# Cracking the Surface of Europa

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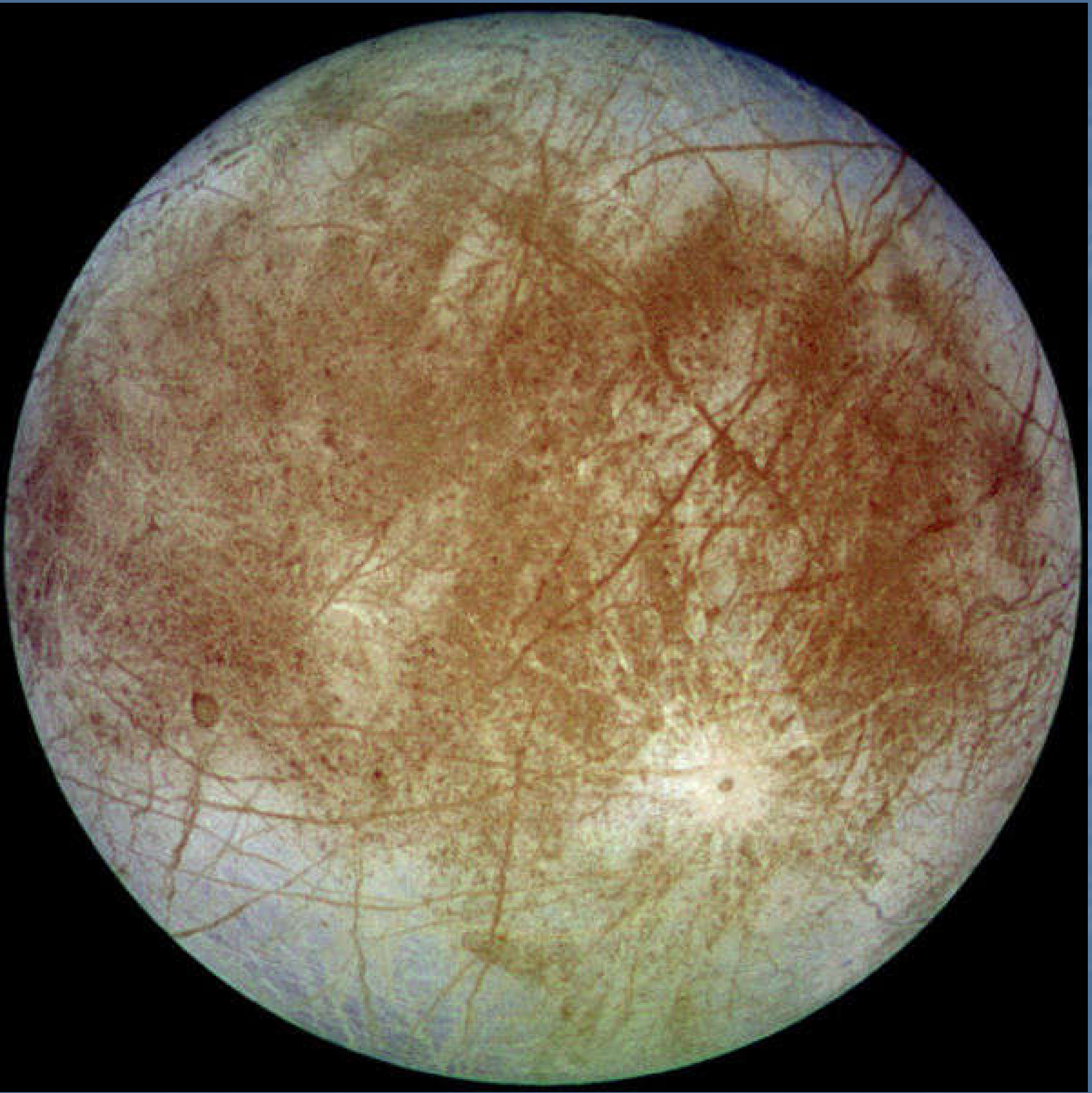
# What is Europa?

