

GEO 325M Spring 2020

Class project: Formation of chaotic terrains on Jupiter's moon Europa

Europa!

Wrong one (continent on Earth)



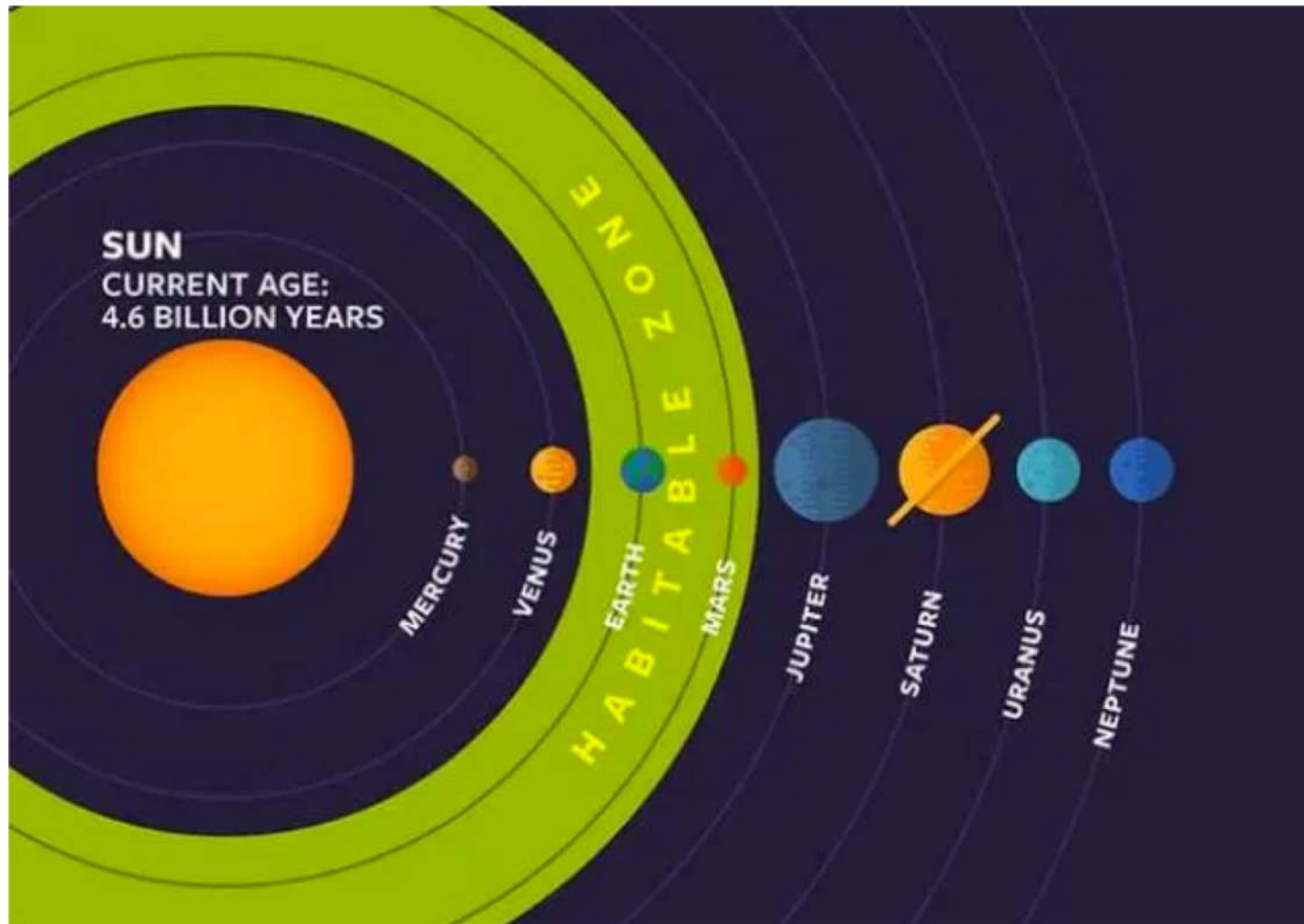
Correct one (moon of Jupiter)



Habitable zone

Sounds good, but is largely BS

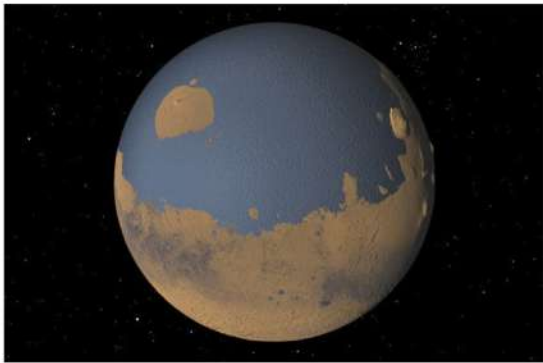
Habitable Zone (surface water)



Follow the water

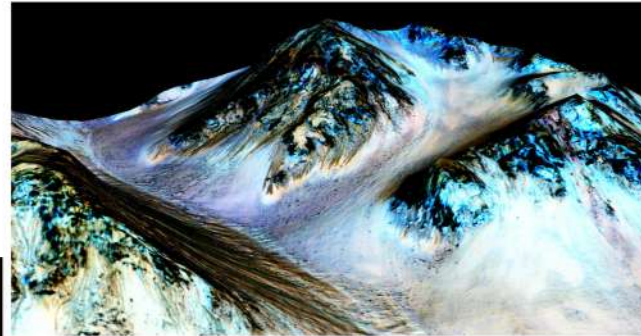
The New York Times

Ancient Mars Had an Ocean, Scientists Say



The New York Times

Mars Shows Signs of Having Flowing Water, Possible Niches for Life, NASA Says



Scientists say these dark, narrow, downhill streaks are evidence of flowing water on Mars. Jet Propulsion Laboratory/University of Arizona, via NASA

