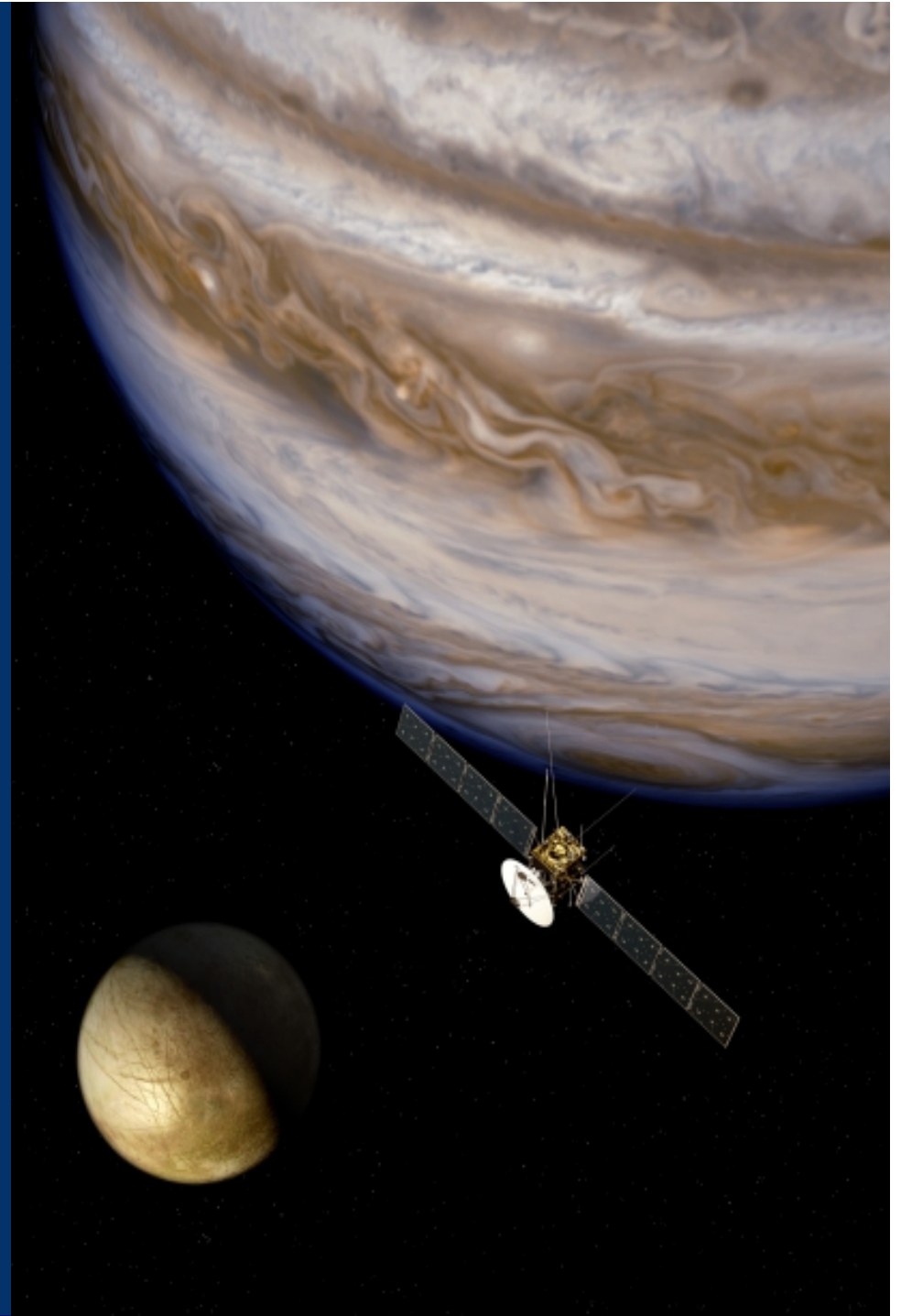


JUICE
Radar for Icy Moon Exploration
(RIME)

Jeffrey J. Plaut (Co-PI)
Jet Propulsion Laboratory

Lorenzo Bruzzone (PI)
University of Trento, Italy

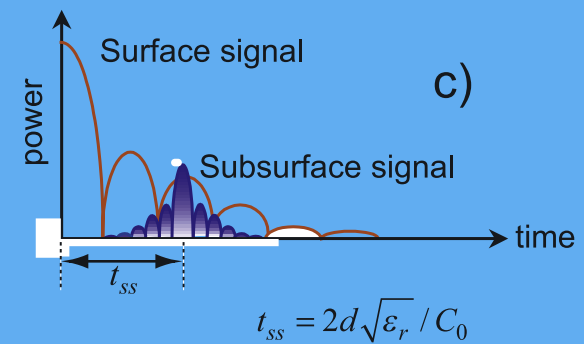
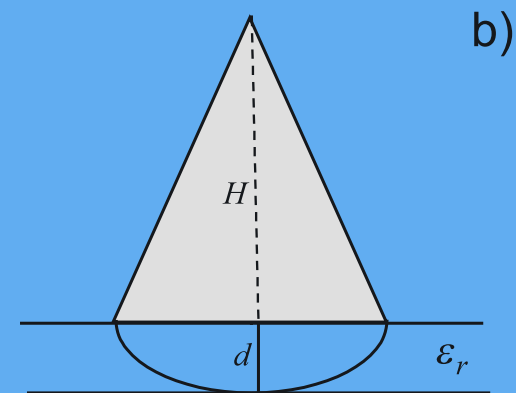
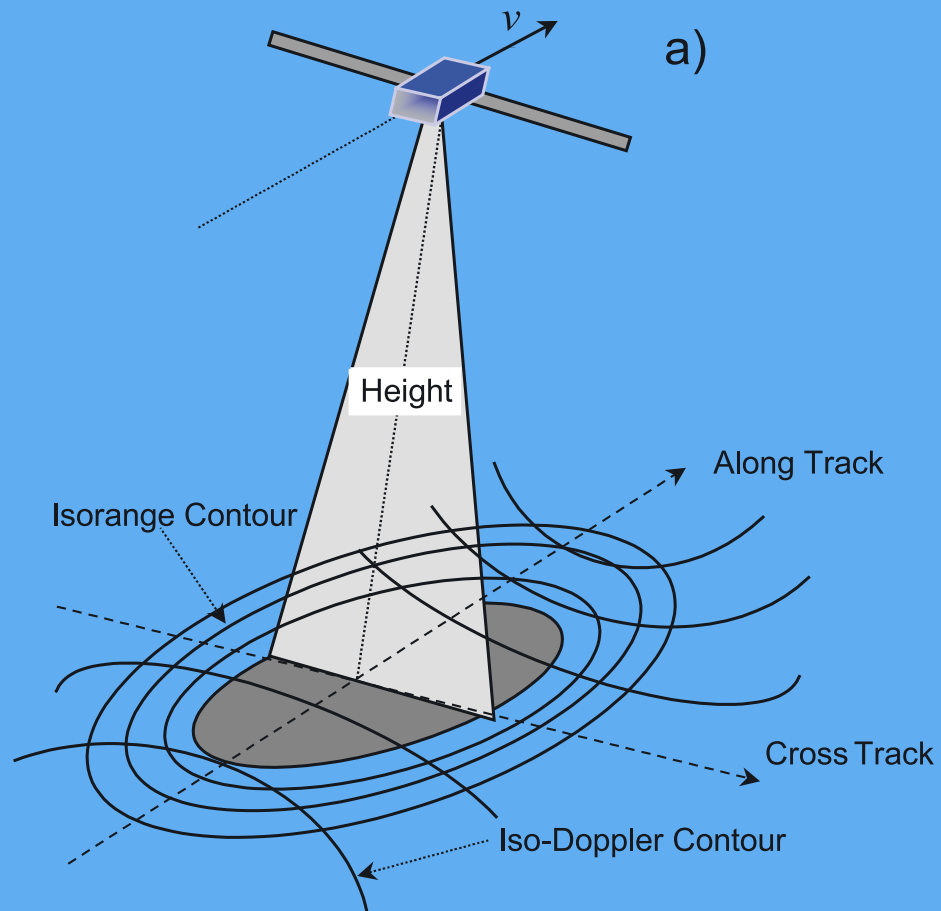


RIME: US/NASA/JPL Role

NASA is contributing to the following areas:

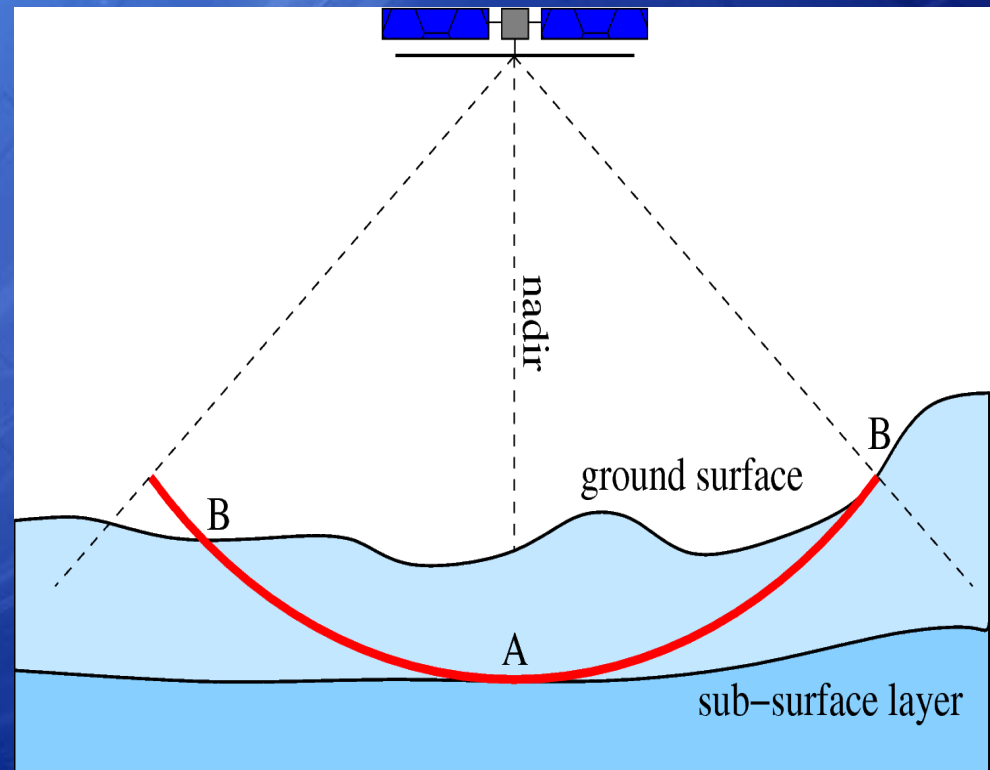
- ✓ Science (Co-PI and Co-Is)
- ✓ System Engineering
- ✓ Radio Frequency (RF) Subsystem
 - Receiver will be designed and built in-house at JPL
 - Transmitter and associated electronics as a subcontract to University of Iowa
- ✓ Mission Assurance