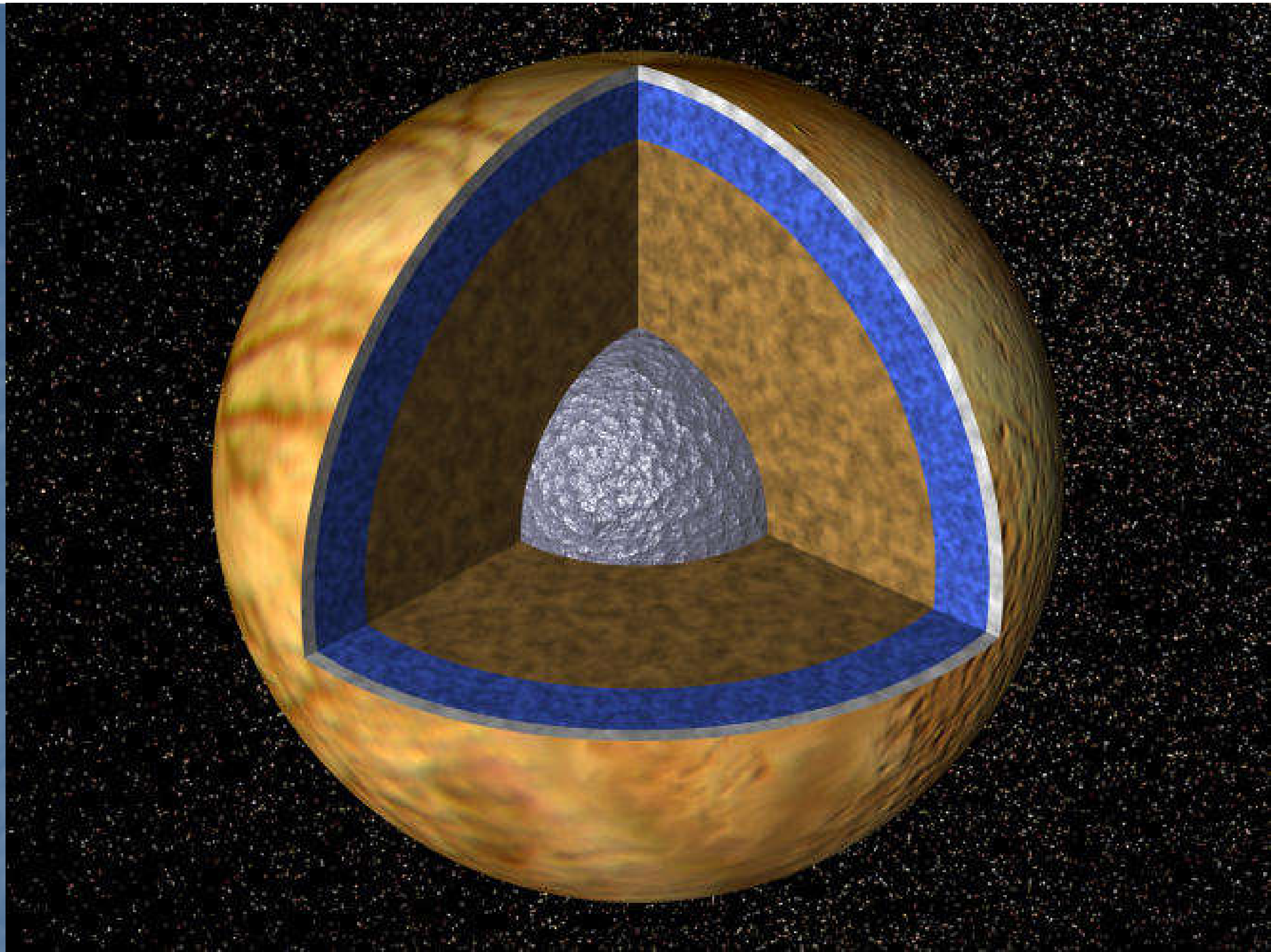

- Europa is the second Galilean Moon of Jupiter which is the sixth satellite that orbits the planet.

- It was discovered in 1610 by Galileo but has only recently been the focus of scientific studies after the data collected from the Voyager and Galileo satellites in the 1970’s and 1990’s respectively.
- This data not only revealed the mysteries on Europa’s surface but also the probable existence of a liquid ocean underneath the icy exterior.

- Europa is similar in size to the Moon with a diameter of ~3130 km.
- The surface of Europa is frozen water ice.



- The composition of the moon is mostly a silicate mantle with a metallic core but the most important feature is the ice shell and the subsurface ocean underneath the shell.



- The internal structure of Europa which is different to other icy satellites in the solar system due to the probable presence of the subsurface ocean.

- In the ice shell of the moon, lineaments stretch across the surface which splits up the surface into different terranes namely mottled terranes, chaotic terranes and cracked surfaces.

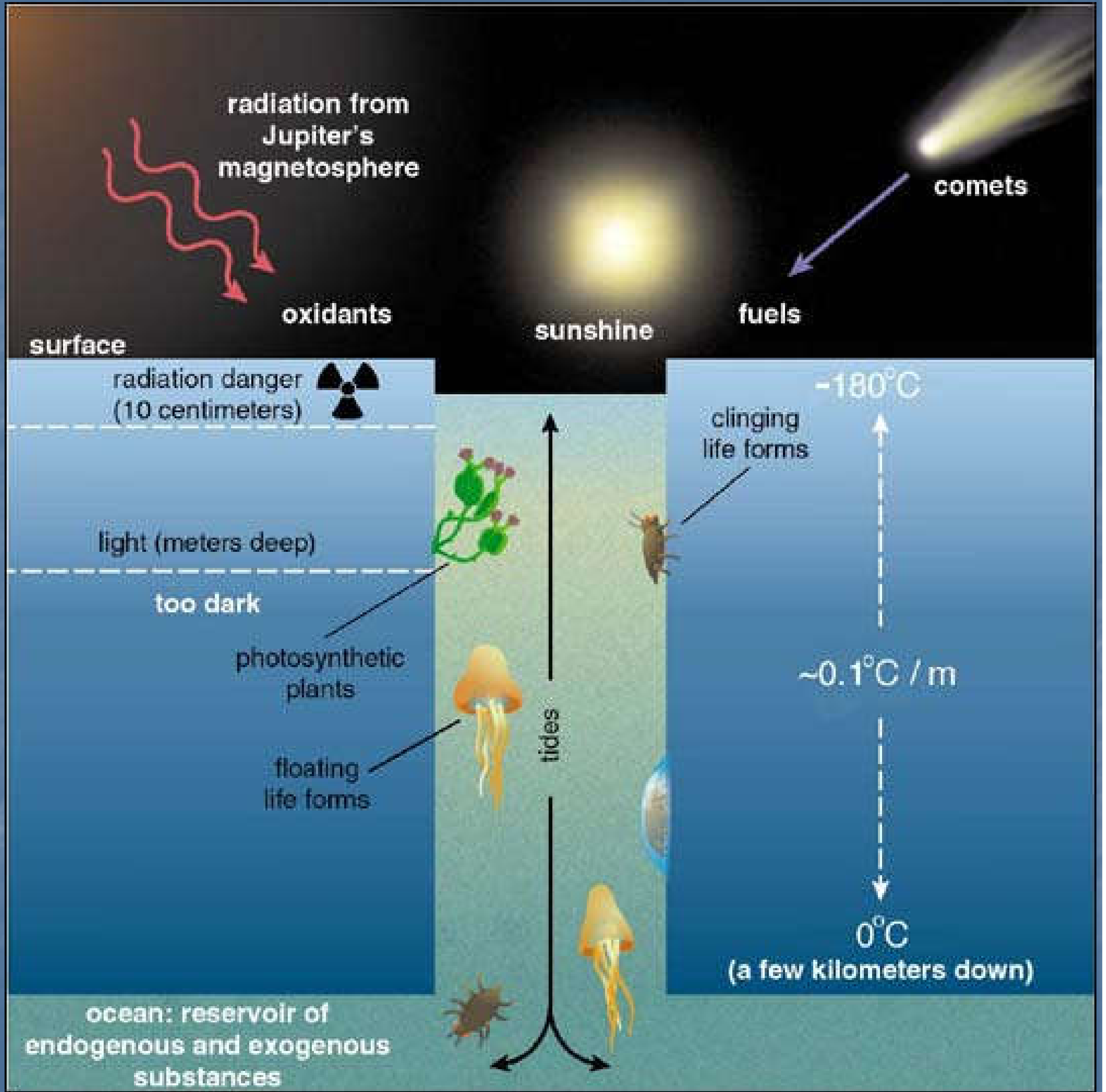
# Life on Europa

- Life has not been found on any other body in the Solar System apart form Earth as life needs specific components to exist.
- Water is the main feature needed for life to exist but energy is the key to sustaining life.
- So how could life exist on this desolate moon so far away from the abundant energy of the sun, with a surface temperature of 110 K?