The New York Times

Account ▾

A Large Body of Water on Mars Is Detected, Raising the Potential for Alien Life

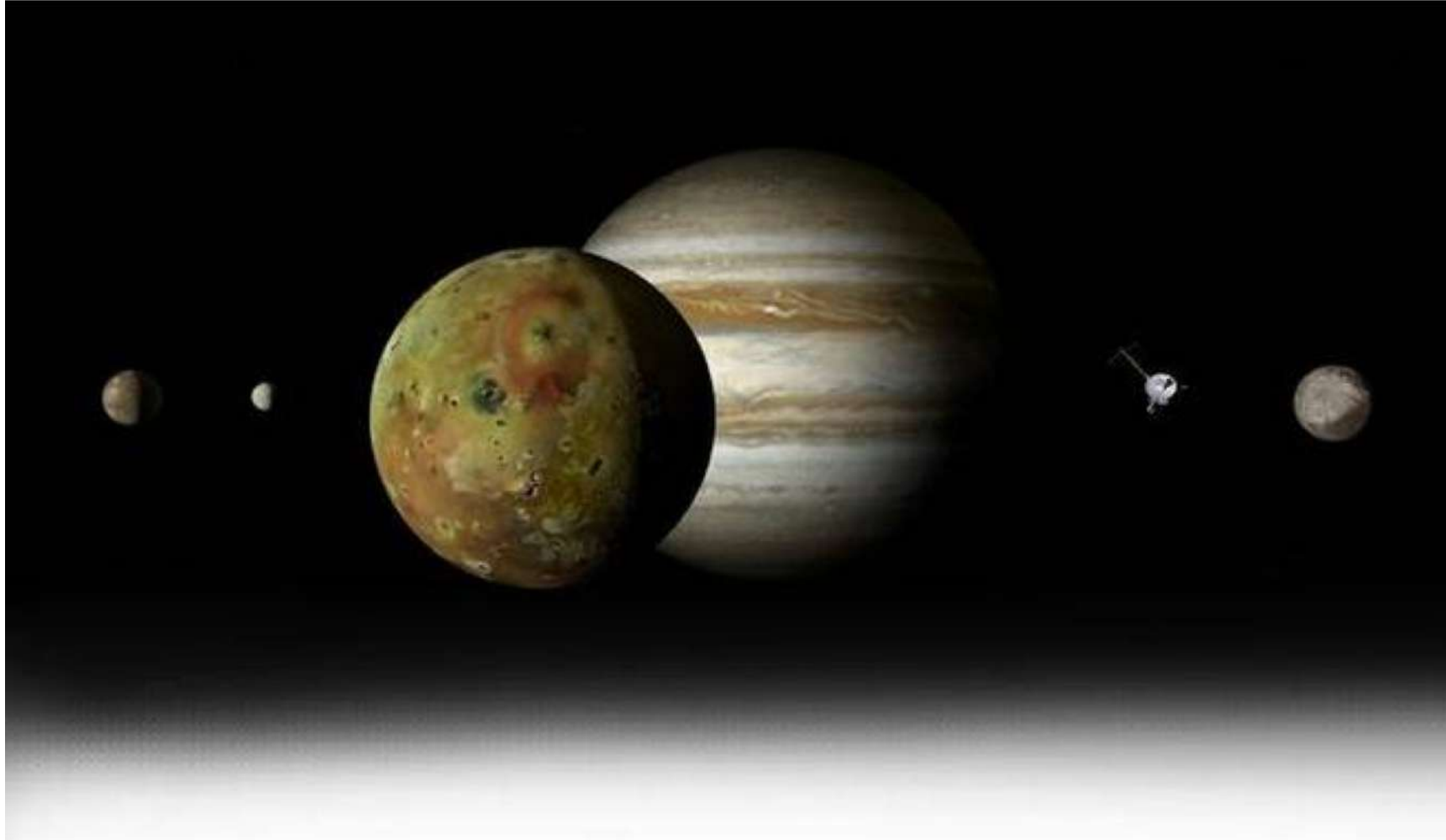
The discovery suggests that the liquid conditions beneath the icy southern polar cap may have provided one of the critical building blocks for life on the red planet.

... but Mars is a pretty dusty place.

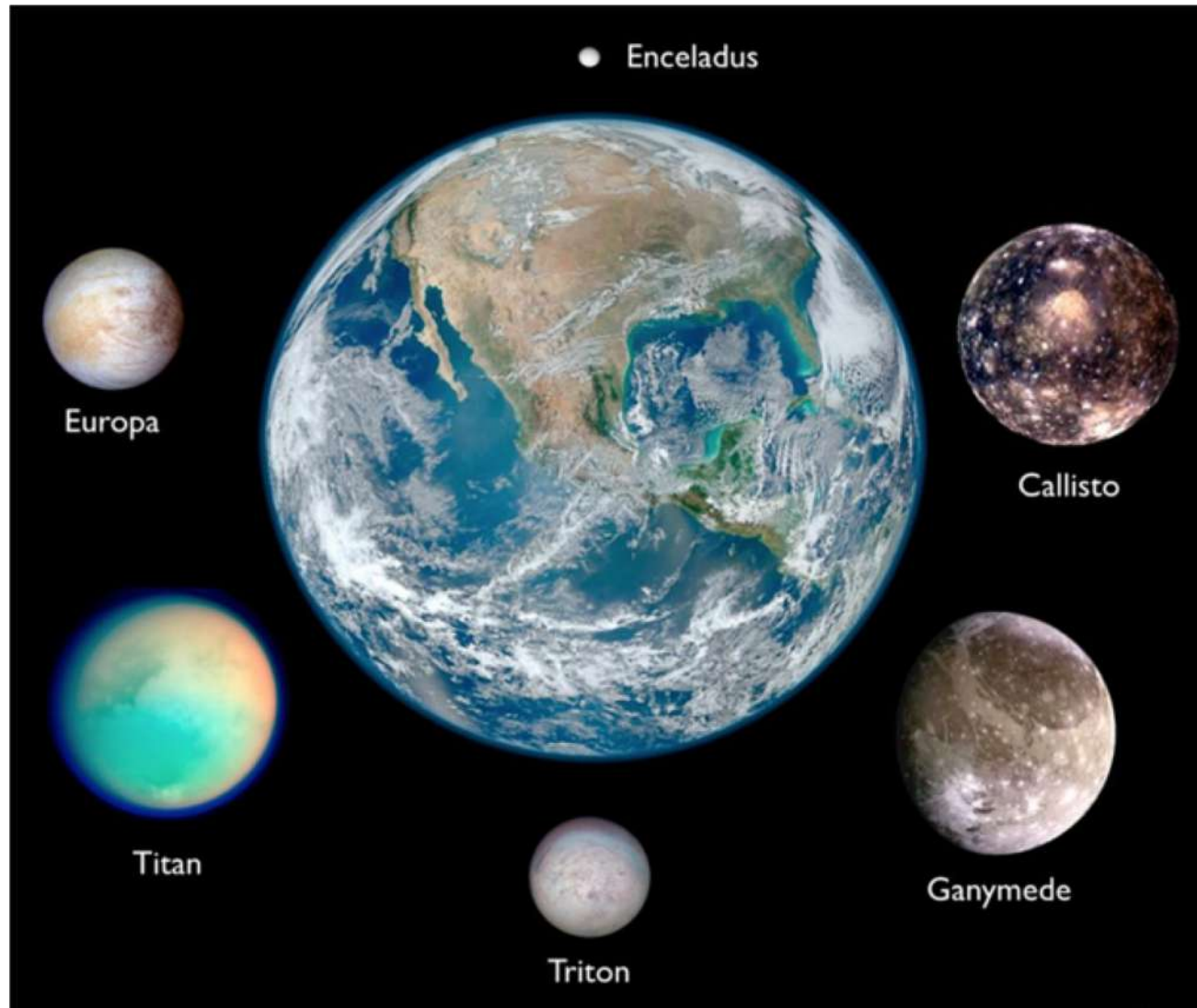


Introduction to Icy Ocean Worlds

Icy moons in the outer solar system



What if the water is not on the surface?



HOW THE SOLAR SYSTEM'S LARGEST OCEAN WORLDS COMPARE IN SIZE



Earth has a surprisingly small amount of water compared to other worlds in the Solar System. Each measurement is the spherical radius of the world and its water (including ice):

ENCELADUS

Water radius:
140 mi./
220 km.

World radius:
157 mi./
252 km.

DIONE

Water radius:
300 mi./
480 km.

World radius:
349 mi./
561 km.

EARTH

Water radius:
430 mi./
690 km.

World radius:
3,959 mi./
6,371 km.

EUROPA

Water radius:
550 mi./
880 km.

World radius:
972 mi./
1,565 km.

PLUTO

Water radius:
630 mi./
1010 km.

World radius:
738 mi./
1,187 km.

TRITON

Water radius:
730 mi./
1170 km.

World radius:
840 mi./
1,352 km.