Orbital Subsurface Sounding



Surface Roughness and Clutter

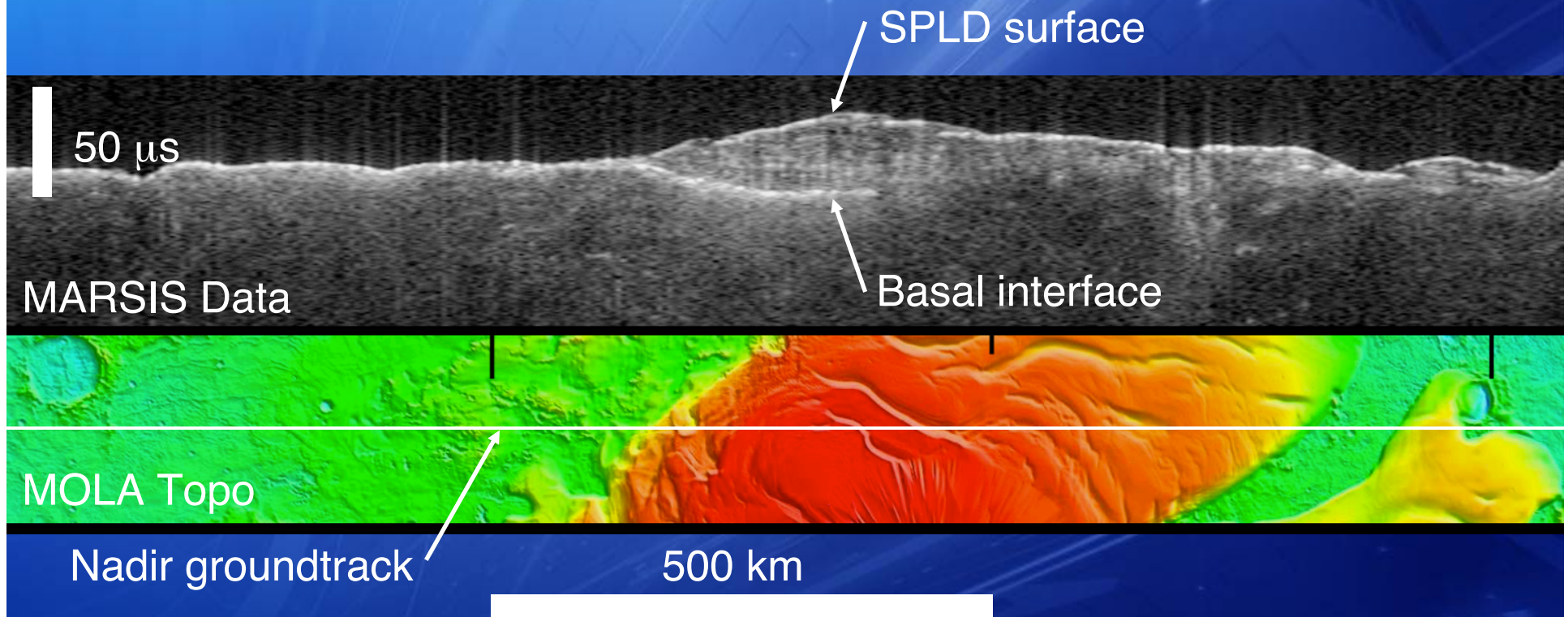
- ✓ Surface clutter is generated by off-nadir echoes caused by surface topography and roughness.
- ✓ High values of surface roughness can degrade the quality of the sounding data:
 - Introduction of surface clutter from large facets off-nadir.
 - Loss of the coherency during passage of the wave across the rough surface



RIME: Heritage

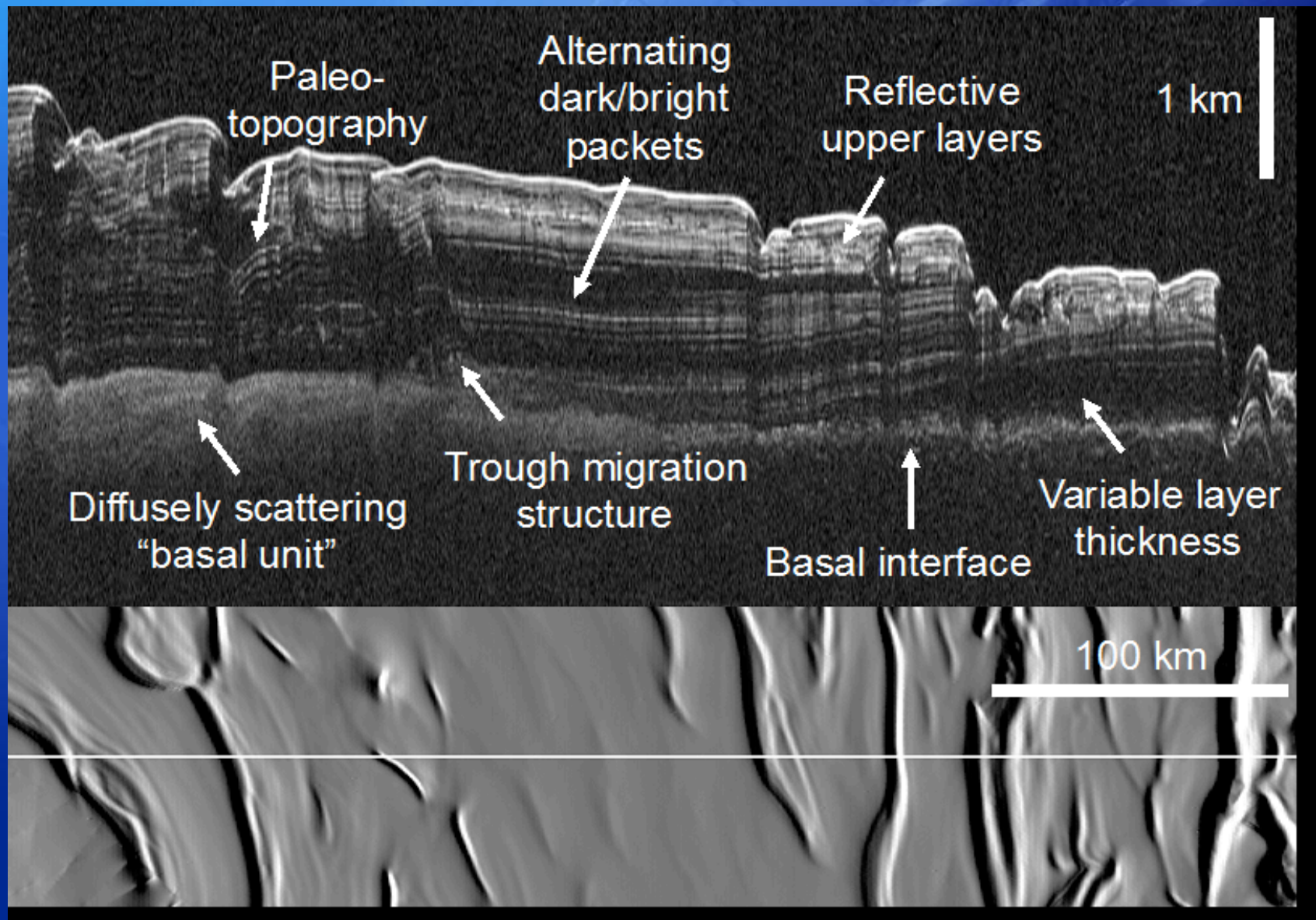
- ✓ RIME is based on a solid heritage from successful radar sounders operating at Mars:
 - Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) on-board ESA's Mars Express S/C.
 - SHAlow RADar (SHARAD) on-board NASA's Mars Reconnaissance Orbiter.
- ✓ Many of the members of the RIME team have been involved with MARSIS and/or SHARAD.

MARSIS Radargram South Polar Layered Deposits (SPLD)



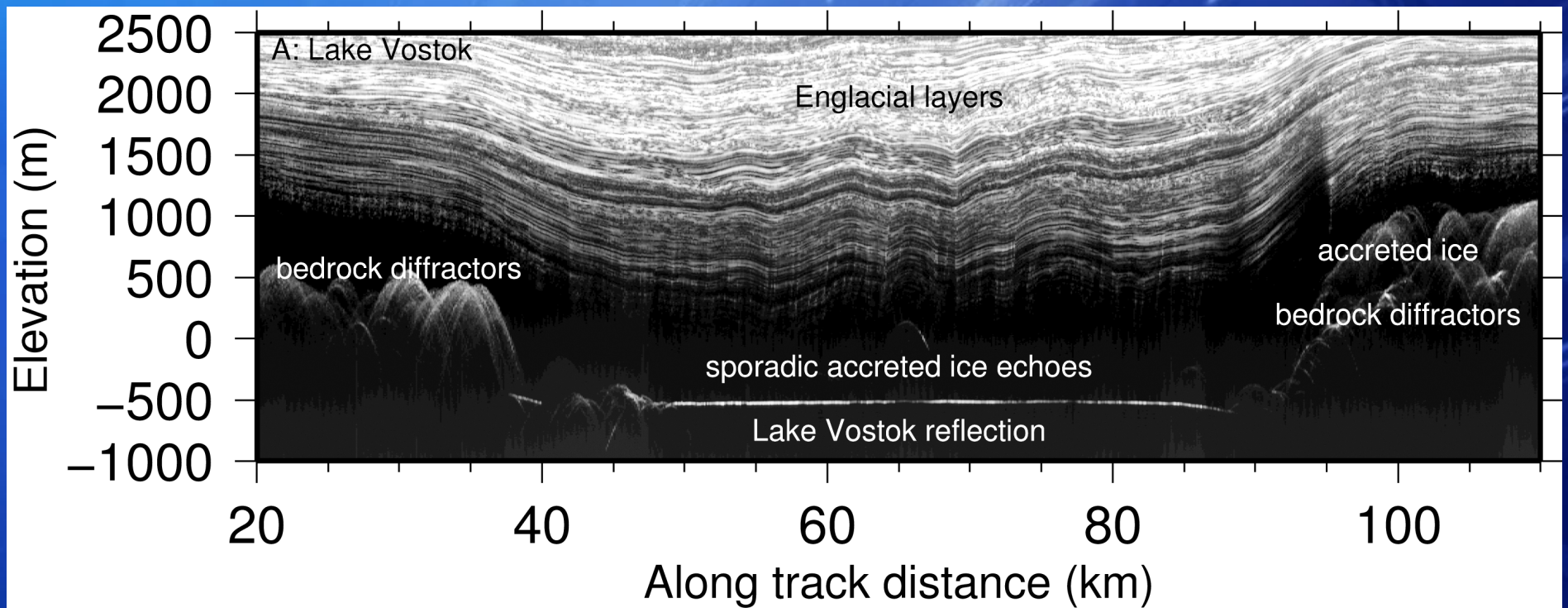
- Base of SPLD detected at thickest point: 3.7 km depth.
- Low loss / strong reflection indicate greater penetration is possible.

