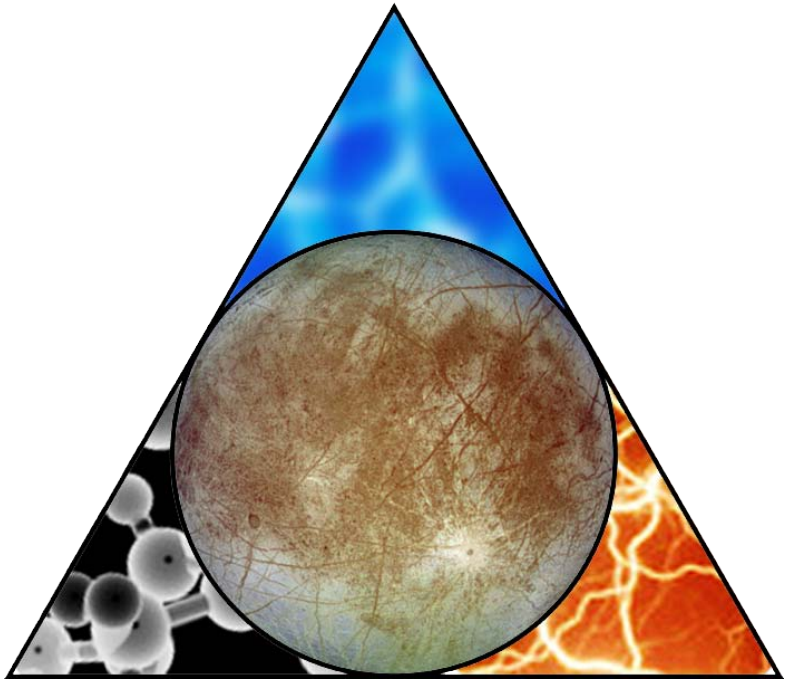
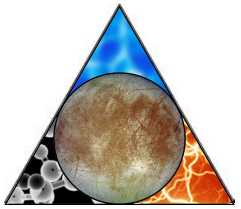


Europa Landed Science

Bob Pappalardo
Europa Study Scientist and SDT Chair

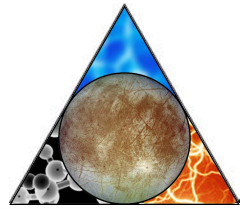
OPAG meeting, Pasadena, CA
10/20/2011

NASA Groundrules



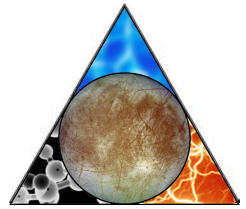
- Redefine the JEO mission to provide a set of **minimum science missions** with a NASA **cost target of $1.5B** ($FY15)
  - **An independent cost and technical review** will be performed on all study results
  - **All deliverables** shall be available to HQ no later than **May 15, 2012**
  - **A reliable estimate of the cost for the minimum science mission takes precedence over the cost target**
- Mission concepts are expected to represent the **minimum science missions**
  - **At or very near the acceptable science "floor"** below which the mission concept is not worth pursuing at the cost estimate
- The study shall utilize a **small well-focused SDT** to provide **guidance on the scientific objectives, measurements, and priorities** for the mission concept
- The study team shall assess the **feasibility of a limited number of focused mission concepts, including ... a Europa surface element**

JIMO Report (2004)
Europa Surface Science Package



- ***Astrobiology*** **– the search for signs of life, past or present, on Europa.**
  - Presence and composition of organic material
  - Search for chemical patterns indicative of biological activity
- ***Geophysics*** **– confirm the presence of an ocean and the thickness and characteristics of the overlying ice layer.**
  - Acoustic/seismic measurements of crustal thickness, ocean depth and levels of seismic activity
  - Geophysical and mechanical properties of the ice
  - Surface magnetic field
  - Track landed element with the orbiter as part of geodynamics investigations
- ***Geochemistry and Geology*** **– determine the ice and non-ice composition of the surface and characterize local geology**
  - Elemental composition
  - Mineralogical characterization, including hydrated materials
  - Physical properties – high-resolution local morphology, surface density, Electromagnetic (EM) properties, thermal characteristic, strength.
  - Interaction of surface with magnetosphere, surface processing and radiolysis (radiation mediated chemical reactions).

