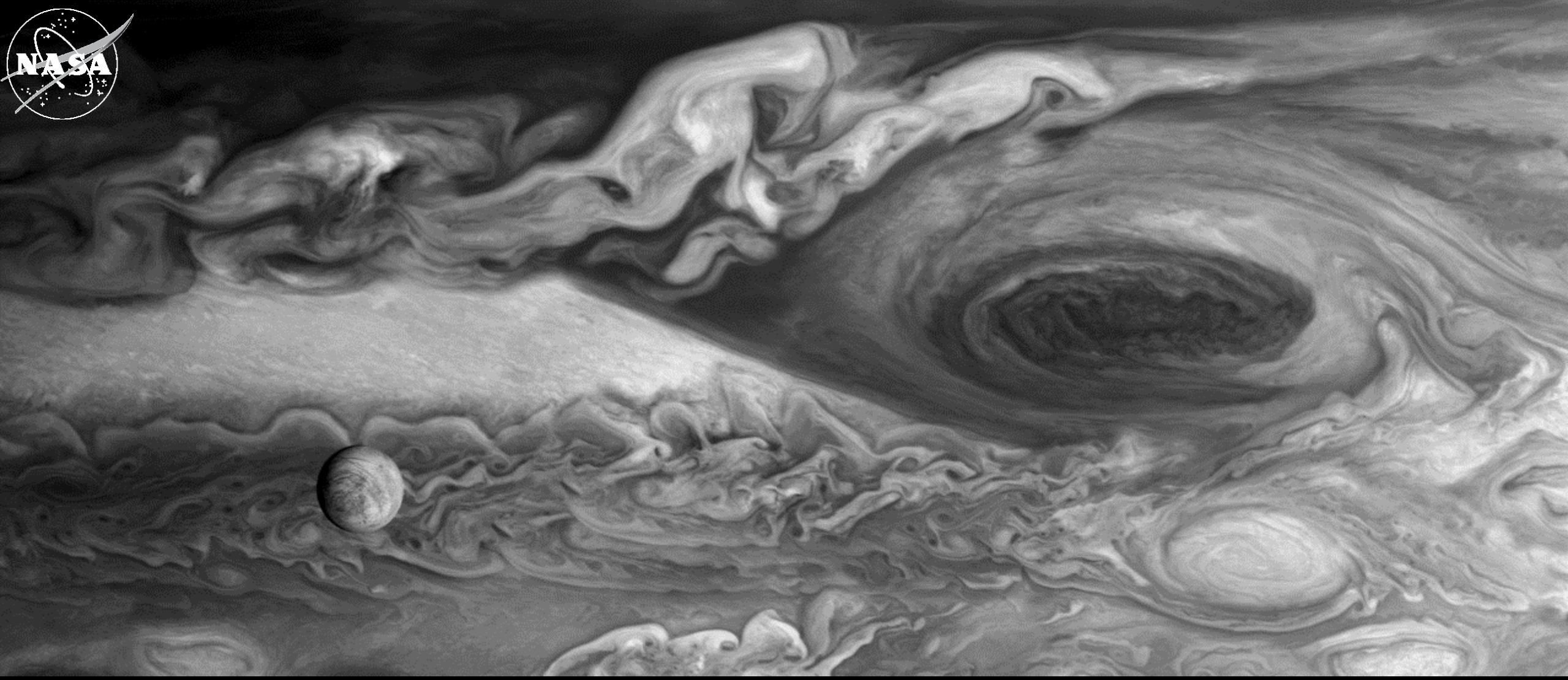

Europa and possible exploration missions

Jason Kastner
Jet Propulsion Laboratory, California Institute of Technology

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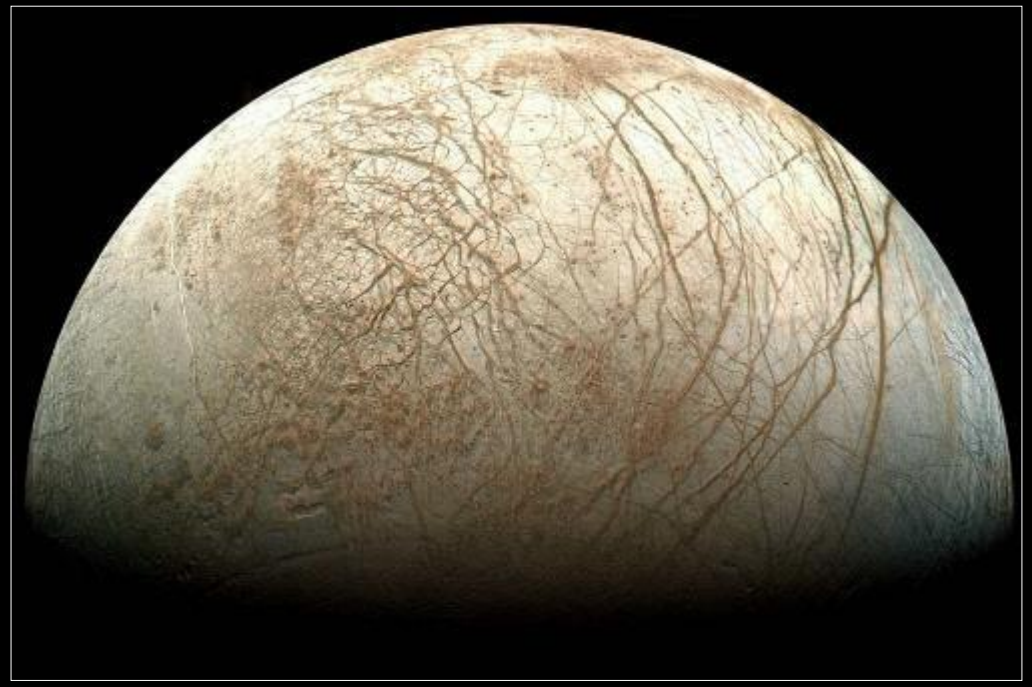
Three Topics for Today

1. Europa: Understanding the Potential for Habitability
2. Europa Clipper Spacecraft
3. Europa Lander Possibilities

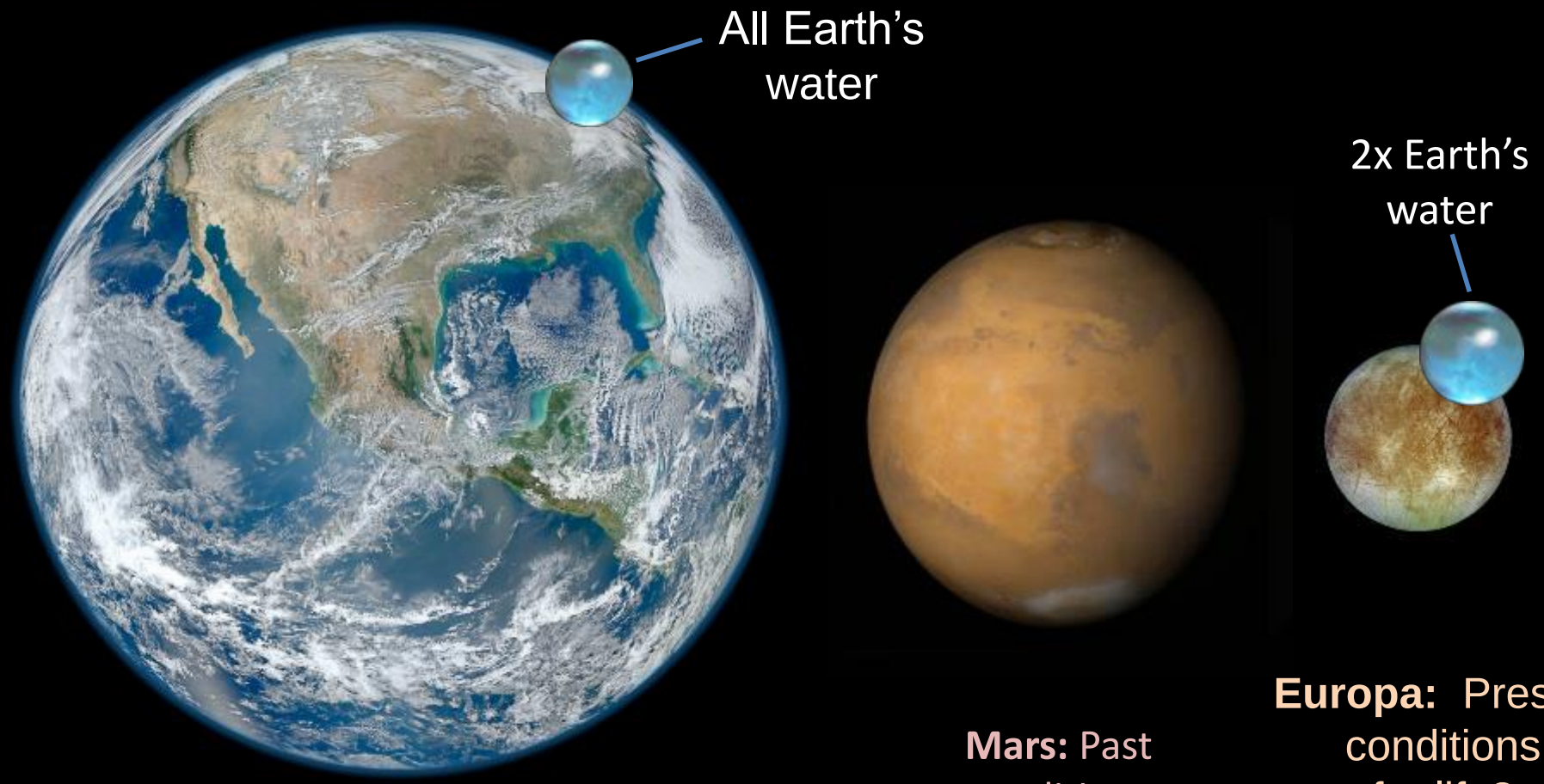
MSFC ★ KSC ★ ASU ★ UTIG
SWRI ★ CU-LASP ★ GSFC
EUROPA
CLIPPER
JPL ★ NASA ★ APL

Europa's youthful surface

- A world of rock, ice, and water approximately the size of Earth's moon
- Very few impact craters suggest that Europa has one of the youngest surfaces in the solar system (~60 Ma)
  - Suggests recent resurfacing = likely an active world