SHARAD Mars North Polar Deposits



Earth Example

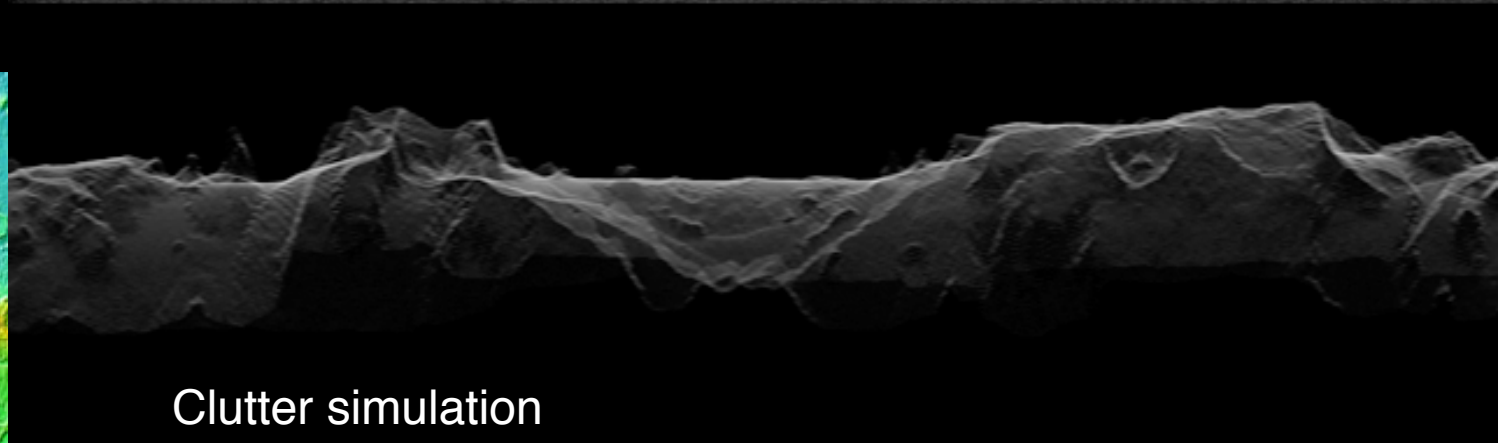
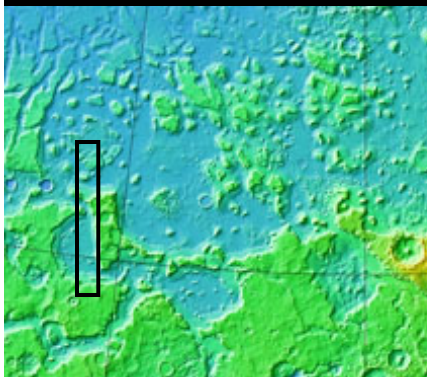
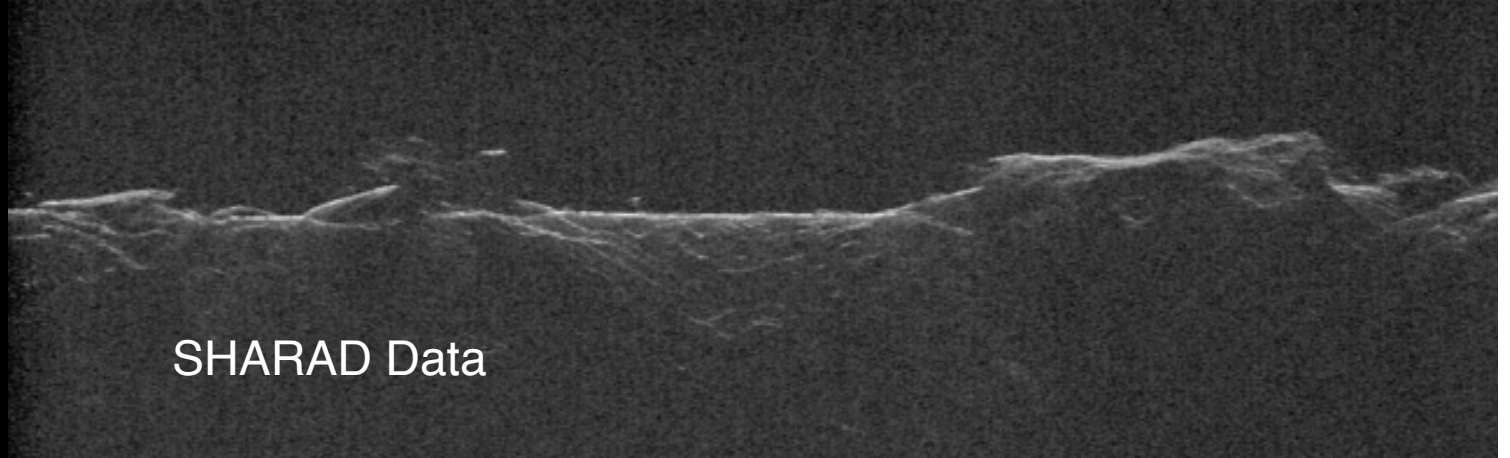
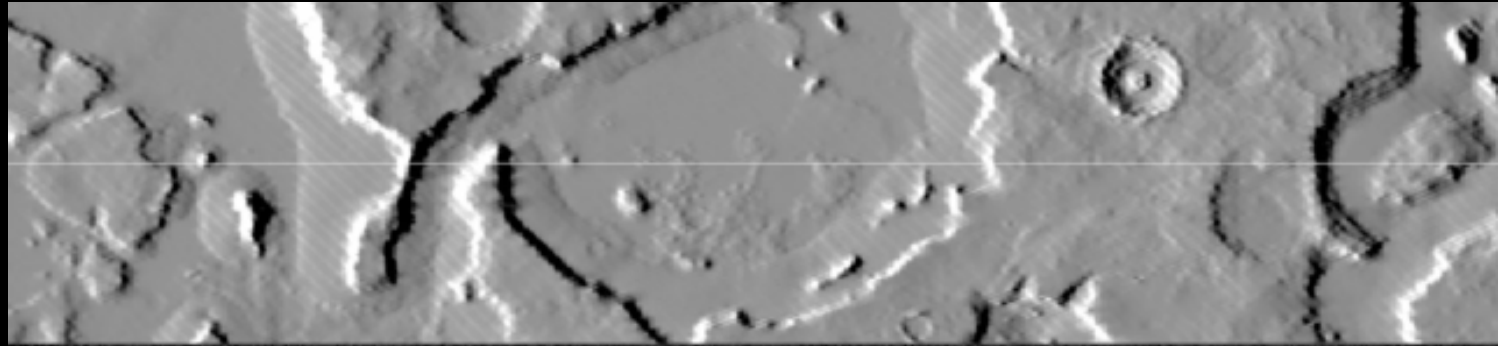
Water Interface – Lake Vostok