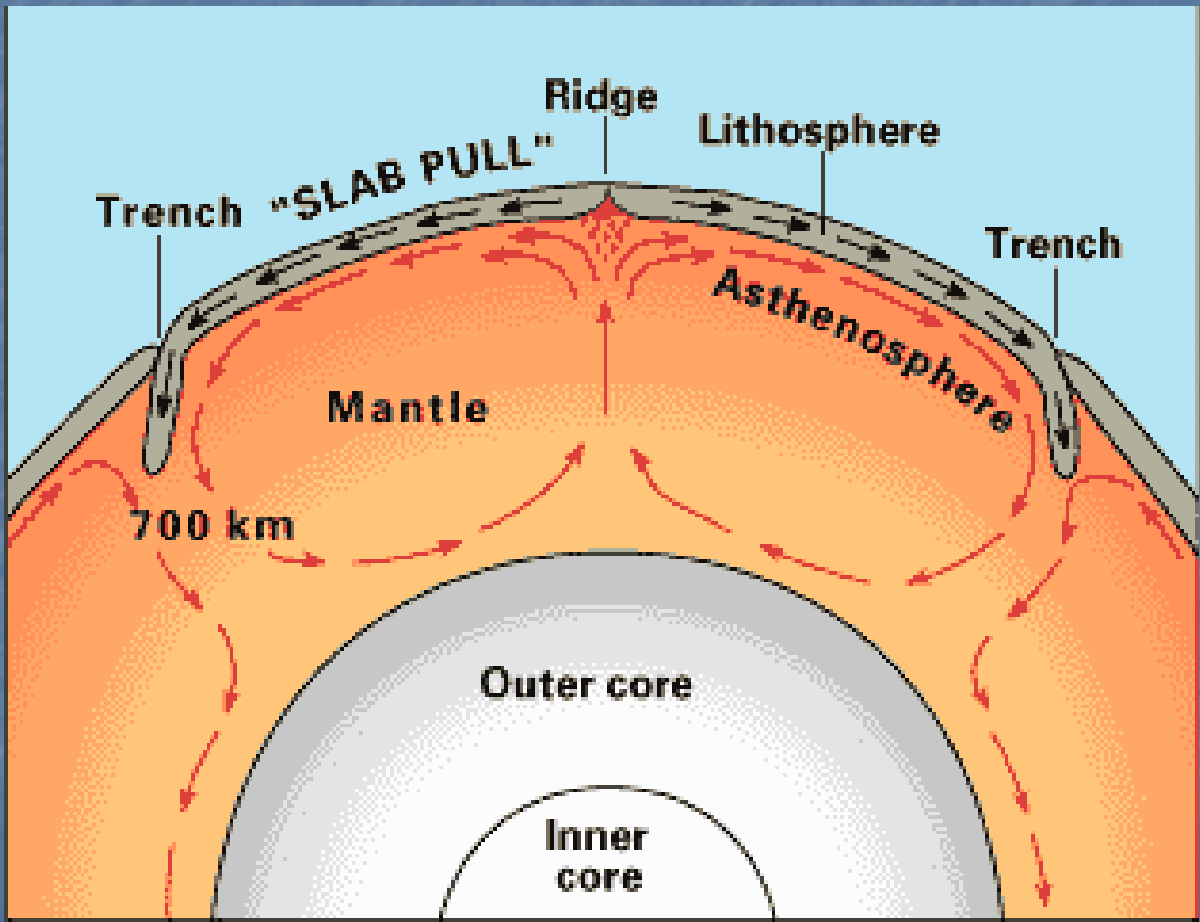
- To understand how life could exist on Europa, geological knowledge must be applied to the cracks found on this icy moon.

- These fractures form when the ice shell breaks apart; as these cracks open it is thought that organisms could rise up with these upwelling currents and get the energy produced from the friction and radioactive energy from near the surface from Jupiter’s magnetosphere.

If there is life on Europa it will be very different to life on Earth due to the probable absence of major elements such as carbon and iron in the subsurface ocean.

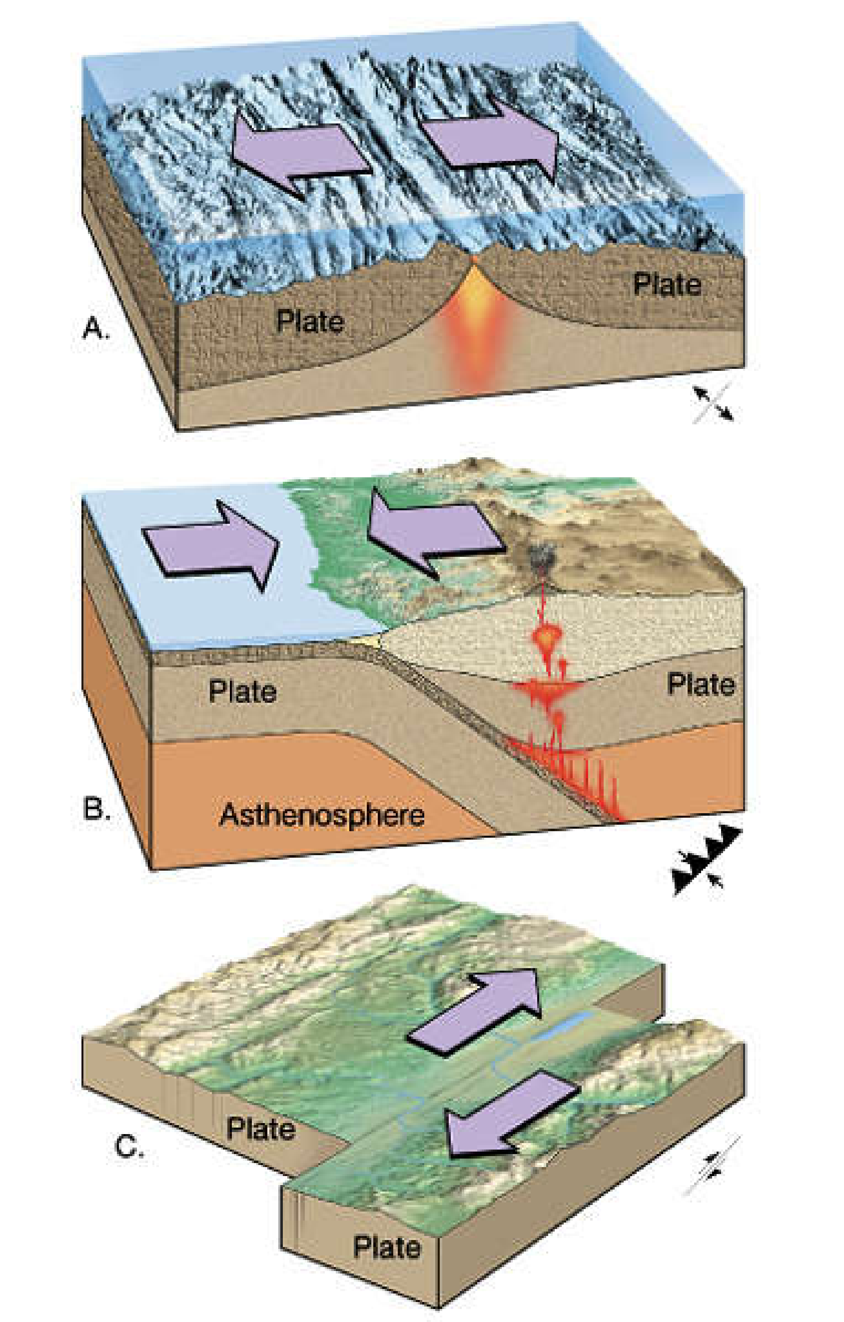


# Fracturing the Earth




- Fracturing in the Earths crust is driven by thermal convection in the mantle known as plate tectonic processes.