CALLISTO

Water radius:
1,120 mi./
1,800 km.

World radius:
1,498 mi./
2,410 km.

TITAN

Water radius:
1,180 mi./
1,890 km.

World radius:
1,601 mi./
2,576 km.

GANYMEDE

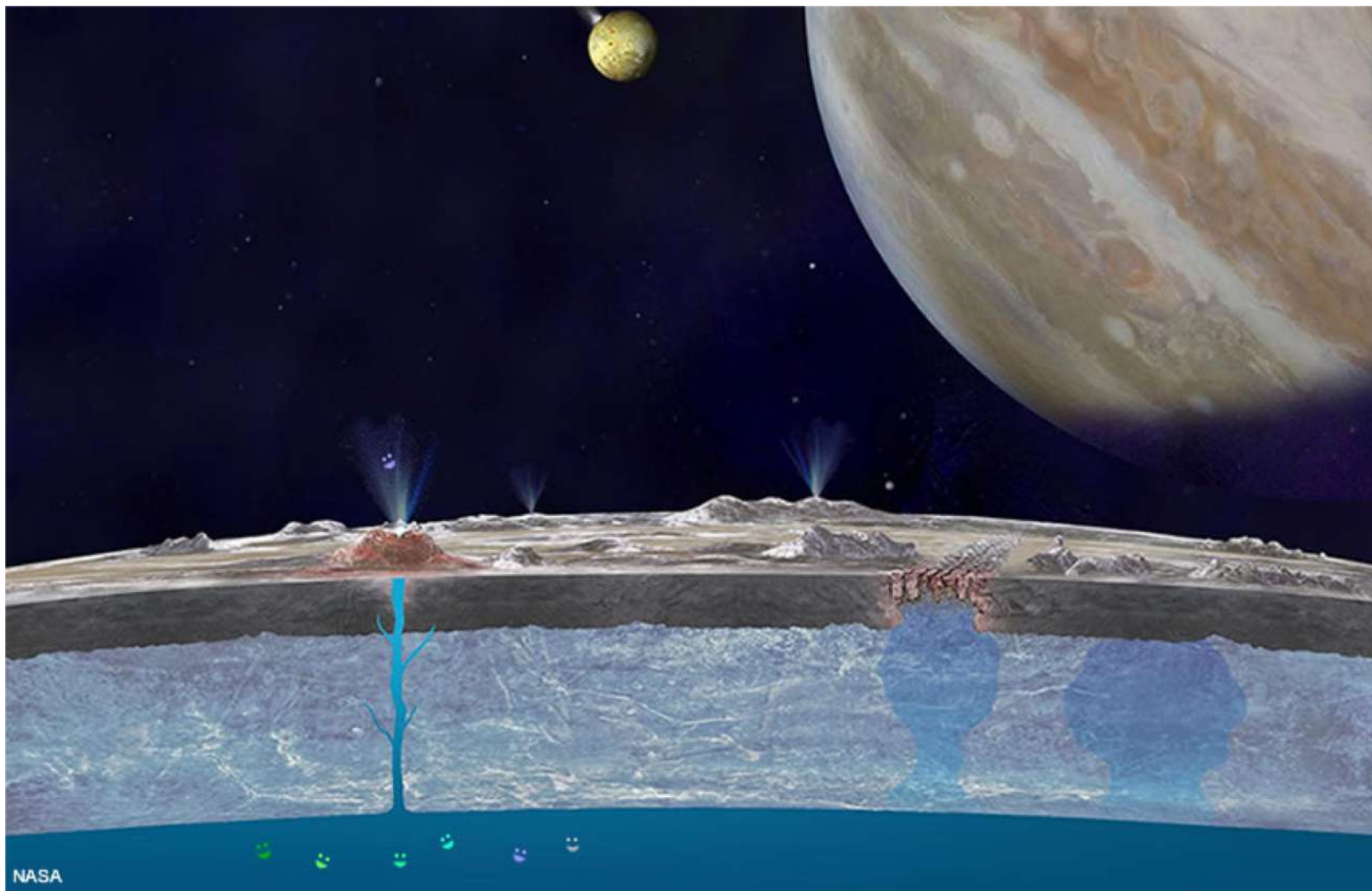
Water radius:
1,460 mi./
2,350 km.

World radius:
1,635 mi./
2,631 km.

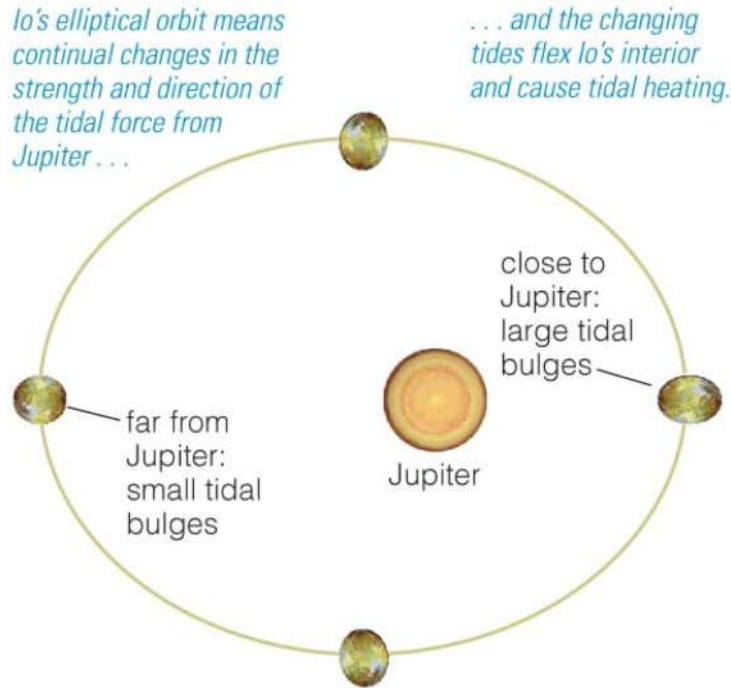
SOURCE: Steve Vance; NASA/JPL-Caltech

BUSINESS INSIDER

These are (thought to be) internal oceans!