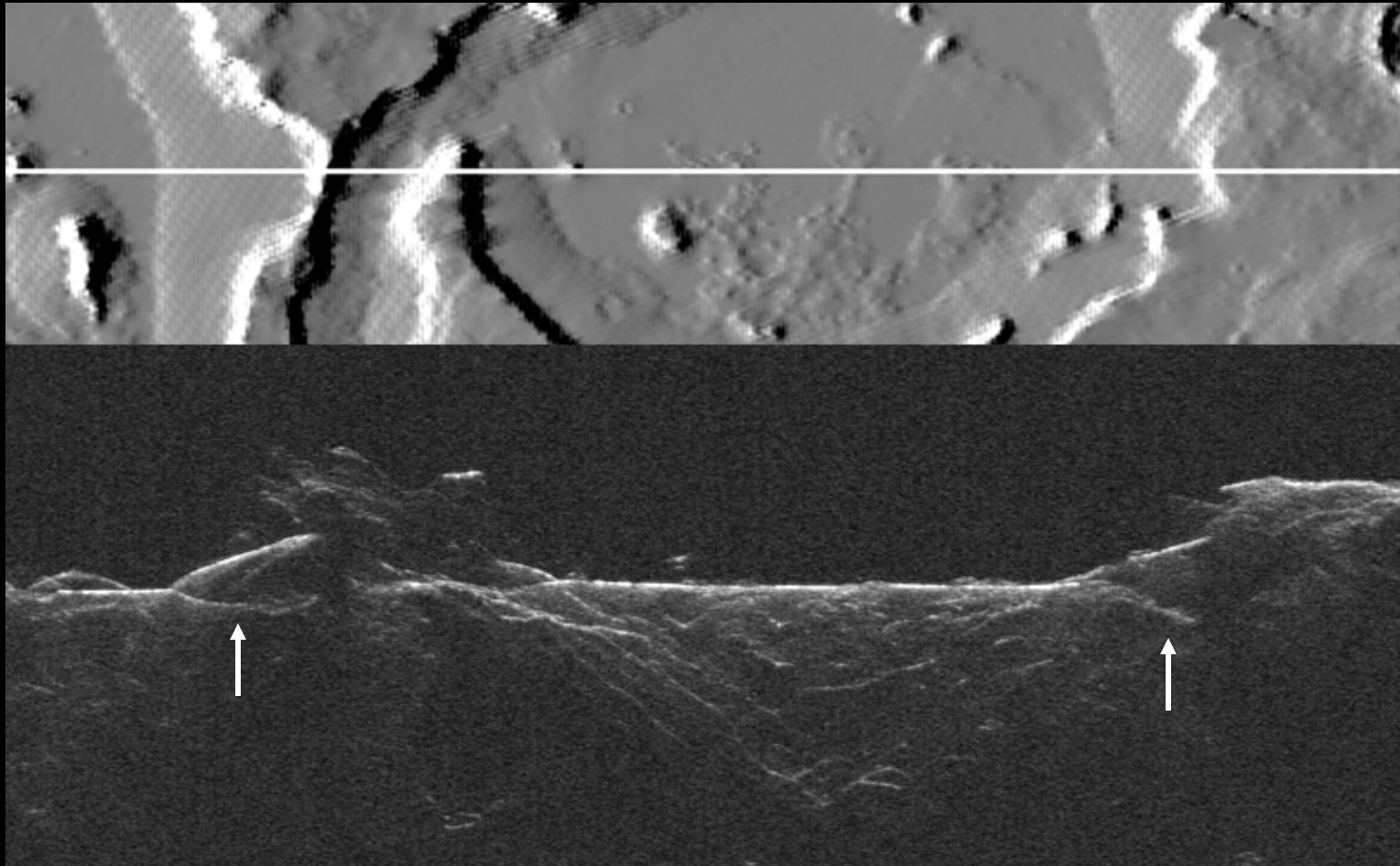


60 MHz Univ. of Texas Institute of Geophysics HiCARS radar

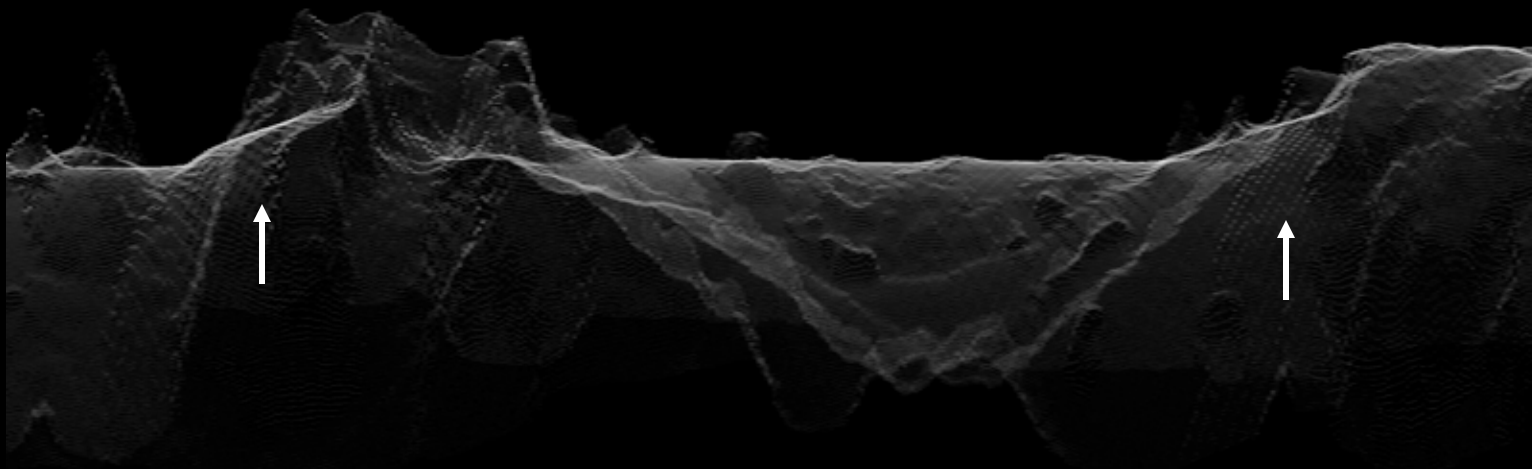
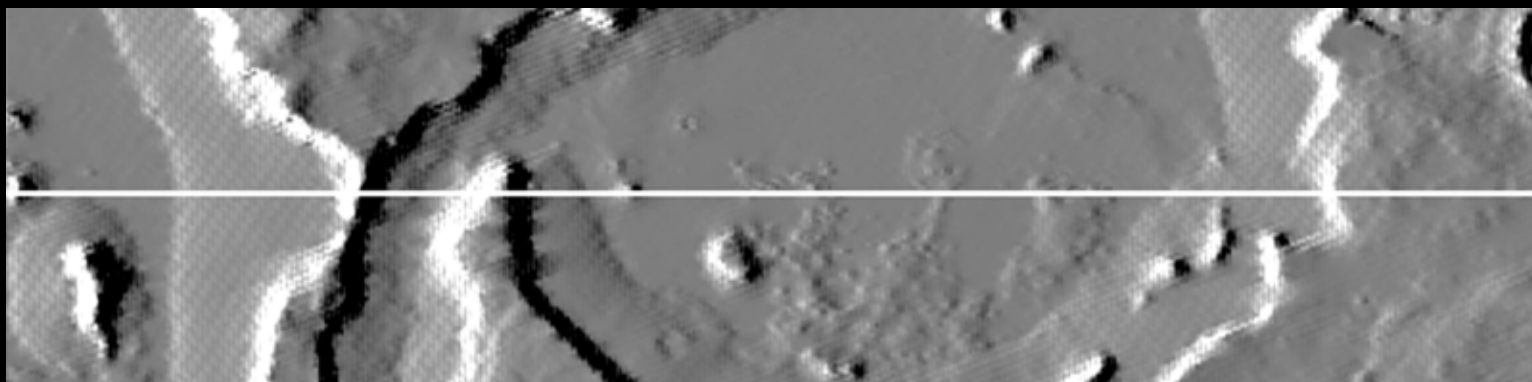
SHARAD: Ice-rich lobate aprons

Distinguishing subsurface from clutter echoes





SHARAD Data

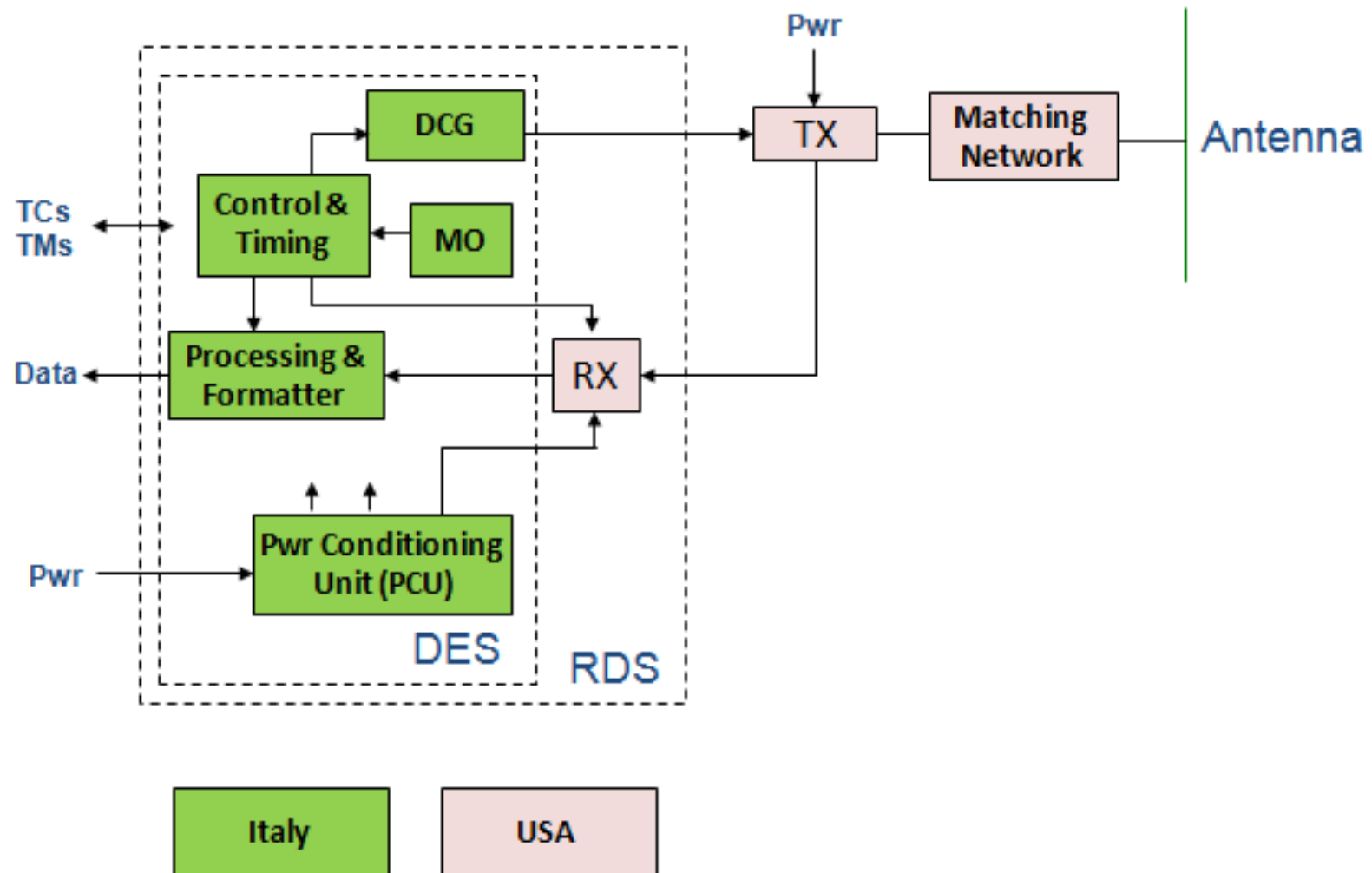


Clutter simulation

RIME: Instrument Data-Sheet

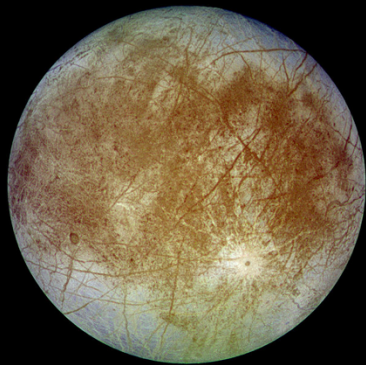
Main Instrument Parameter	Parameter Values
Transmitted central frequency (MHz)	9
Antenna type	Dipole
Optimal antenna length (m)	16 m baseline (other lengths TBC)
Peak radiated power (W)	10
Stand-by power with cont. (W)	13.3
Avg. power during sounding with cont. (W)	25.1
Peak power (W)	25.1
Penetration depth (km)	As deep as 9
Chirp length (μ s)	50 - 100
Vertical resolution in ice (m)	30 - 90
Cross-track resolution (km)	2 - 10
Along-track resolution (km)	0.3 - 1.0
Instrument modes	Off, Initialisation, Stand-by, Safe, Measurement
Operative modes	Calibration, Raw data, On-board processing

RIME: Block Diagram

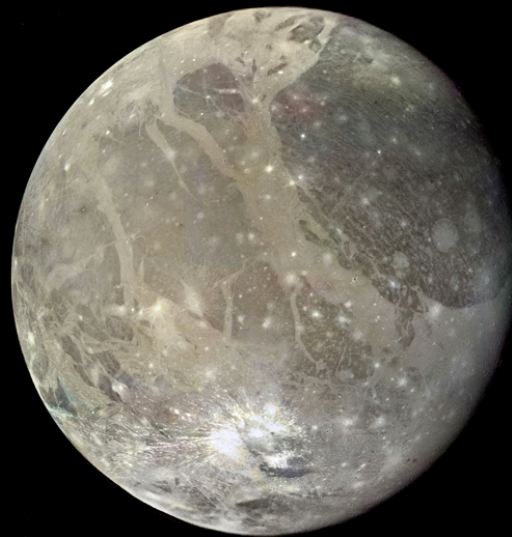


JUICE: Scientific Objectives for Icy Satellites

1. Characterize Ganymede as a planetary object and possible habitat.
2. Explore Europa's recently active zones.
3. Study Callisto as a remnant of the early Jovian system.



