Hot Science Cool Talks

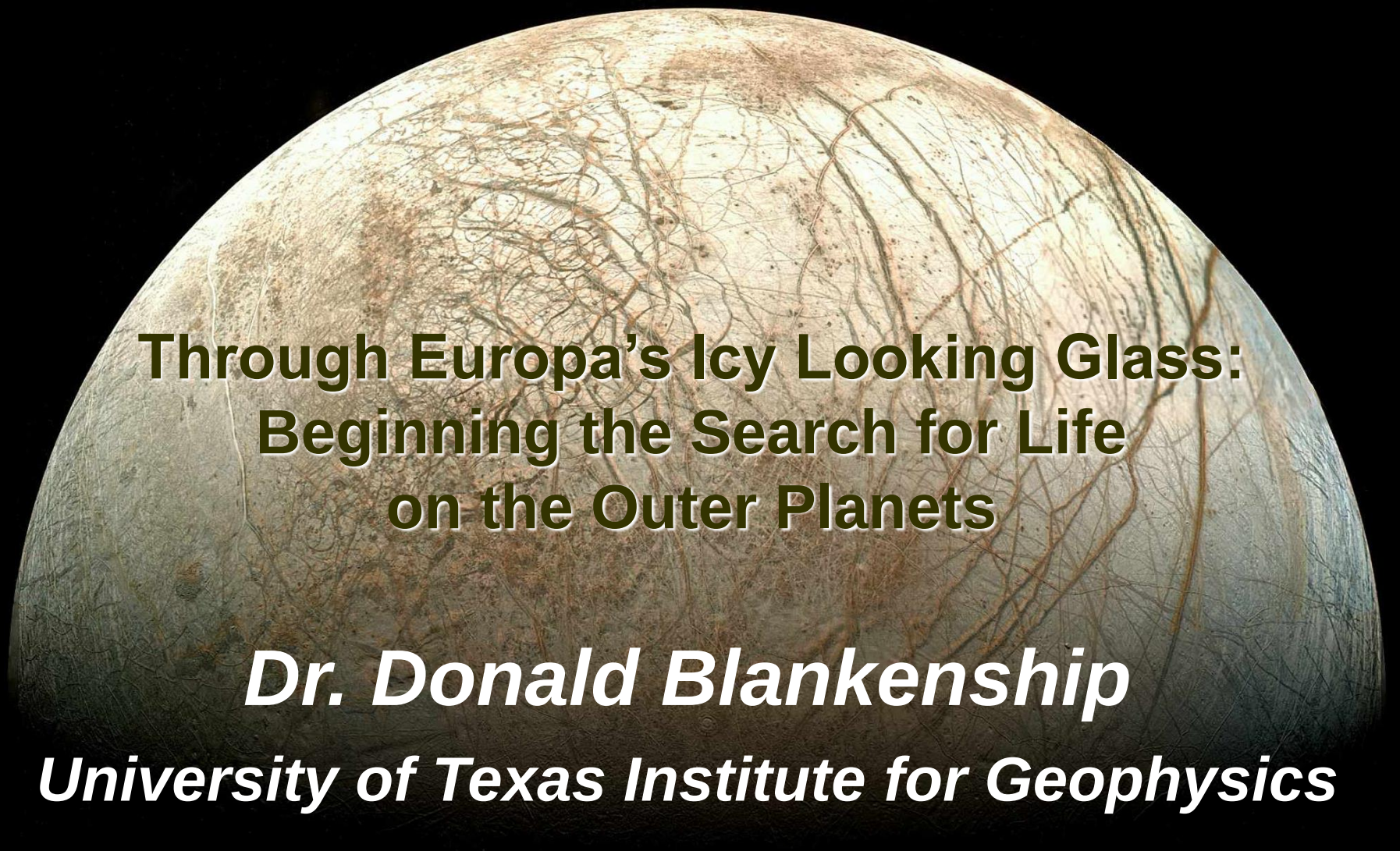
UT Environmental Science Institute

57

Beginning the Search for Life on the Outer Planets

Dr. Donald Blankenship

November 14, 2008

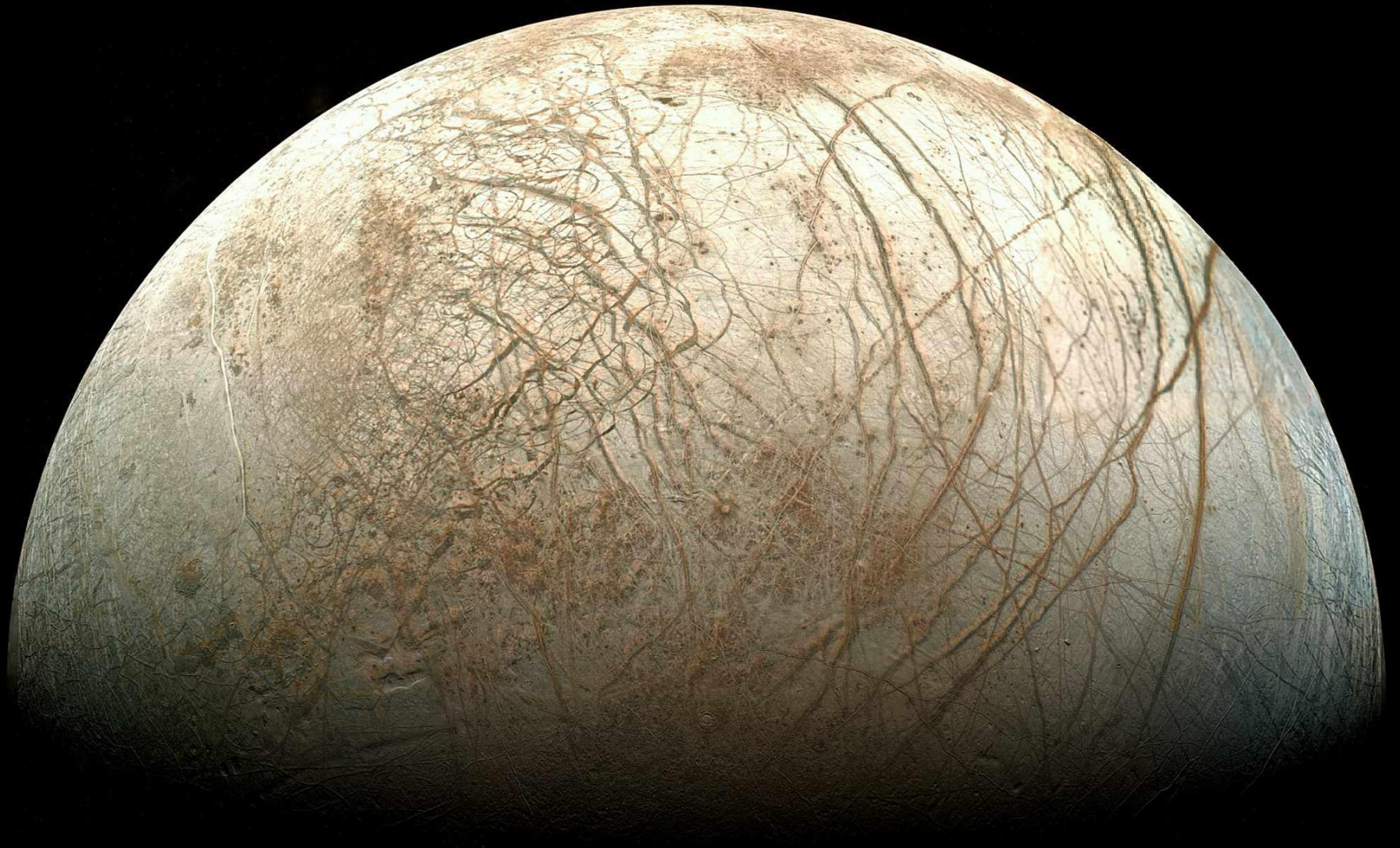


Through Europa's Icy Looking Glass: Beginning the Search for Life on the Outer Planets

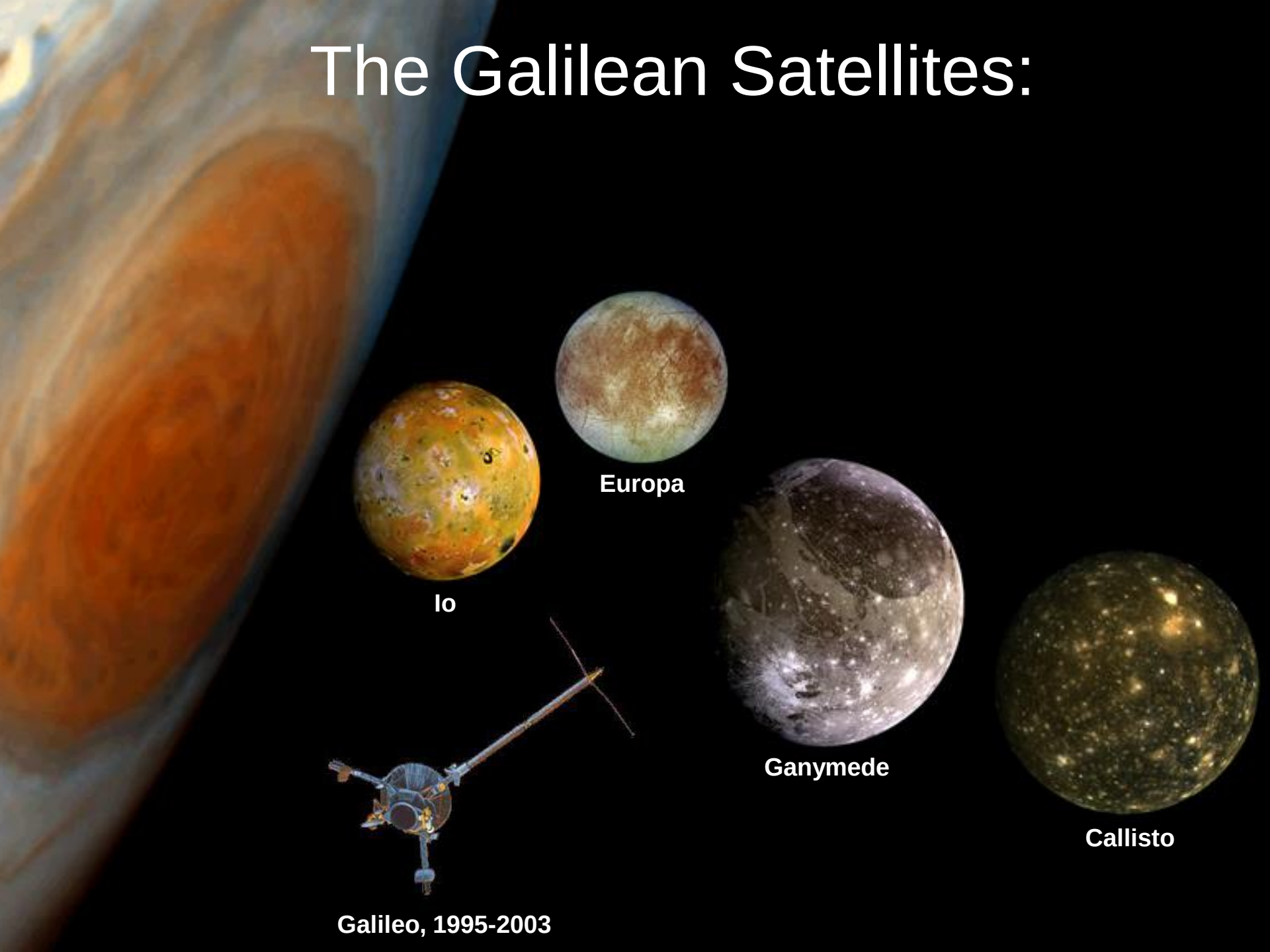
Dr. Donald Blankenship

University of Texas Institute for Geophysics

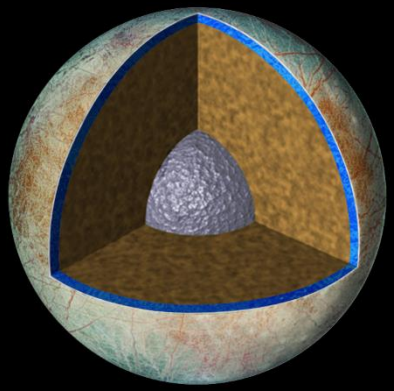
Mosaic by Ted Stryk



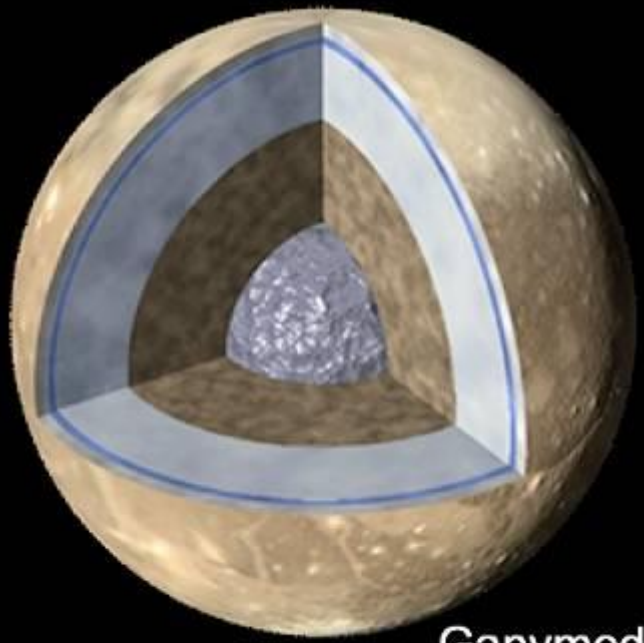
The Galilean Satellites:

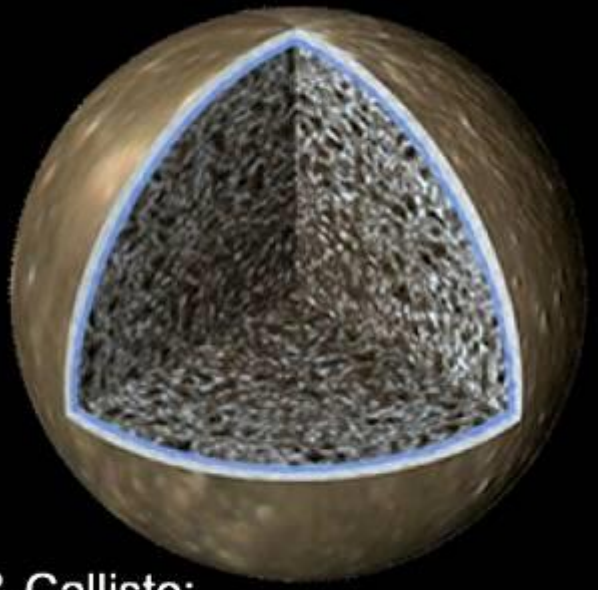


Icy Worlds: Oceans 13?



Europa:
warm salty H_2O, mantle contact, high energy

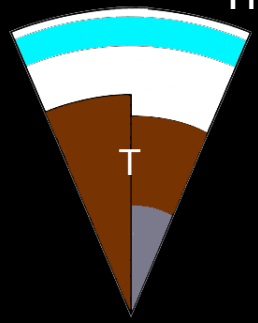




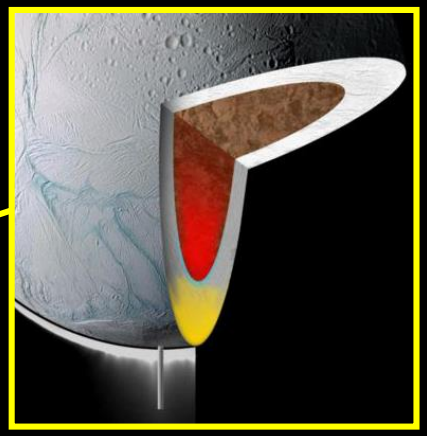
Ganymede & Callisto:
perched salty $H_2O(-NH_3?)$

Icy Worlds: Oceans 13?

