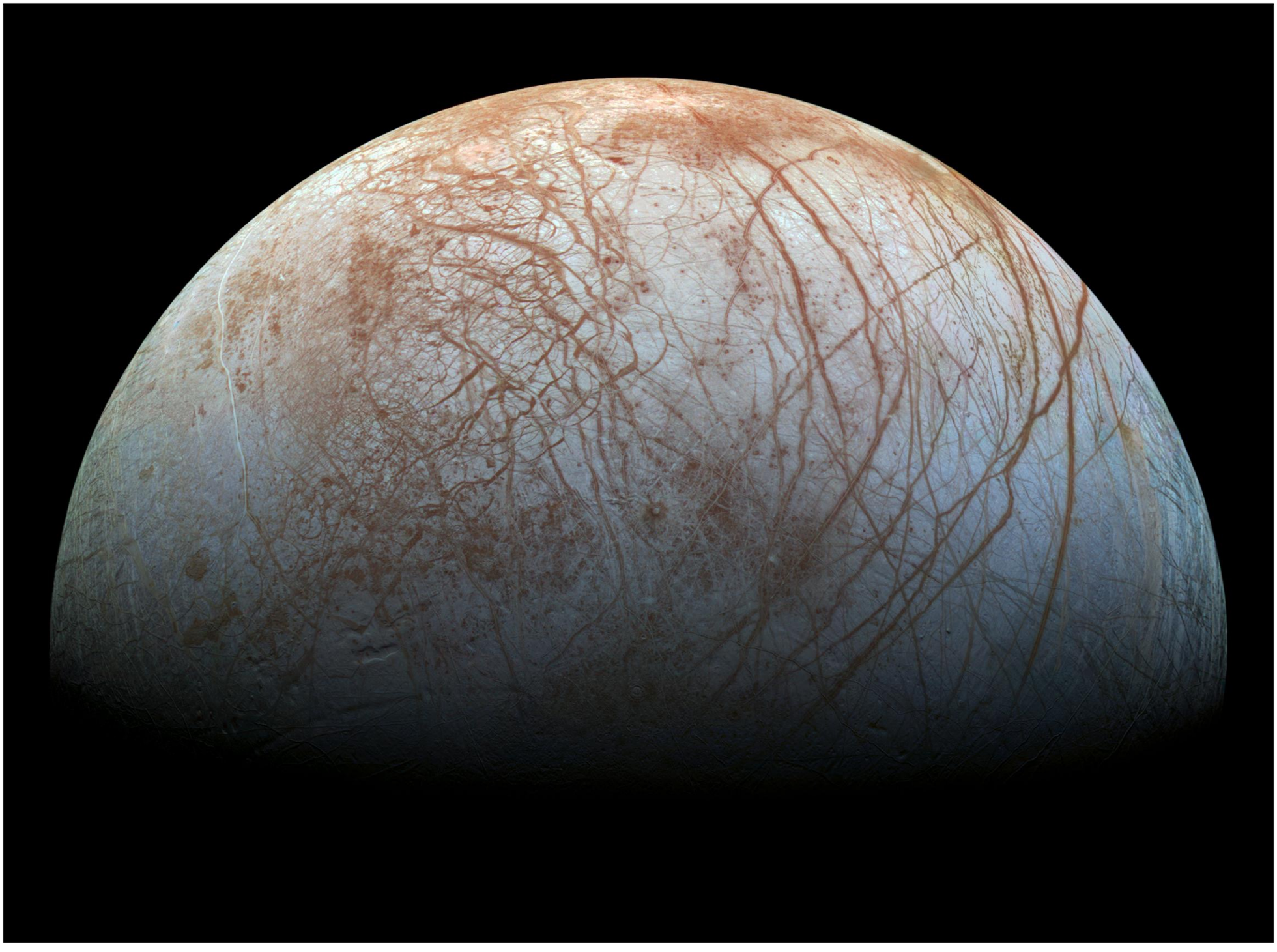
A. because of tidal forces due to Jupiter

B. because Io was captured

C. because of orbital resonances with the other three Galilean moons

D. because of a giant impact which occurred in the past

We're switching gears now to talk about Europa!



Activity – Europa's Characteristics and Ocean

- We'll be doing **Part B** right now, focusing on Europa's characteristics and how they provide us with evidence for a subsurface ocean.