Europa



Ganymede

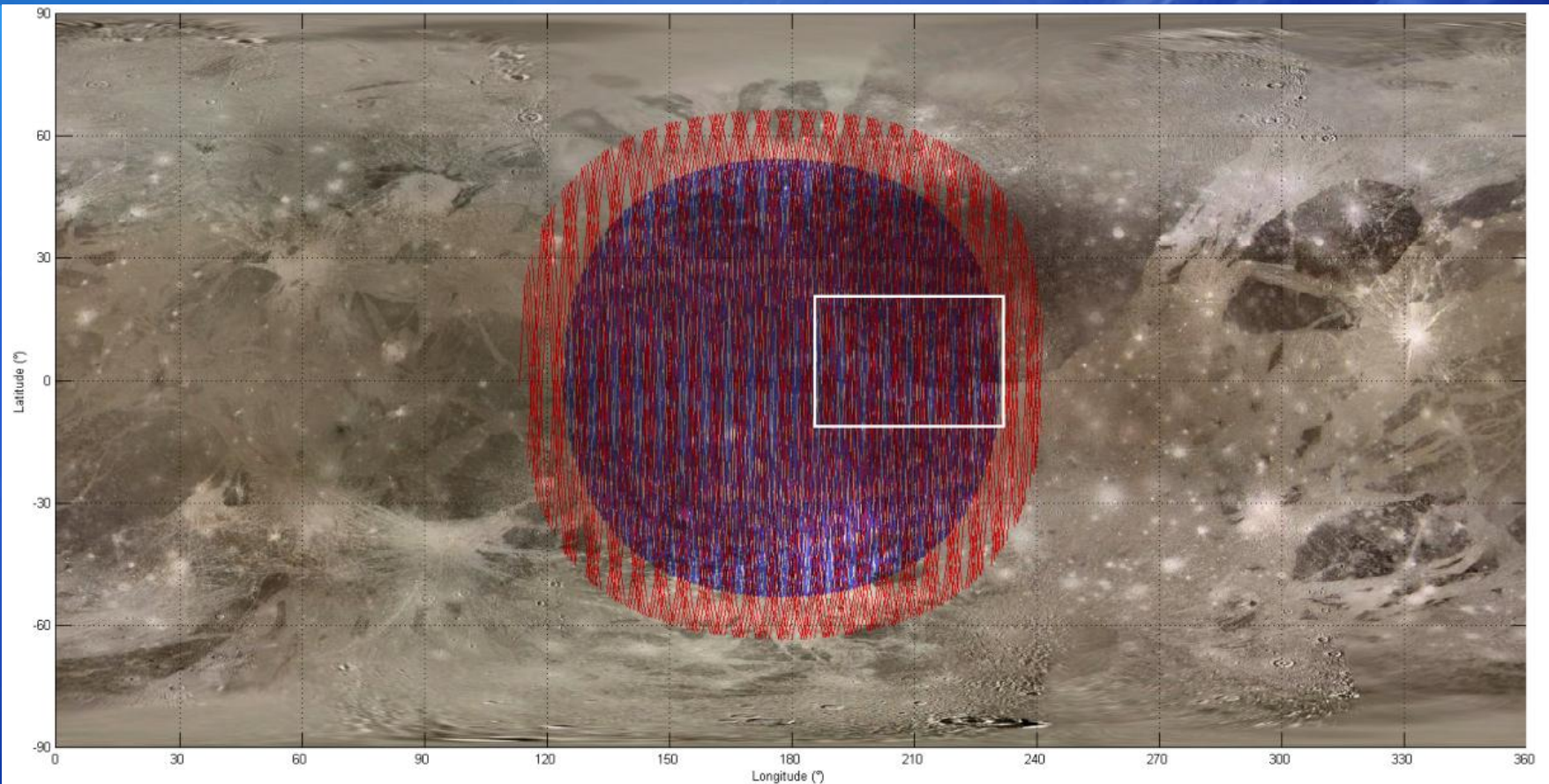


Callisto

JUICE: Scientific Objectives for Icy Satellites

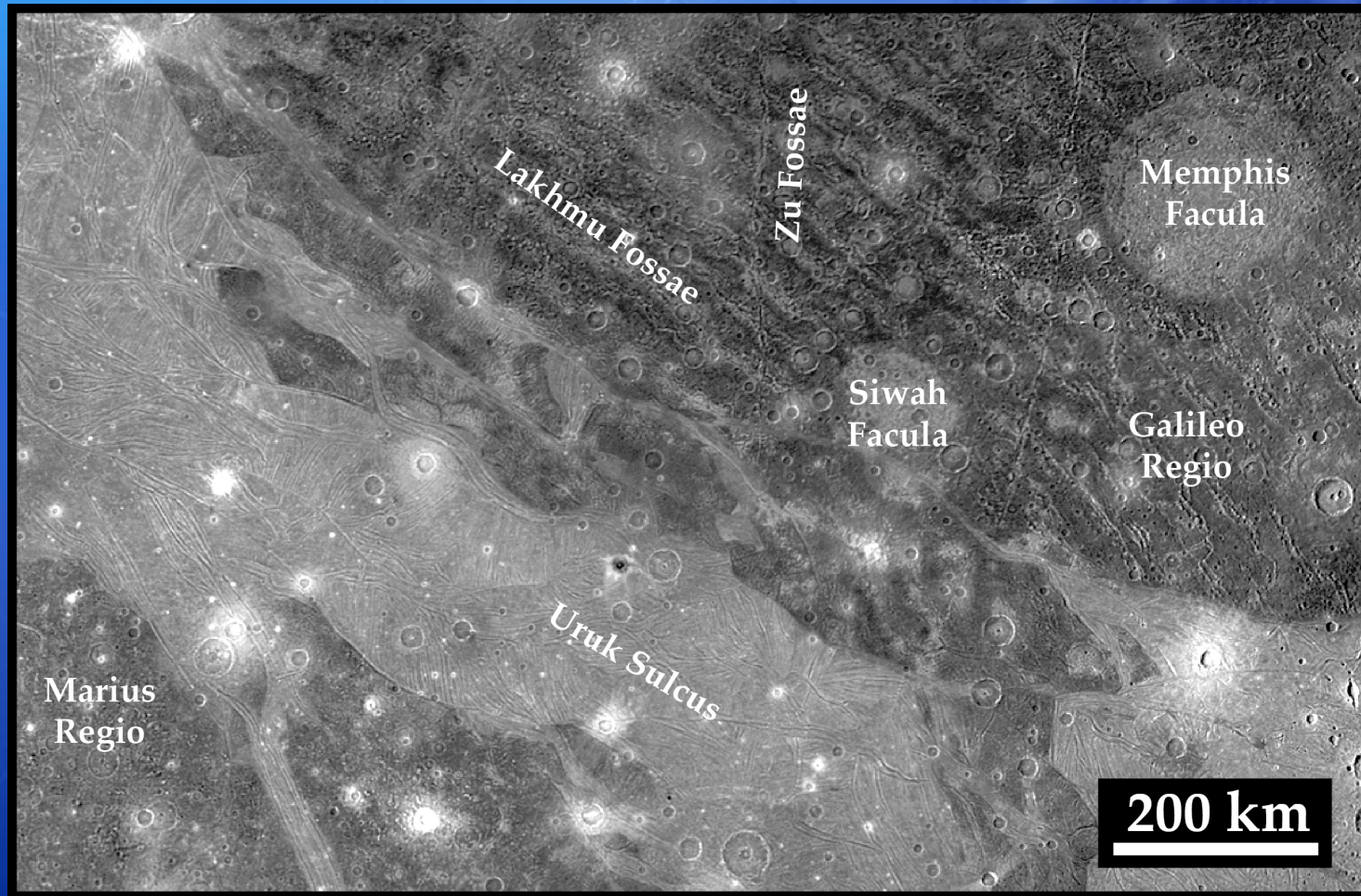
1. Characterize Ganymede as a planetary object and possible habitat
 - a. Characterize the ice shell (GB)
 - b. Formation of surface features and search for past and present activity (GD)
 - c. Global composition, distribution, evolution of surface materials (GE)
2. Explore Europa's recently active zones
 - a. Determine the composition of the non-ice material, especially as related to habitability (EA)
 - b. Look for liquid water under the most active sites (EB)
3. Study Callisto as a remnant of the early Jovian system
 - a. Characterize the outer shells, including the ocean (CA)
 - b. Determine the composition of the non-ice material (CB)
 - c. Study the past activity (CC)

Characterize Ganymede as a Planetary Object and Possible Habitat



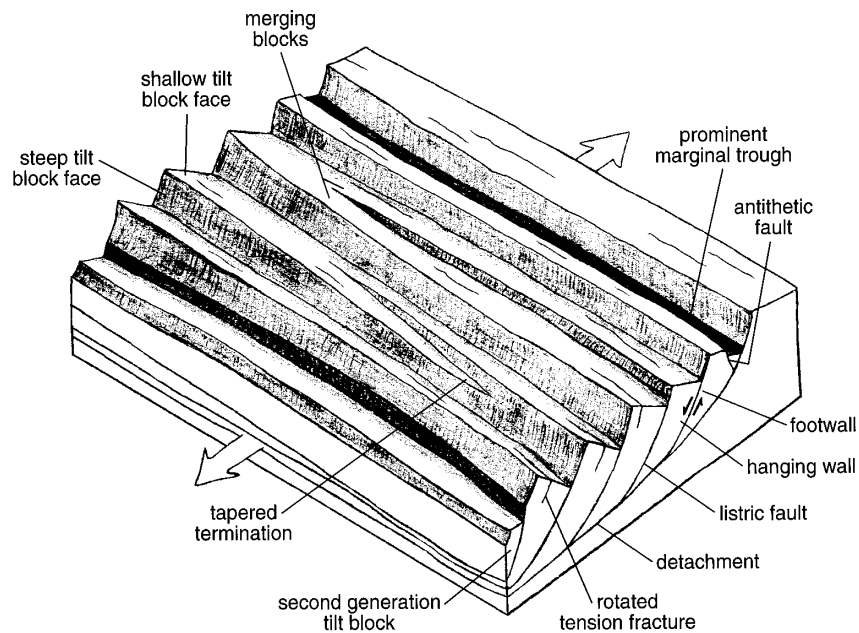
- ✓ JUICE ground tracks on Ganymede during which the spacecraft is completely screened from Jovian radio emission.
- ✓ Ground tracks for the 500 km orbit phase are shown in blue, and those for the 200 km orbit are shown in red

Characterize Ganymede as a Planetary Object and Possible Habitat

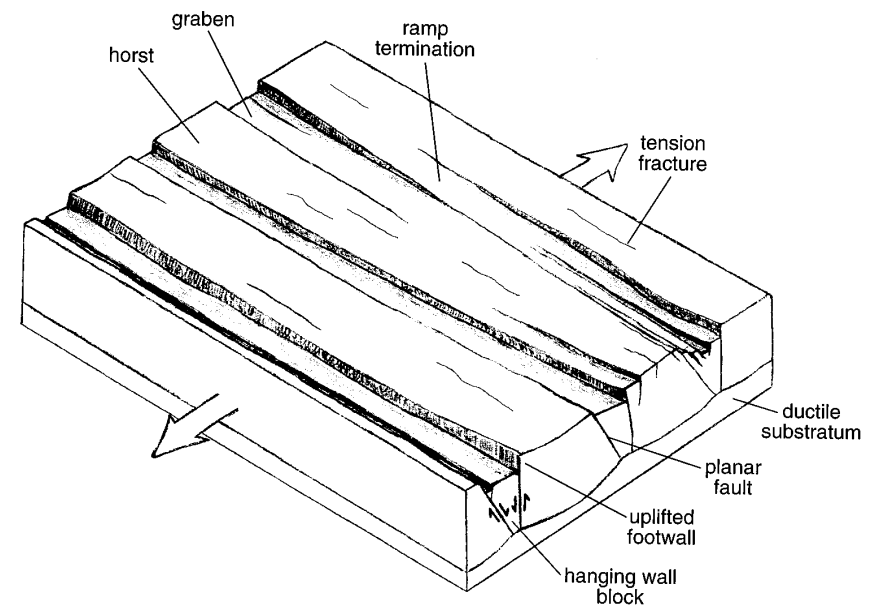


- ✓ While the region accessible to RIME observations is less than 50% of Ganymede's surface, it contains all the major terrain types.