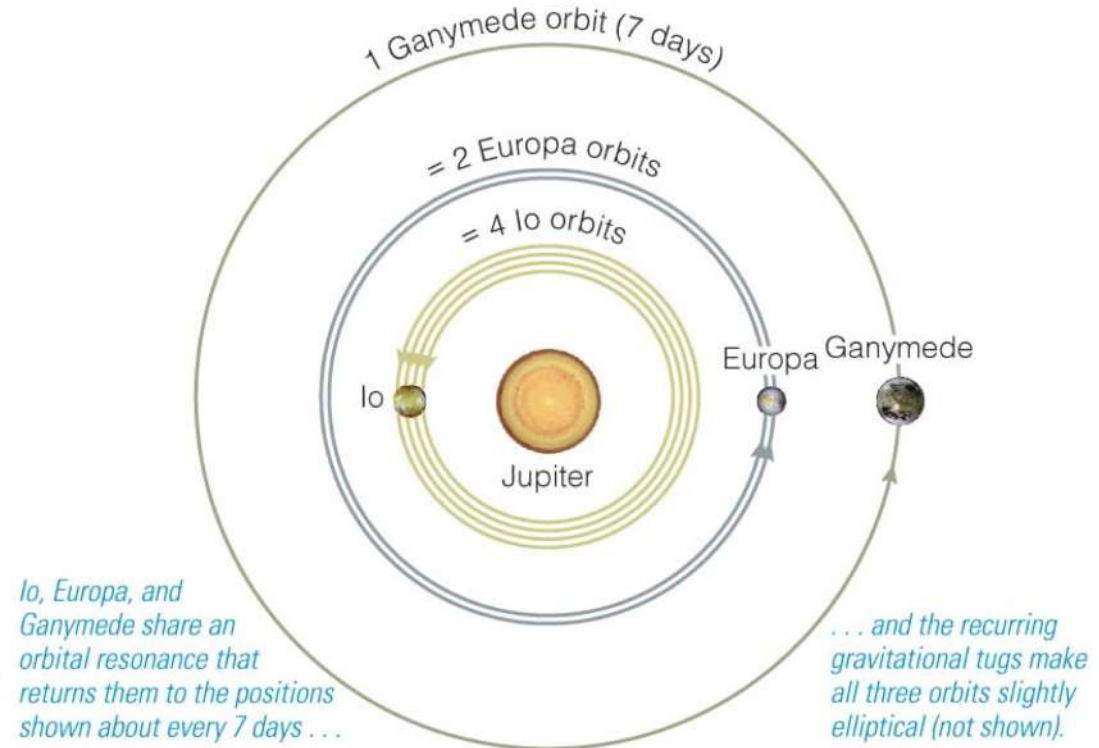


Tidal heating of moons



a Tidal heating arises because Io's elliptical orbit (exaggerated in this diagram) causes varying tides.

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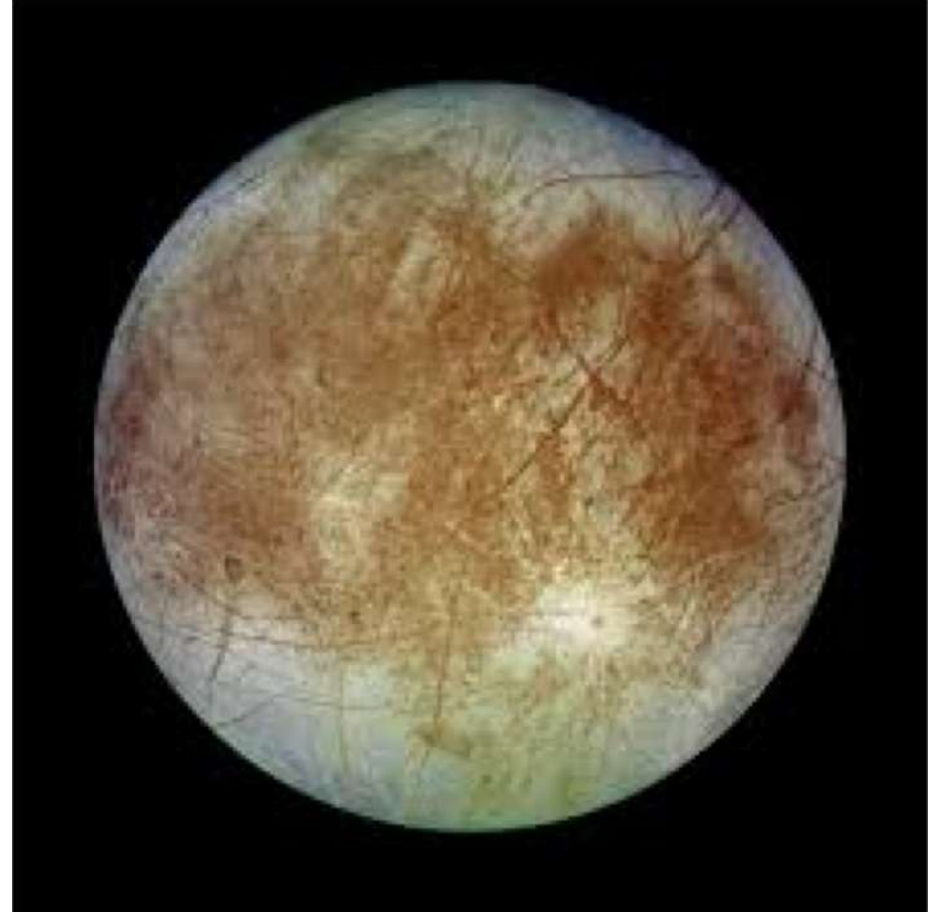


b Io's orbit is elliptical because of the orbital resonance it shares with Europa and Ganymede.

How do we know there is water?



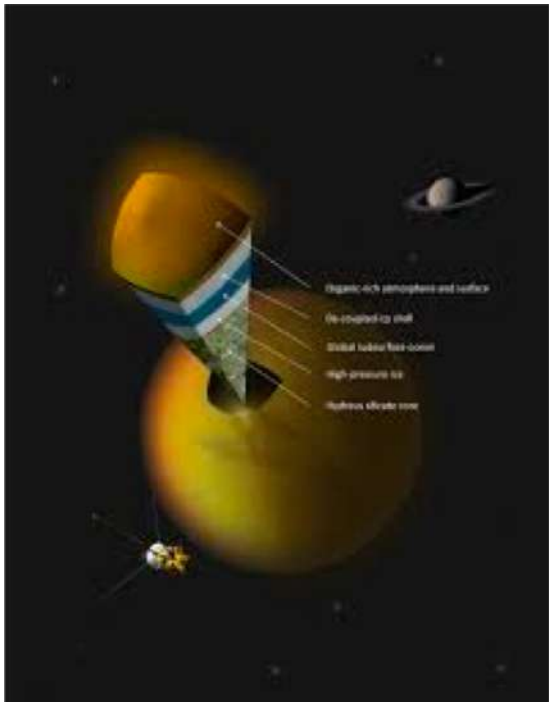
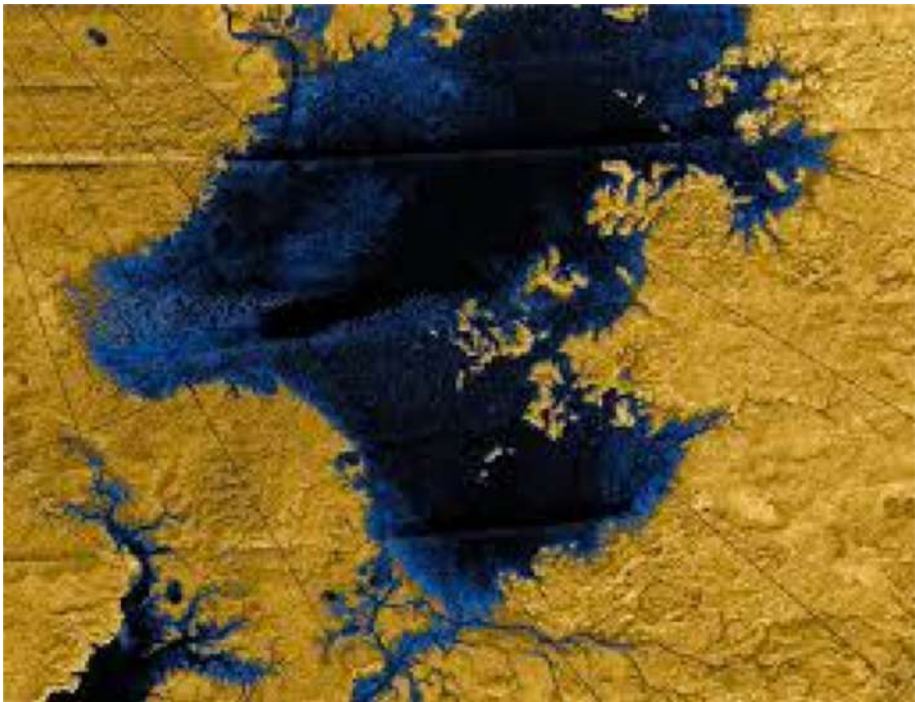
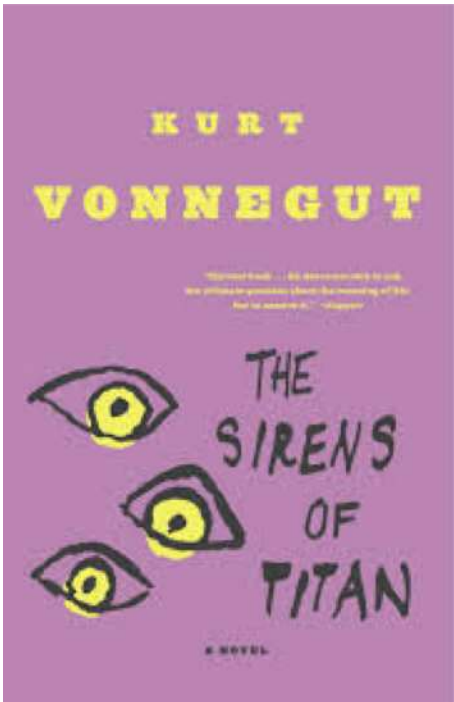
Europa (Moon of Jupiter)