Water World

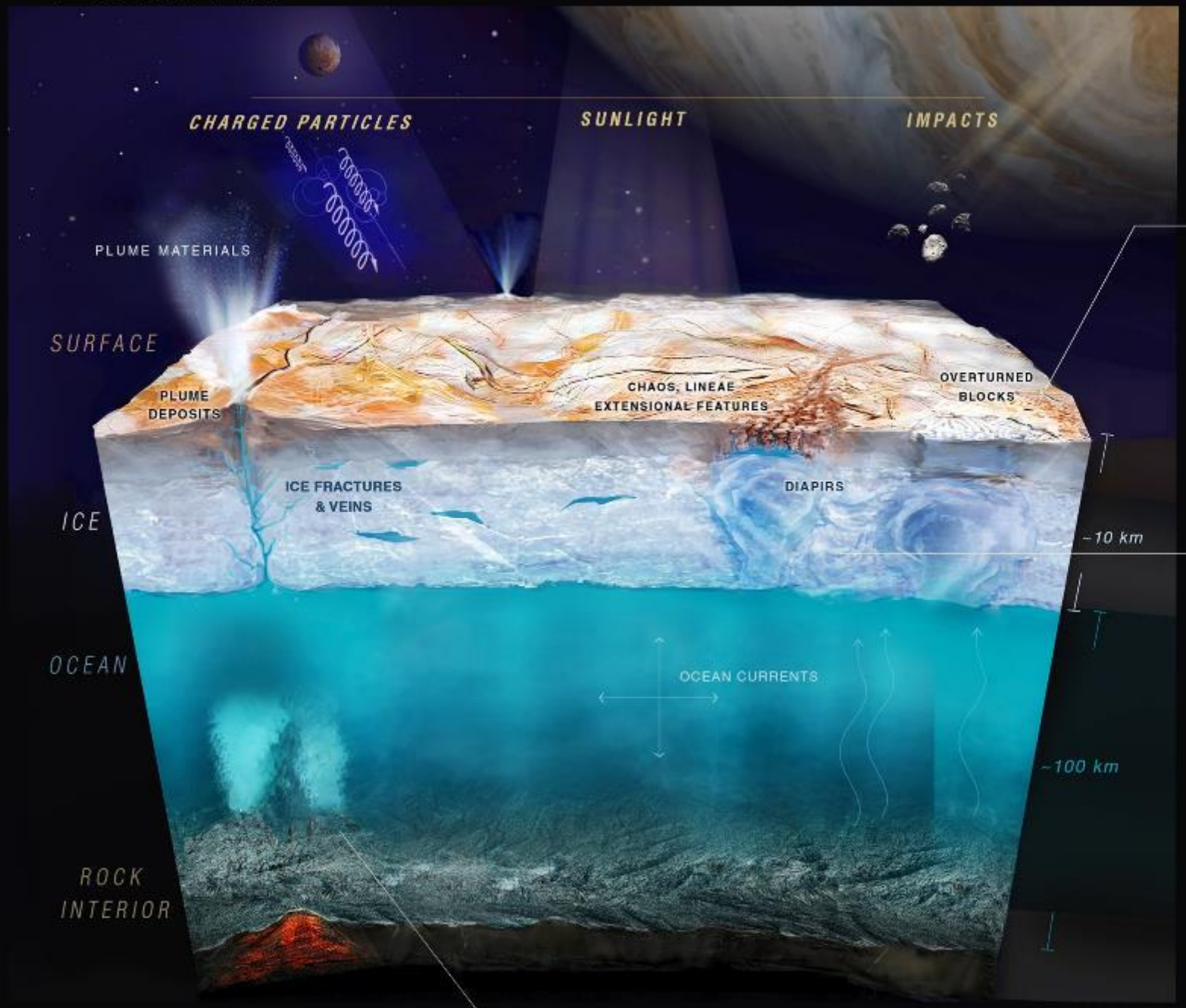


Earth: Known life

Mars: Past conditions for life

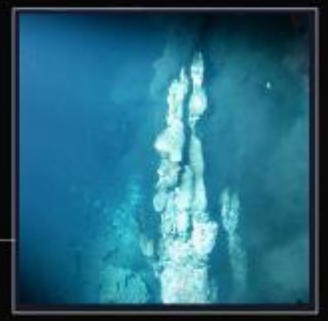
Europa: Present conditions for life?

EUROPA



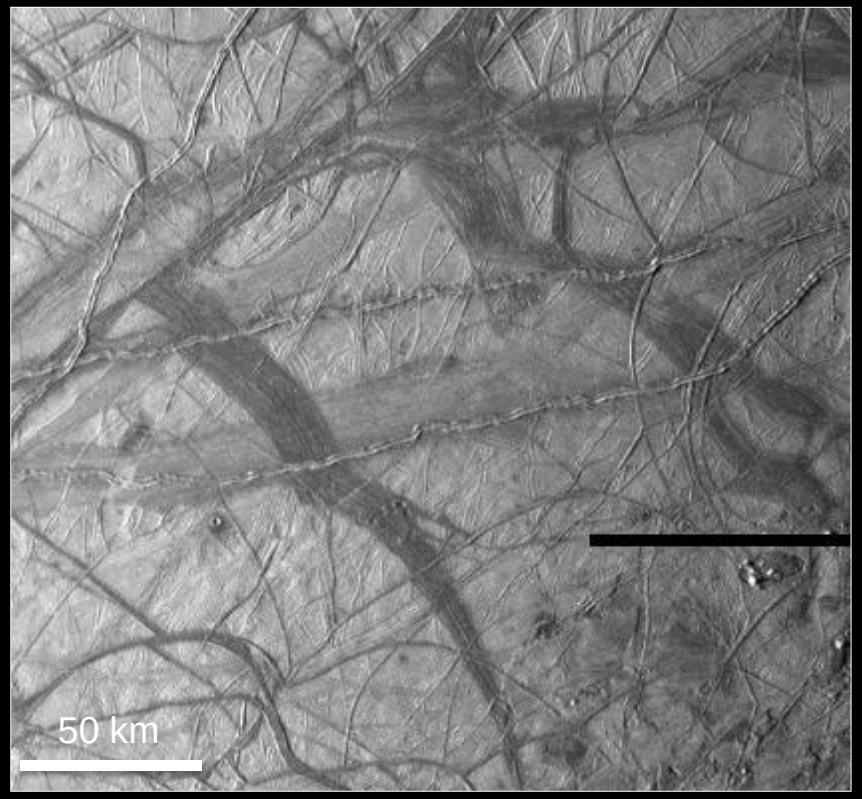
ICE BLOCKS

ICE FRACTURES

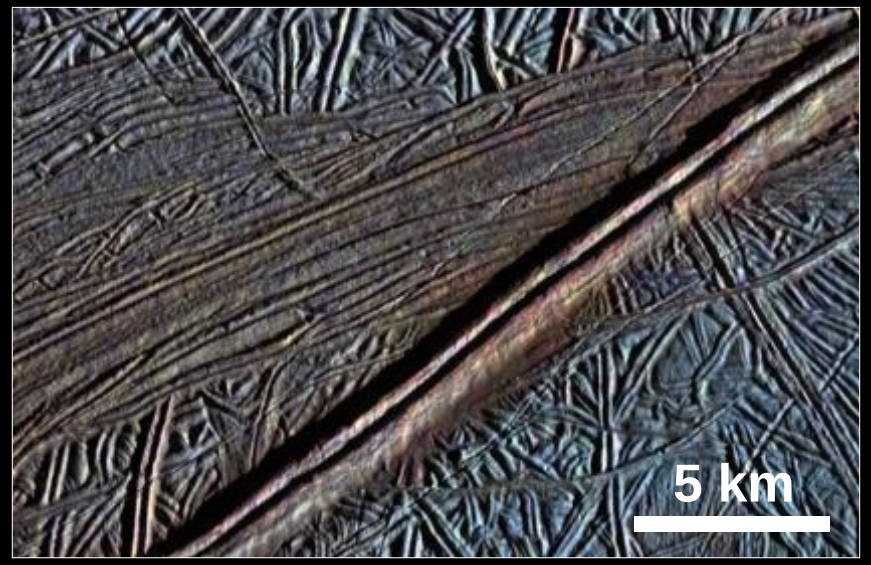


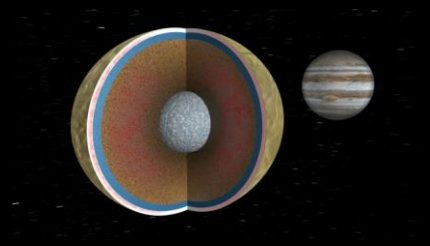
HYDROTHERMAL VENTS

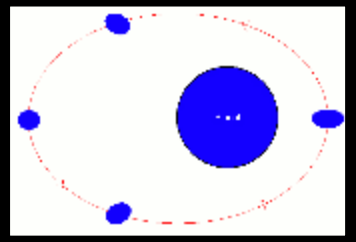
Global tectonic activity



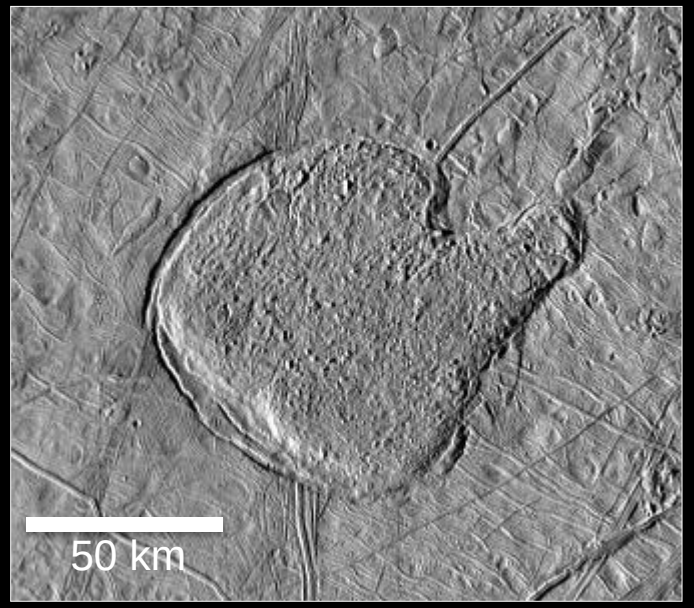
- Surface is criss-crossed by bands and ridges in all orientations, and at all scales
- Driven by tidal squeezing causes cracking on the surface
- May have plate tectonics system