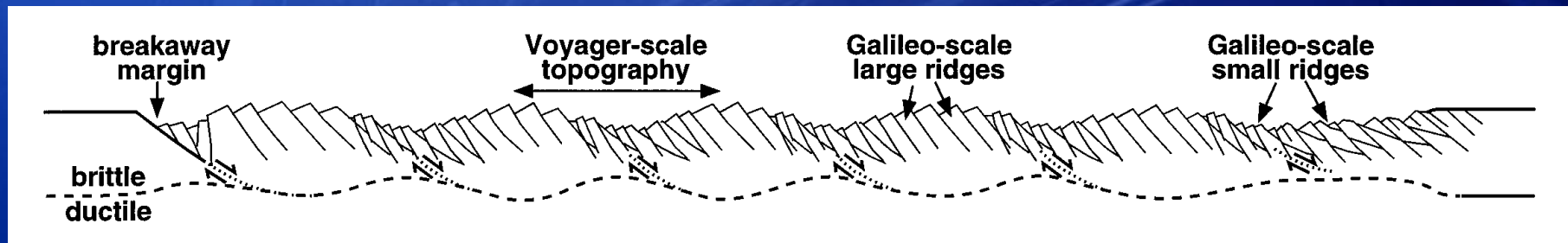
Characterize Ganymede as a Planetary Object and Possible Habitat



tilt-block-style normal faulting



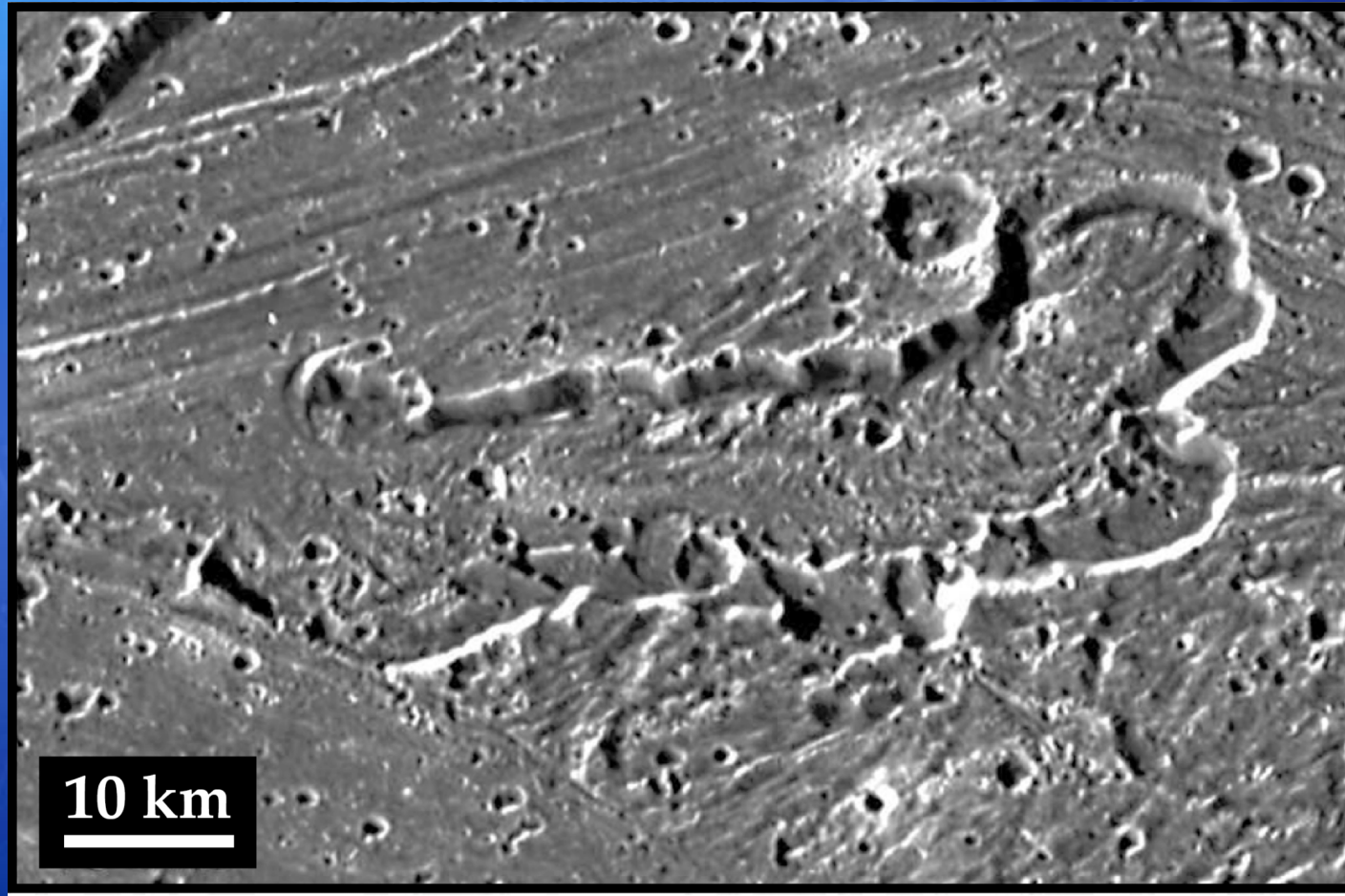
tilt-block-style normal faulting



possible fault geometry of parallel ridged terrain in Uruk Sulcus
Pappalardo et al. (1998)

Characterize Ganymede as a Planetary Object and Possible Habitat

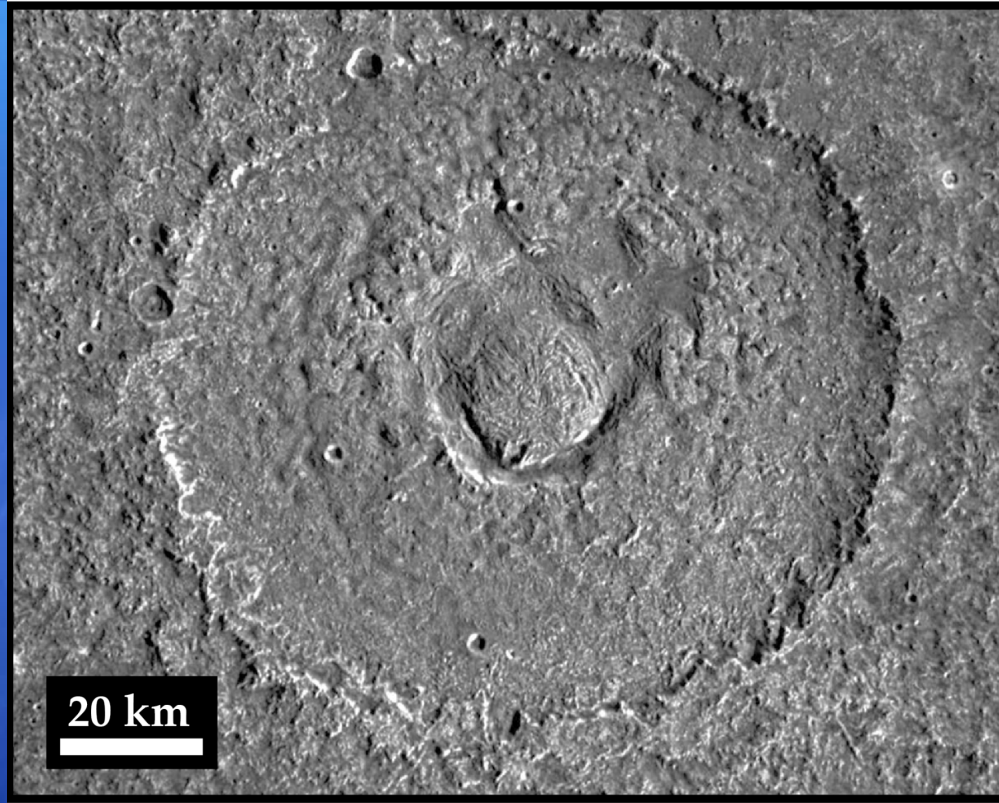
**Patera in
Sippar Sulcus**



- ✓ RIME will constrain the nature of paterae by looking for compositional interfaces or absorption characteristic of subsurface cryomagmatic reservoirs.

Characterize Ganymede as a Planetary Object and Possible Habitat

**Central dome
crater Melkart**



- ✓ Possible formation mechanisms: refrozen impact melt, post-impact diapirism, or rapid uplift of deep material during impact.
- ✓ RIME will differentiate between these hypotheses by searching for compositional interfaces produced by melt with differing subsurface geometries (blanketed material vs plume shaped) and/or deflected upward during post-impact uplift and relaxation.