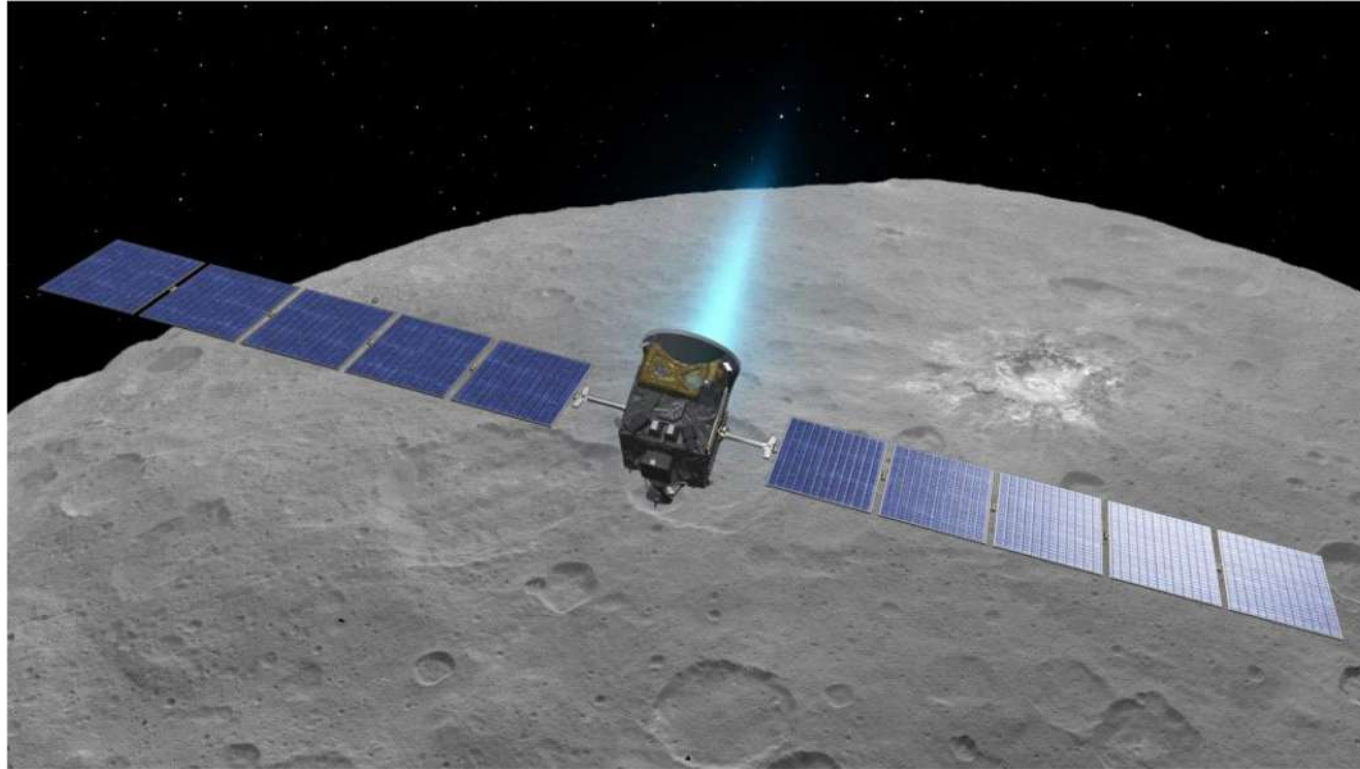
Three upcoming space missions!

1. Europa Clipper (NASA - JPL): Europa
<https://www.jpl.nasa.gov/missions/europa-clipper/>
Launch: 2022, Arrival:
 2. JUICE - Jupiter Icy Moons Explorer (ESA): Callisto and Ganymede
<https://sci.esa.int/web/juice>
Launch: 2022, Arrival: 2030
 3. Dragonfly (NASA-APL): Titan
<https://dragonfly.jhuapl.edu/>
Launch: 2026, Arrival: 2034
- ⇒ Exciting area to get involved in now.

Titan



Just completed Dawn mission



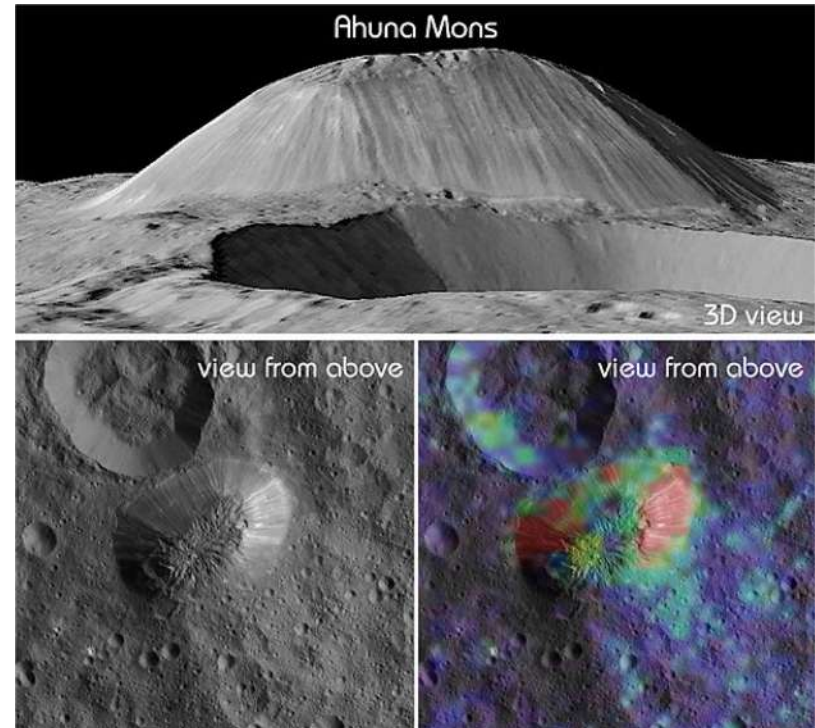
Ceres and Ancient Ocean World from the dawn of time?