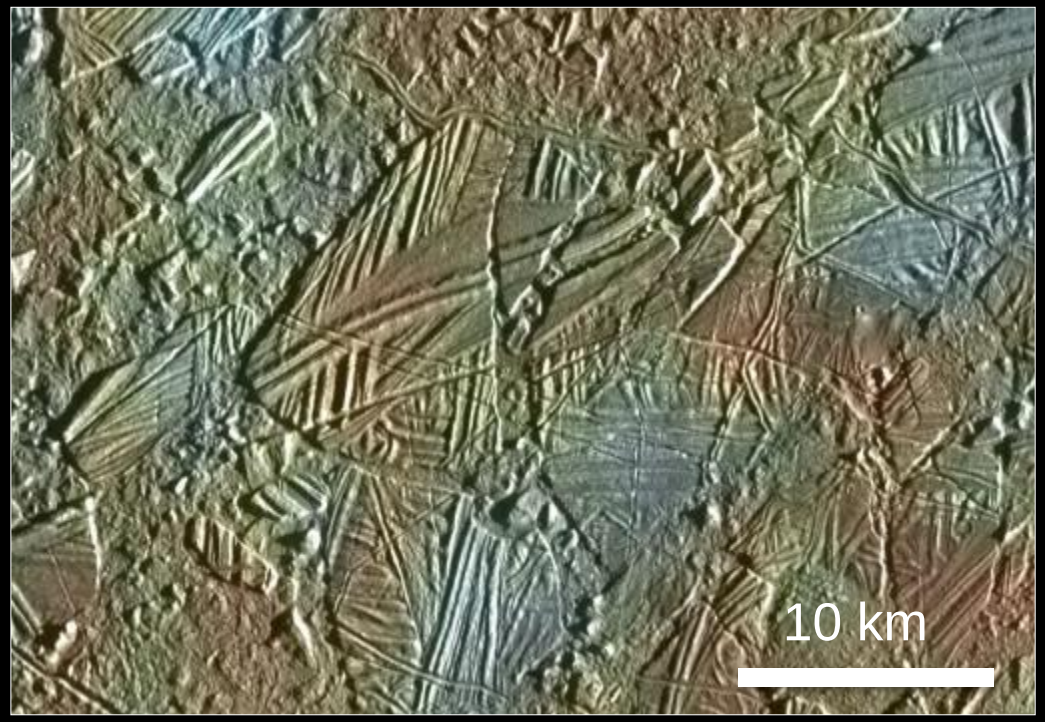




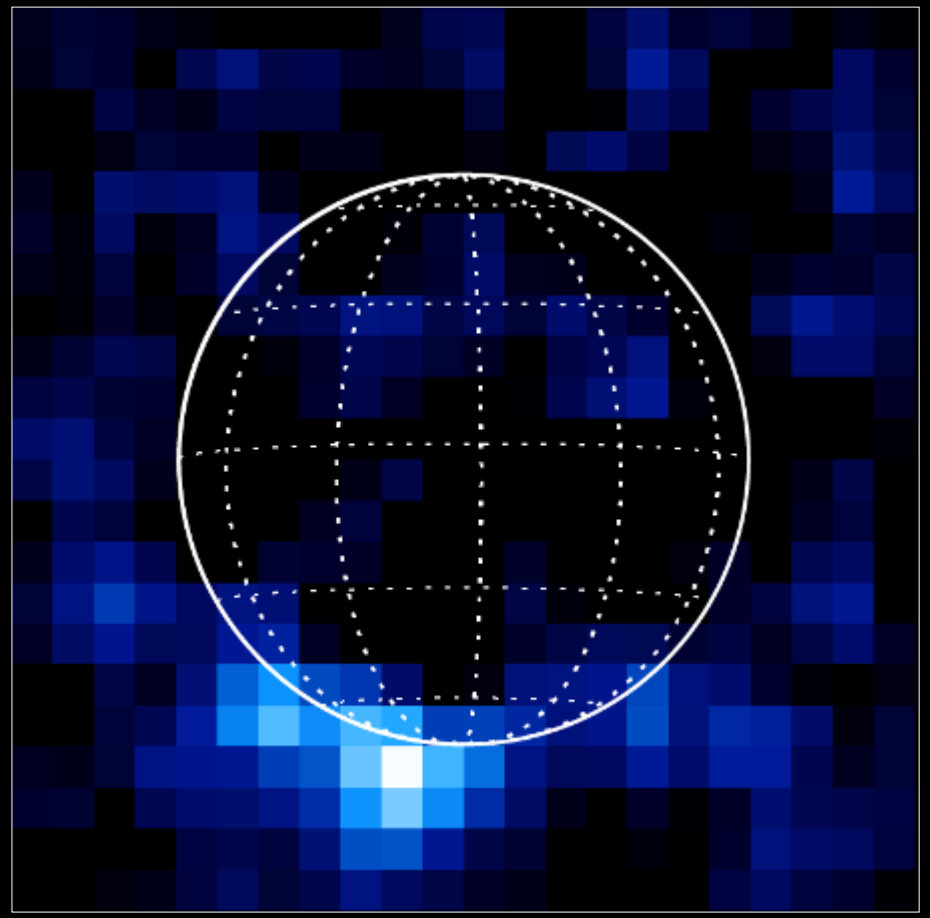
Extensive cryovolcanism



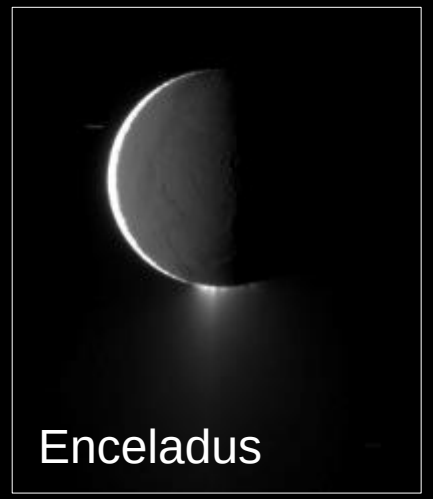
- Evidence of solid-state and liquid water volcanism
- Chaotic terrain consists of plates, matrix
- Energy from tidal squeezing likely causes convection and melting in the ice