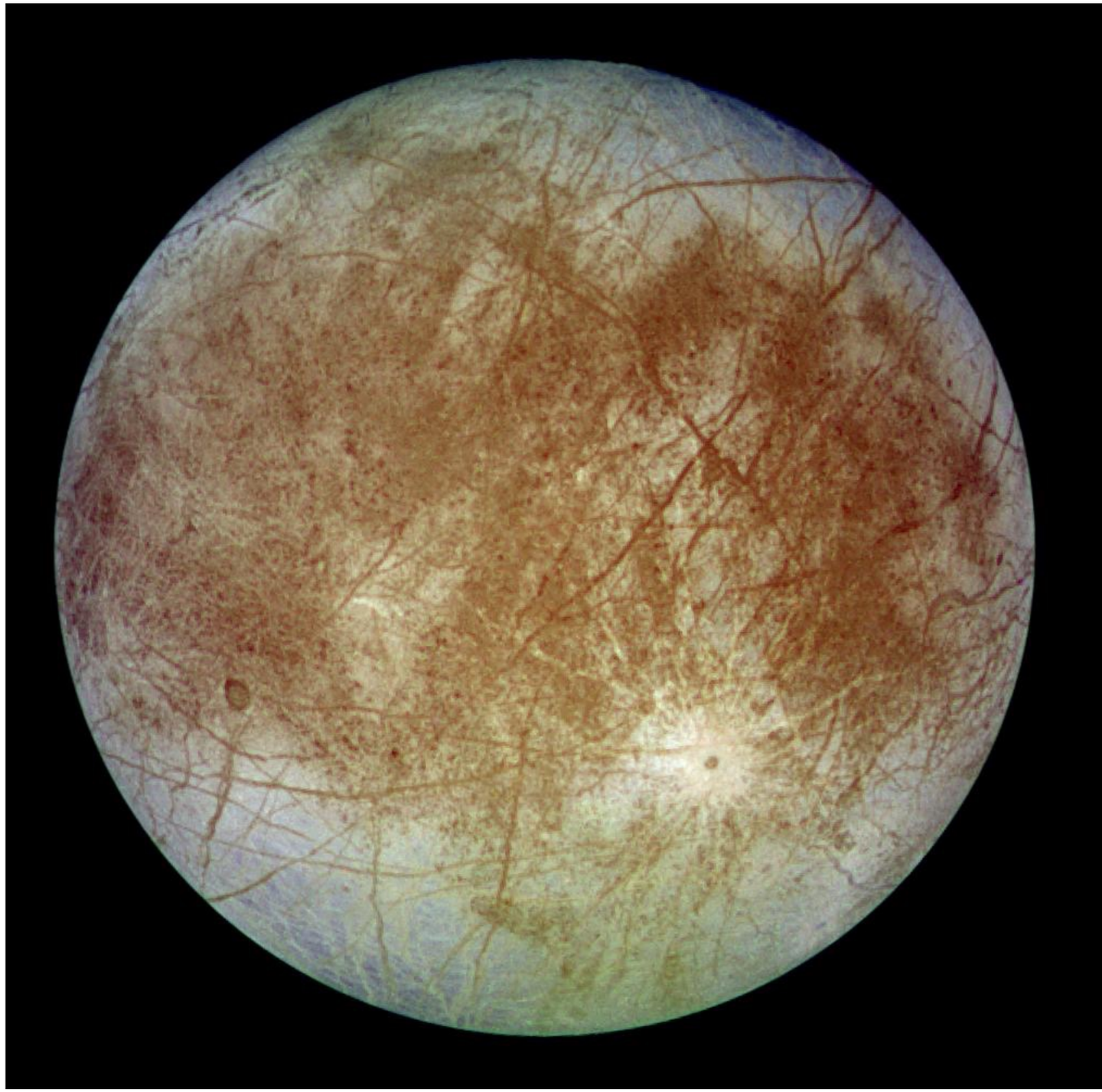
- Raise your hand if you have any questions!