- Separate plates form the crust on the Earth.
- These plates are able to move along a boundary layer in the mantle which causes different plates to either collide, separate or slide past one another.




A. Divergent plate boundaries and the emplacement of new mantle material.

B. Convergent plate boundary and the destruction of oceanic crust.

C. Strike-slip plate boundary where two plates slide past each conserving crustal material.

# Plate Tectonics in the Solar System

- Plate tectonics may have once existed on Venus as the planet is near the size of the Earth and could possibly have had thermal convection in the mantle.
- Early Mars may also have had some form of plate tectonics when water existed on the planet as water aids deformation and therefore fracturing.

- However the Moon and Mercury have never had any form of plate tectonics and have never been resurfaced as they never experienced mantle convection as they are too small.
- So how do we explain the features found on Europa if we know plate tectonics has never occurred on the small celestial body?

- There are two possible processes which could form the surface features on Europa:

  1. Thermal convection within the subsurface ocean could drive movement in the ice shell and produce the fractures.

  However:

  - Europa’s mantle is solid and no longer conducts heat from the interior therefore convection cannot occur with an internal heat source.

2. Tidal Flexing and heating due to Jupiter's gravitational pull on Europa. This is the most likely process which causes the cracking on Europa's surface.

- Io, Europa and Ganymede are locked in tidal resonance around Jupiter and throw off each others circular orbits to form eccentricities in their orbits and therefore elliptical paths.
- Jupiter is so immense that the gravity it produces is enough to affect at least the two first Galilean Moons: Io and Europa.

- Tidal Flexing of Io is due to the pull Jupiter exerts on the small moon.
- This flexing causes bulges in the moon resulting in extensive volcanism on Io and cracking in Europa’s ice shell.