Possible plumes of water

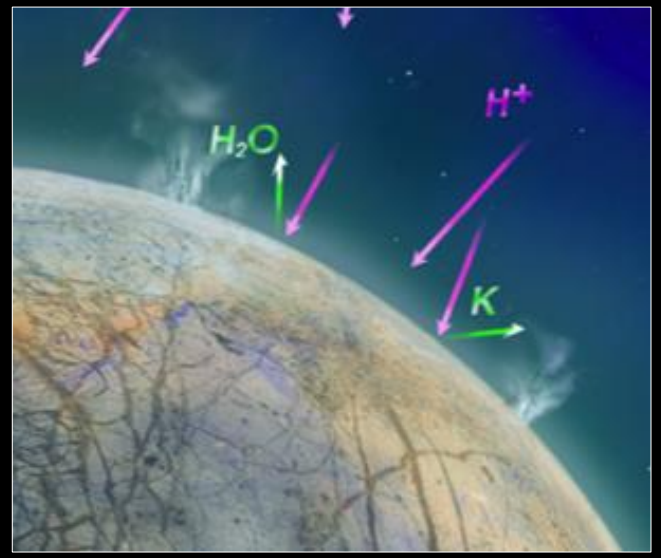


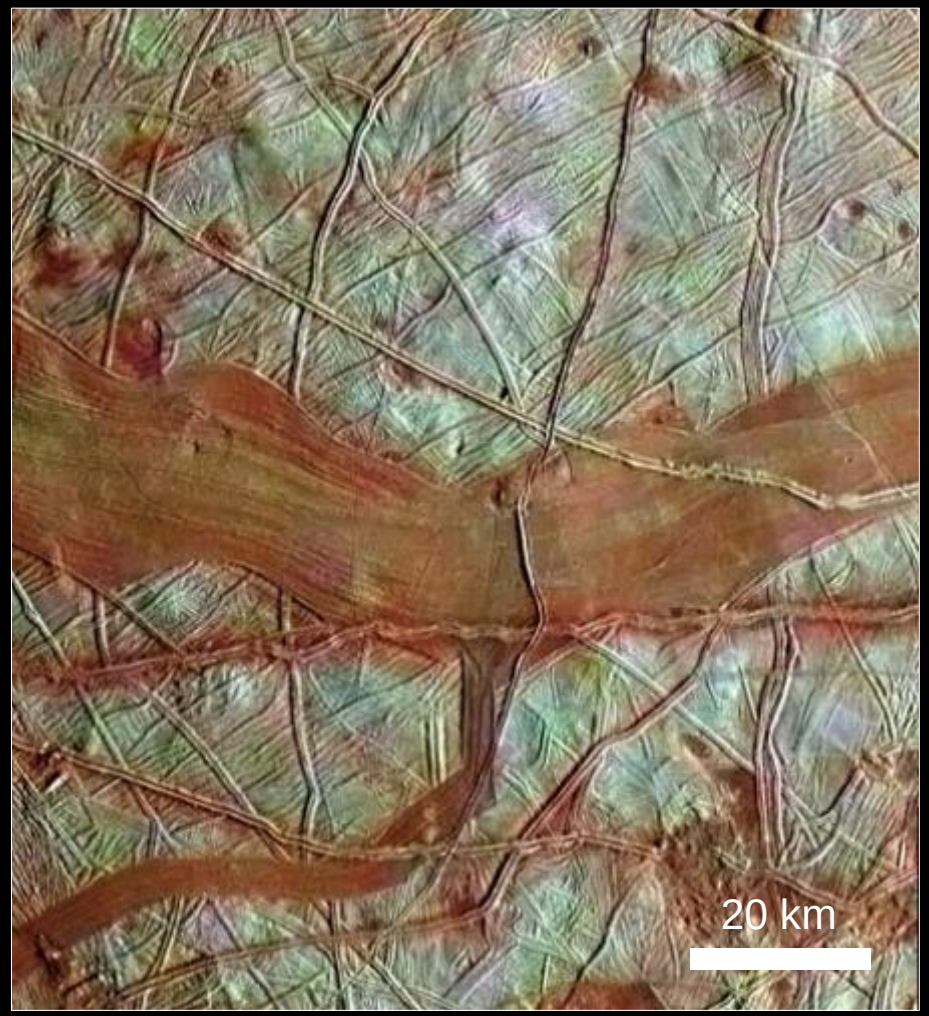
- Recent Hubble observations of hydrogen and oxygen ions concentrated at high southern latitude
- Interpreted as plumes of water vapor ~200 km high



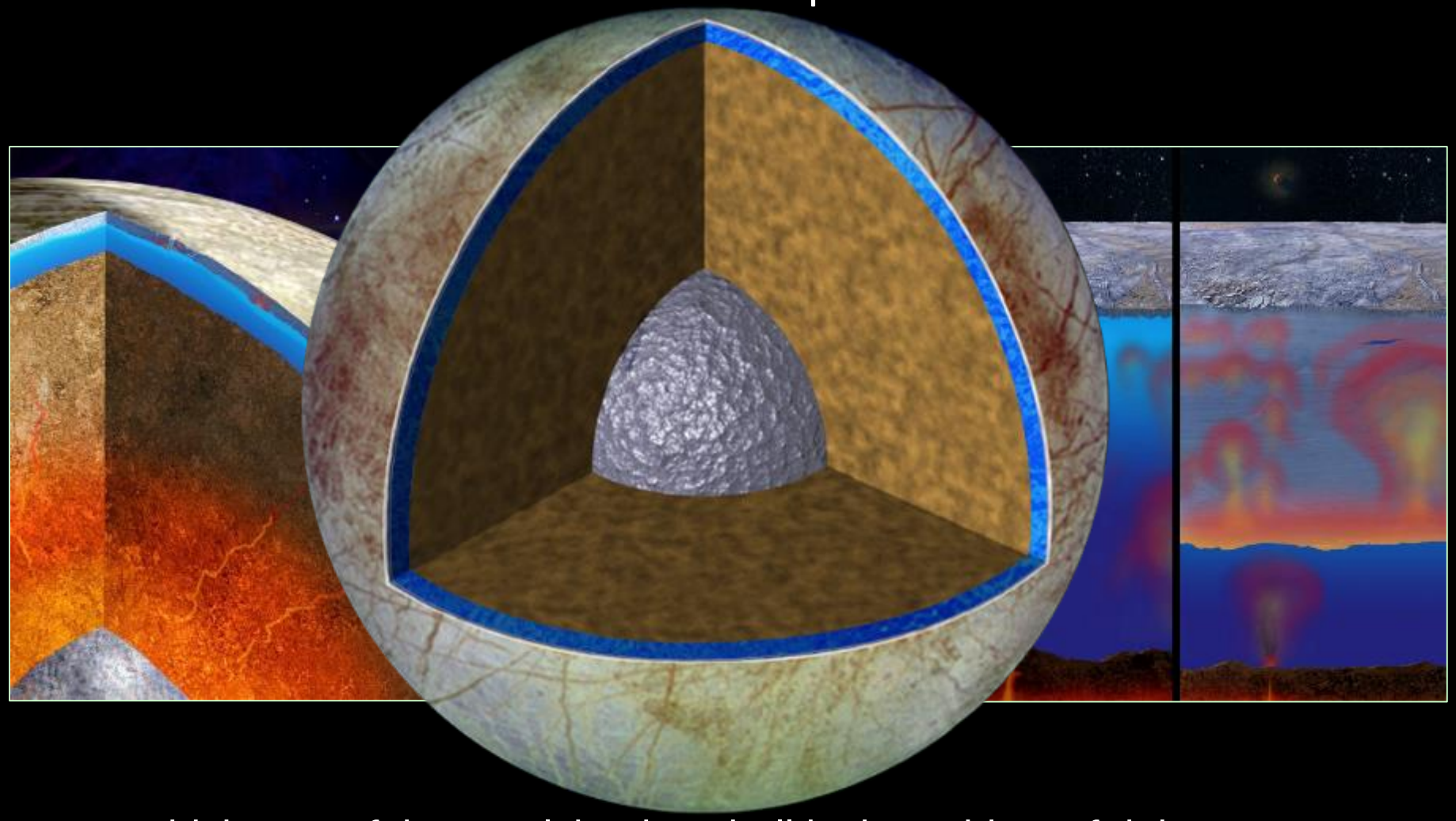
Surface chemistry of salts and acid

- Surface is bombarded by charged particles from Jupiter's magnetosphere
- Interaction of these particles with the surface leads to intriguing chemistry





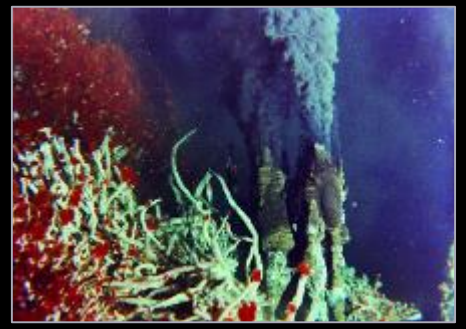
Magnetometer + gravity data indicate a ~100 km thick subsurface liquid water ocean at Europa



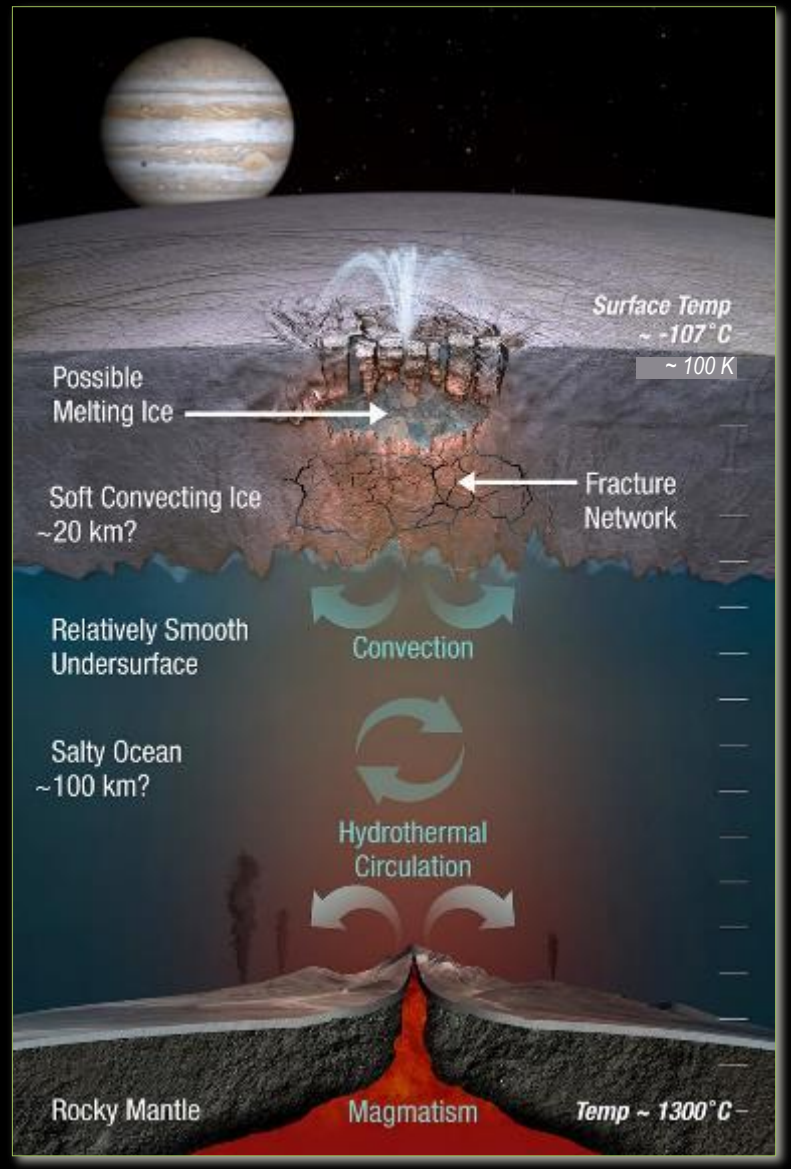
Thickness of the overlying ice shell is the subject of debate – estimates range from a few km to ~30 km

Europa: Ingredients for Life?