Explore Europa's Recently Active Zones

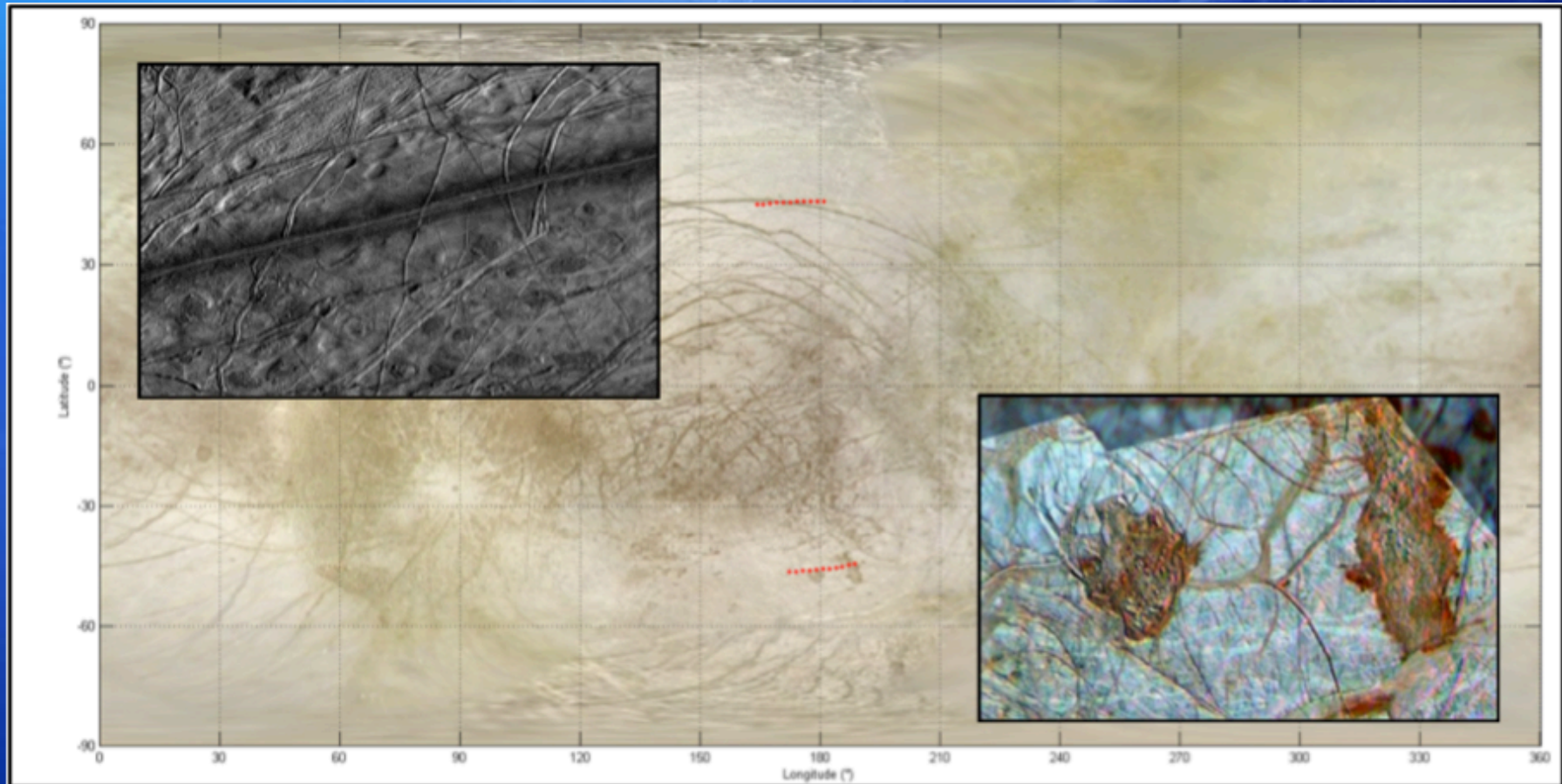
2.a. Determine the composition of the non-ice material, especially as related to habitability (EA)

- ✓ Relating the distribution of non-ice material to geological features and processes, especially material exchange with the interior.

2.b. Look for liquid water under the most active sites (EB)

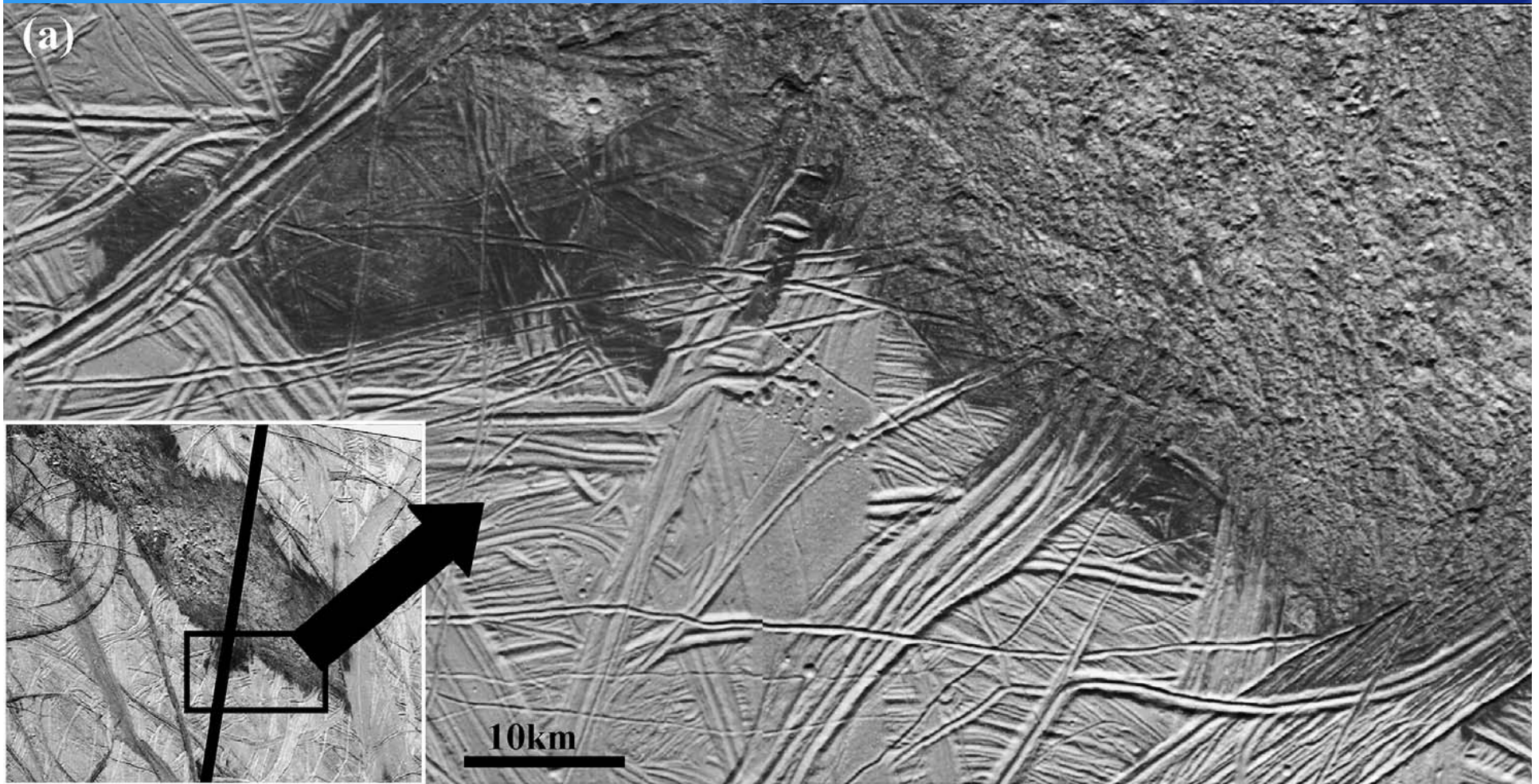
- ✓ Exploring the icy crust below young and resurfaced areas to look for water reservoirs.
- ✓ Determining the minimal thickness of the icy crust on the most active regions.
- ✓ Searching for possible active regions on the surface of Europa-

Explore Europa's Recently Active Zones



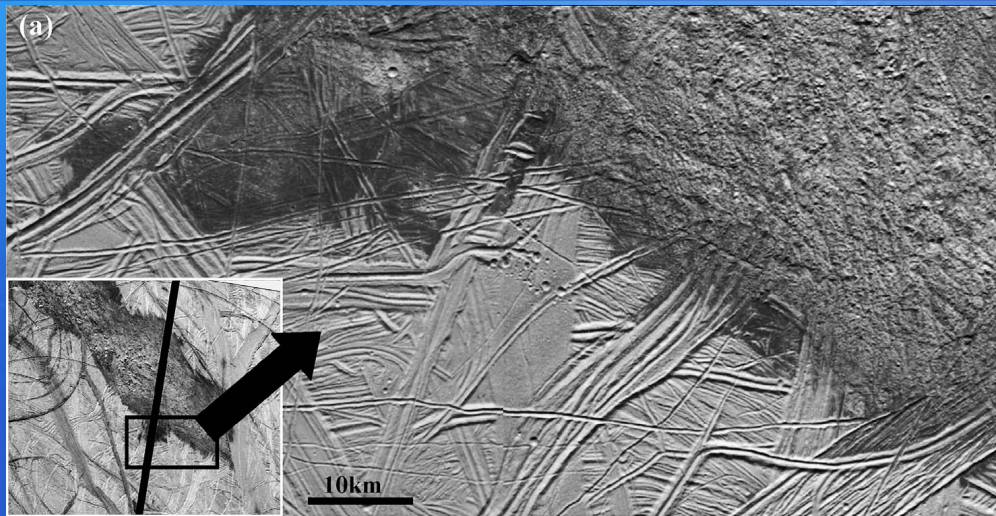
✓ JUICE flybys of Europa will target Thrace and Thera Macula and Minos Linea.

Thrace Macula

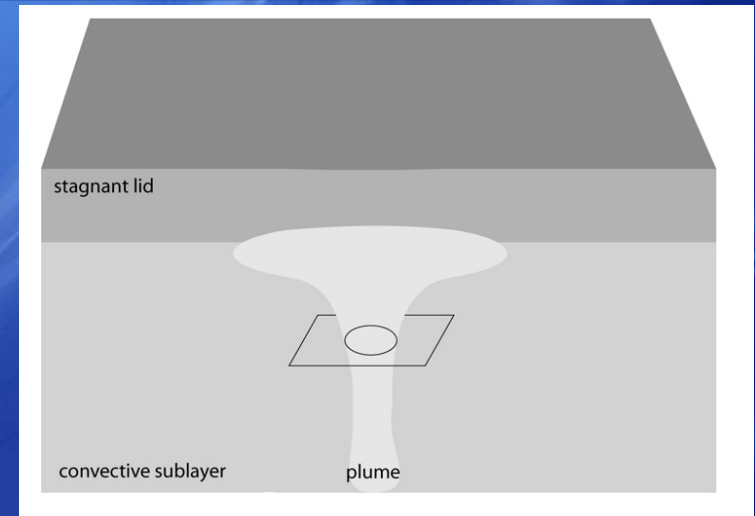


Miyamoto, Mitri et al. (2005)