2010 JEO Report

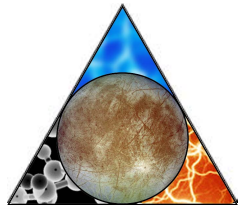


- 1: chemistry, geophysics, surface properties
  - astrobiology (mass spectrometer)
  - geophysics (seismometer)
  - physical state (temperature, radiation, light level, acceleration profile)

----------base-line payload ----------

- 2: enhanced chemistry
- 3: camera
- 4: enhanced geophysics

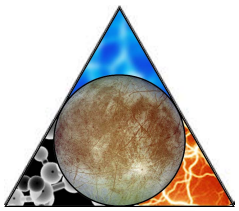
2011 JPL Lander Study



GOAL	Science Objective	Science Investigation	Notional Instrument
Explore Europa to Investigate its habitability	Determine surface composition and chemistry, especially as related to habitability	Characterize surface organic and inorganic chemistry, including abundances and distributions of materials, with emphasis in indicators of habitability and potential biosignatures.	Mass spectrometer with m/z 1-550 [NMS, SAM, Huygens] Microscopic imager
	Determine if Europa is geologically active in the modern epoch.	Measure tectonic activity and surface motion within the ice shell over a europan day and characterize any changes in the ice shell surface.	Seismometer Cameras/OpNav
	Assess the regional and local geology to advance our understanding of the relationship of Europa's ocean with the overlying ice shell.	Constrain regional surface ages and investigate processes of erosion and deposition, and their effects on the physical properties of the surface.	Cameras/OpNav

Europa Science Definition Team

Subgroup Structure



Objectives subgroups:

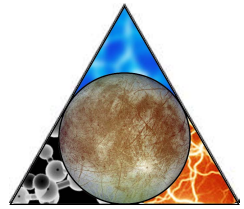
- **Ocean & Ice:**
  - **Bills**, Barr, Blankenship*, Connerney, Senske, Smith)
- **Composition**:
  - **Blaney**, Bagenal, Hoehler, Hand, Shock*, Brinckerhoff, Vance
- **Geology**:
  - **Moore**, Kurth, McGrath, Mellon, Patterson, Prockter*

Cross-Cutting subgroups:

- **Astrobiology**:
  - **Hoehler**, Blankenship, Hand*, McGrath, Senske, Shock
- **Instrumentation**:
  - **Mellon**, Bills, Blaney, Brinckerhoff*, Connerney, Kurth
- **Landing Sites**:
  - **Prockter**, Bagenal, Barr*, Moore, Patterson, Smith, Vance

- Each subgroup informs and iterates with every other
- Strong dependence on subgroups' expertise and mutual conversation

2012 Europa Lander Study
Strawman Objectives & Investigations



C. Composition

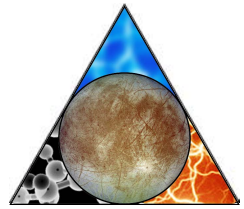
Understand the habitability of Europa's ocean through composition and chemistry

C.1 Characterize surface and near-surface organic and inorganic chemistry and composition to investigate Europa's composition and the endogenic processes that affect it

C.2 Characterize surface and near-surface organic and inorganic chemistry and composition to investigate exogenic materials and processes

C.3 Characterize surface and near-surface organic and inorganic chemistry and composition in order to constrain satellite origin and evolution

2012 Europa Lander Study
Strawman Objectives & Investigations

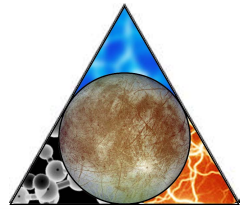


O. Ocean & Ice Shell

Characterize the local thickness, heterogeneity, and dynamics of any ice and water layers

- O.1 Determine Europa's magnetic induction response to constrain salinity and ocean thickness
- O.2 Constrain the thickness of ice and the thickness of the water layers in the region
- O.3 Search for local heterogeneity of the ice and any subsurface water
- O.4 Characterize Europa's seismic activity and its variation over the tidal cycle

2012 Europa Lander Study
Strawman Objectives & Investigations

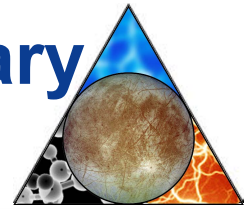


G. Geology

Characterize one or more localities of high scientific interest to understand the formation and evolution of the surface at local scales