Europa's surface

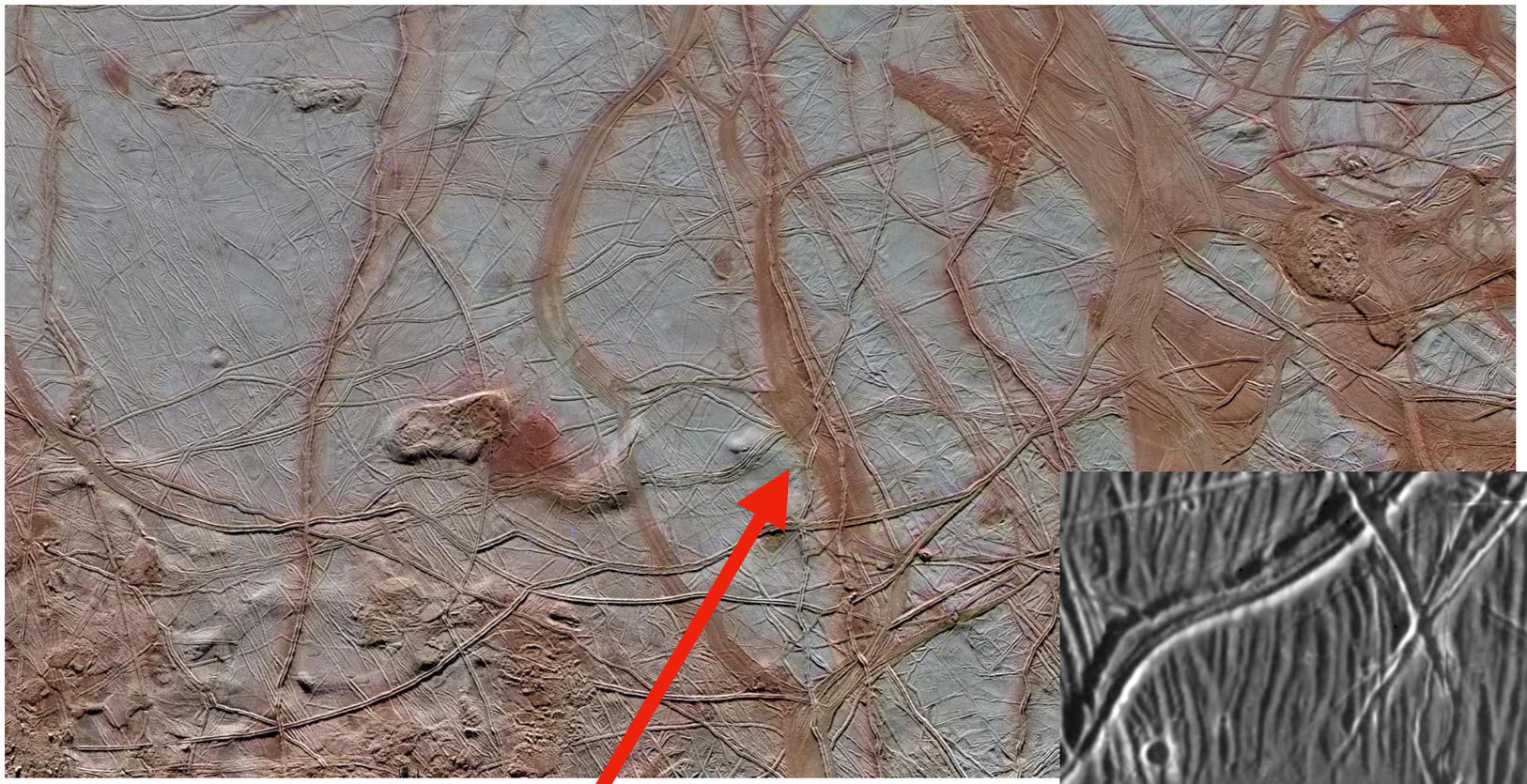
- Mostly a very smooth surface, has few impact craters – **young!**

- Covered with features called ***linea*** which are surface fractures

- Also covered with **reddish material** – salty minerals!