Titan: *open CH_4 seas*



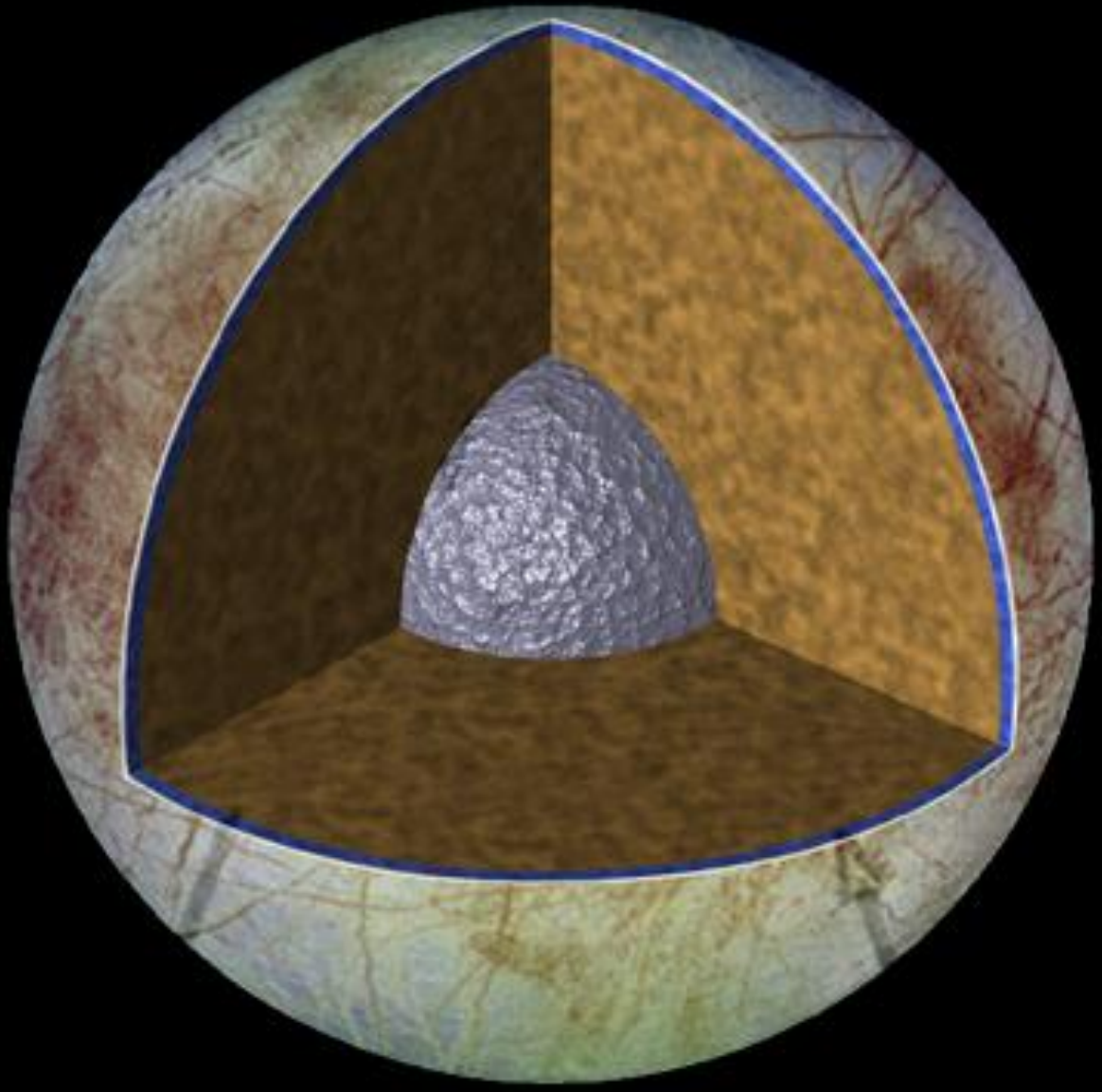
Titan, Triton, large KBOs, & mid-sized icy satellites:
cold NH_3-H_2O, some perched, some mantle contact, low energy



Enceladus:
cold H_2O-NH_3, or hydrothermal?

Earth:
open salty H_2O

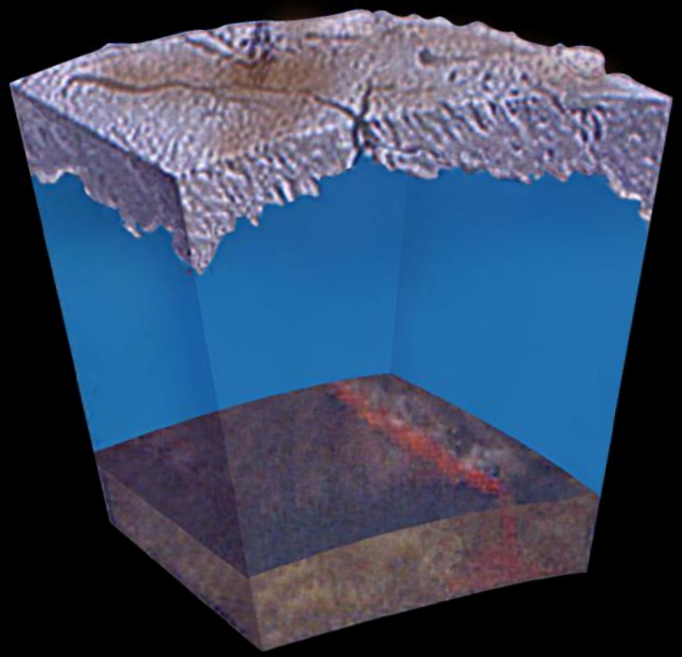
Europa's Interior



Europa is a rocky moon with an outer layer of H_2O!

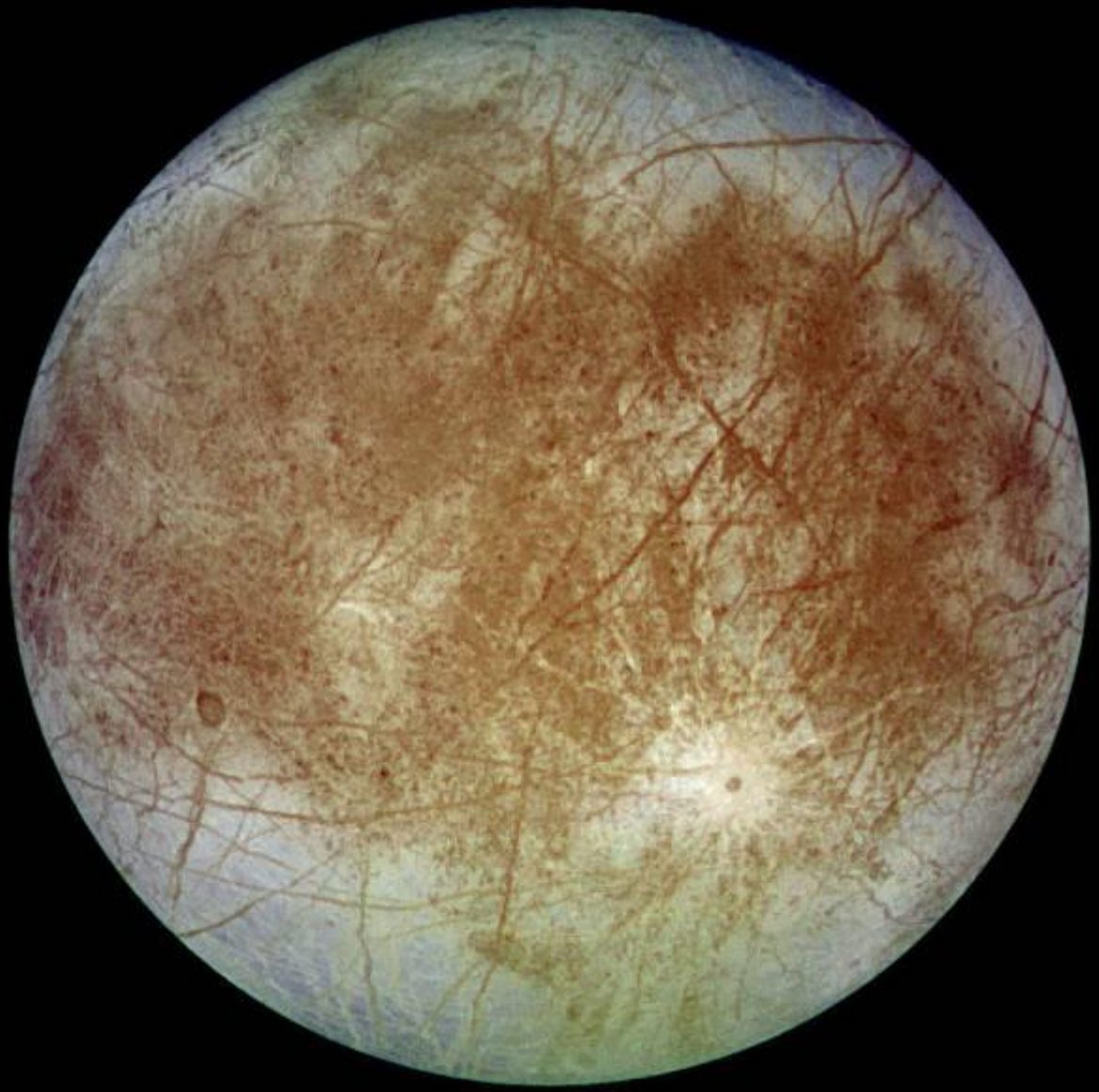
Europa: Ingredients for Life?

- Water: much more than all of Earth's oceans
- Organic molecules: from accretion and comets
- Chemical energy: from above and below?

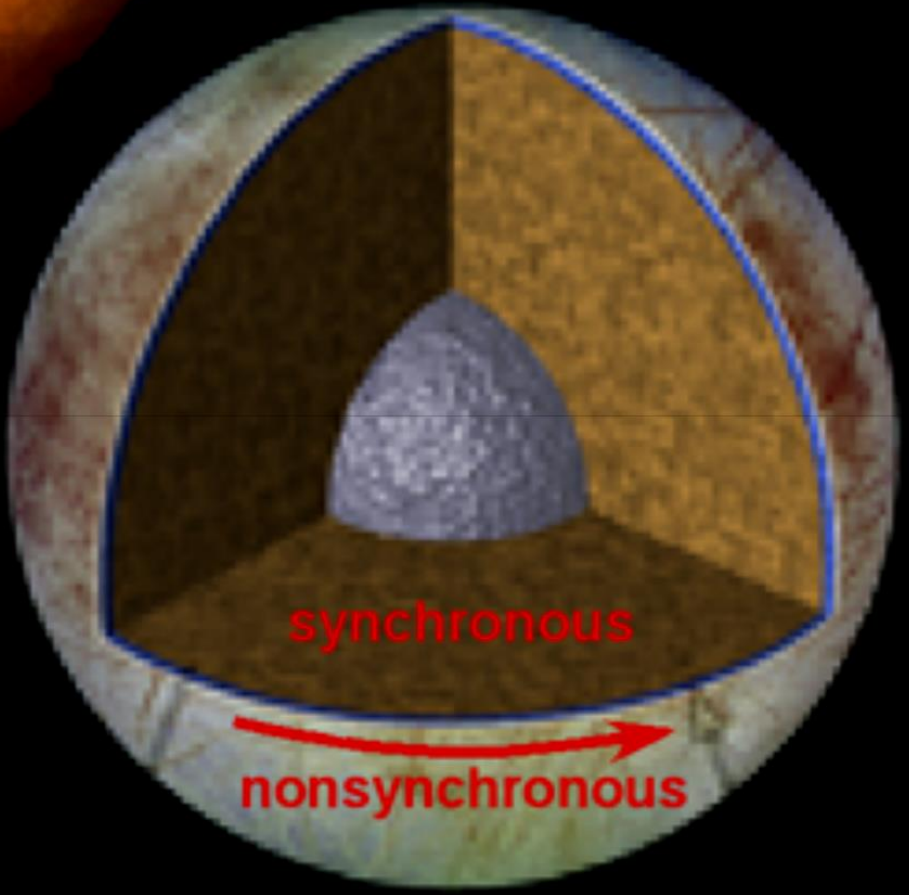


"Black smoker" on Earth's ocean floor

Europa's Surface

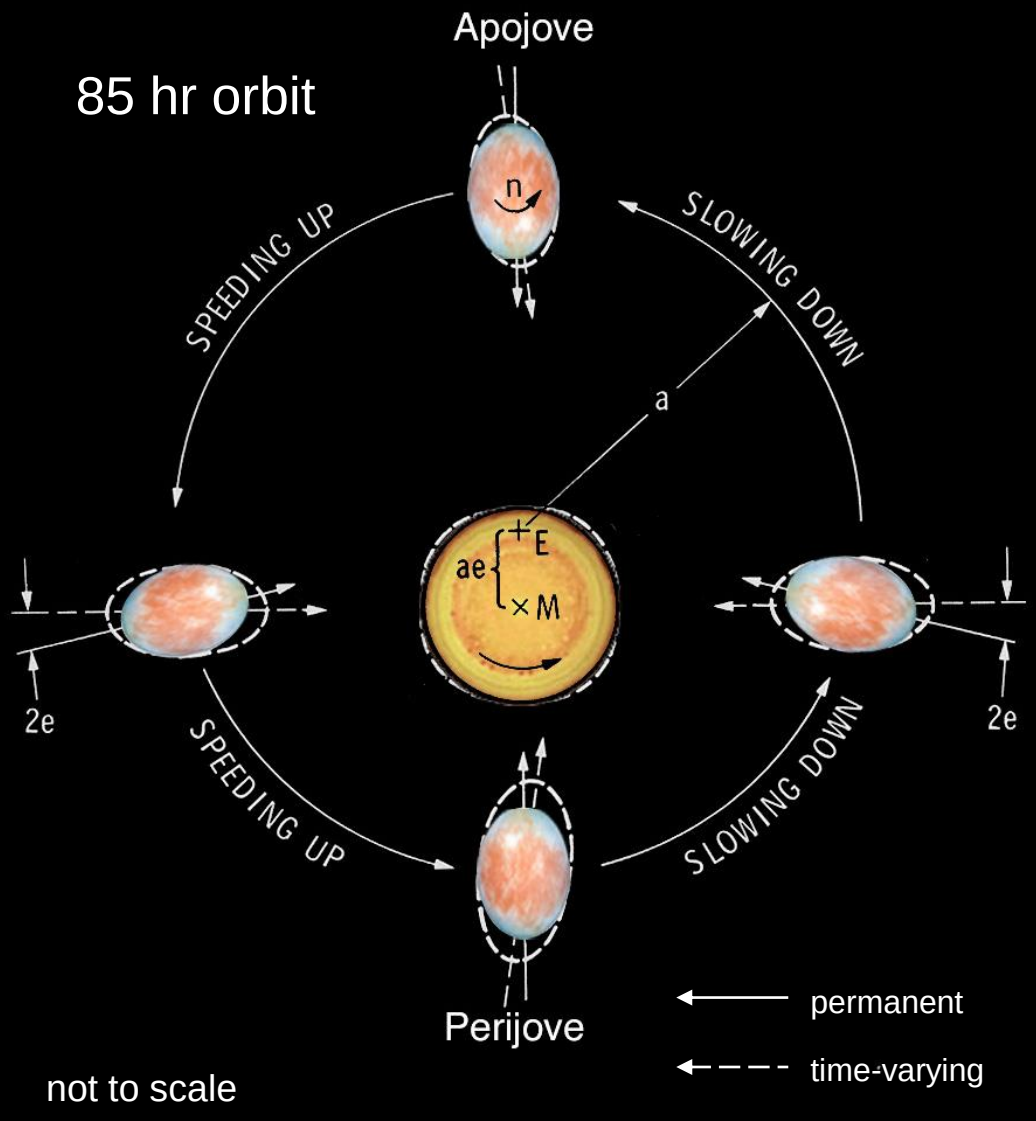


Stressing Europa I: Non-synchronous Rotation



If surface ice is separated from the rocky mantle by a global ocean, the icy shell will rotate at a different rate than the rocky mantle