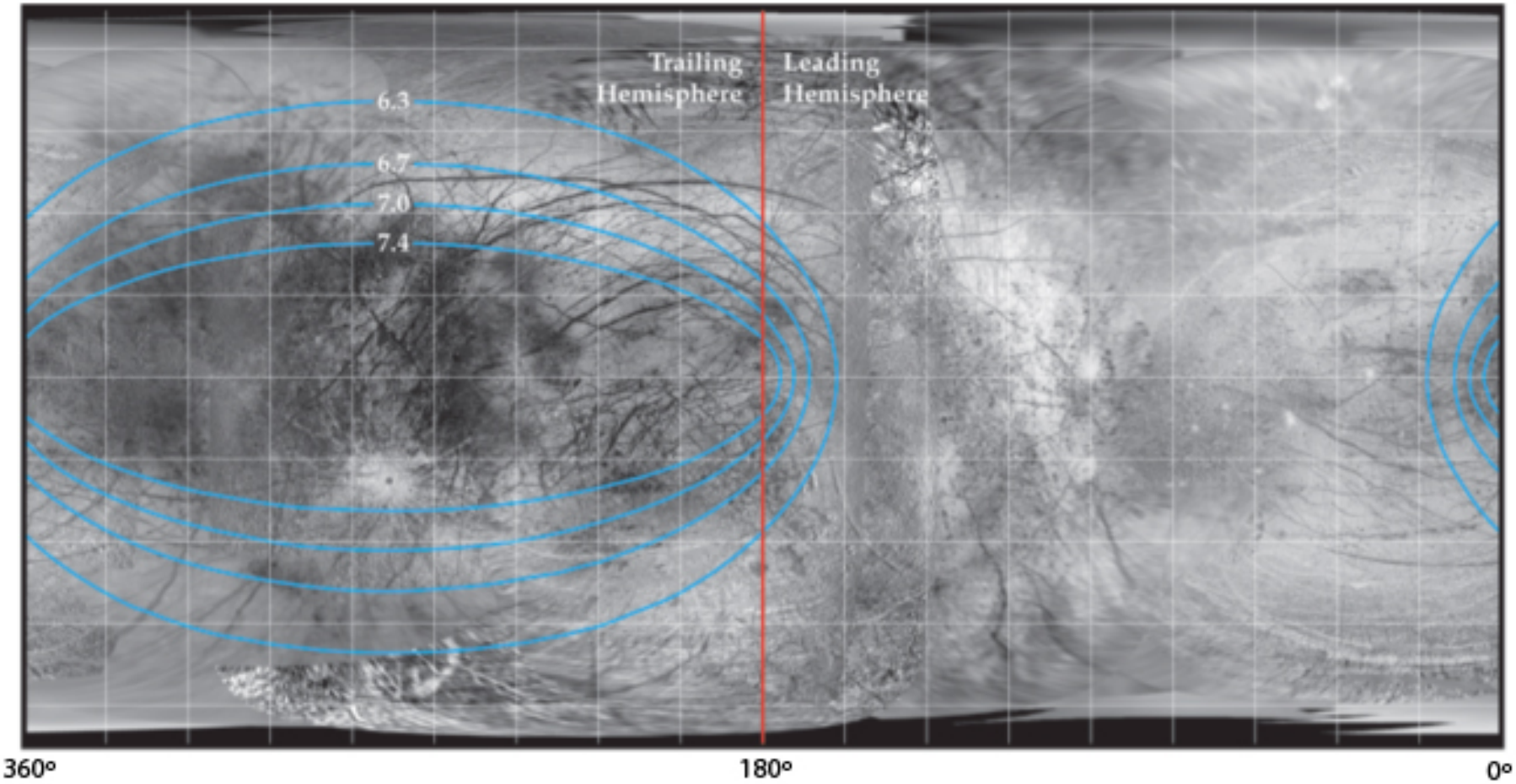
- G.1 Constrain the processes that exchange material between the surface, near-surface, and subsurface
- G.2 Constrain the processes and rates by which the surface materials (regolith and bedrock) form and evolve over time
- G.3 Understand the regional and local context of the landing site
- G.4 Constrain the physical properties (e.g., mechanical, thermophysical) of the surface and near-surface at the landing site
- G.5 Constrain the context of compositional measurements (sample handling)