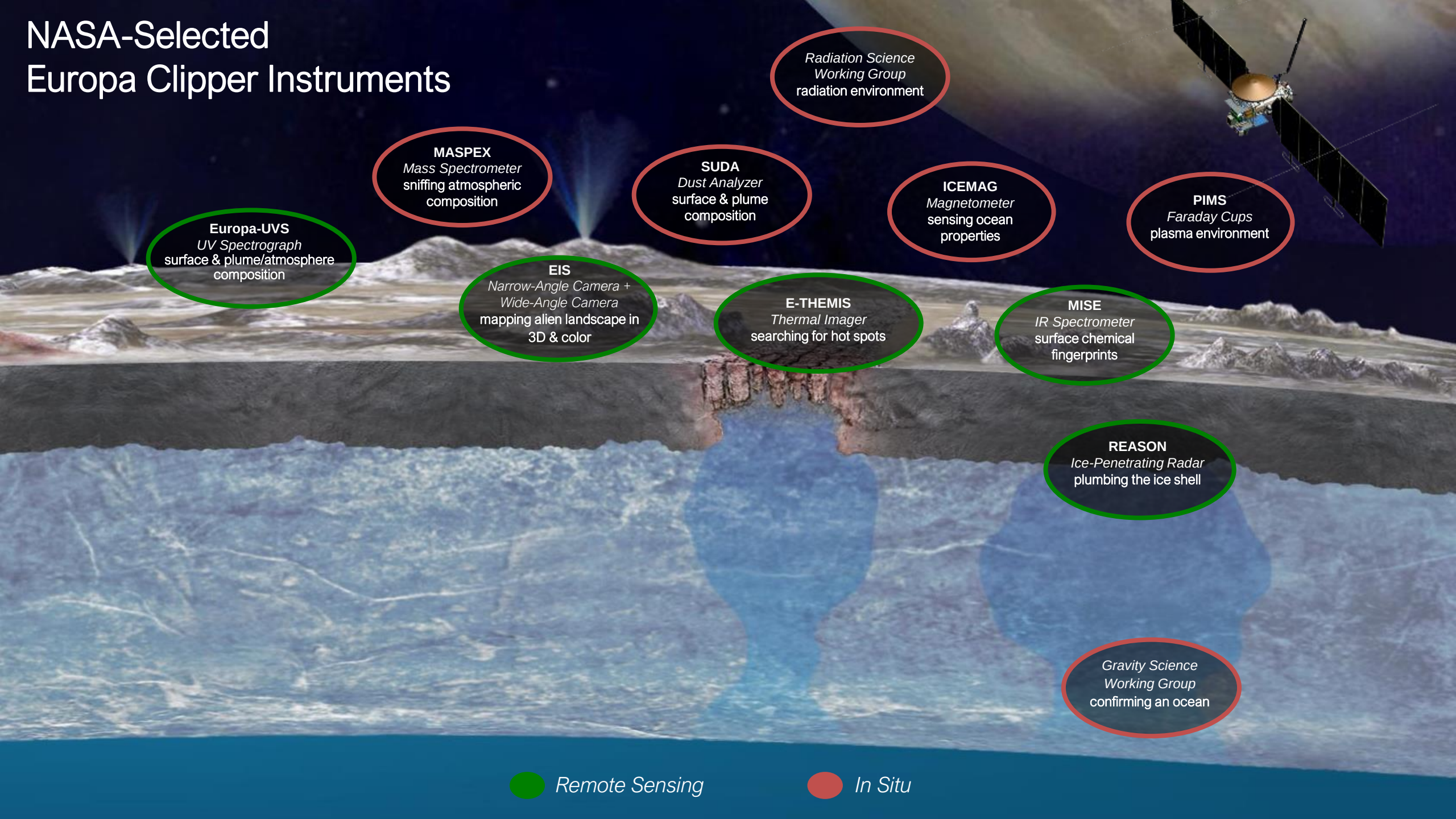
- Water
  - *More than 2x all of Earth's oceans*
- Essential elements
  - *From formation and impacts*
- Chemical energy
  - *Potentially from above and below*
- Stability
  - *Variable, but "simmering" for 4 By*