Stressing Europa II, and Tidal Heating



Stressing Europa II, and Tidal Heating

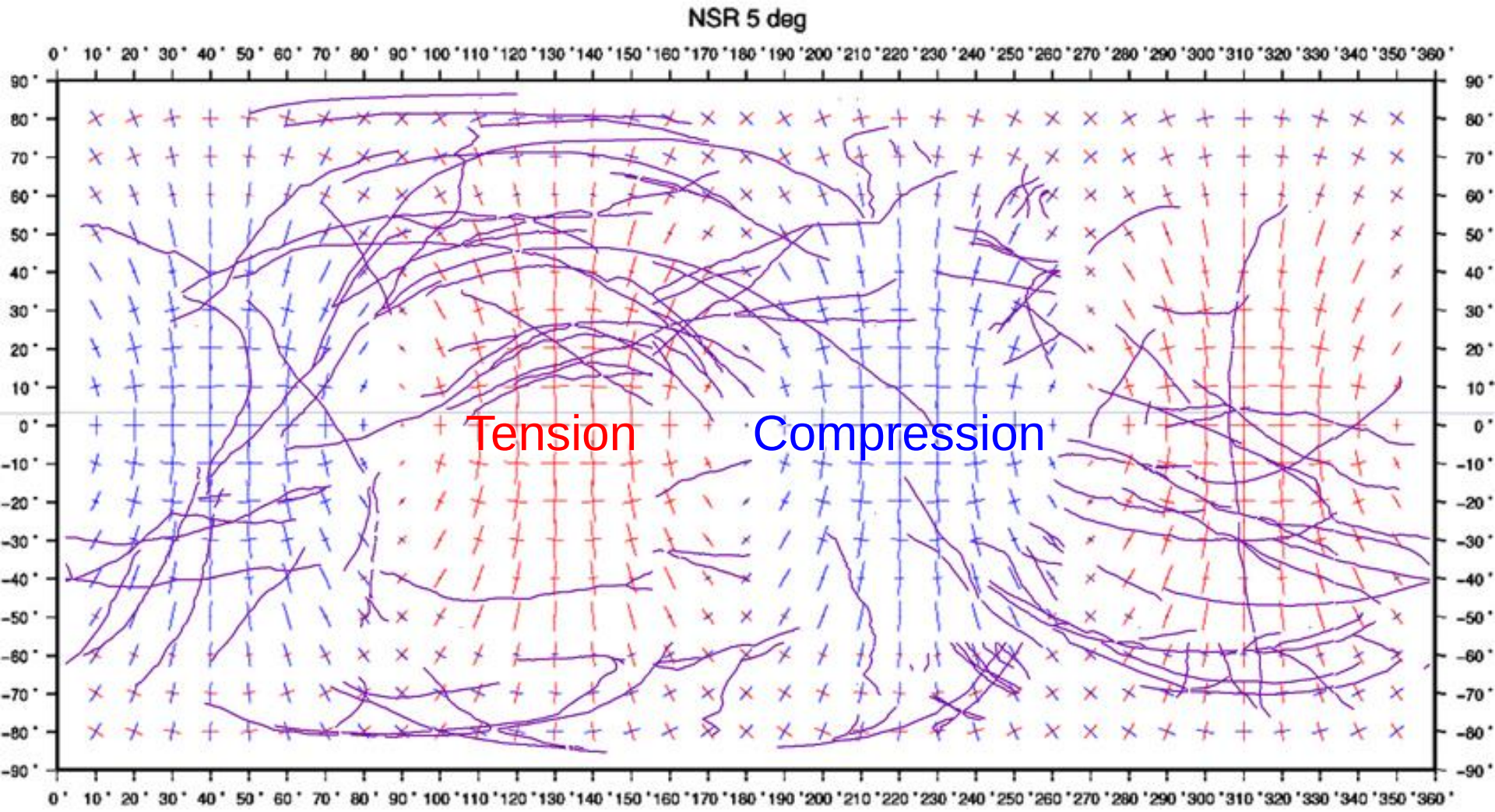
Animation by Dana Berry
for the Science Channel program
***Europa: Mystery of the Ice Moon*,**
Dan Birman producer.

Squeezing stresses surface and heats up ice (or rock)!

Global Patterns

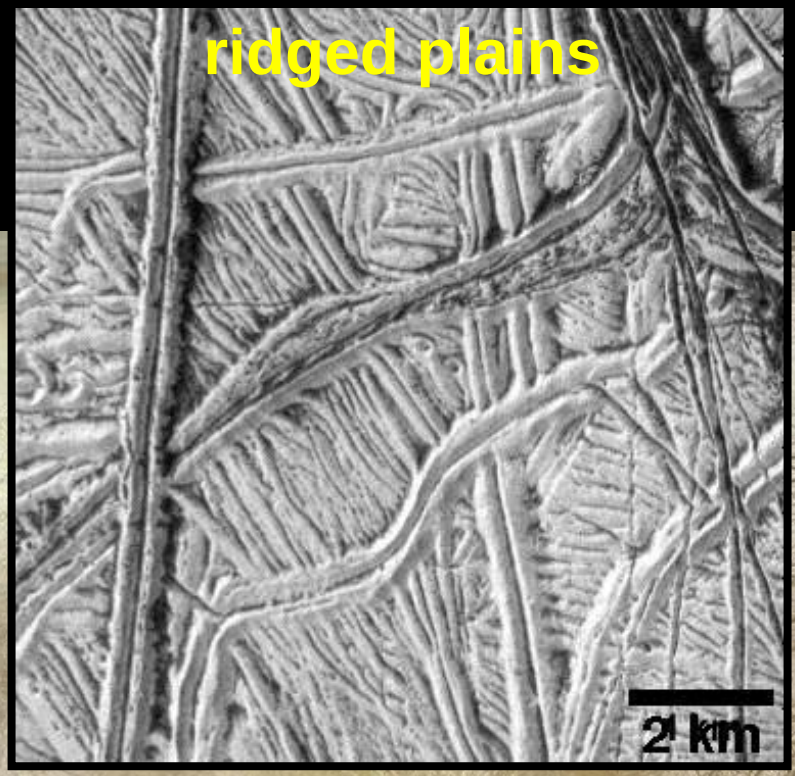
Map projection of Europa’s surface

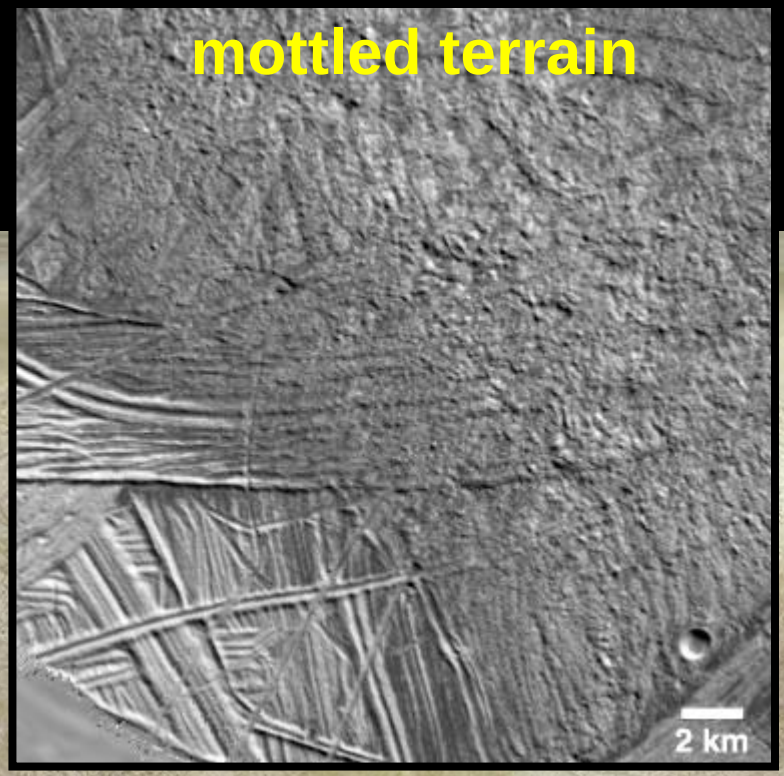
Global Patterns



Map projection of Europa's surface

Dynamic and Bizarre Geology



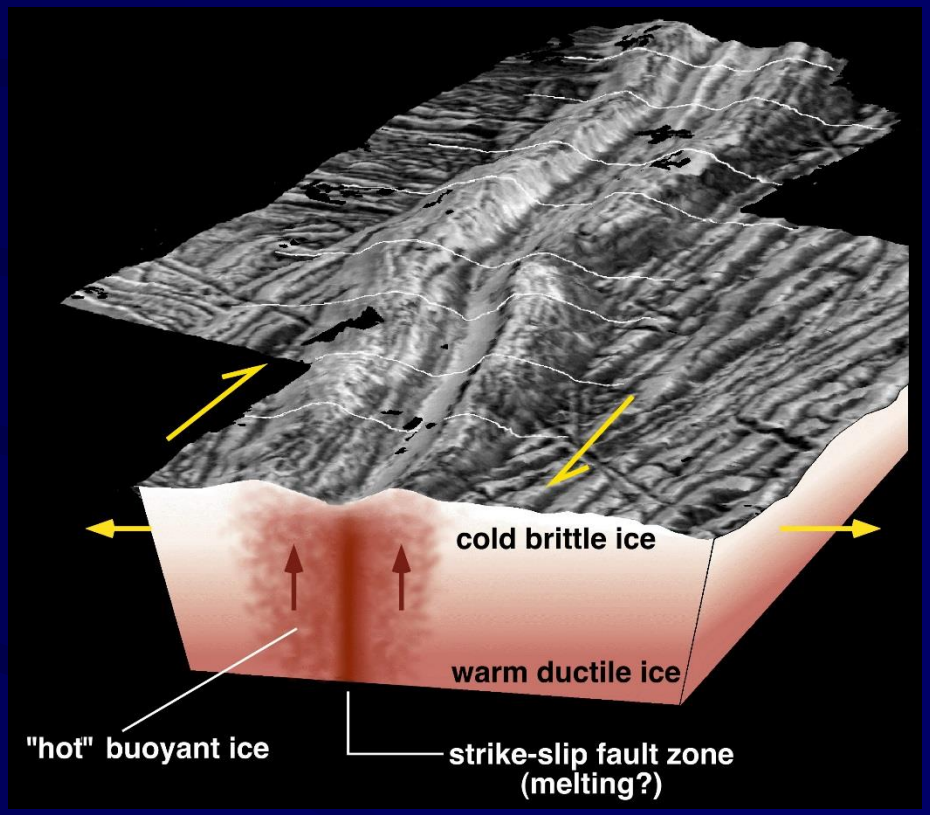


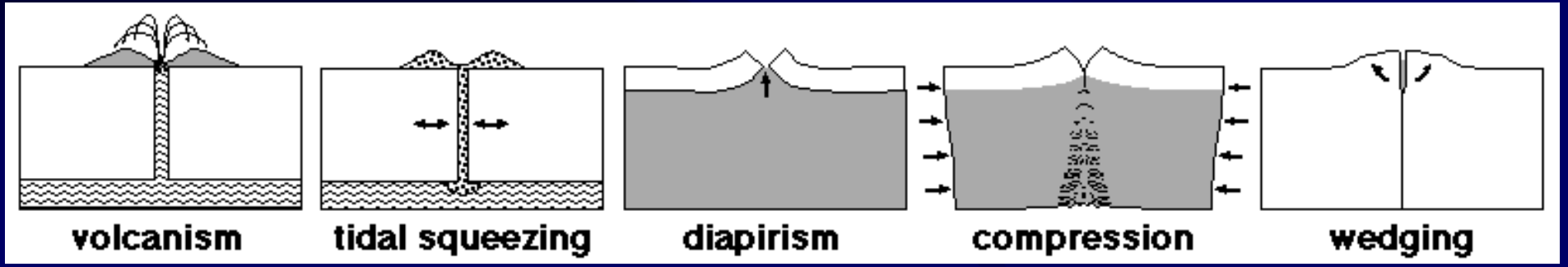
Ridged Plains

Mosaic by Ryan Sicilia

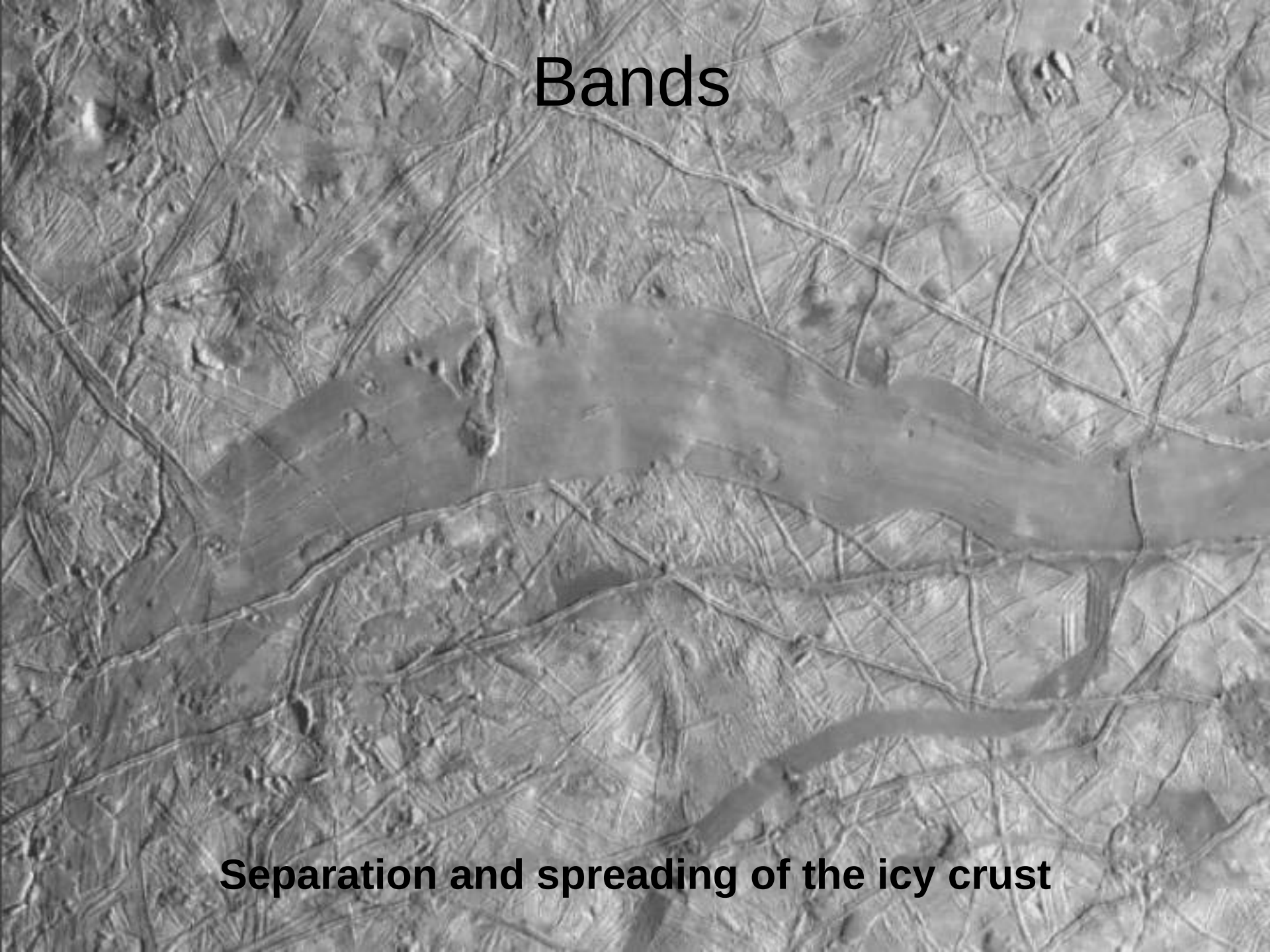
Ridge Formation Models

- Several candidate models
- Shear heating along fracture plains is a leading model.