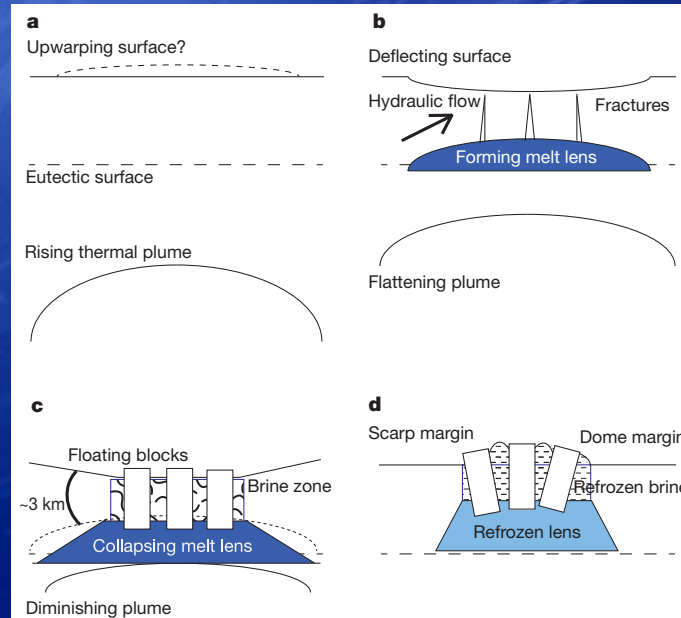
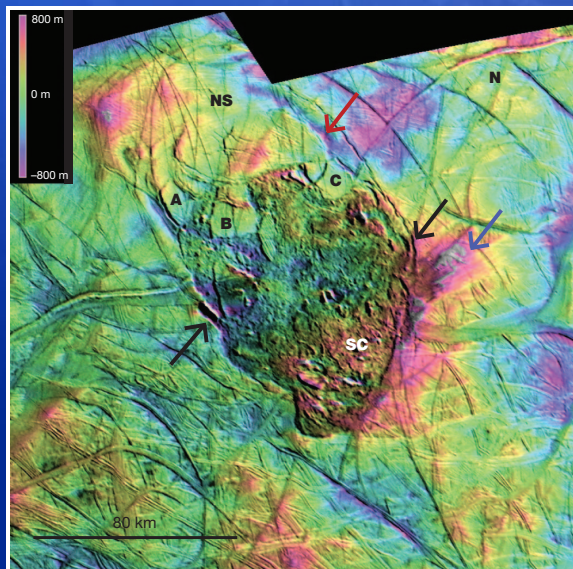
Thera and Thrace Macula



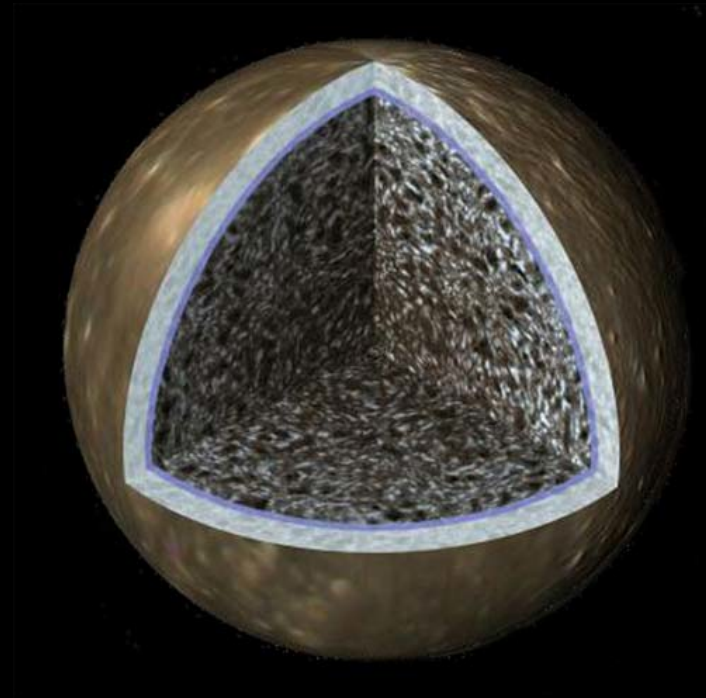
Schmidt et al. 2011



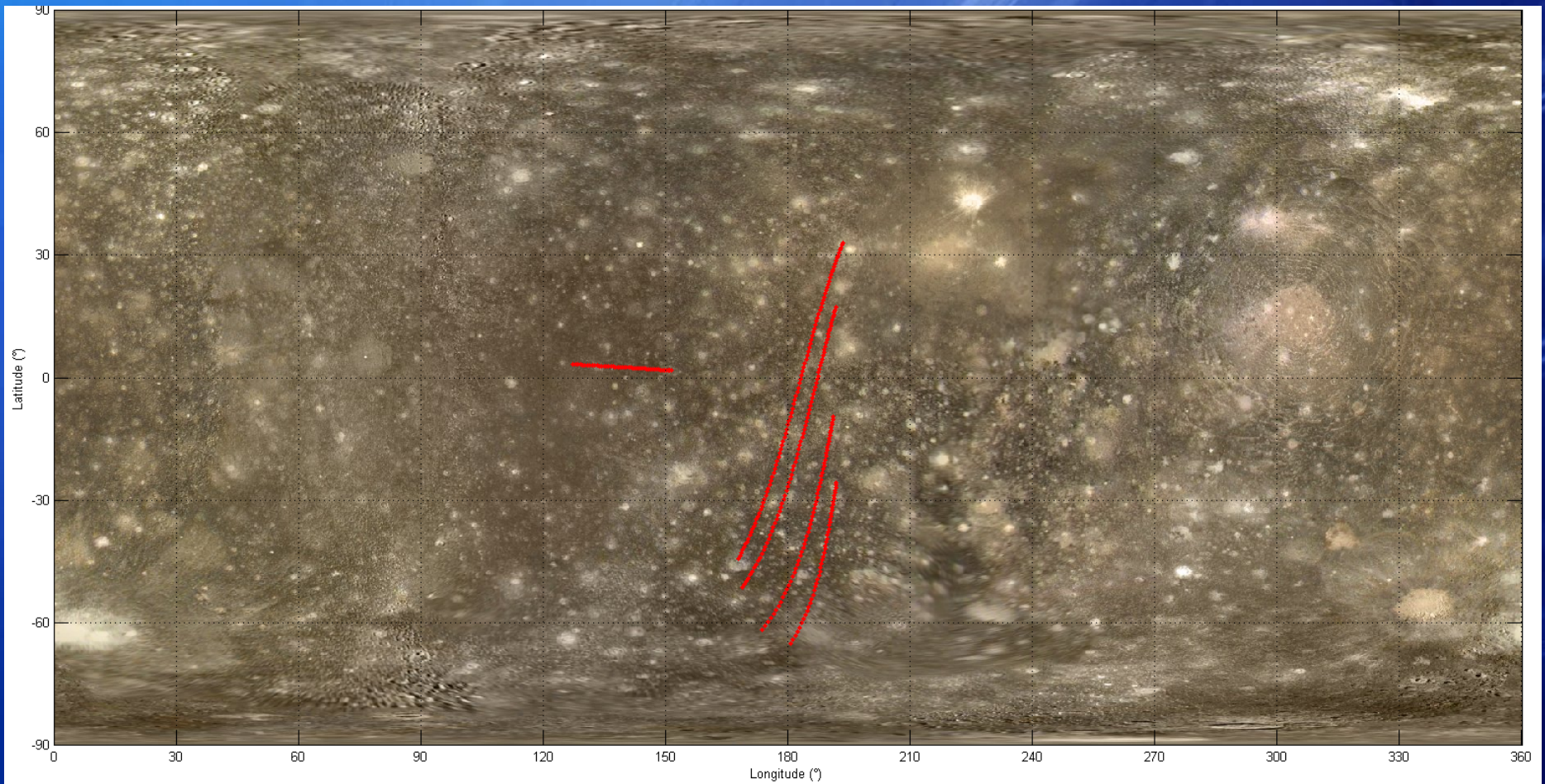
Mitri and Showman (2008)



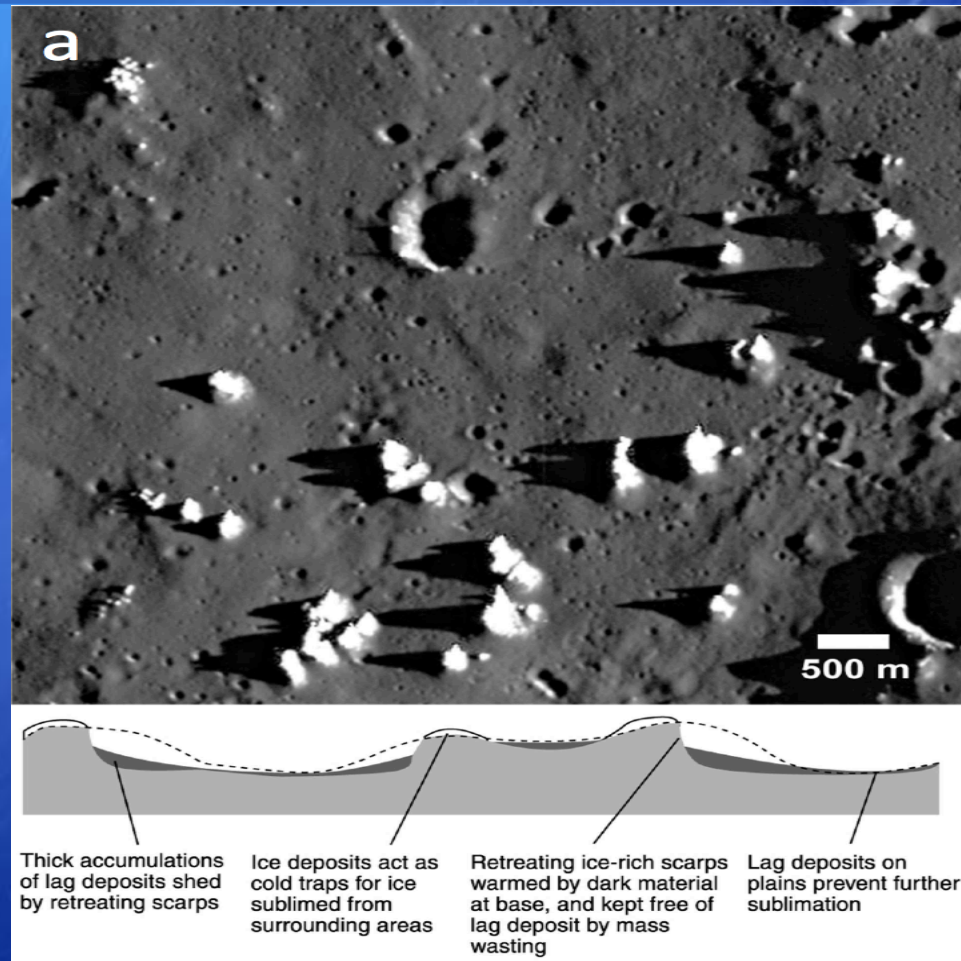
Study Callisto as a Remnant of the Early Jovian System



Coverage at Callisto



Study Callisto as a Remnant of the Early Jovian System



- ✓ Mass wasted Callisto terrain, with illustration of regolith/sublimation-lag formation.
- ✓ RIME will determine the thickness of these deposits and characterize the transition to “intact” crust below.