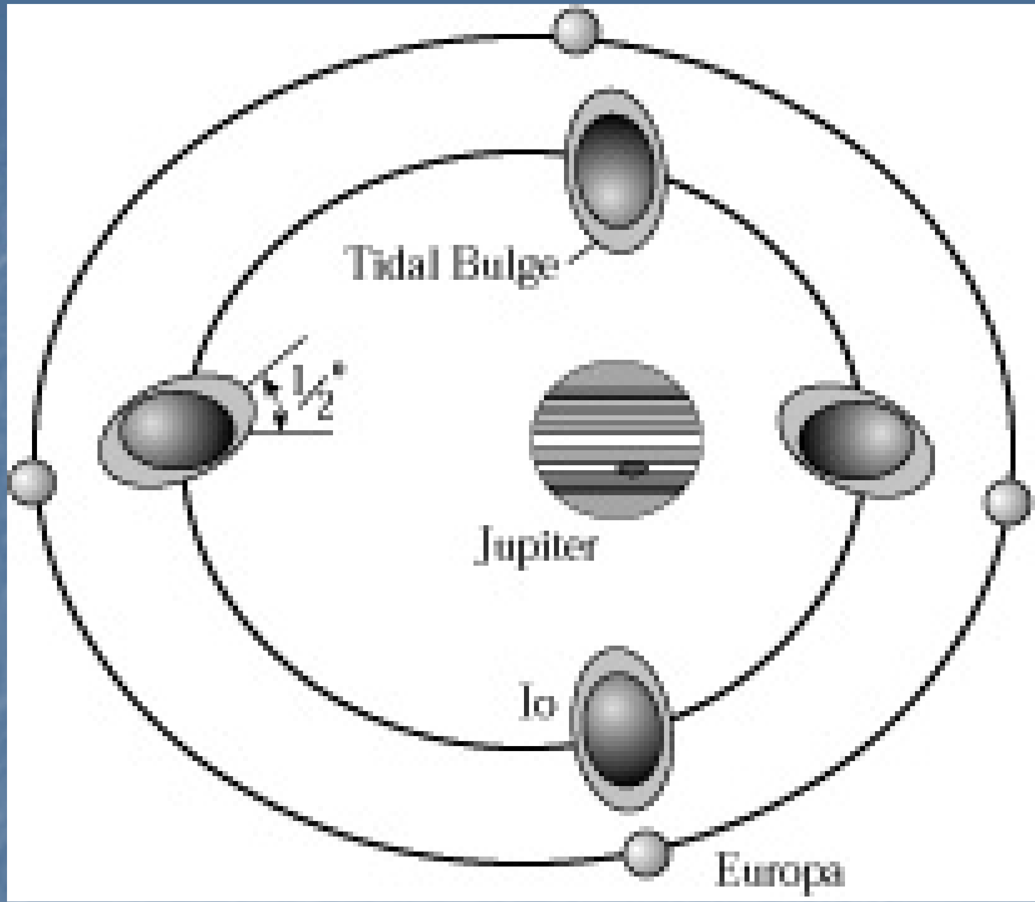
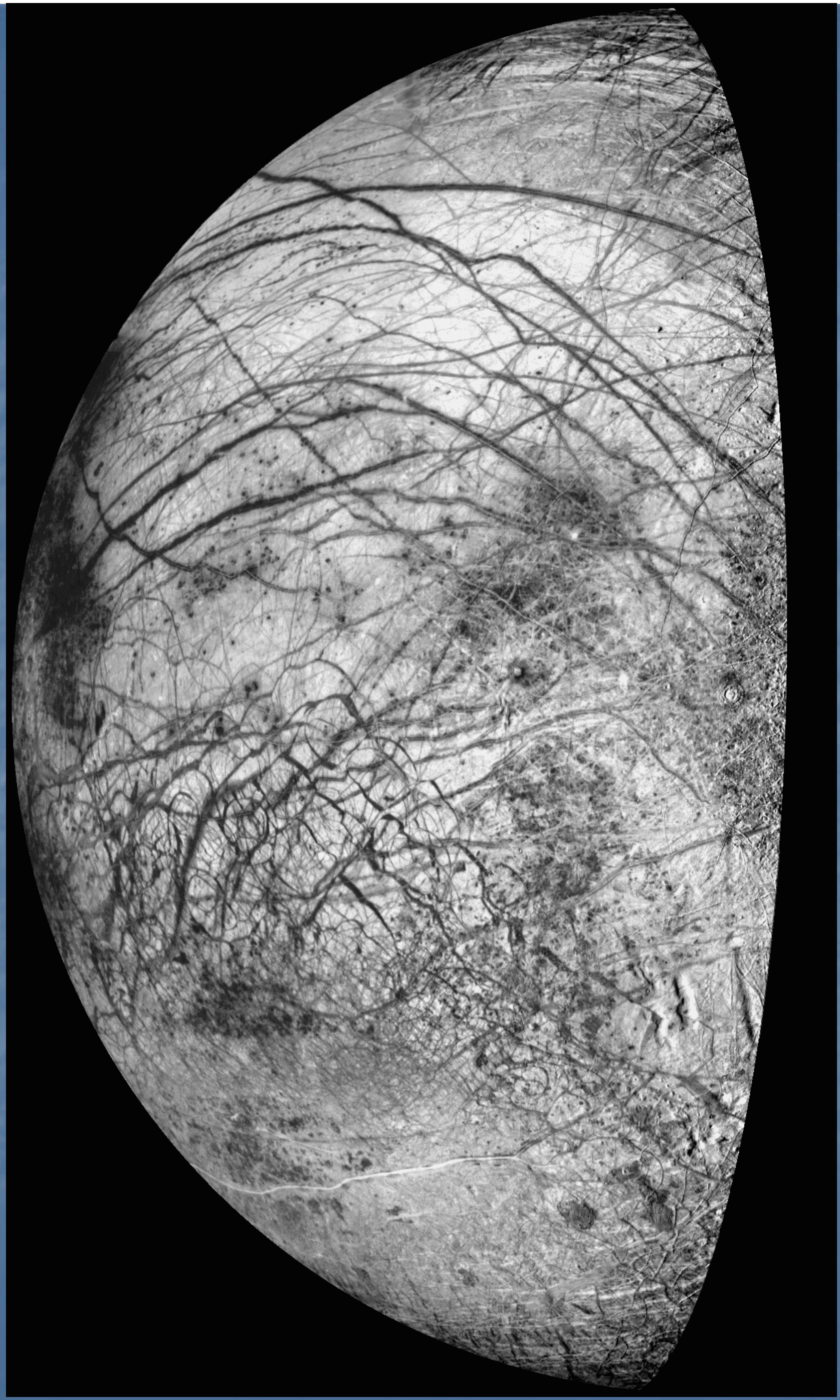
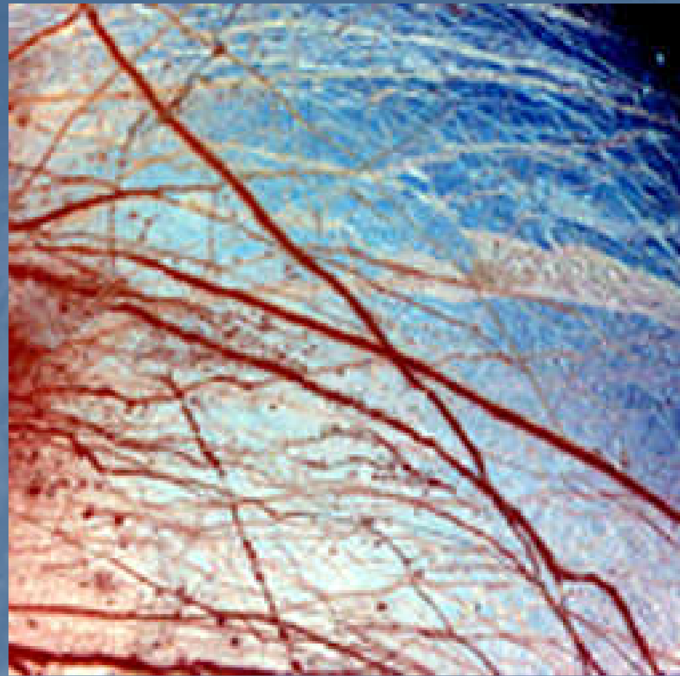


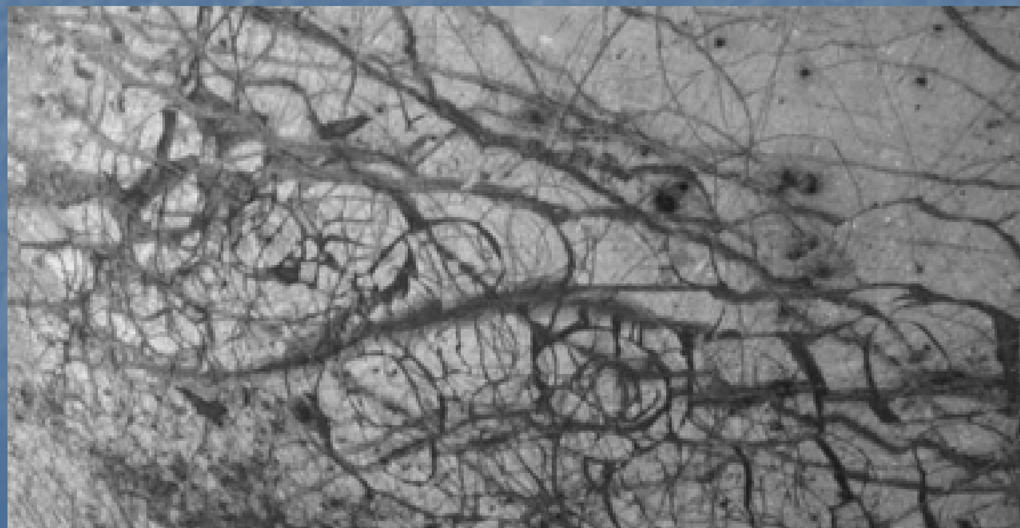

Diagram not to scale

- The subsurface on Europa allows for the movement of the ice shell and therefore fracturing in the ice to produce different features on the surface.
- Specific features appear to dominate the surface at different latitudes.