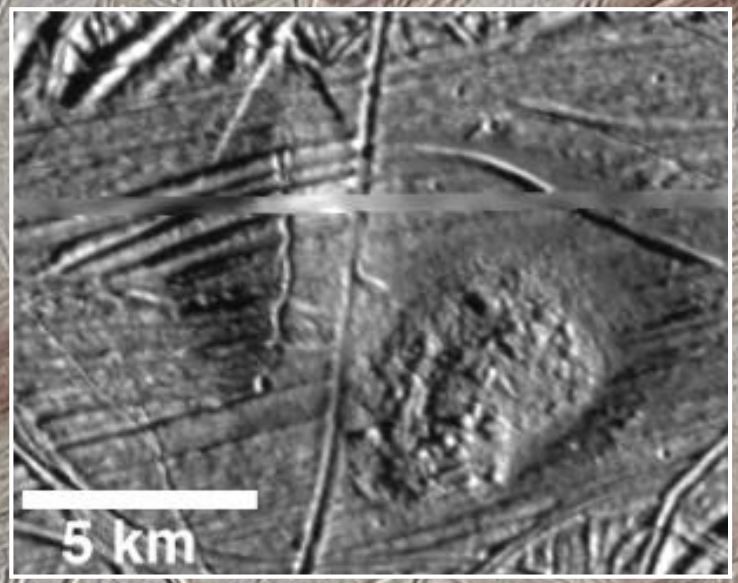


Bands



Separation and spreading of the icy crust

Freckles of Europa's Mottled Terrain

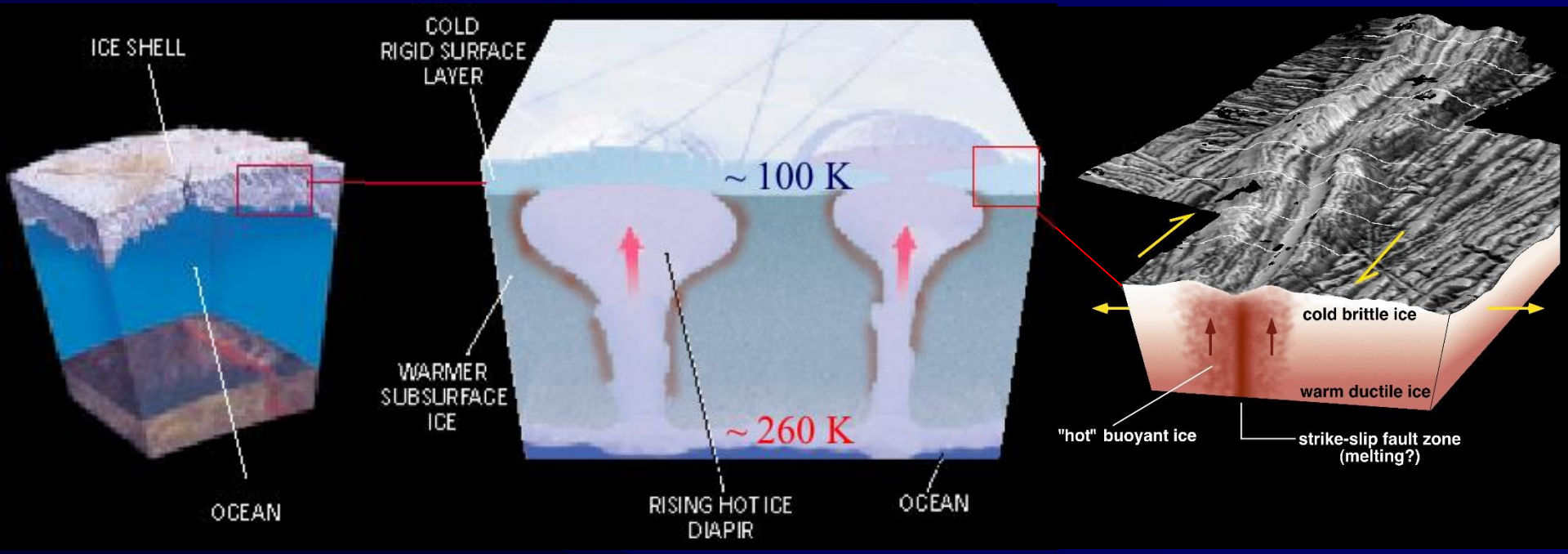


Mosaic by Ryan Sicilia

Convection in Europa's Ice Shell

- Pits, spots, and domes suggest ice convection (hot/light ice rising, heavy ice sinking).
- Near-surface melt?
- Salts may be expelled from warm plume cores.

Convection in Europa's Ice Shell



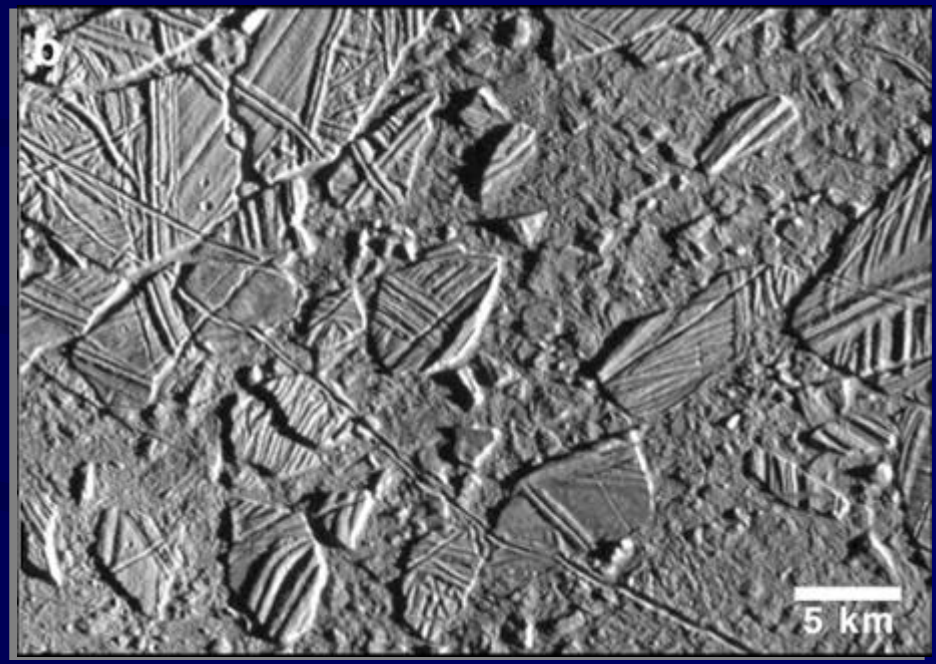
Melt?

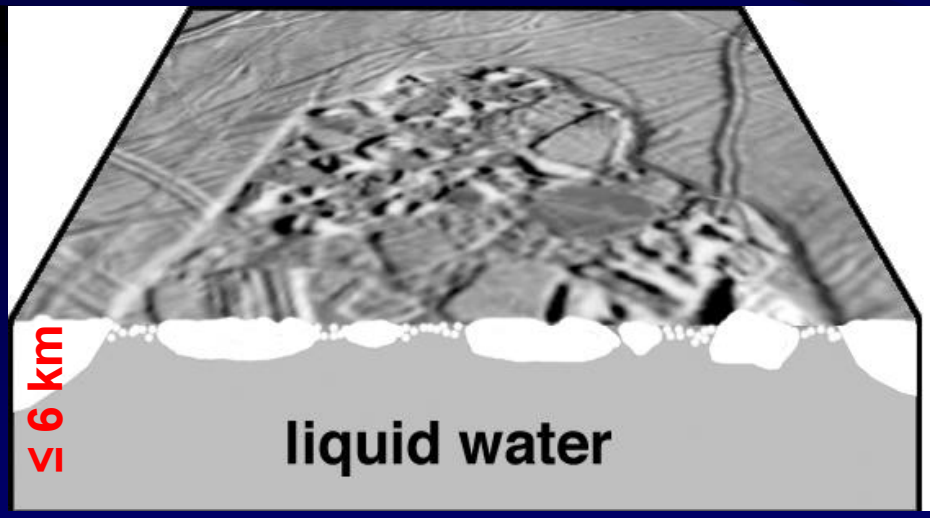
Convection?

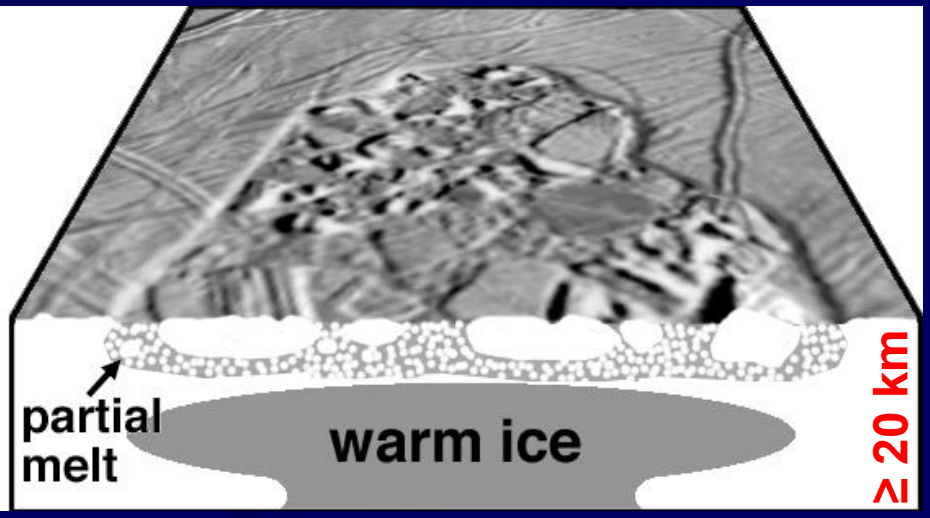
Frictional Heating?

Chaos Models

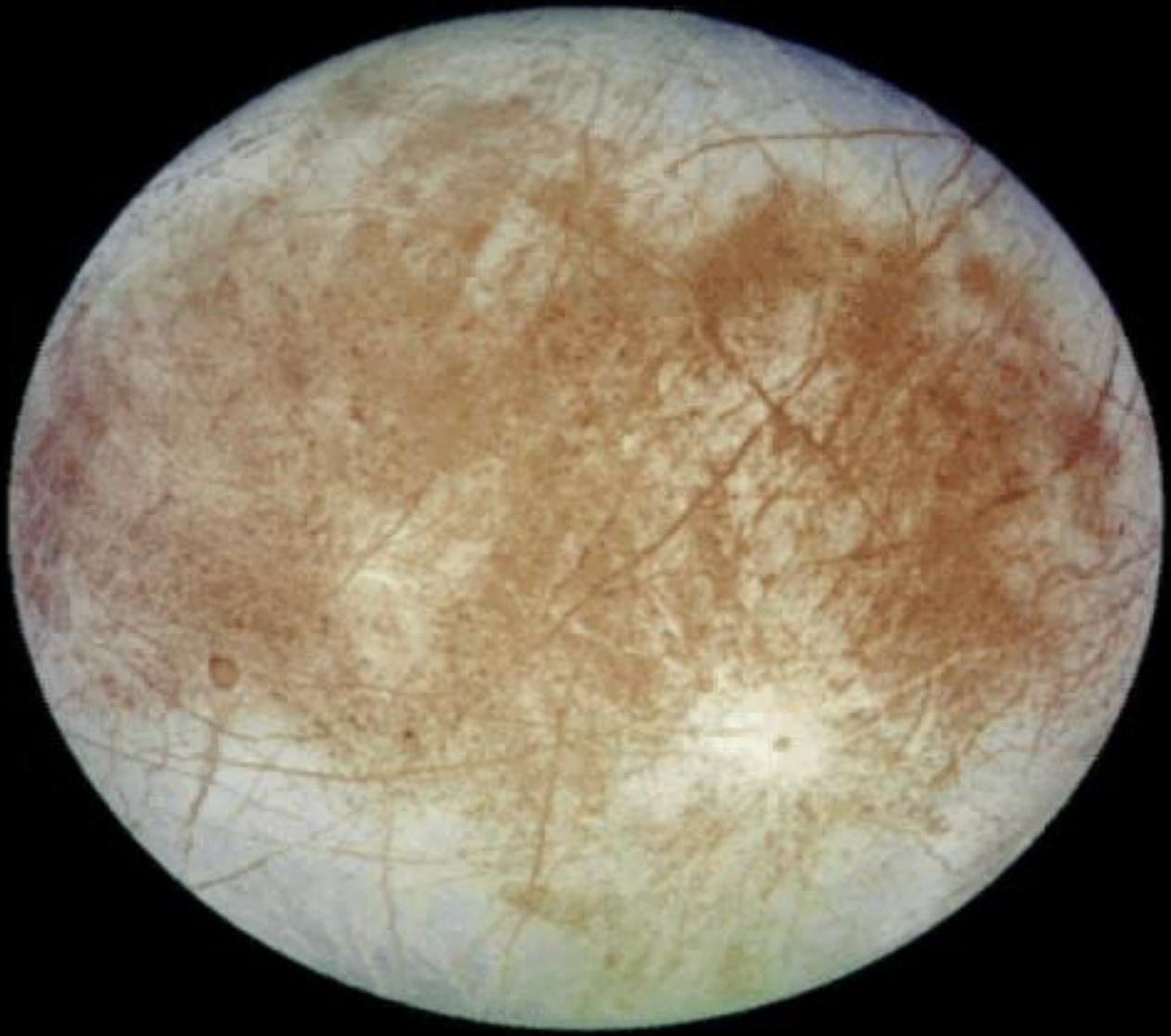
- *Melting model:*
  - ✧ Ice shell thins and melts above oceanic megaplumes.
- *Diapirism model:*
  - ✧ Ice convection partially melts salty ice.