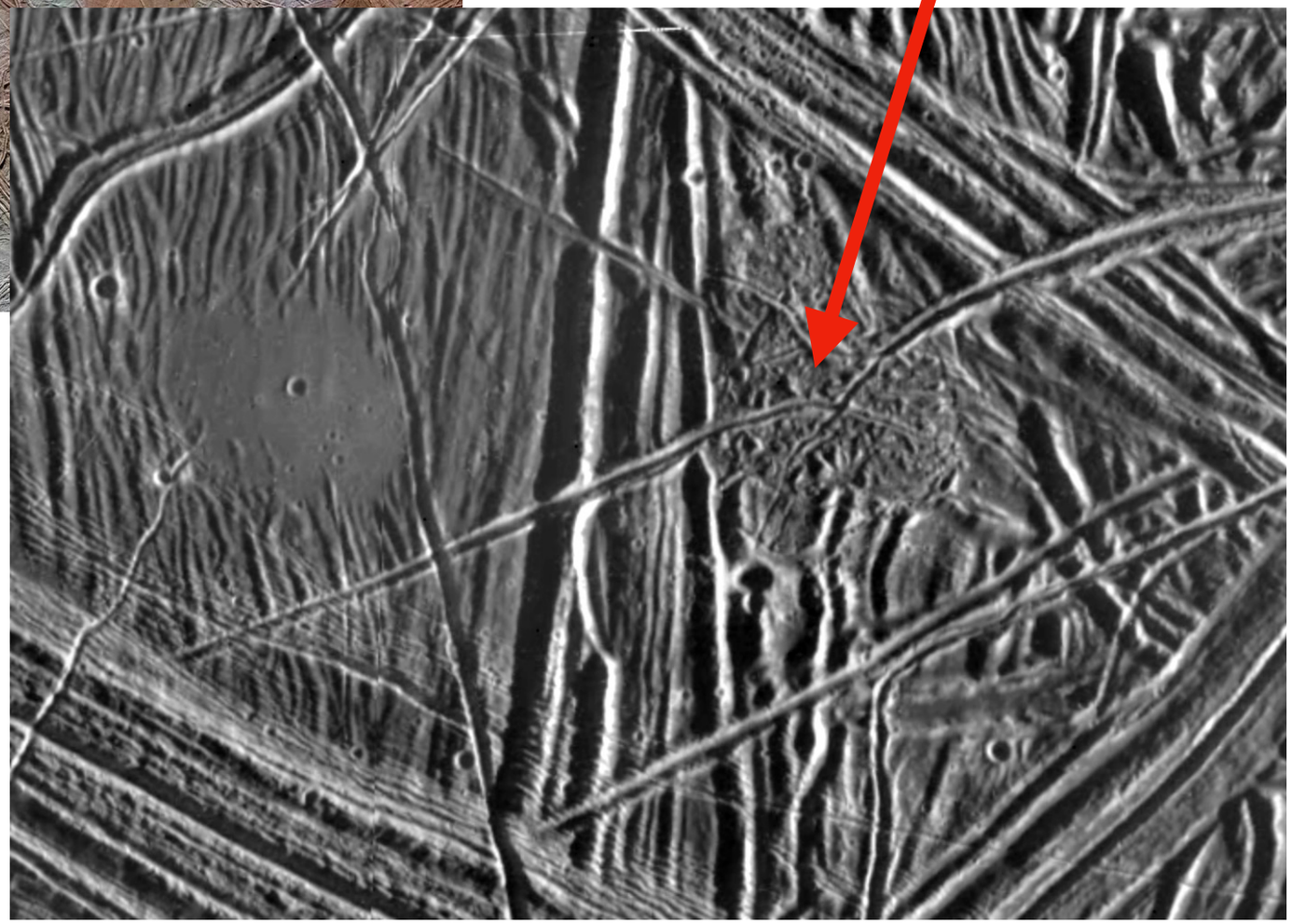


Europa's surface up close



Chaotic terrain

Might sit atop subsurface lakes

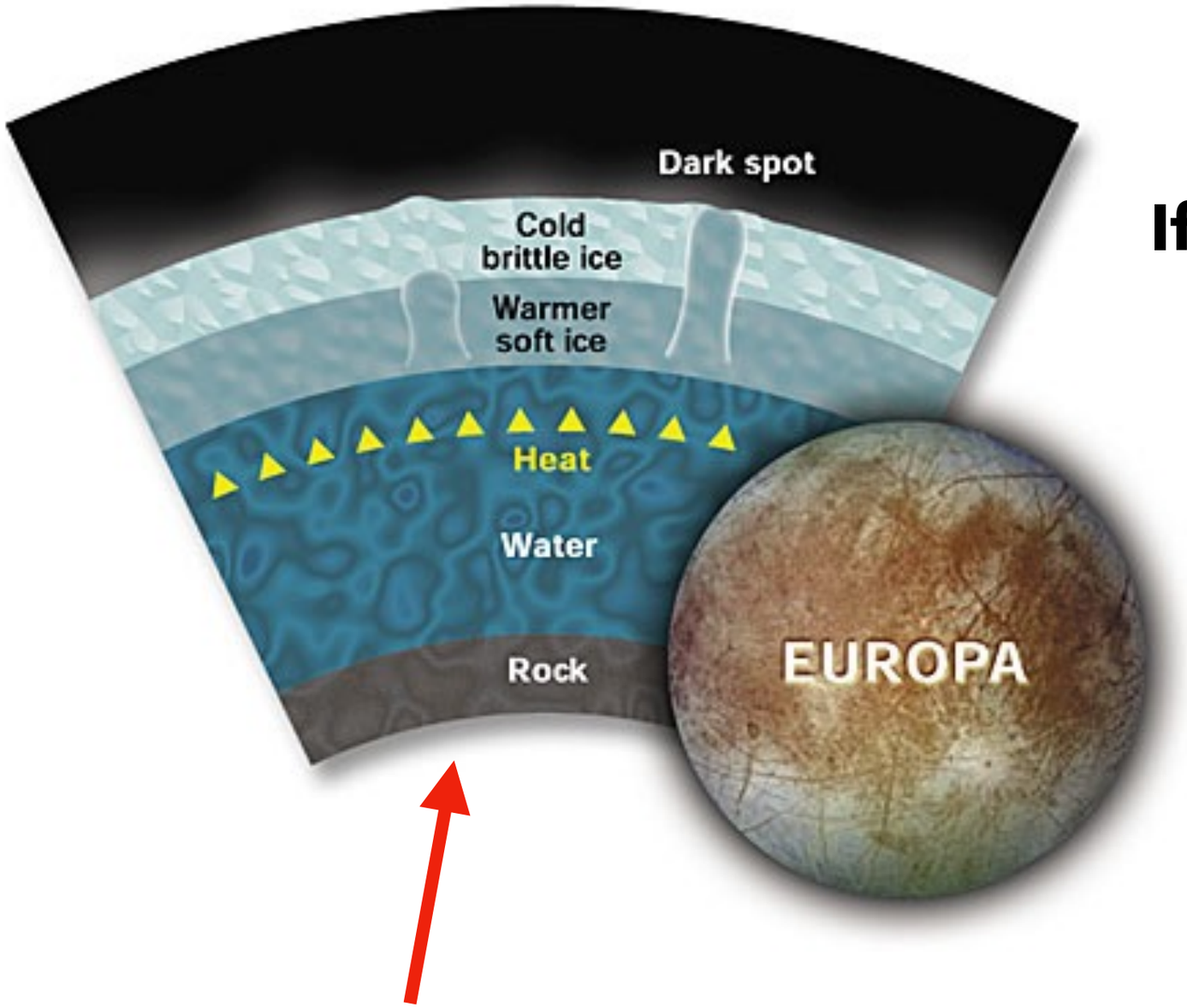