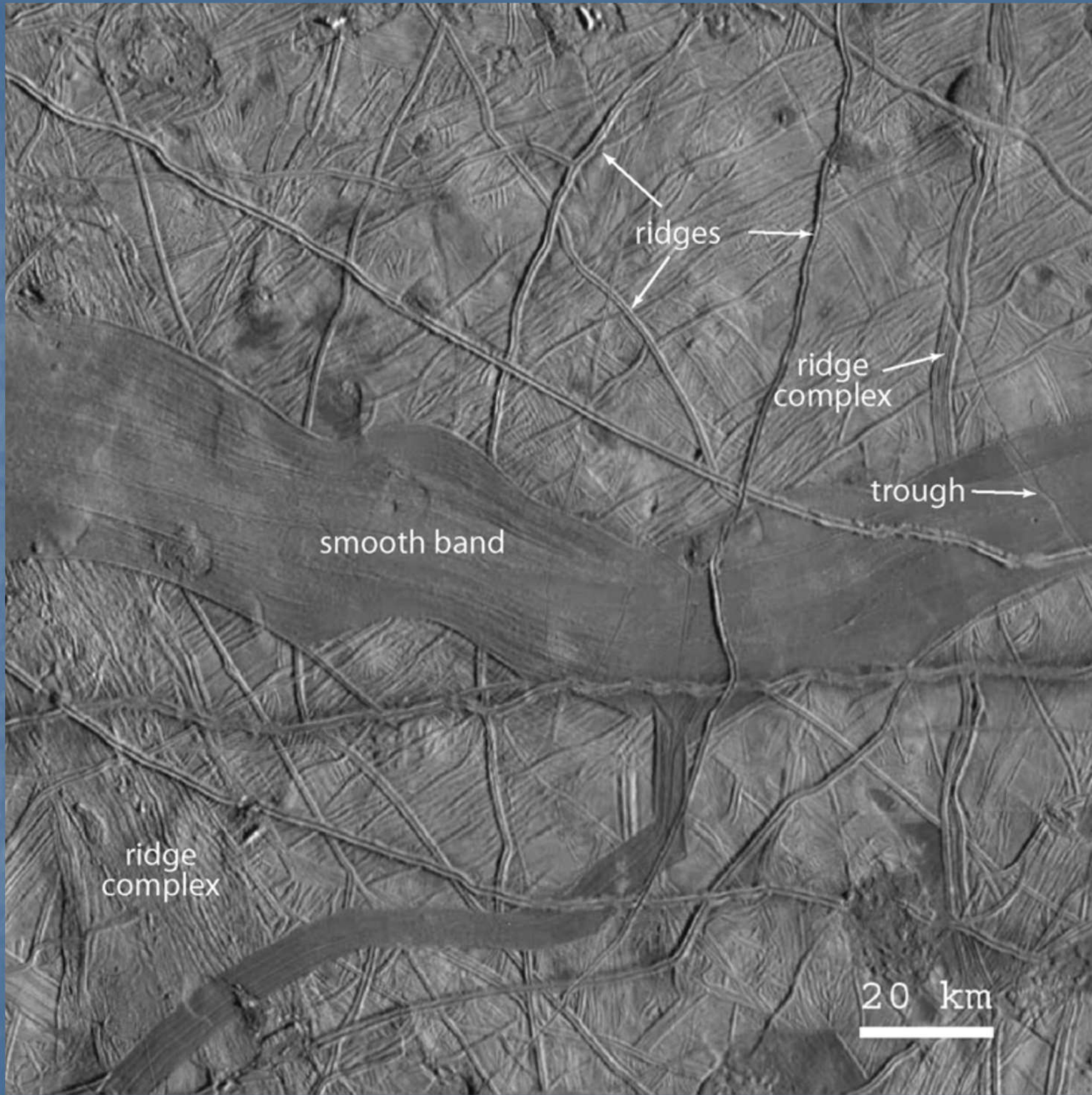


- Strike-slip faults, bands and ridges dominate the latitudes above 40° north and below 40 ° south.
- Cycloids are found in the centre latitudes which are thought to form rapidly through non-synchronous rotation.





A typical portion of Europa's surface with a smooth band, troughs, ridges and ridge complexes.