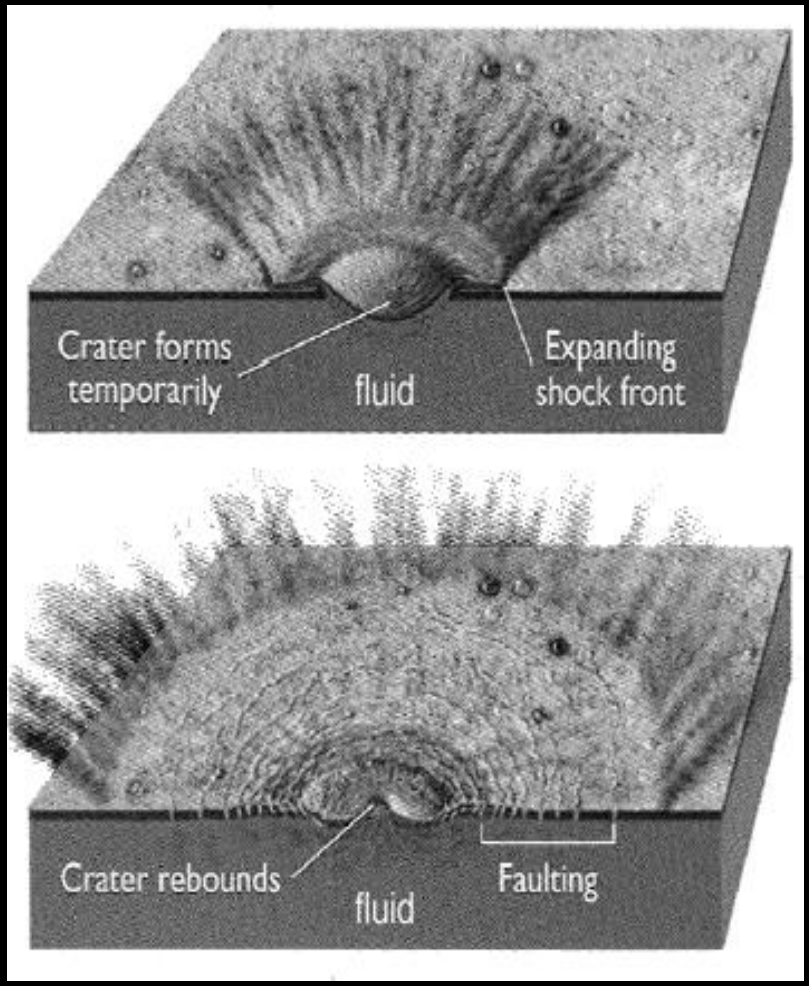


Journey to Conamara Chaos



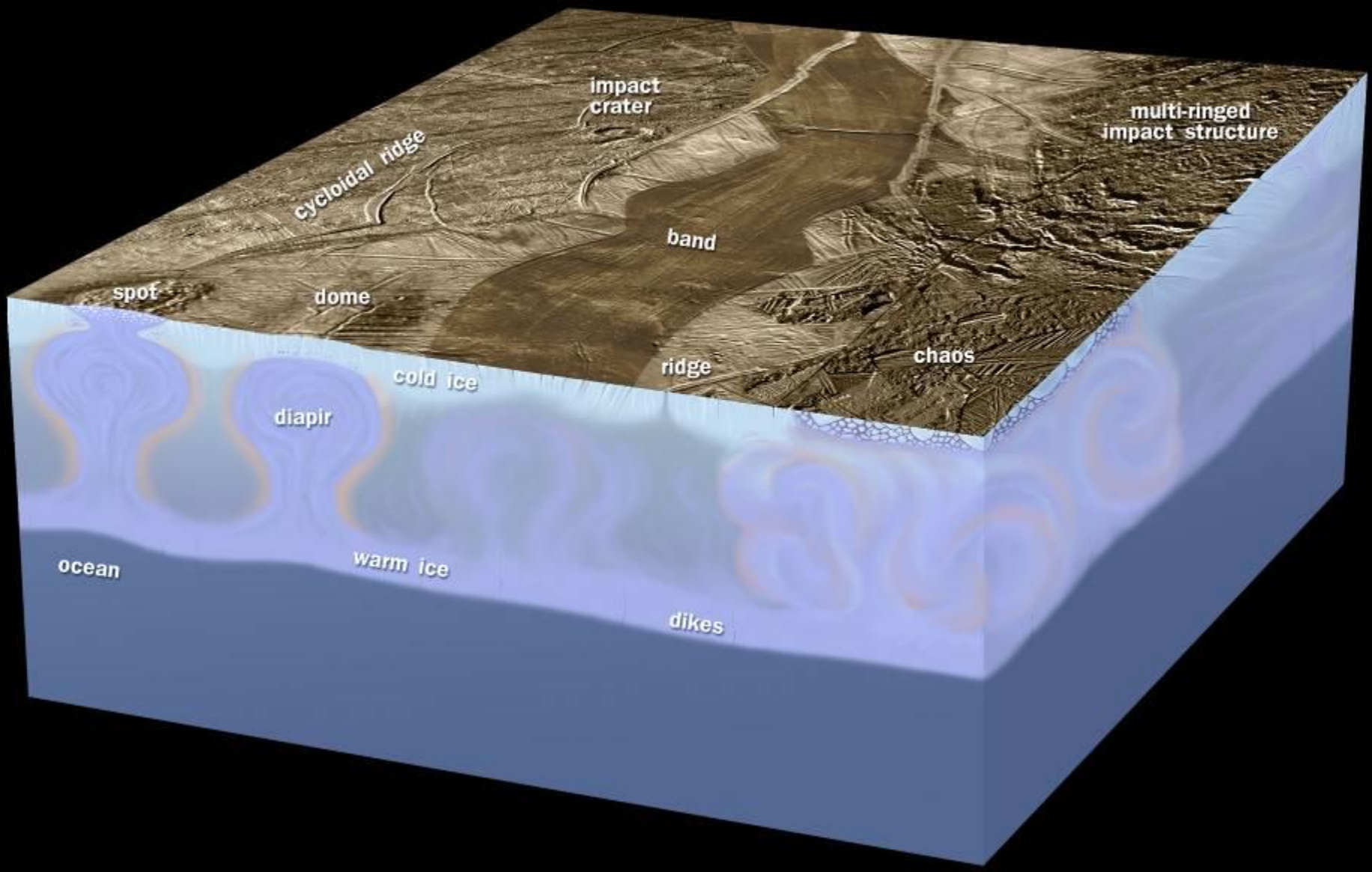
Icebergs?

Large Impacts



Few large impact craters suggests 60 million year old surface.
Multi-ringed impacts punched through 20 km thick ice!

Europa's Floating Ice Shell

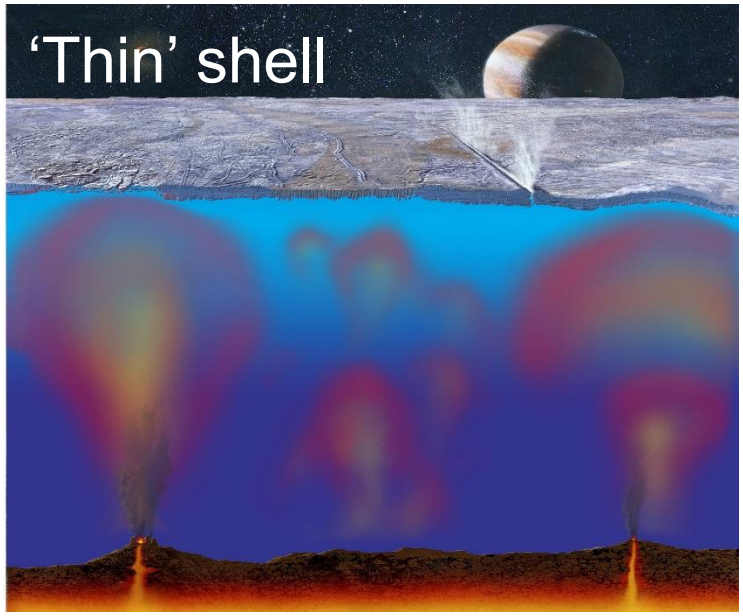


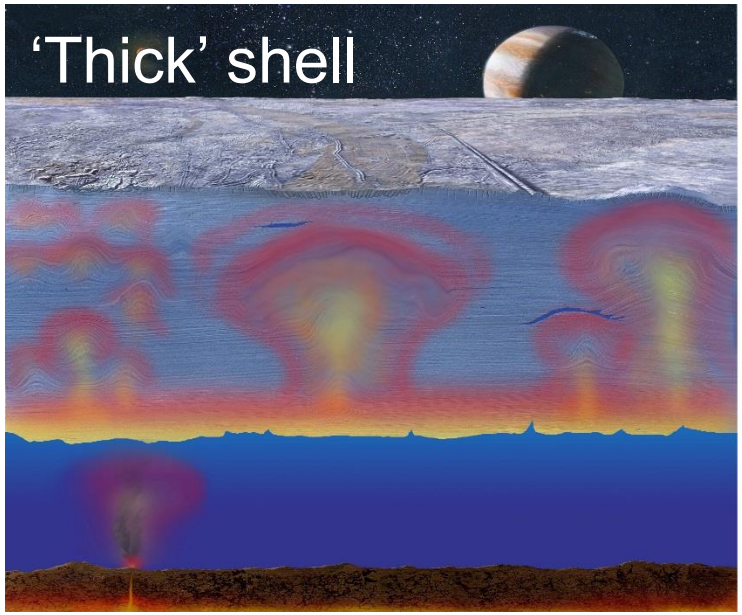
Europa Orbiter: NASA's Formal Science Objectives

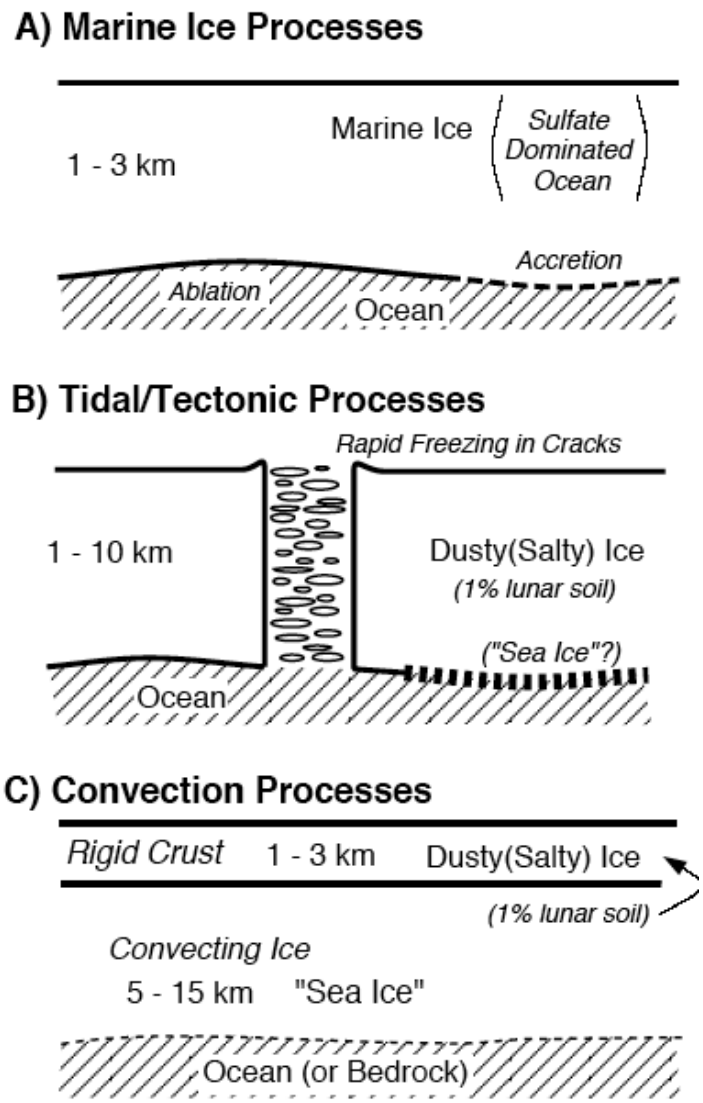
1. Determine the presence or absence of a subsurface ocean

- Characterize the three-dimensional distribution of any subsurface liquid water and its overlying ice layers
- Understand the formation of surface features, including sites of recent or current activity, and identify candidate landing sites for future lander missions.

We need to see both into and through Europa's icy shell.

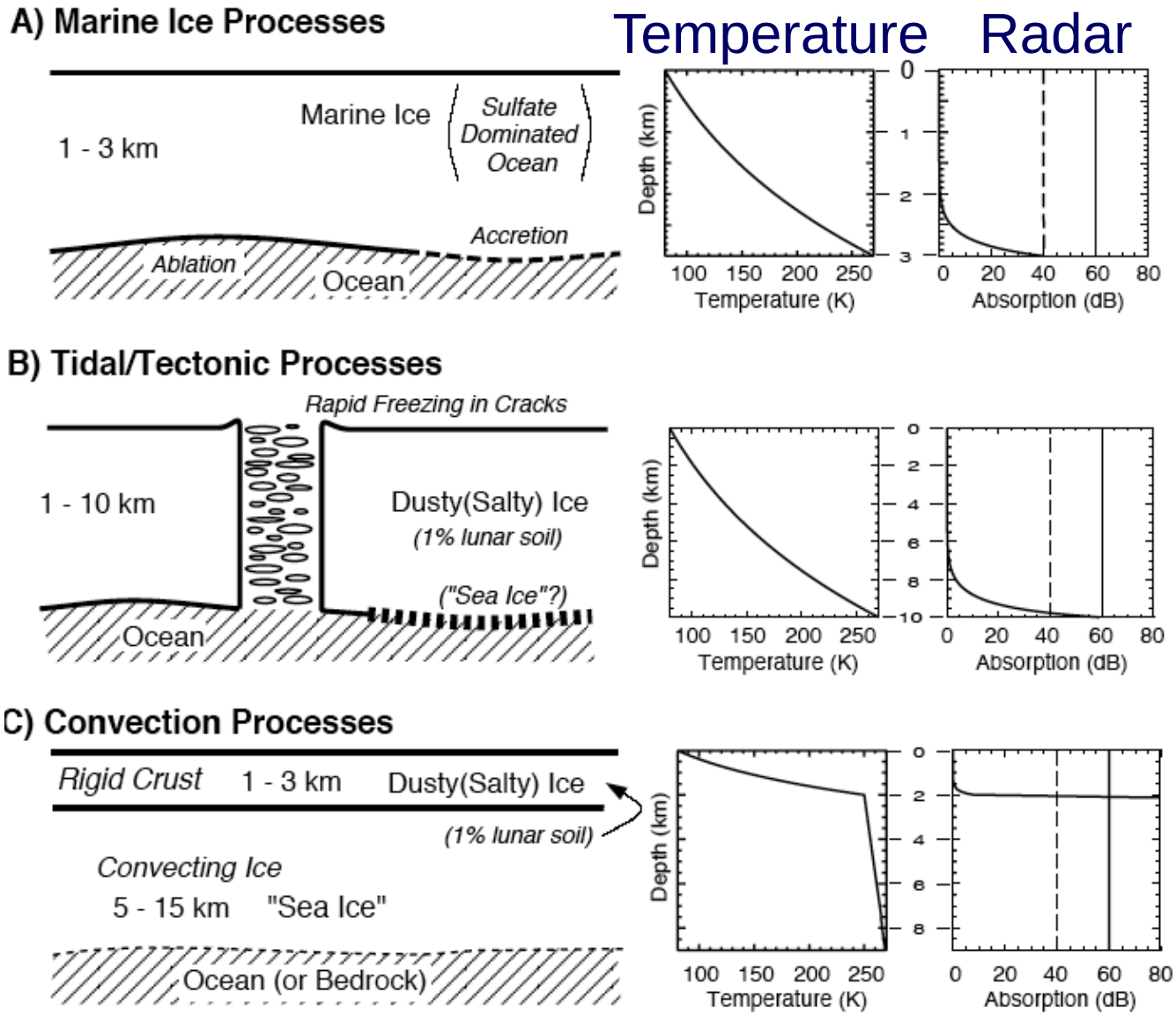






Chyba et al., (1999); Moore, (2000), Blankenship et al (1999, in press);

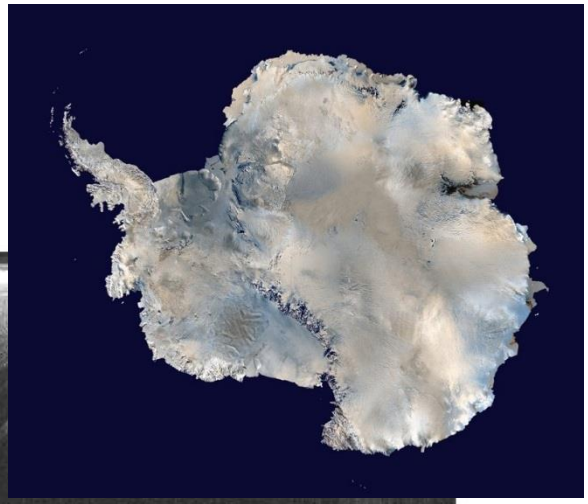
Radar Sounding Models for Europa

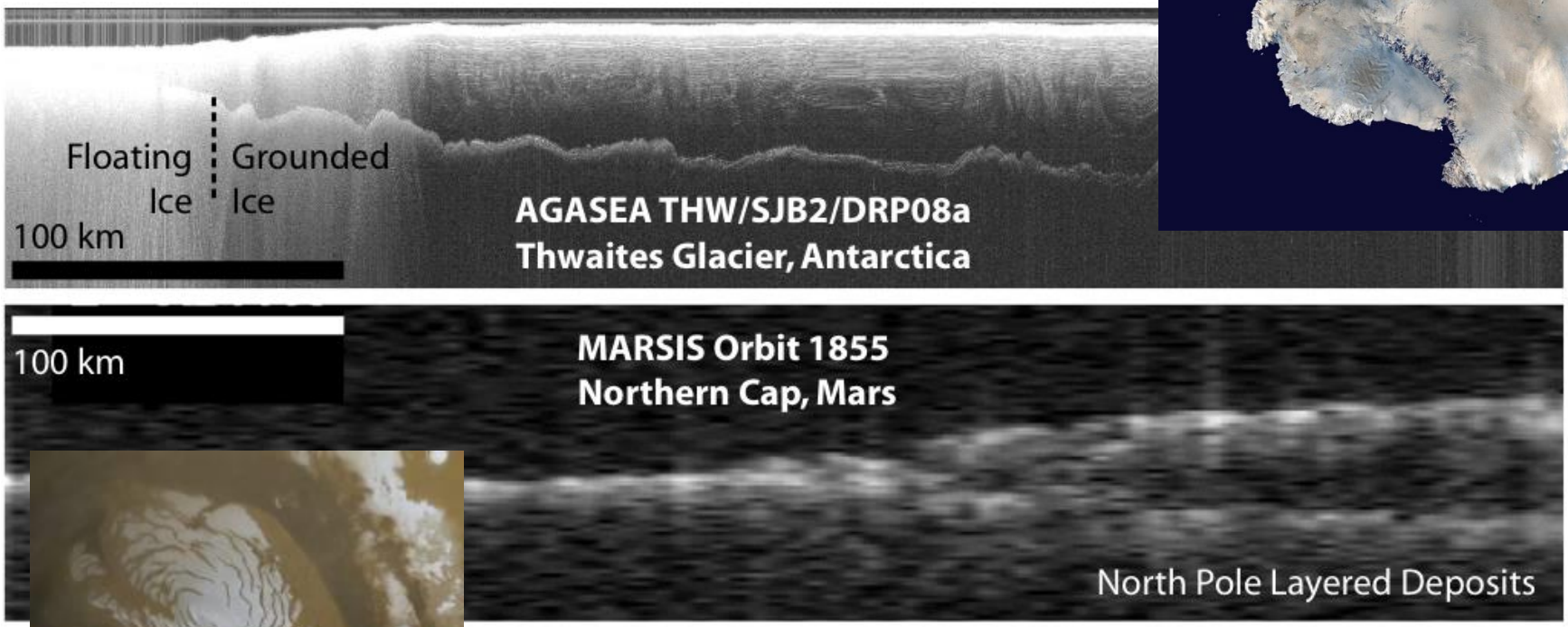


Orbital radar sounding works!