A Europa mission would verify key* habitability *hypotheses

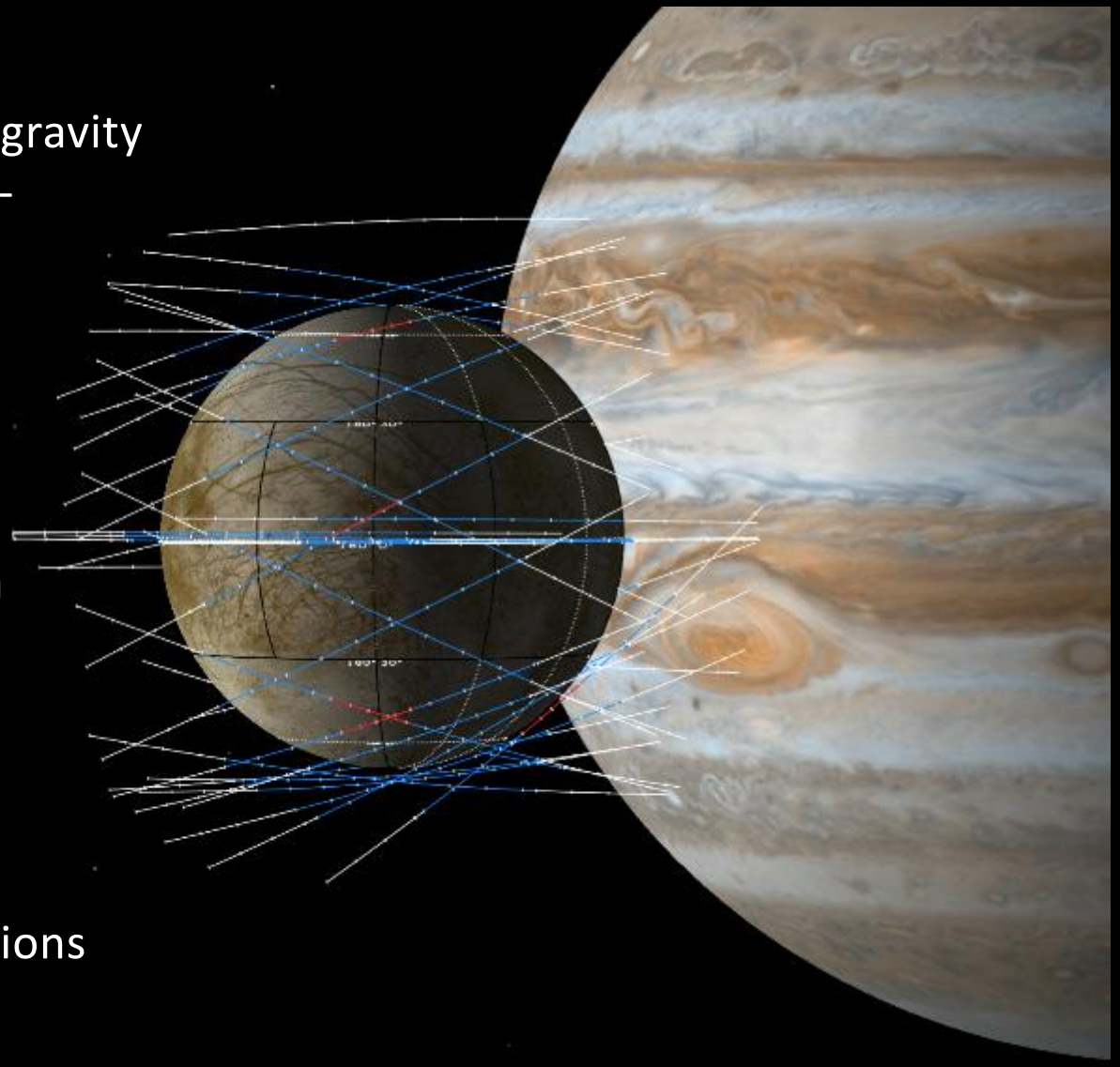


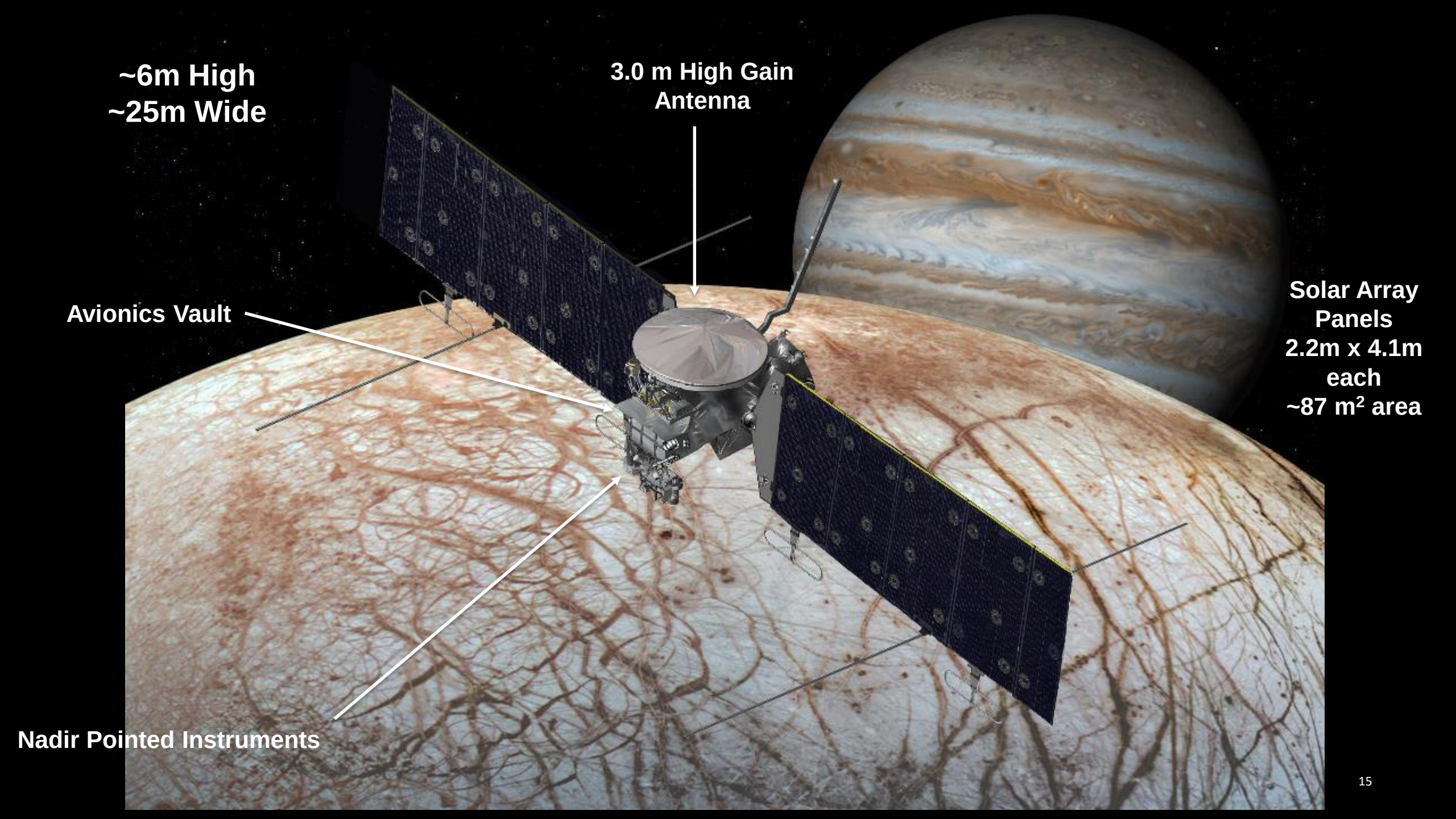
NASA-Selected Europa Clipper Instruments



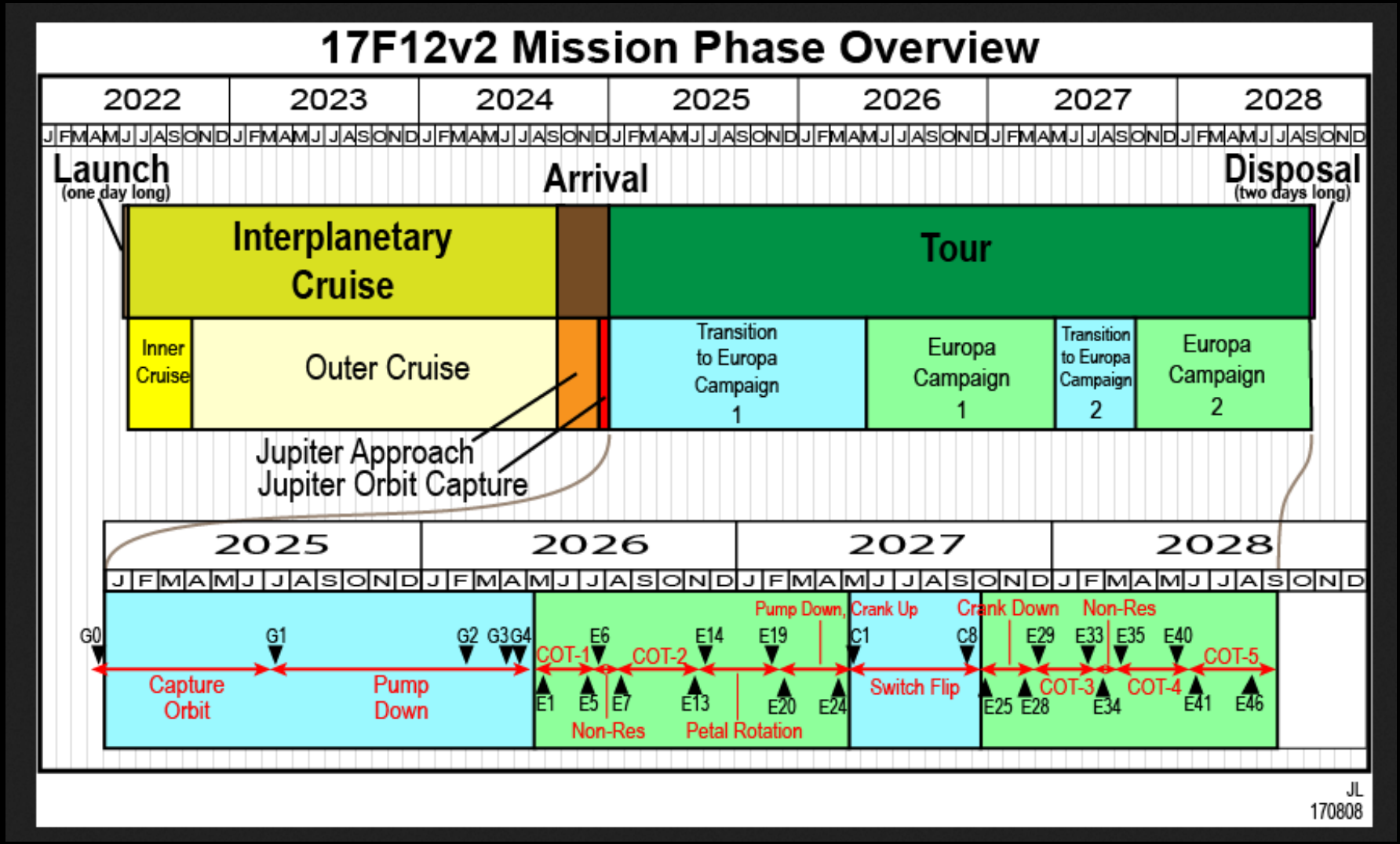
Clipper Mission Concept

- Utilize multiple satellite gravity assists to enable “global-regional coverage” of Europa while in orbit around Jupiter
- Current mission design consists of 45 low-altitude flybys of Europa in prime mission from Jupiter orbit over 3.5 yr
- Minimizes time in high-radiation environment
- Simple repetitive operations




~6m High
~25m Wide
3.0 m High Gain Antenna
Avionics Vault
Solar Array Panels 2.2m x 4.1m each ~87 m² area
Nadir Pointed Instruments

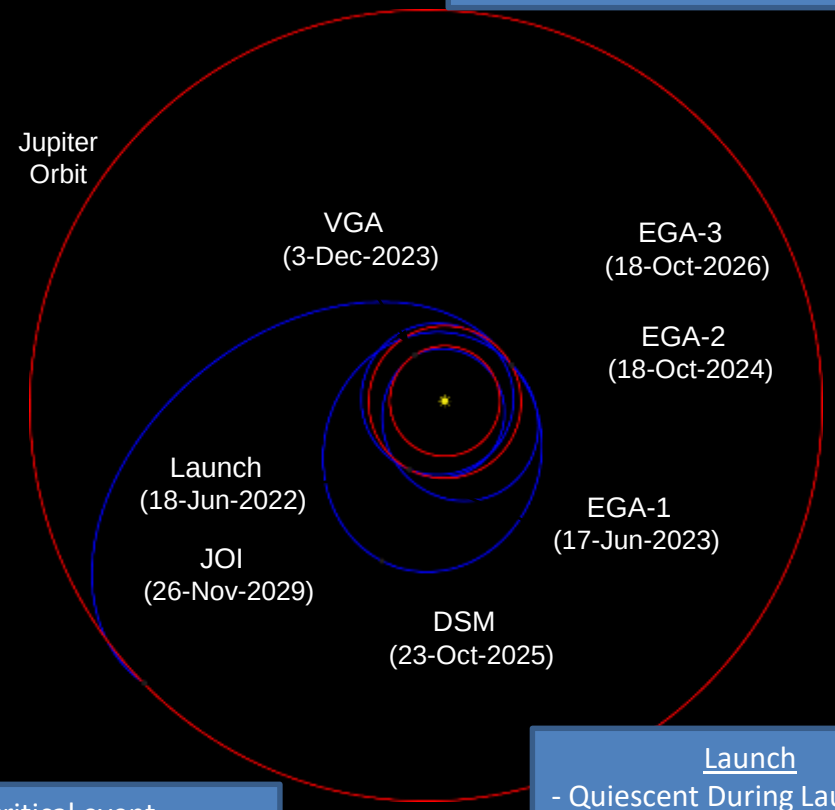
Clipper Notional Mission Timeline



Clipper Mission Operation

Outer Cruise
- Instrument Calibrations
- Sun Point Arrays

Inner Cruise (Option)
- Sun Point
- Thermally Limited Off Sun Activities
- Off Point Arrays From Sun