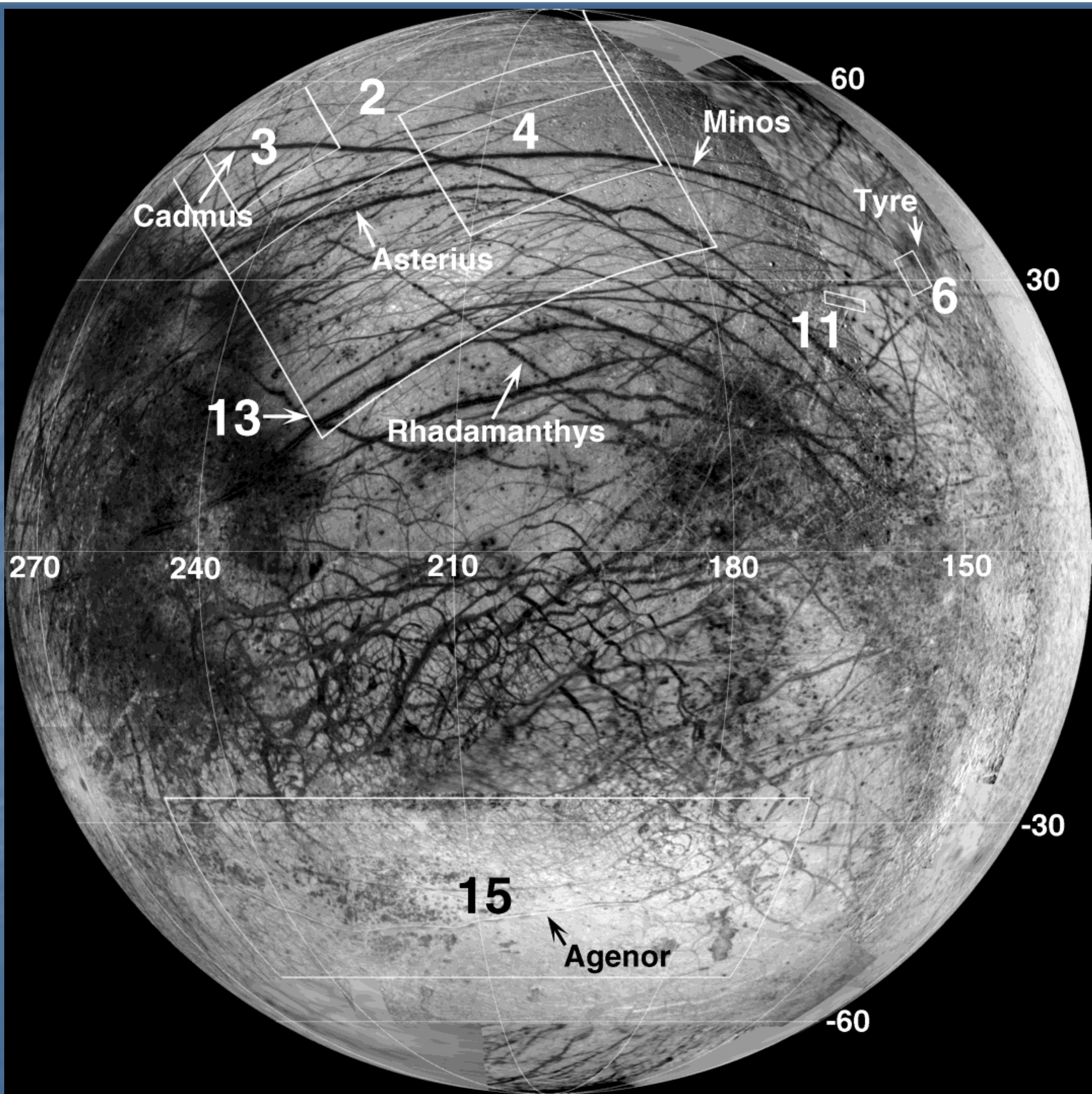


# Agenor Linea

My focus on Europa is aimed at the band-like “crack” found in Europa's trailing hemisphere; Agenor Linea.

This band is a fault with lateral displacement but also has infilling of new material from below.

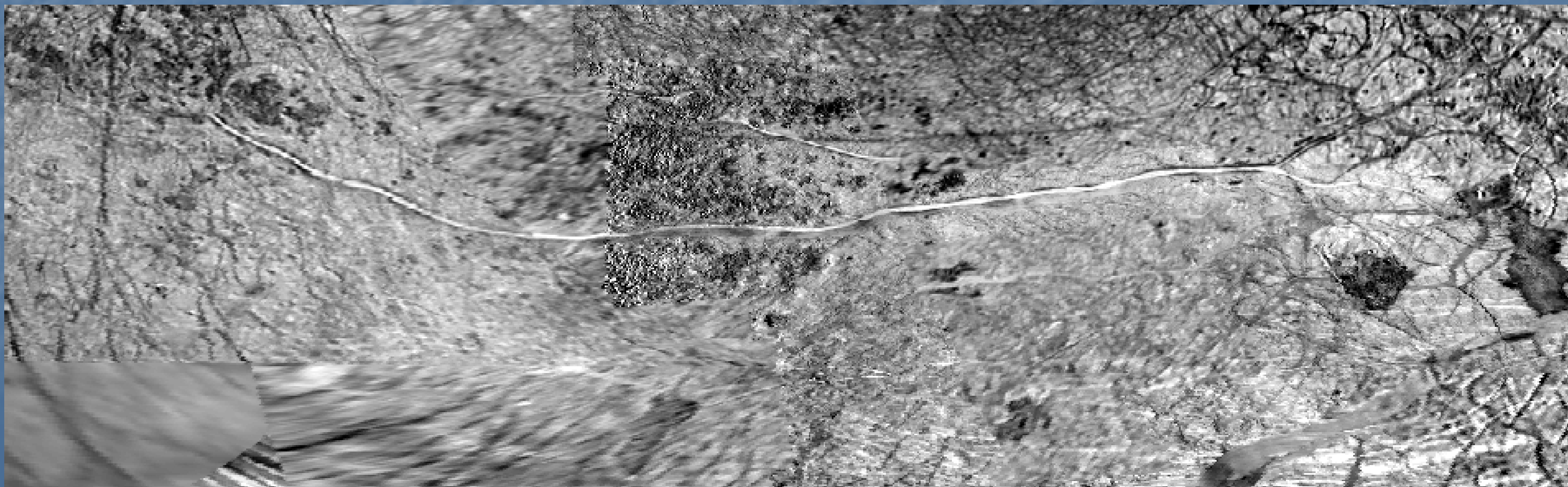
Therefore compared to Earth tectonics, this fracture shows both characteristics of divergence and lateral shearing, also known as strike-slip motion.



60
2
4
3
Minos
Cadmus
Tyre
Asterius
30
6
11
13
Rhadamanthys
270
240
210
180
150
-30
15
Agenor
-60

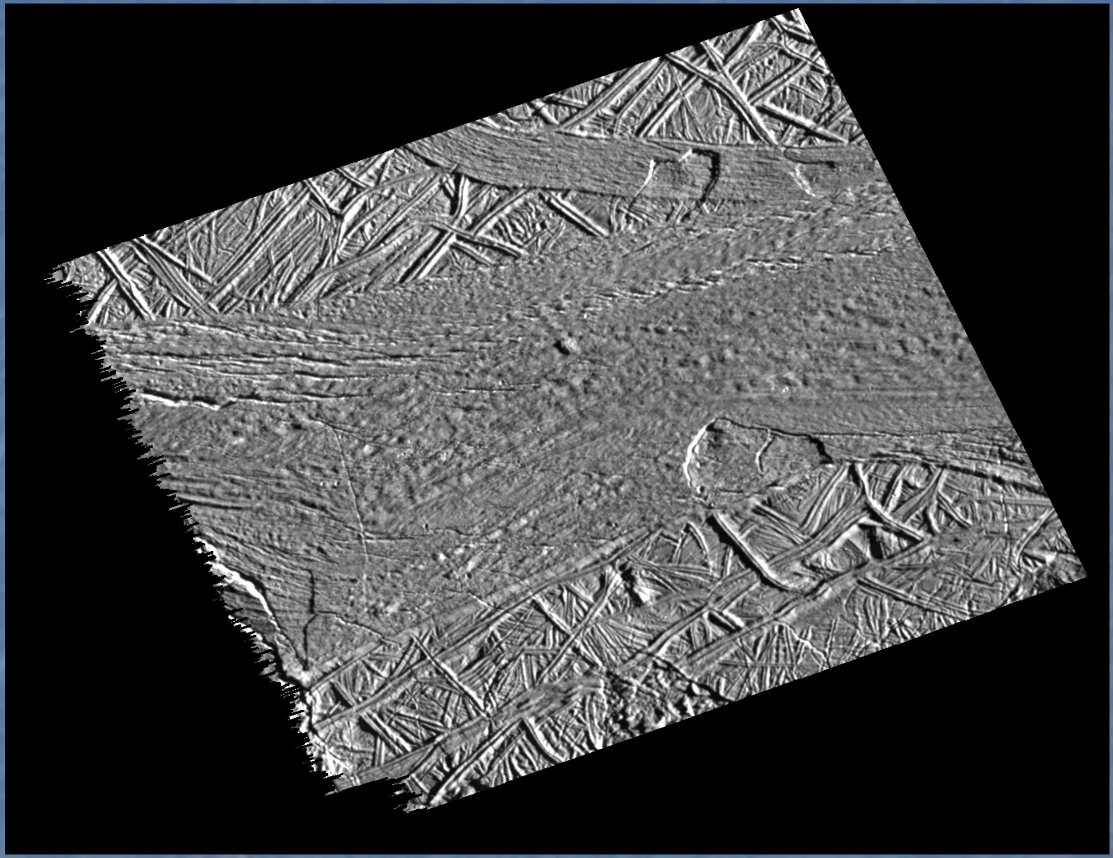
This band is ~1500 km long and is classified as a dextral strike-slip system. Strike-slip faults on Europa can dilate, and create a gap where new material can infill the gap and form a band.