Earth/MARSIS profiles

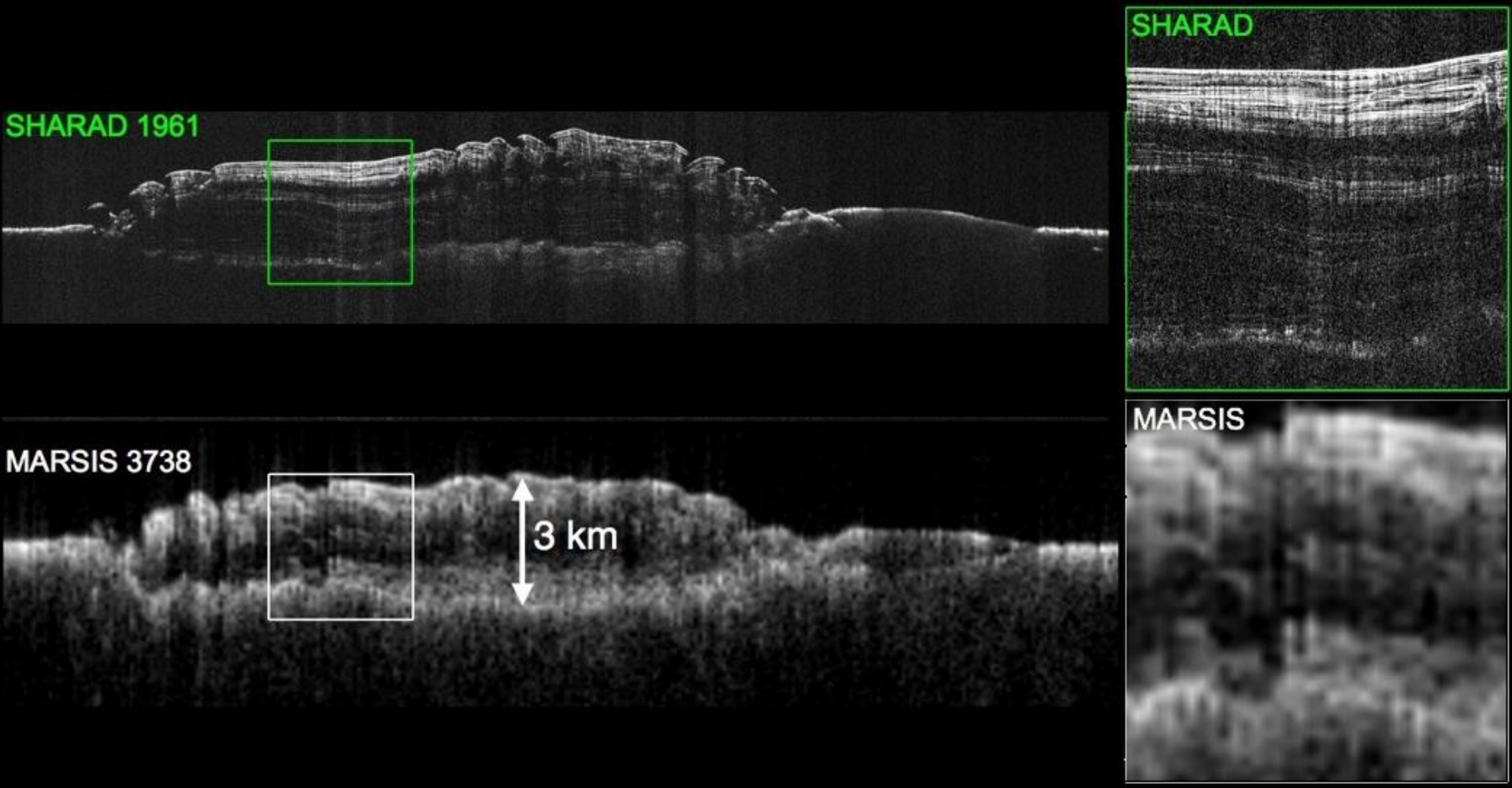
Antarctica





Mars

Orbital radar sounding of Mars' polar caps has been successful twice!



A. Safaeinili pers. comm

UTIG Instrumentation: Ice-Penetrating Radar

Phase Coherent

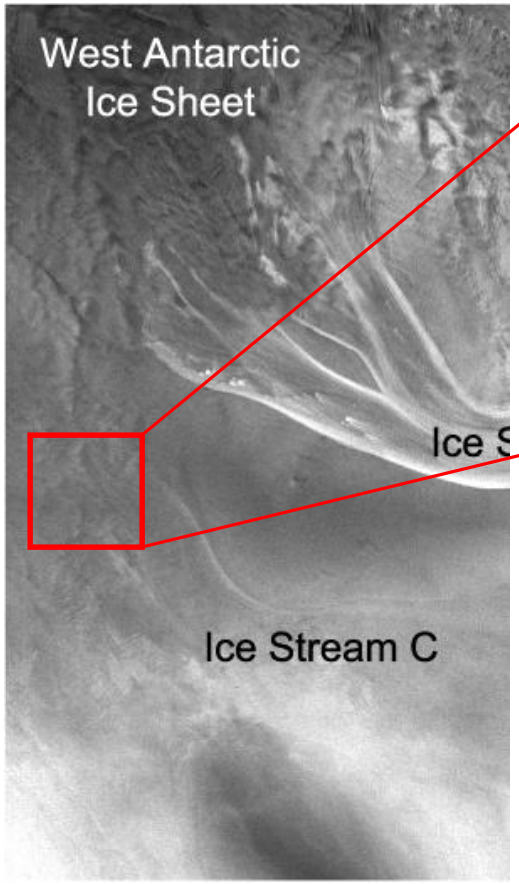
60 MHz center frequency

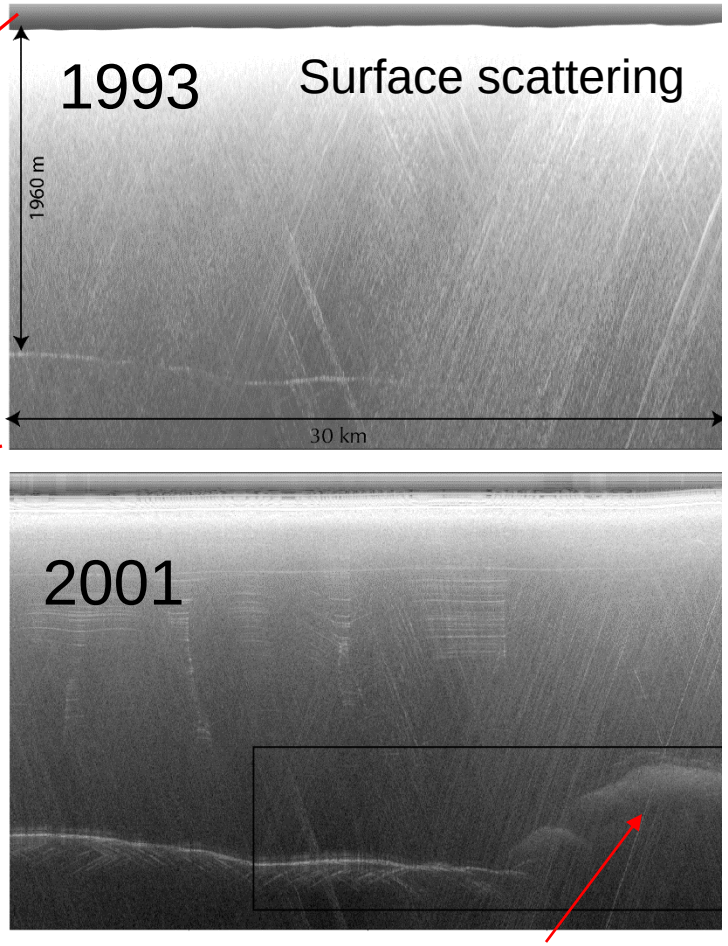
8 kW peak power

- **15 MHz bandwidth chirp (52.5 – 67.5 MHz)**
- **1 μs pulse duration**
- **6400 pulses per second, 16 returns stacked**

Radar sounding of Earth's ice sheets is routine…

Europa has inspired development of new radar acquisition and imaging technologies….

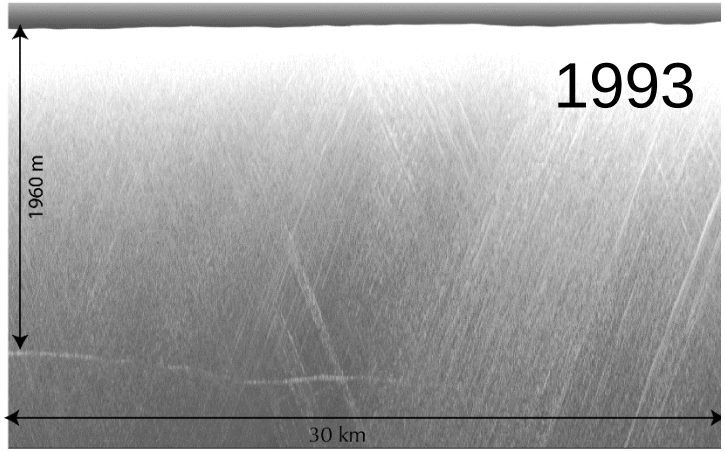


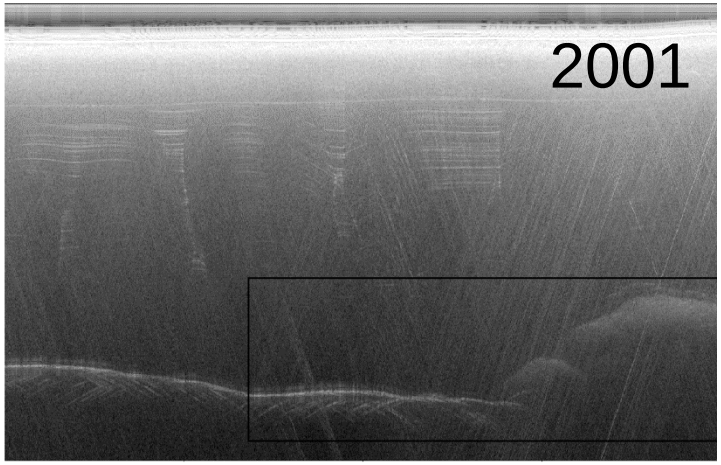


(Peters et al. 2005, 2007)

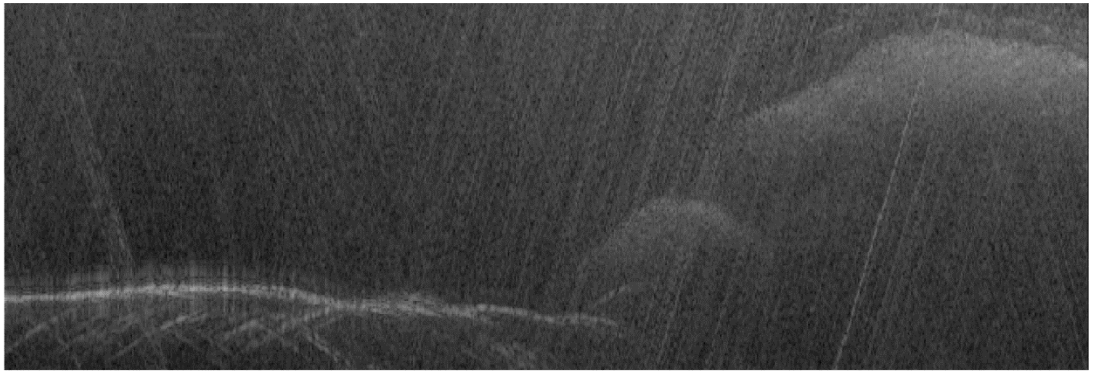
New features seen with reduced scattering

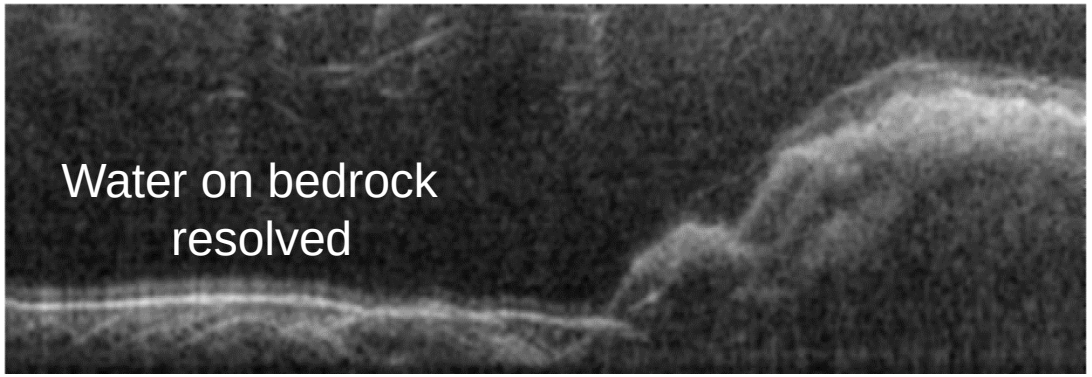
Europa has inspired development of new radar acquisition and imaging technologies….