Geologically recent activity!

Occator crater



Ahuna mons

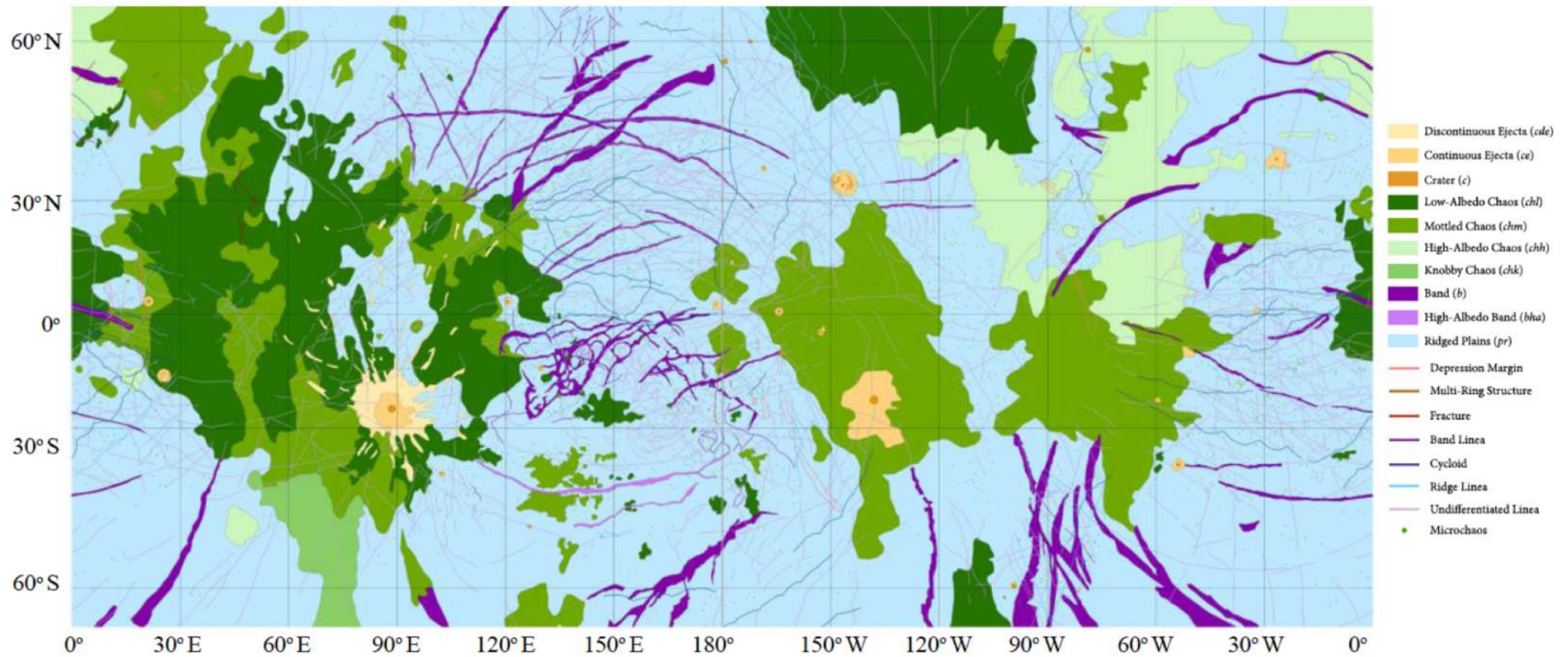


Interesting features

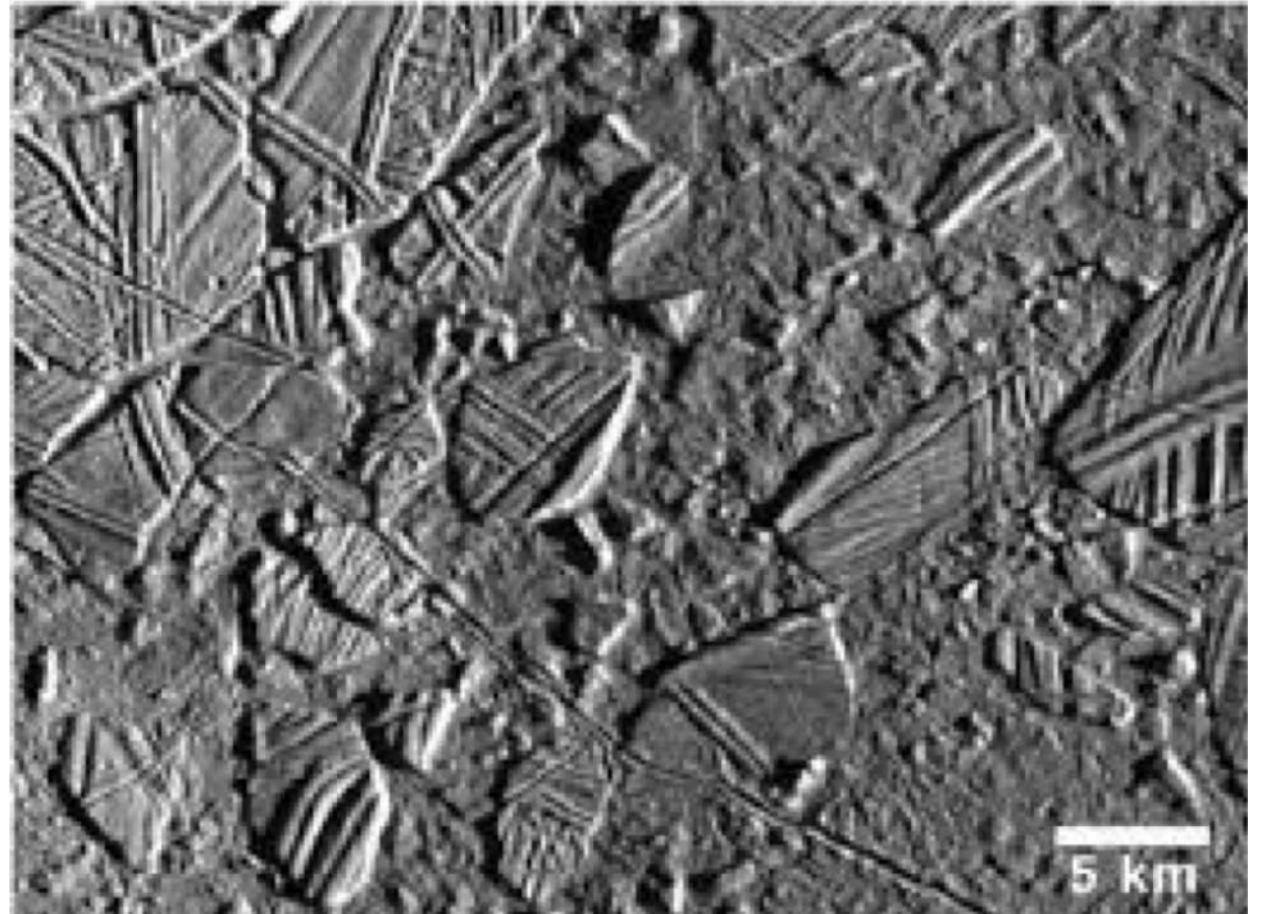
we don't understand (yet!)