***Linea*, like mid ocean ridges**

Notice how the red is concentrated around the *linea*

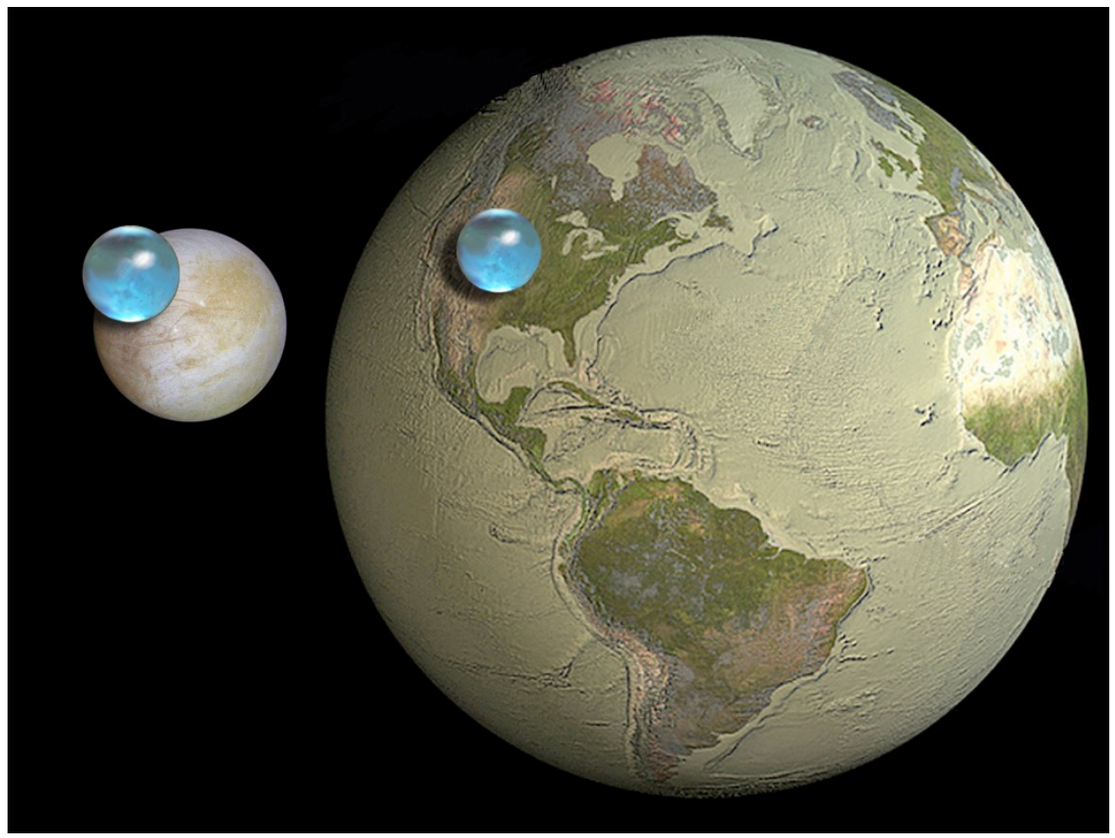
Europa’s magnetic field

Europa's internal structure and ocean

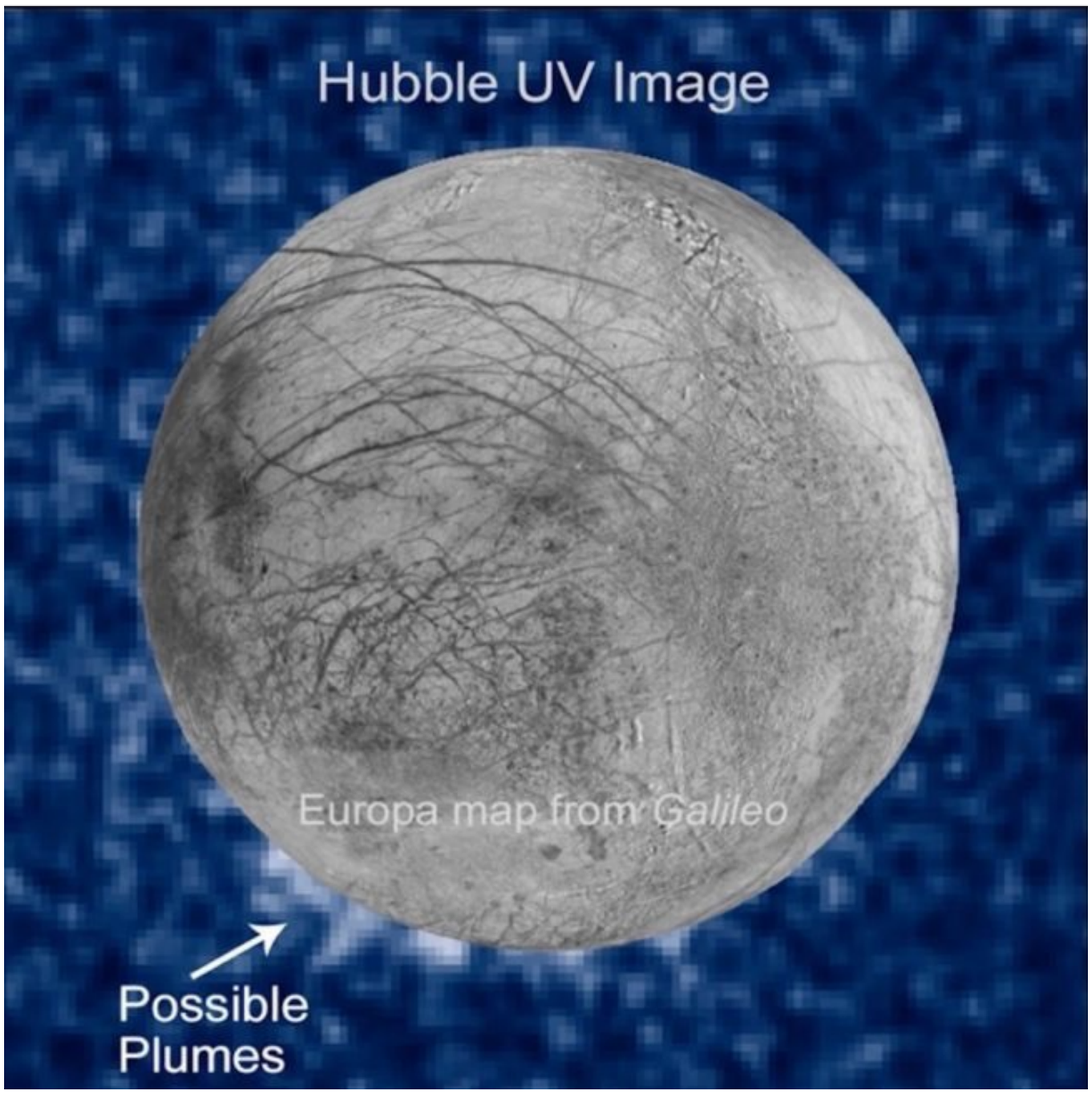


Ocean is probably above a rocky mantle, and below a thick ice shell

If our model of Europa's ocean is right it contains twice as much water as all of Earth's oceans!