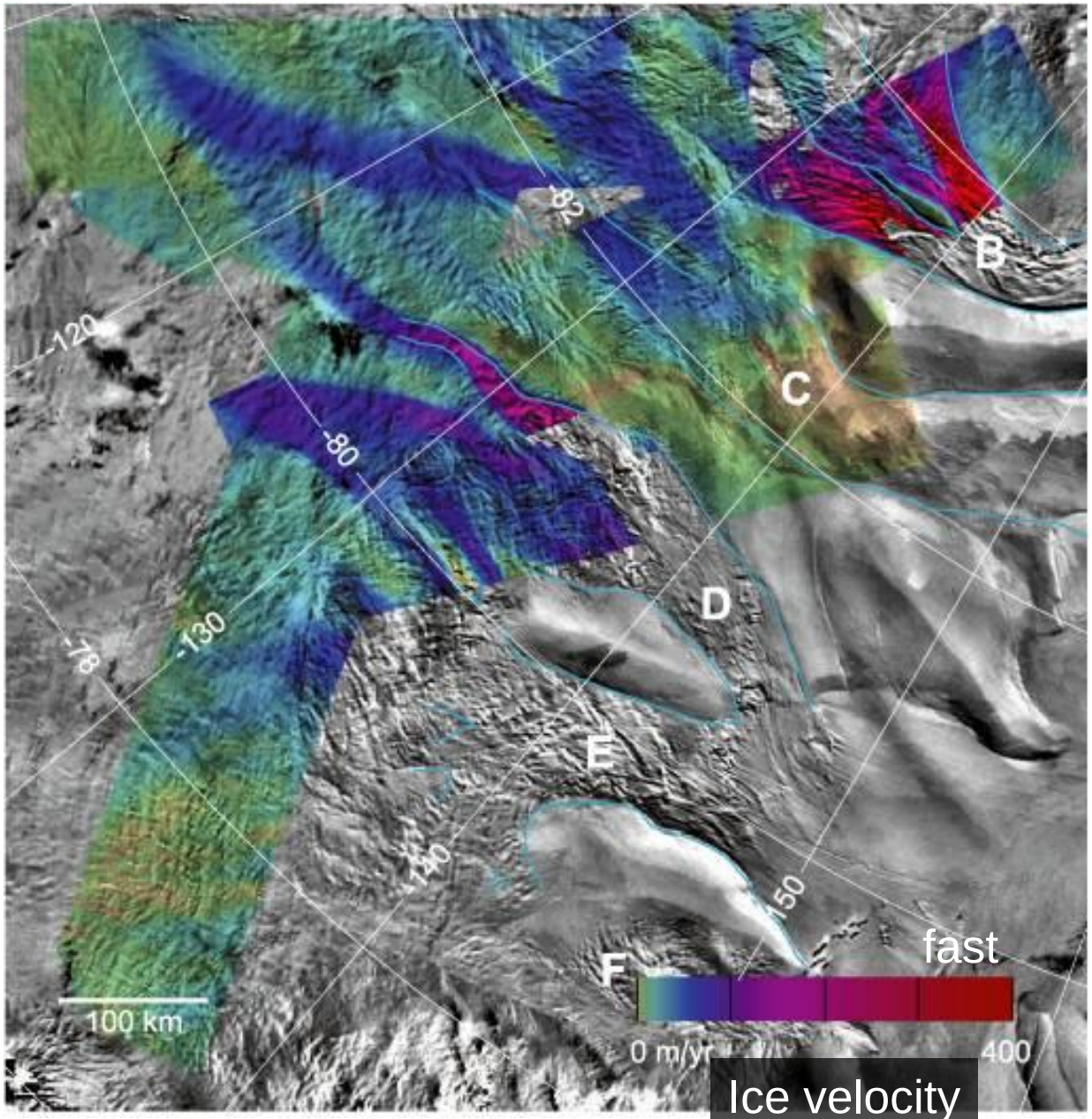
Surface scattering



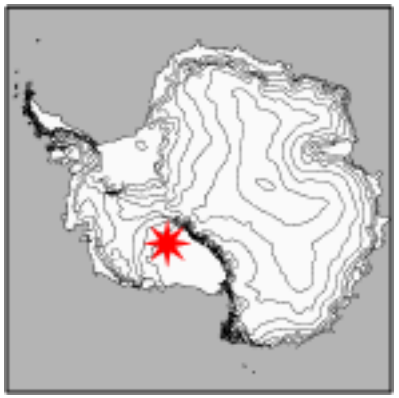


And with the latest supercomputer processing….

Earth Analogs: Antarctic Ice Sheet and Ice Streams

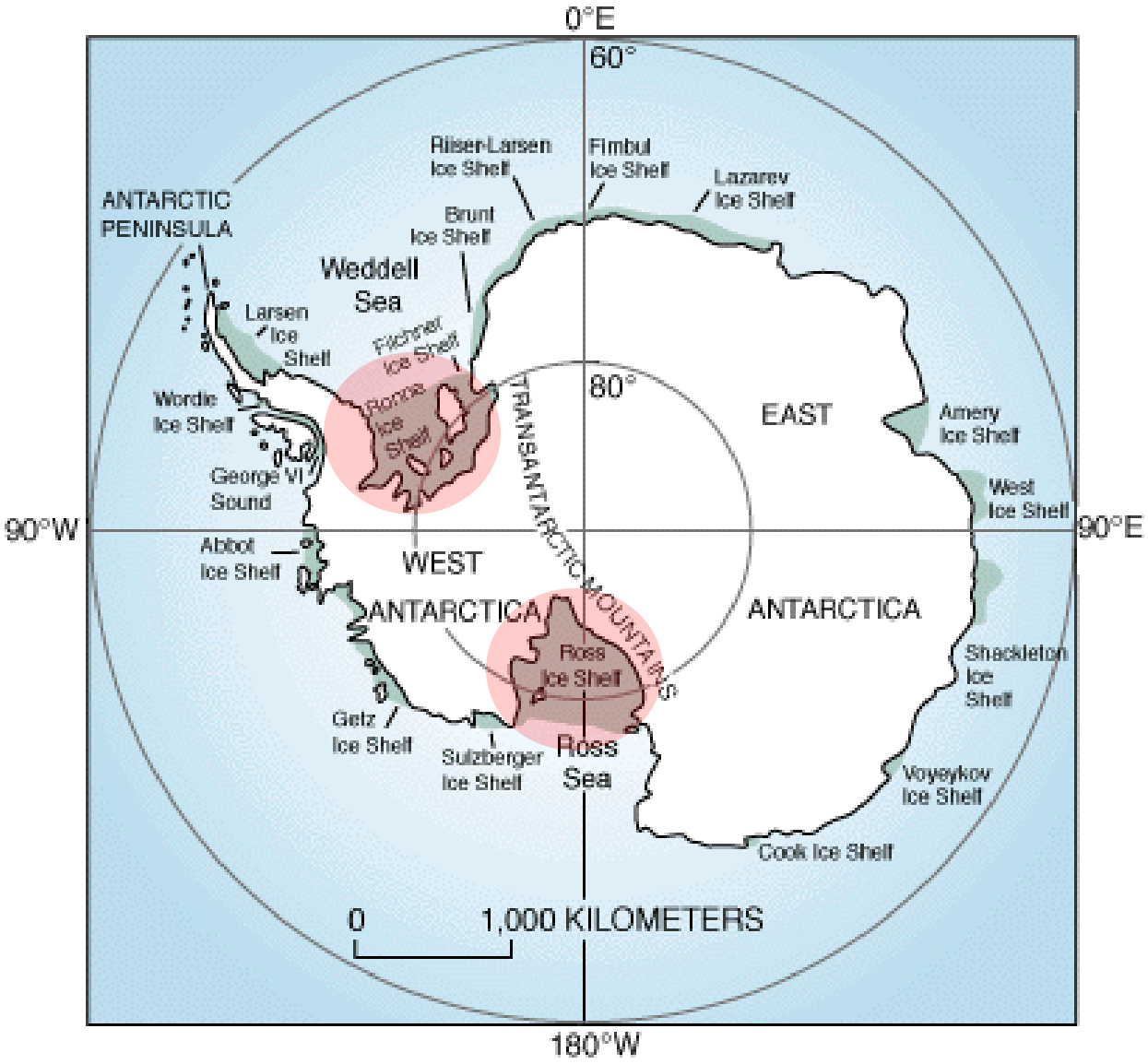


Europa's ice is under tension and compression.
So is Antarctica's!



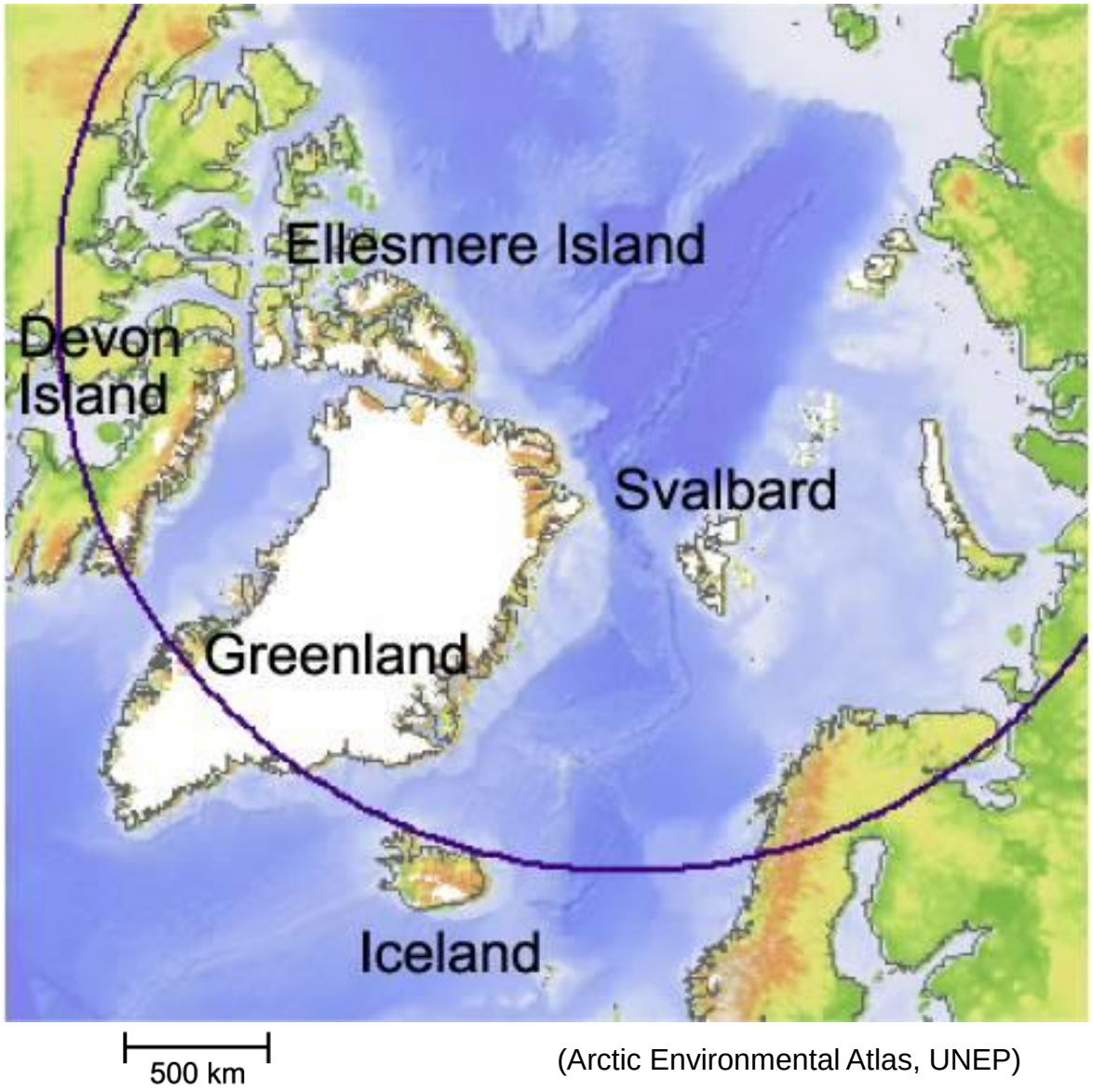
(Joughin, et al., 1999)

Earth Analogs: Antarctic Ice Shelves



Europa's ice is floating. So are parts of Antarctica.

Earth Analogs: Arctic Ice Caps

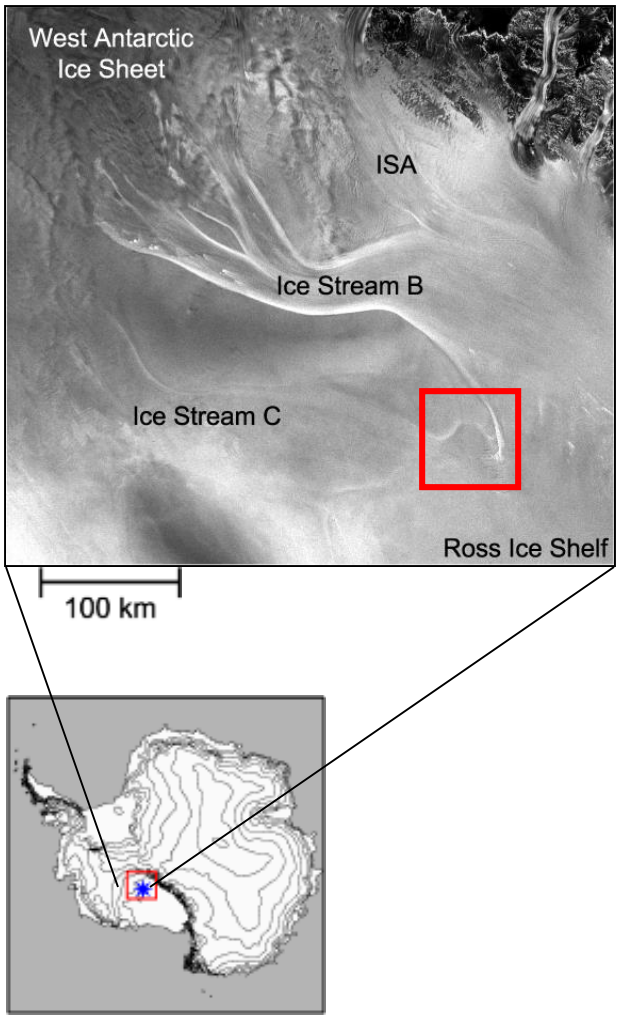


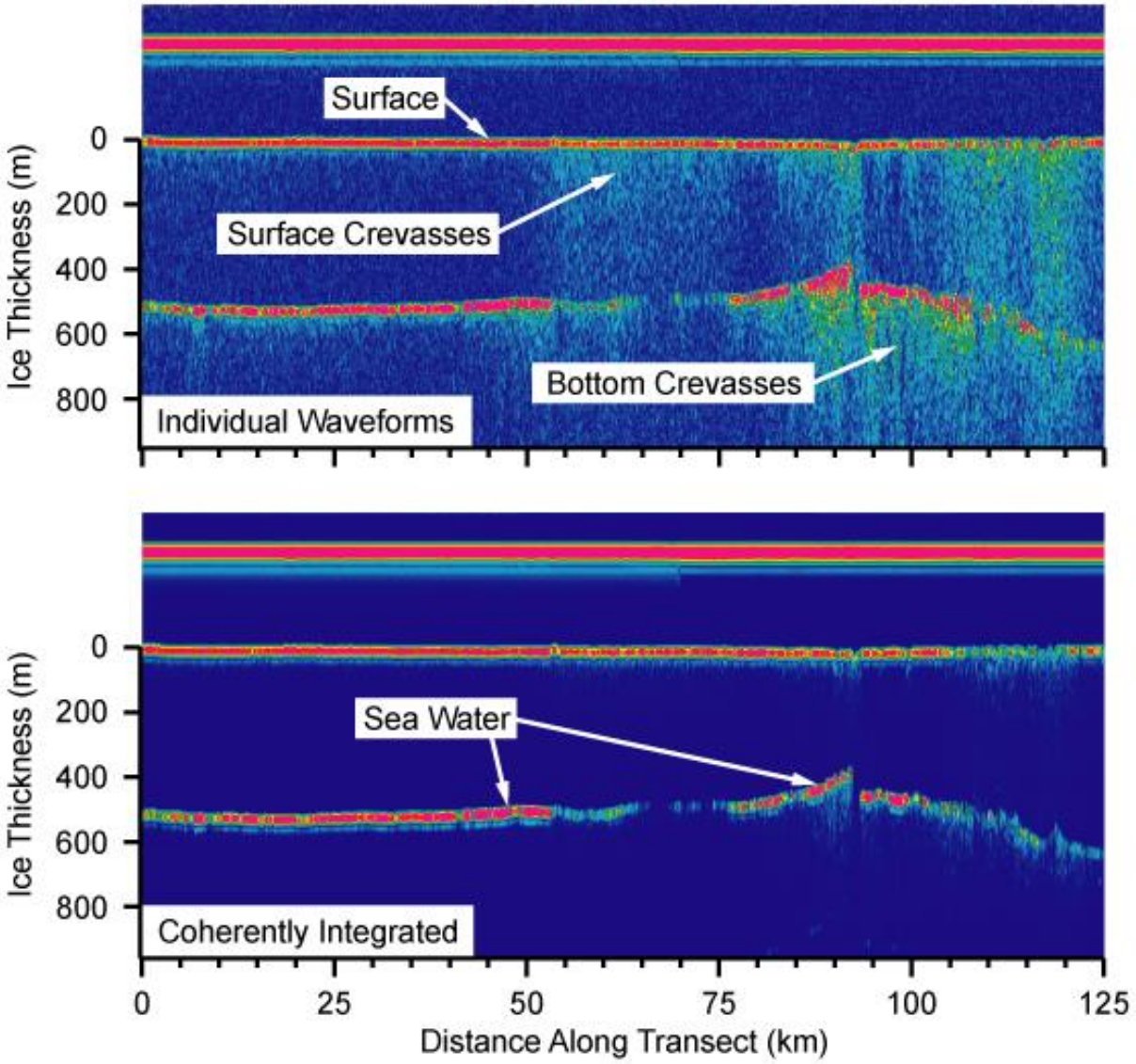
(Arctic Environmental Atlas, UNEP)

Europa has complex patterns of warm and cold ice.