1. Chaotic terrains on Europa

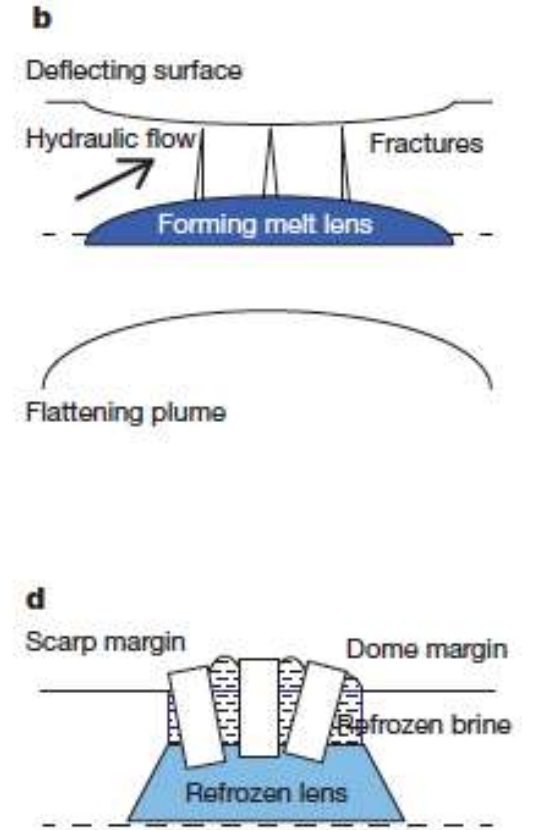
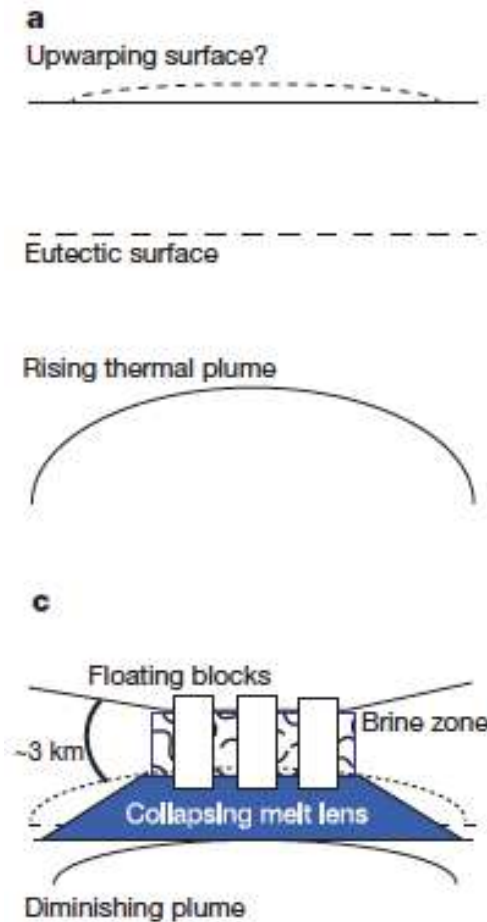
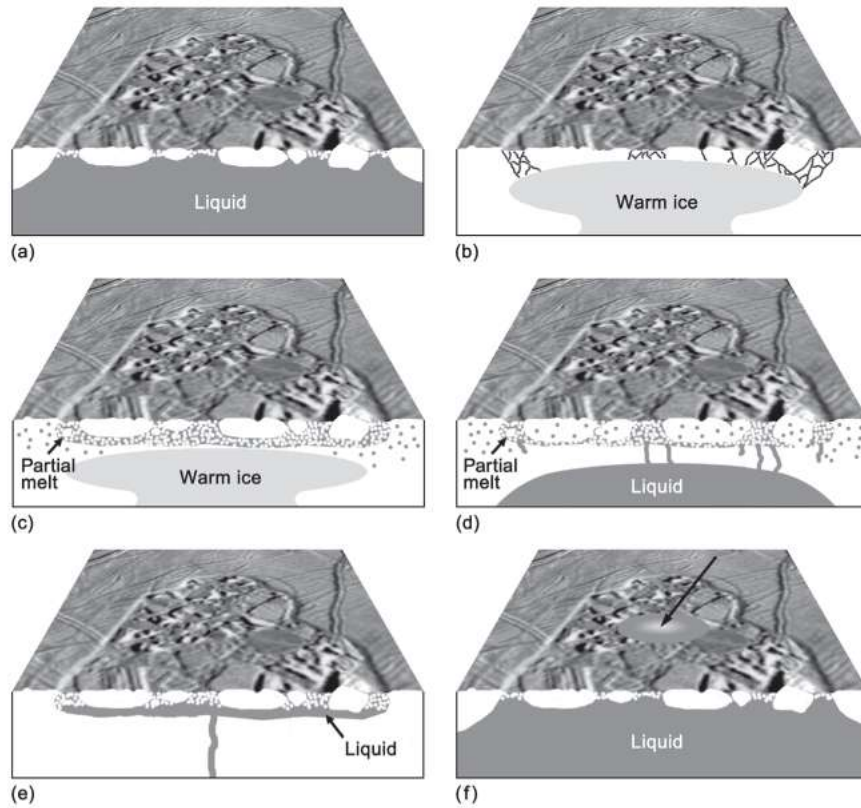
Map of Europa's surface