We even have slight evidence for geysers on Europa!



We started this lecture discussing why we think the Jovian moons are good places to look for life.

So is Europa habitable?

Let’s recall the 3 major needs for life to develop and thrive

Let's recall the 3 major needs for life to develop and thrive

1. A **liquid medium** for transporting organic molecules and in which life's required chemical reactions occur

2. A **source of energy** for metabolism and growth.

3. A **source of elements and materials** (e.g. carbon) with which to form organic molecules and eventually life.

Activity – Potential life in Europa's ocean

- We'll be doing **Part C** right now, focusing on potential life in Europa's subsurface ocean.

- Raise your hand if you have any questions!

Where would we expect life to form in Europa's subsurface ocean?

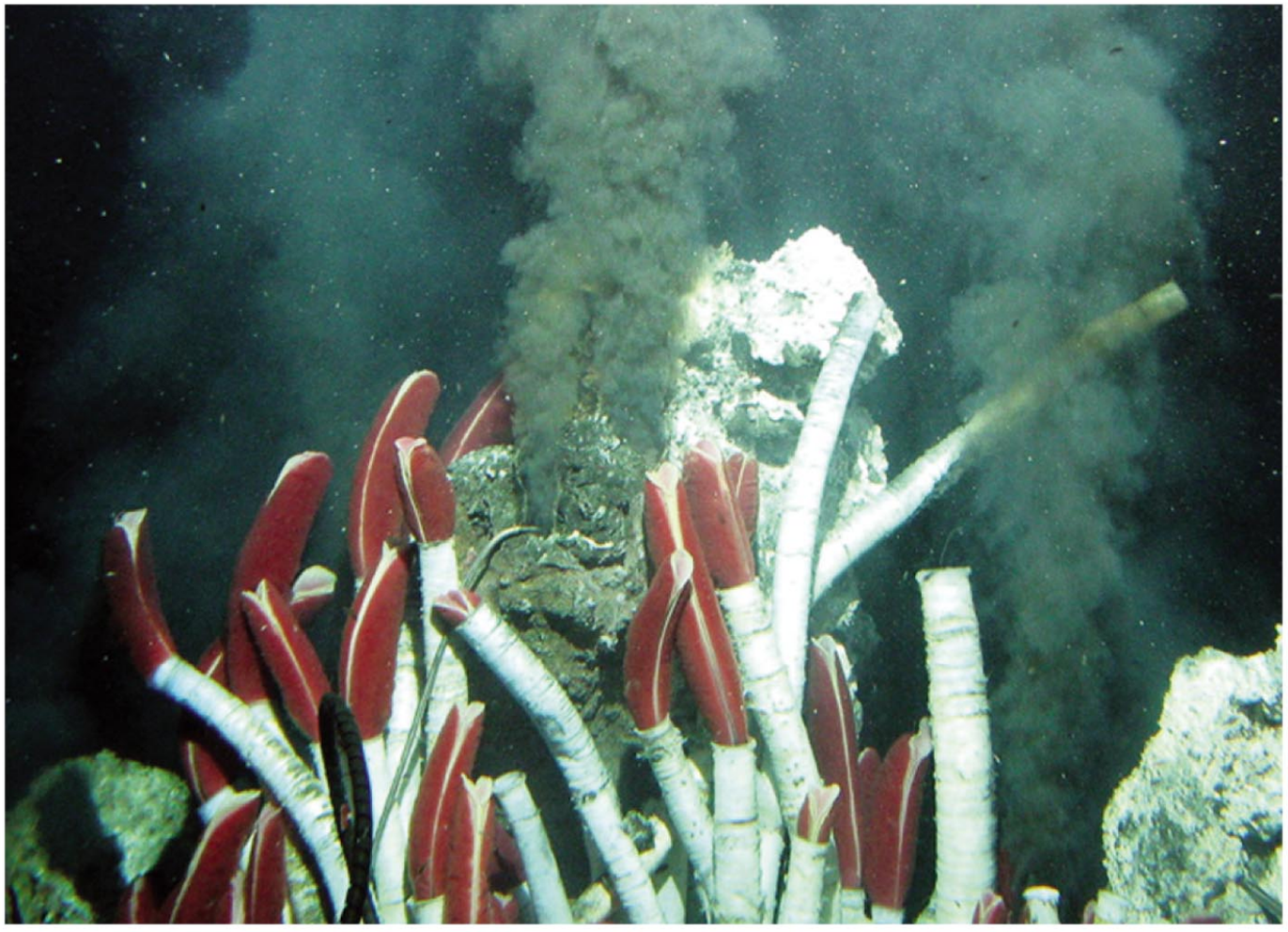
Around hydrothermal vents at the bottom of the ocean – similar to ecosystems here on Earth!