Earth's arctic is also thermally complex.

Radar can detect water-filled fractures beneath a thin ice shell





Peters et al., 2005. 2007

Earth: tidal cracking near ice shelf origin

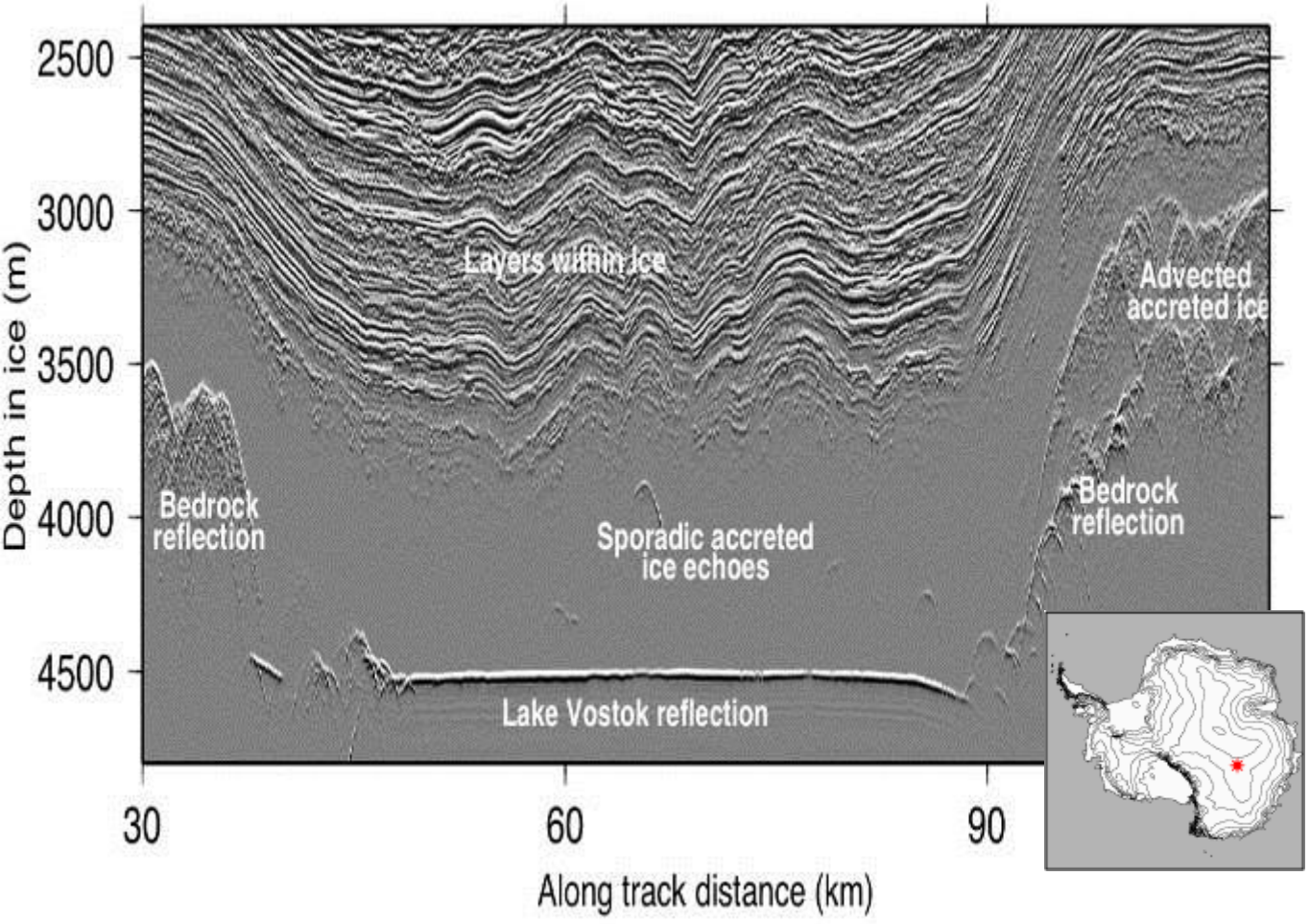
Europa: ridge/band formation and transition

Radar can detect processes beneath an ice shell

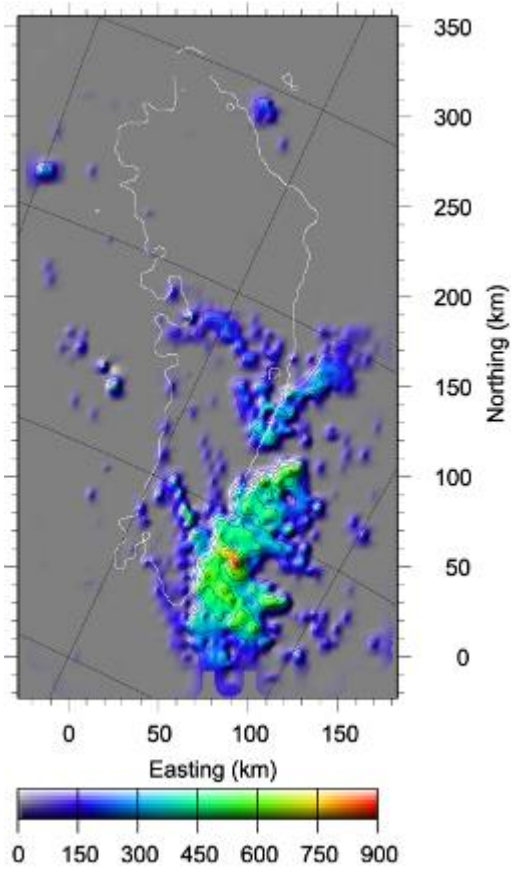
Subglacial Lake Vostok

(Falola and Oliason, 2001; Studinger et al., 2003)

Cross-section



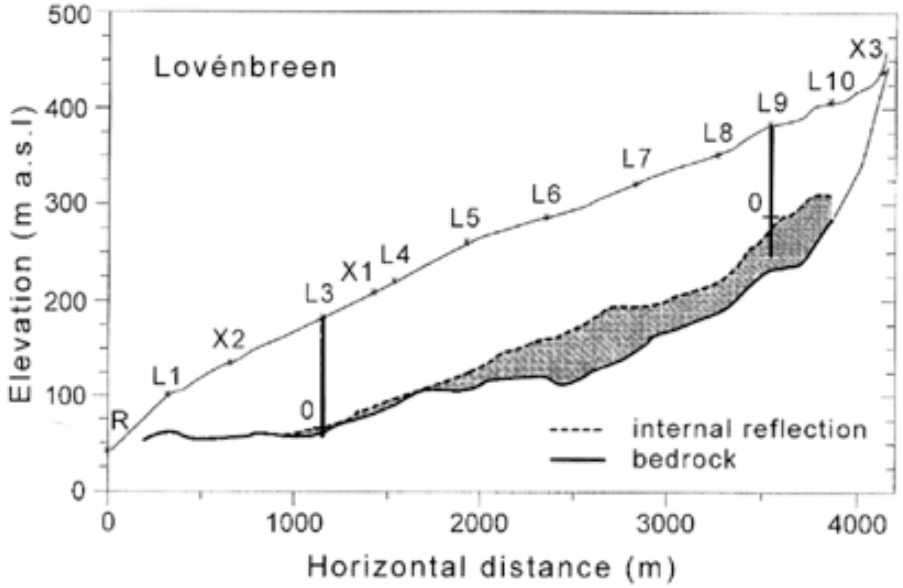
Map of accreted ice

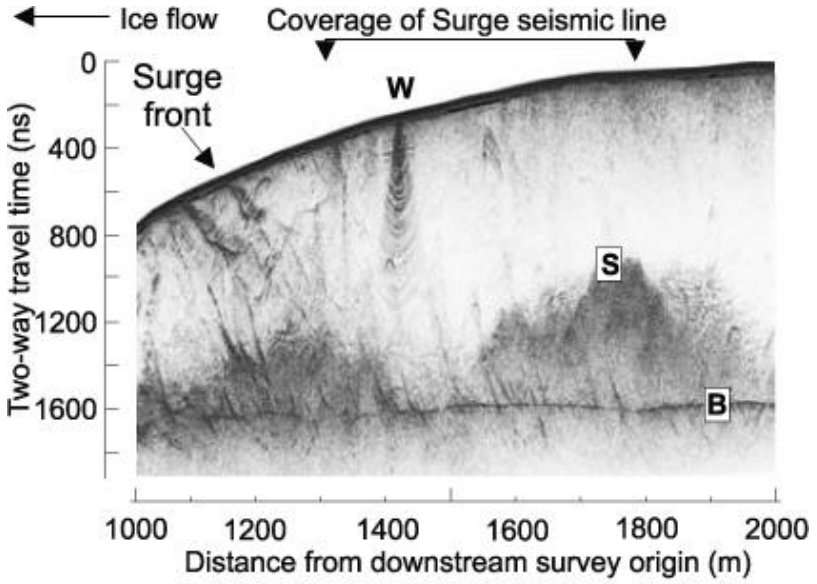


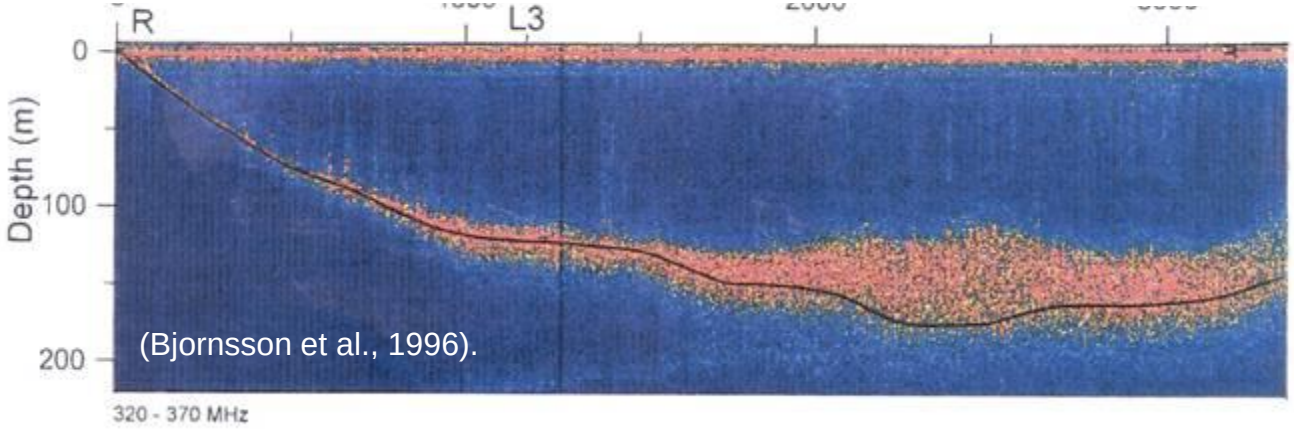
Earth: lake-ice accretion

Europa: rigid shell or ductile layer accretion

Radar can detect water within an ice shell – Arctic Glaciers







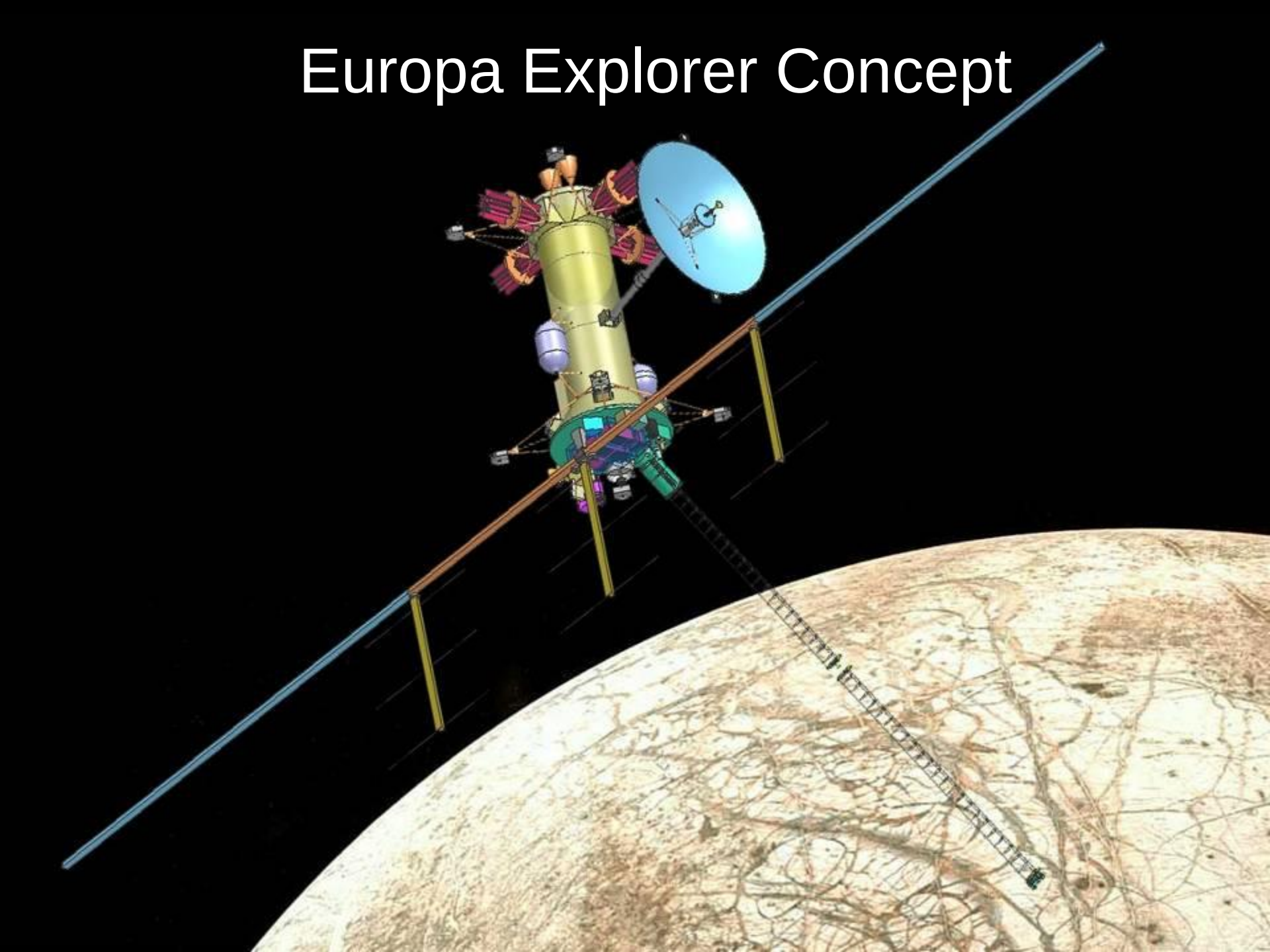
Earth: polythermal glaciers (melt drainage, mobile ice)

Europa: ridged plains + mottled terrain (mobile ice/diapirism)

Studies of ice on Earth will be essential for successful orbital radar sounding of Europa's subsurface

Byrd Glacier, Antarctica

Europa Explorer Concept



Europa Lander

Illustration by Dana Berry for the Science Channel show *Europa: Mystery of the Ice Moon*, Dan Birman producer.

Europa Cryobot

Thank You!

Dr. Donald Blankenship
blank@ig.utexas.edu

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Dr. Donald Blankenship

Dr. Donald D. Blankenship, a research scientist at UT's Institute for Geophysics (UTIG), is are cognized expert on Antarctica's ice sheets. Building on his expertise in radar sounding and ice sheets, Blankenship has become involved in the planning of an unmanned space mission to Europa, one of Jupiter's moons, which is thought to have an ice-covered ocean that may host exotic life. He has served on several definition teams for NASA's Europa Orbiter Mission. Blankenship has been actively involved in outreach to the public about his work, including interviews with the New York Times and National Public Radio. He received his Ph.D. from the University of Wisconsin- Madison in 1989 and has been with UTIG since 1991.