Chaotic terrain look like ice shelves/pack ice

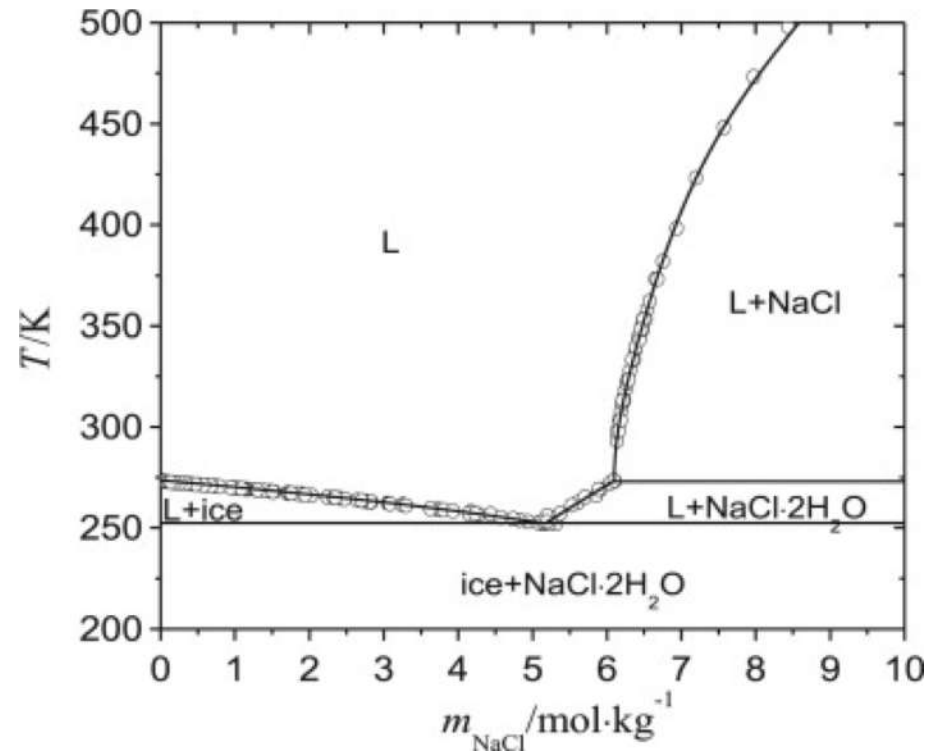


Theories for Chaos formation

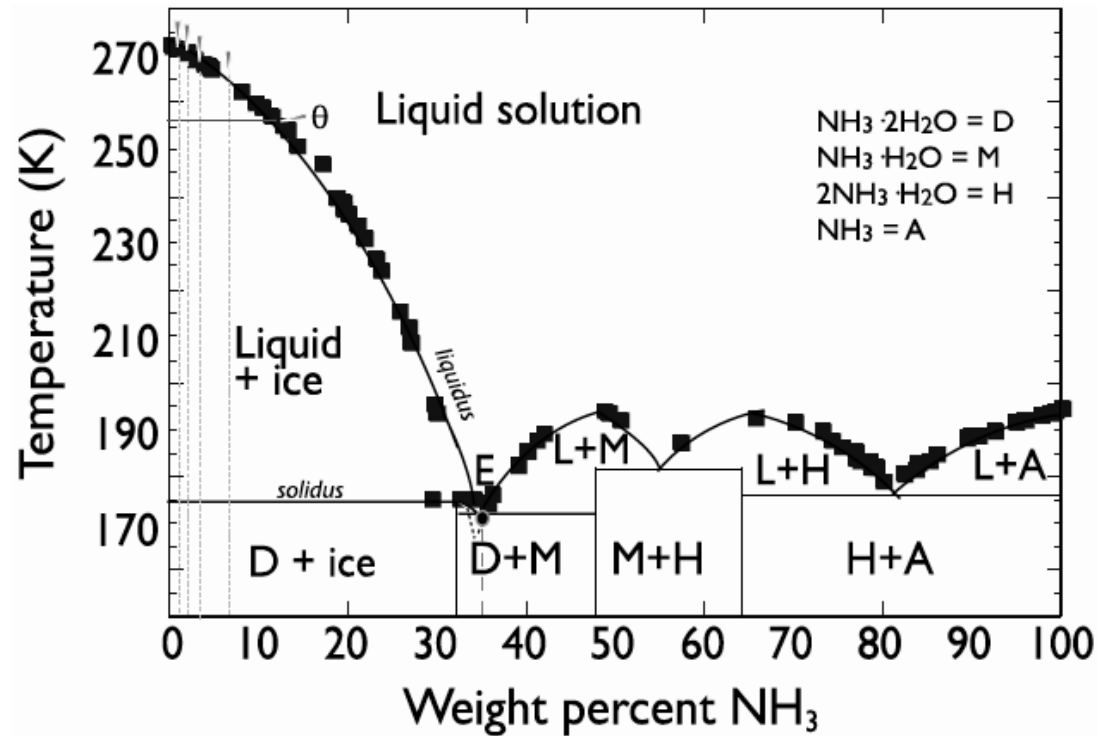


Lowering ice melting point

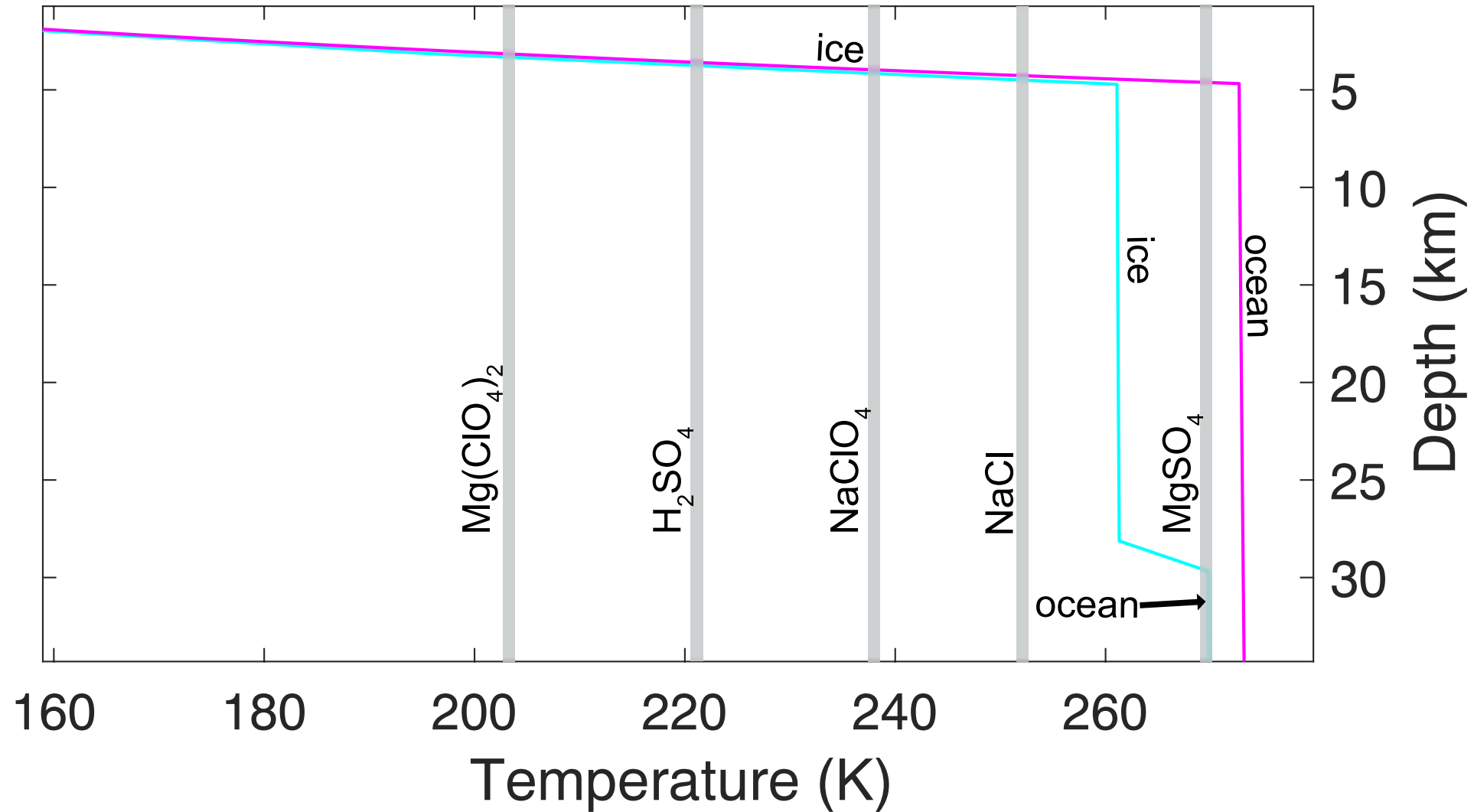
Salt against road ice



Ammonia as antifreeze



Europa's geotherm & common eutectics



Where does the heat come from?

- Not enough to lower the melting point we also need to be able to deliver sufficient heat to the surface to melt substantial amounts of ice. Over come the substantial latent heat.
- Can ice shell convection deliver this heat for normal heat flux?
- 2020 Class project:
Aim is to build a 2D Stokes-Thermal convection code and couple it with the phase behavior of the ice+salt system
- Significantly more complicated than last year but achievable!