Potential energy sources for life in Europa's ocean

- Even some life in the depths of Earth's ocean is dependent on the Sun – photosynthesizing organisms/material sinks from the surface.

- Need to use **chemical reactions** to provide energy (recall chemotrophs).

- Tidal heating provides heat, not energy.



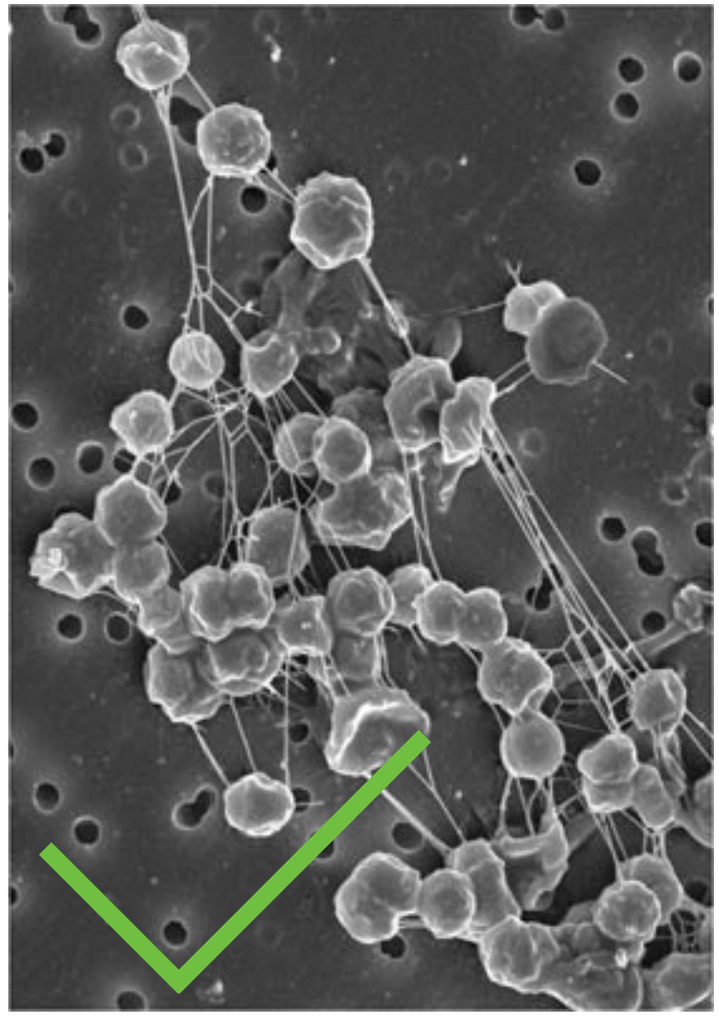
These energy sources wouldn't provide as much energy for life as here on Earth.

So what would an ecosystem on Europa look like?

Life on Europa

Giant alien squid?

Uh... Probably not



Where would the materials needed to form life come from?

- Well we know that the elements needed for life (Carbon, Hydrogen, Nitrogen, etc.) are **likely abundant in most places** in our solar system.

- Need the ocean to have a **rocky floor** – hydrothermal vents (heat) + rock-water reactions could help create organic molecules.

- Start search with Earth life building blocks: hydrocarbons, amino acids, nucleotides, lipids

We think there might have been panspermia between Earth and Mars.

Is this likely to have happened between Earth and Europa?

If life originated independently on Europa, what does this mean for life in our universe?

Instapoll #4:

Which of the following provide evidence for an ocean below the surface of Europa?

A. A weak magnetic field is generated by Europa.

B. Europa's surface is covered in salt minerals, particularly near linea.

C. Europa's surface is smooth and lacks craters.

D. All of the above.

Instapoll #5:

Life in the subsurface ocean of Europa will most likely consist of:

A. creatures similar to seals and penguins which enter the ocean through holes in the icy crust

B. plants on the ocean floor

C. simple single-celled organisms

D. fish and other complex aquatic organisms