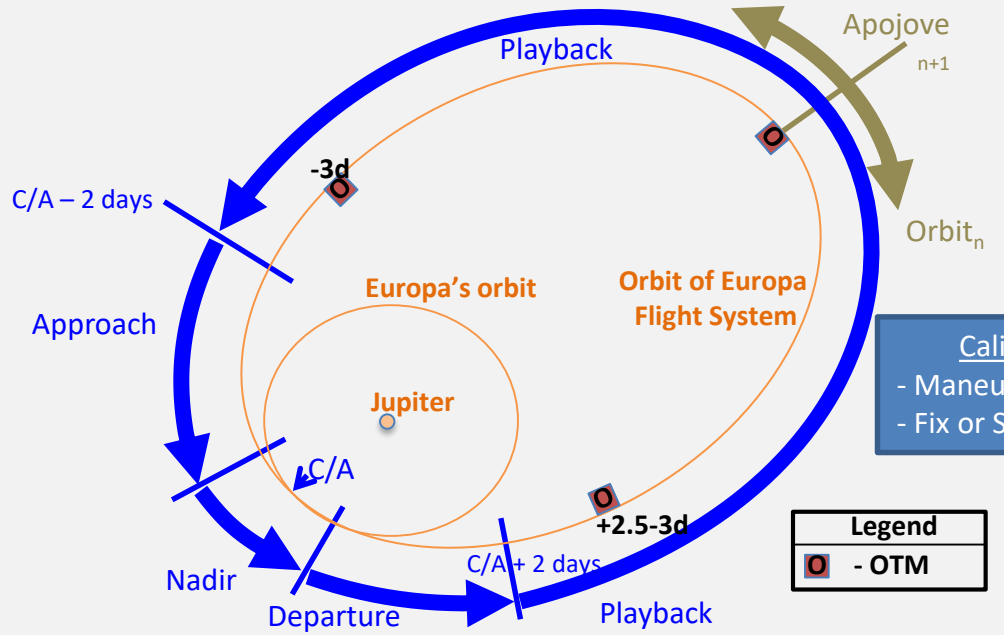
JOI, critical event
- 5.5 – 6.5 Hour Engine Burn
- Fixed Arrays

Launch
- Quiescent During Launch
- Deploy Array: Sun Point, critical event

Encounter Period 10-14 Days

Science Playback
- Downlink Data
- Sun Point Arrays

OTMs
- Fixed Arrays



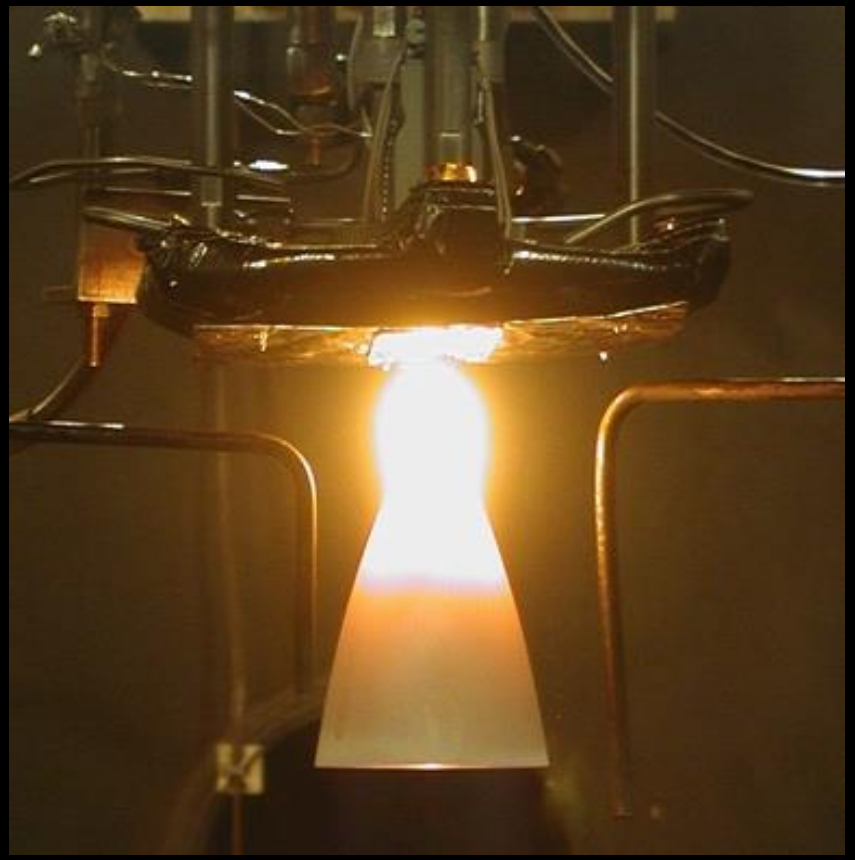
Calibration
- Maneuvers
- Fix or Sun Track

Legend
O - OTM

Europa Flyby
- Nadir Point
- Science Operations
- Fix Arrays during flyby

Clipper Hardware Development & Testing

3 Meter Diameter High Gain Antenna Prototype



Cold Engine Test

Clipper Hardware Development

Full Size Solar Array Panel Demonstrator (2.2m x 4.1m)

One of Ten!

EUROPA LANDER MISSION CONCEPT TEAM

Science Definition Team *(affiliations provided in Chapter 1)*

Co-Chairs: Dr. K. P. Hand, Prof. A. E. Murray, Dr. J. B. Garvin,

Dr. W. B. Brinckerhoff	Dr. T. M. Hoehler	Dr. D. E. Smith
Prof. B. C. Christner	Prof. S. M. Horst	Prof. A. R. Rhoden
Dr. K. S. Edgett	Prof. J. I. Lunine	Dr. M. J. Russell
Prof. B. L. Ehlmann	Prof. K. H. Nealson	Prof. A. S. Templeton
Dr. C. R. German	Dr. C. Paranicas	Dr. P. A. Willis
Prof. A. G. Hayes	Prof. B. E. Schmidt	Dr. R. A. Yingst

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Phillips, C. B.	Craft, K. L. (APL-JHU)	Nordheim, T. A.	

Project – Engineering

Jet Propulsion Laboratory, California Institute of Technology

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Bhandari, P.	Frick, A.	Laubach, S. L.	Smith, M. W.
Bolotin, G. S.	Greco, M. E.	Lin, J. C.	Spaulding, M. D.
Boykins, K. T.	Harris, J. R.	McElrath, T. P.	Stehly, J. S.
Brandon, E. J.	Heverly, M. C.	Montgomery, R. H.	Tan-Wang, G. H.
Bugga, R. V.	Ilott, P. A.	Murphy, J.	Thompson, A.
Burns, B.	Johnson, B. A.	Park, E. L.	Truong, H. D.
Carr, G. A.	Jun, I.	Parker, J. M.	Warner, N. Z.
Chen, Y.	Kawata, J. M.	Ratliff, J. M.	Yahnker, C. R.
Cook, B. T.	Kipp, D. M.	Reeves, G. E.	Young, M. E.
Davis, G. L.	Klesh, A. T.	Reiz, J. M.	Zimmer, A. K.
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Briere, M.	Hartka, T.	Murray, K.	Schwartz, P.
Butler, M.	Holdridge, M.	Napolillo, D.	Wolfarth, L.
Davis, A.	Hong, A.	Norkus, M.	
Ensor, S.	Hunt, J.	Pfisterer, R.	
Gannon, M.	Iskow, J.	Porter, J.	

Goddard Space Flight Center

Cardiff, E. H.	Davis, A.	Grob, E. W.

Marshall Space Flight Center

Adam, J. R.	Betts, E.	Norwood, J.

Europa Lander Mission Concept

Key Parameters for Science:

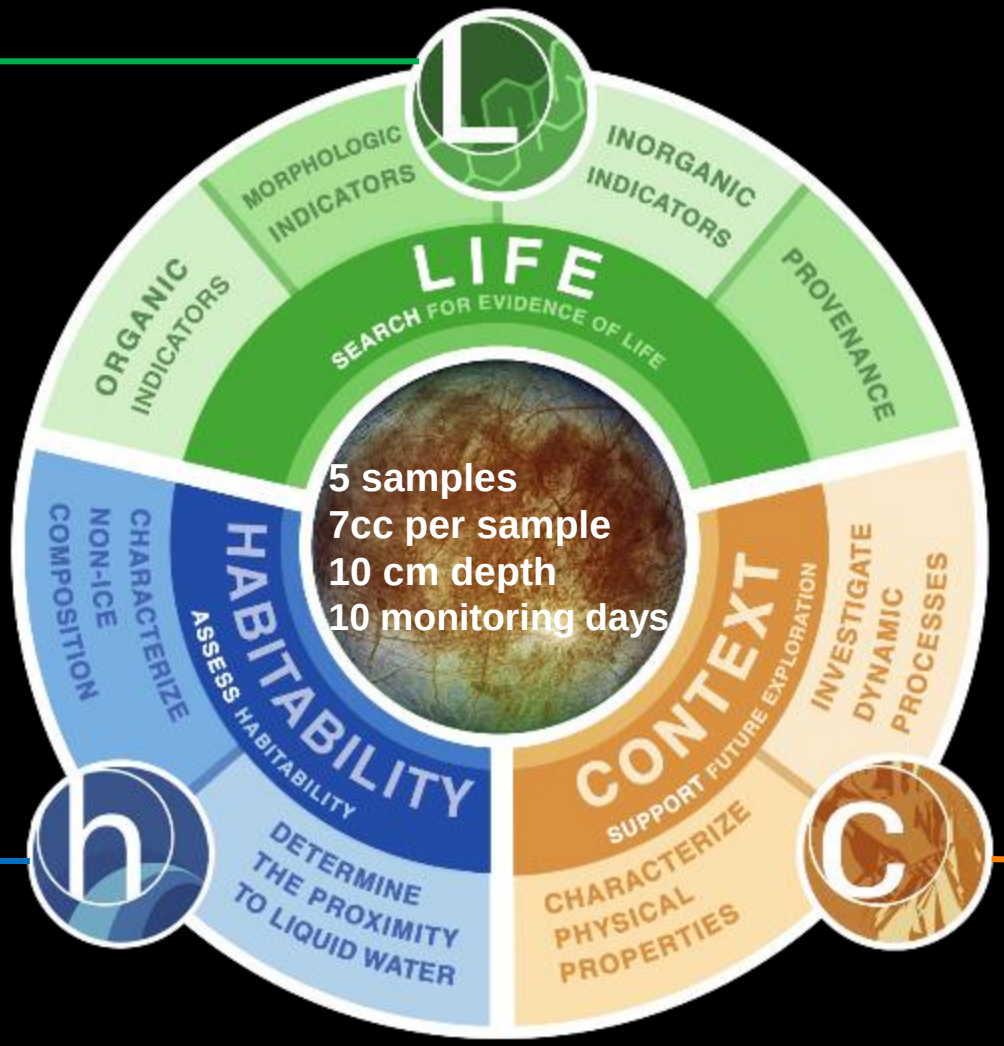
- Lander would be launched as a separate mission than Clipper, enabling improved recon and data return.
- Battery powered mission: 20+ day surface lifetime.
- Spacecraft provides 42.5 kg allocation for science payload (with reserves).
- Baseline science includes:
  - Analyses of 5 samples,
  - Samples acquired from 10 cm depth or deeper (beneath radiation processed regolith) and from 5 different regions within the lander workspace,
  - Each sample must have a minimum volume of 7 cubic centimeters.