Agenor Linea is a relatively new feature on the surface as it is only cut by recent tension fractures.

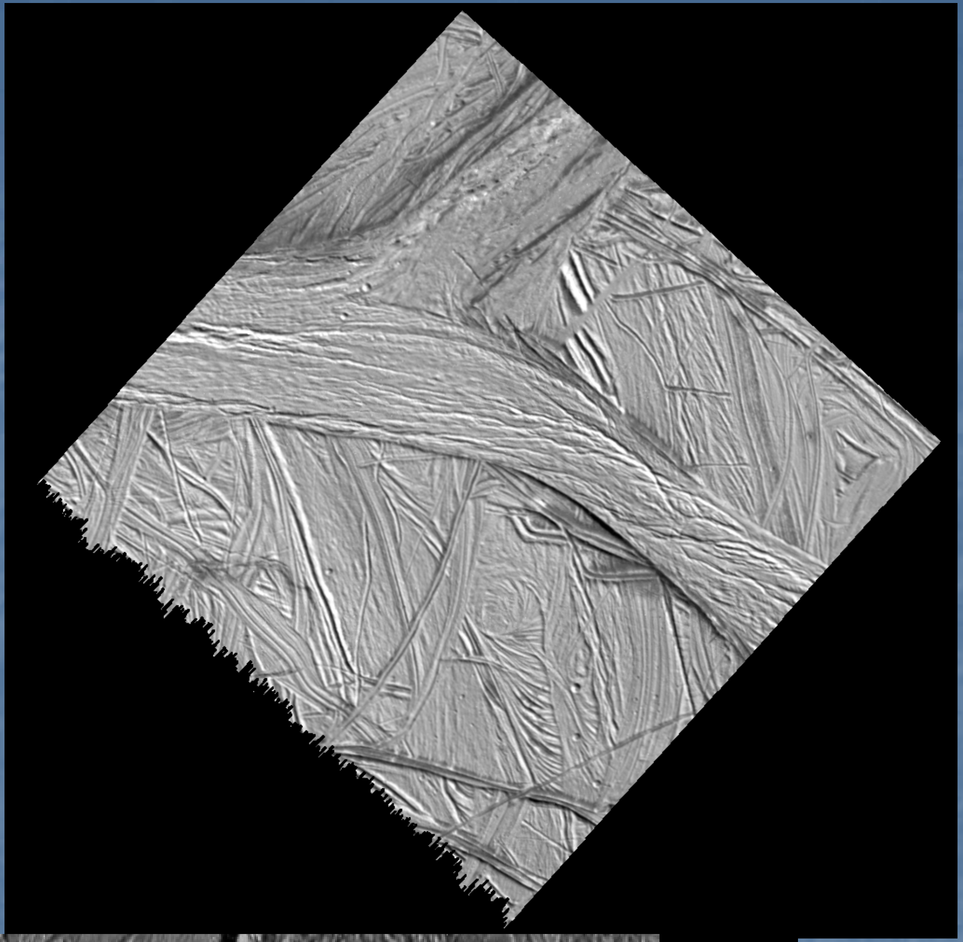


Tailcracks are found on the eastern tip of Agenor Linea, this is further confirmation that this faults shows dextral displacement.

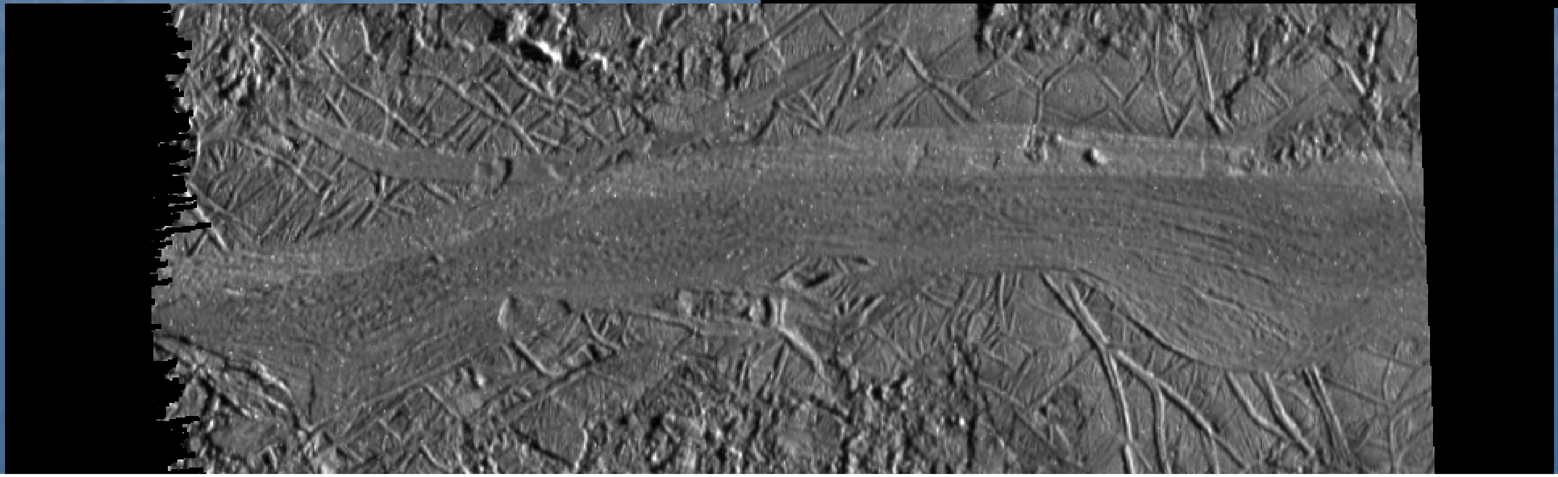
- This is a specific portion of Agenor Linea showing the extensive internal features which are being used to analyse the processes of formation and deformation of the fault.



This image shows the bend in the fault towards its eastern tip.



The darker band in the southern portion of Agenor Linea could possibly be an older fault with the higher albedo material being new material from reactivation.



- Studying Europa has been fascinating and has only extended my interests in cosmology and geology and I hope I have shared a little of that with you.

Thank you