Lander Science Definition Team Recommendations

A connected set of goals and objectives addressed with a focused model payload

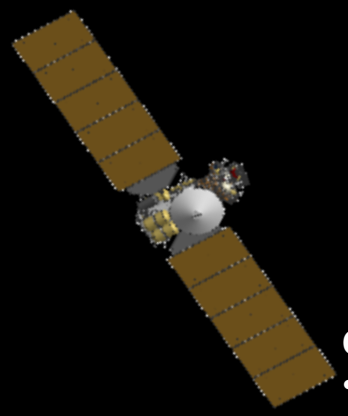
GC-MS
Microscope
Raman spectrometer
Context cameras

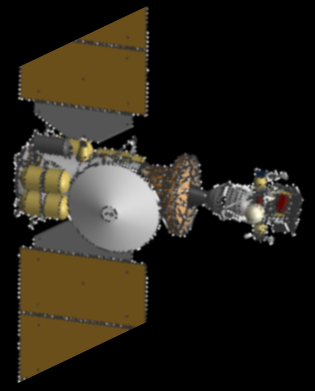
Raman spectrometer
Microscope
GC-MS
Context cameras
Geophone

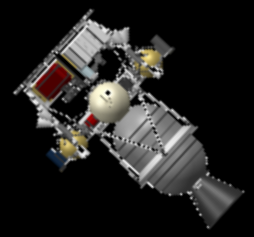


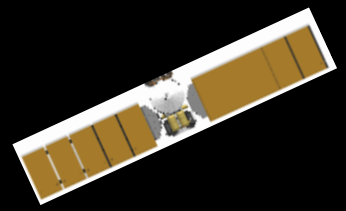
Raman spectrometer
Microscope
GC-MS
Context cameras
Geophone

Possible Lander Mission Concept







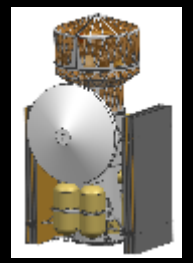


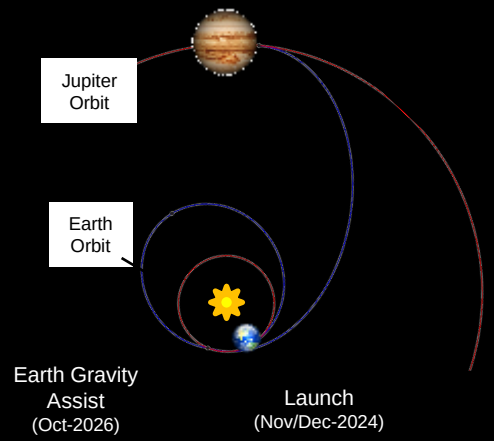
Cruise/Jovian Tour

- Earth gravity assist Oct 2026
- Jupiter orbit insertion Oct 2029
- Earliest landing on Europa: April 2031

Carrier Relay Orbit

- 24 hour period
- >10 hours continuous coverage per orbit



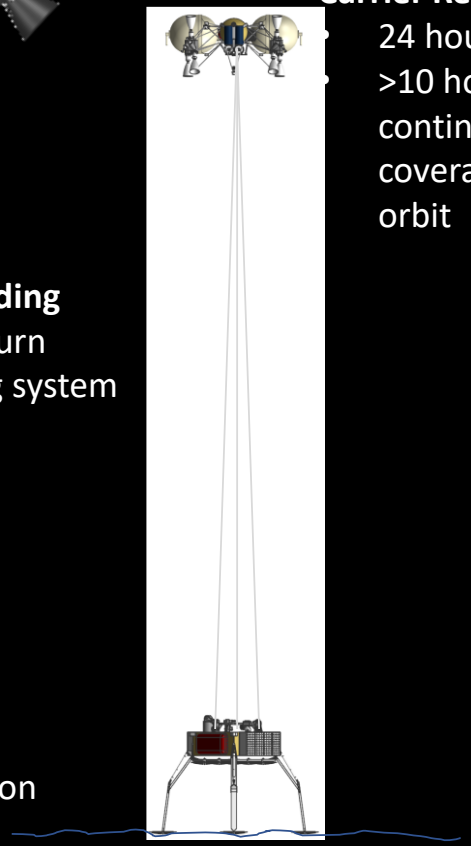


Launch

- SLS Block 1b
- Nov/Dec 2024

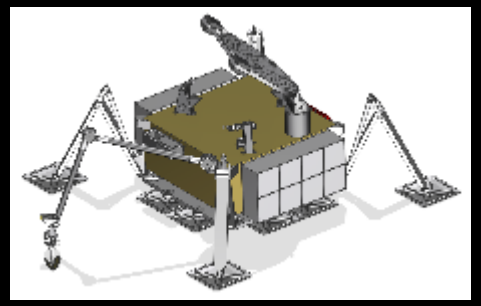
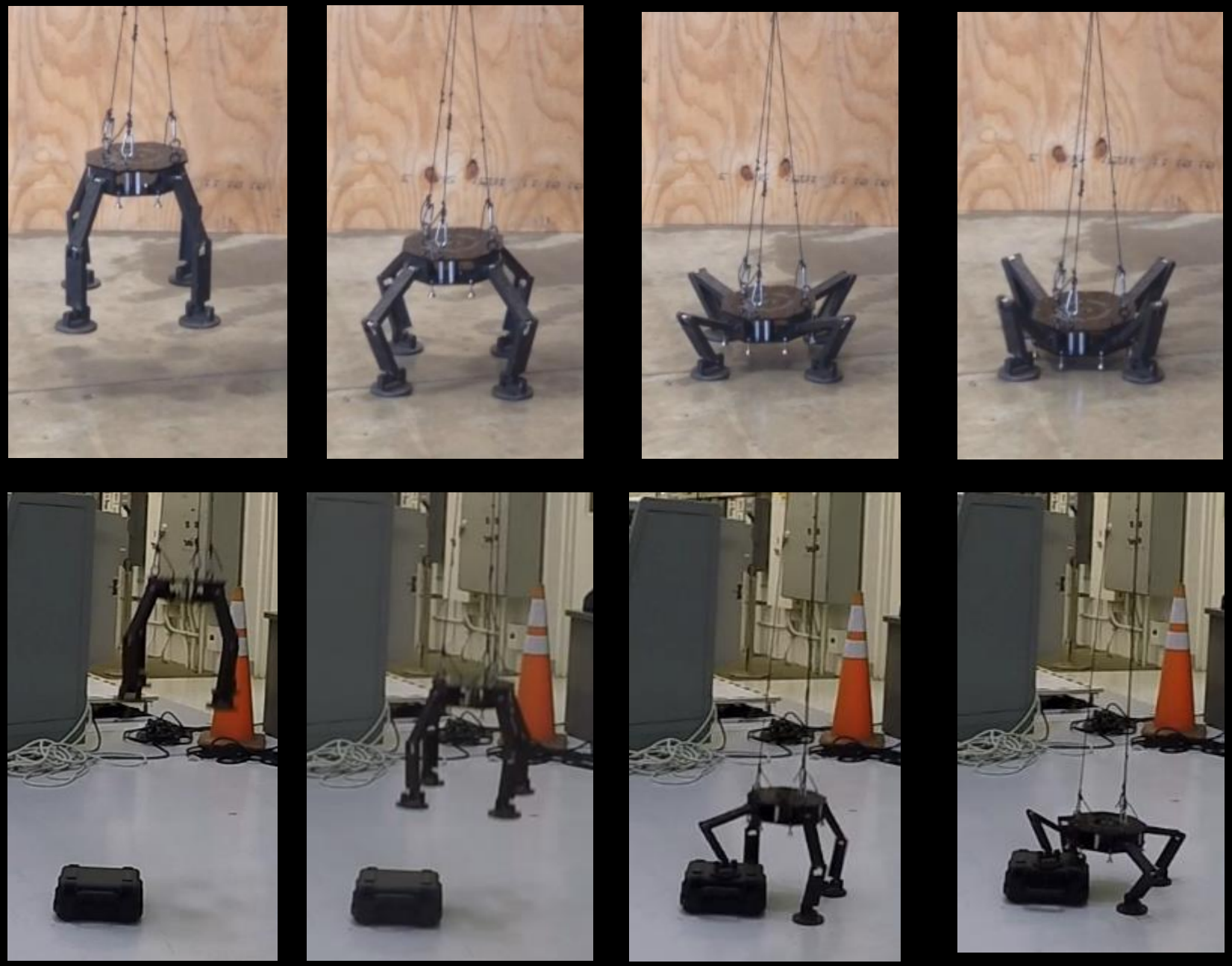
Deorbit, Decent, Landing

- Guided deorbit burn
- Sky Crane landing system
- 100m accuracy



Surface Mission

- 20+ day surface mission
- 5 Samples
- Relay communications through Carrier spacecraft or Clipper (backup)
- 3-4 Gbit data return
- 45 kWh battery



Prototype "cricket" lander concept