First Rough Preliminary Notional Temporary Cut at Instrument Payload



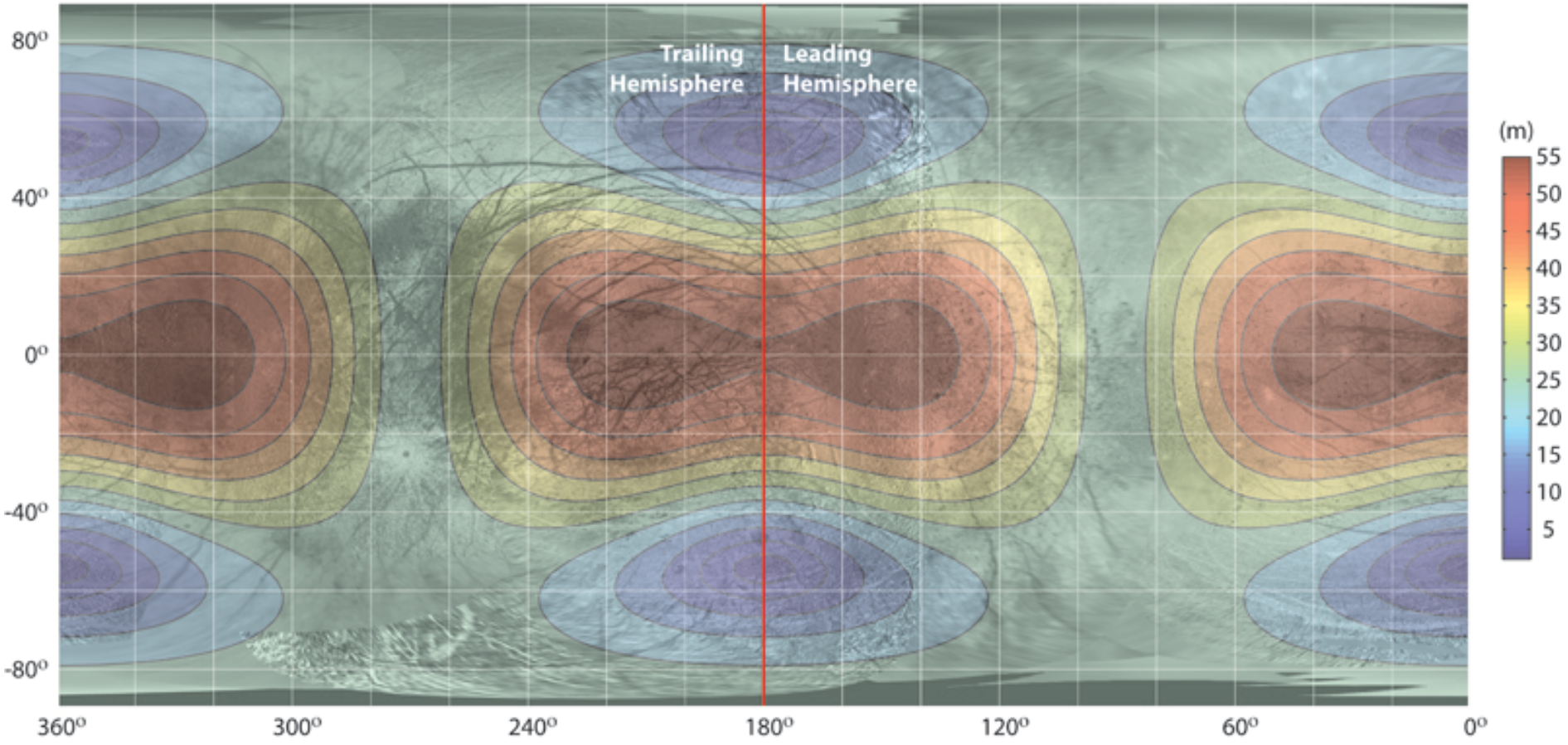
INSTRUMENT	PRIMARY GROUP
• Broadband seismometer x1 - deployed – Deployment system	• Ocean and Ice, Geology
• High Frequency seismometer x2	• Ocean and Ice, Geology
• Magnetometer	• Ocean and Ice
• Imaging (panoramic, color, stereo)	• Geology, Composition
• Imaging (descent)	• Geology
• Imaging (microscopy)	• Geology
• Thermal Radiometer	• Geology
• Charged-Particle Detector	• Geology, Composition ?
• Sample Acquisition Engineering Data	• Geology
• Mass Spectrometer with front end (DSC-EGA, GC, etc.) – Sampling system	• Composition
• Remote sensing composition (Spectroscopy)	• Composition, Instrumentation

Location Constraints:
Integrated Particle Flux

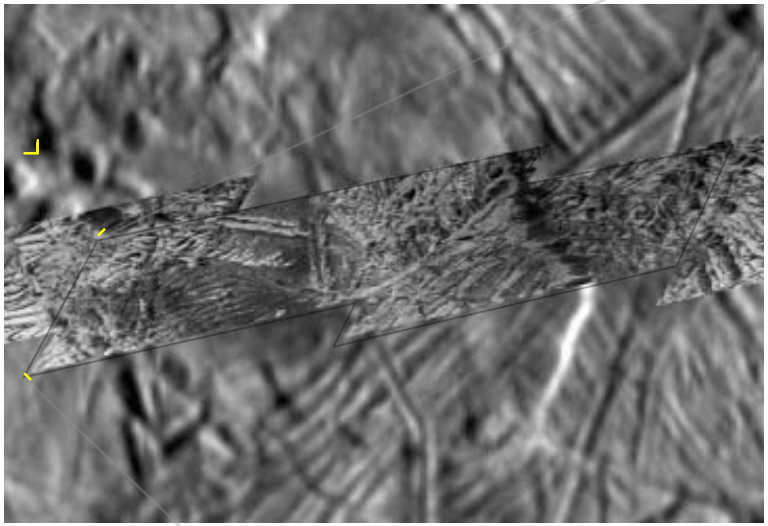


Patterson et al., in review

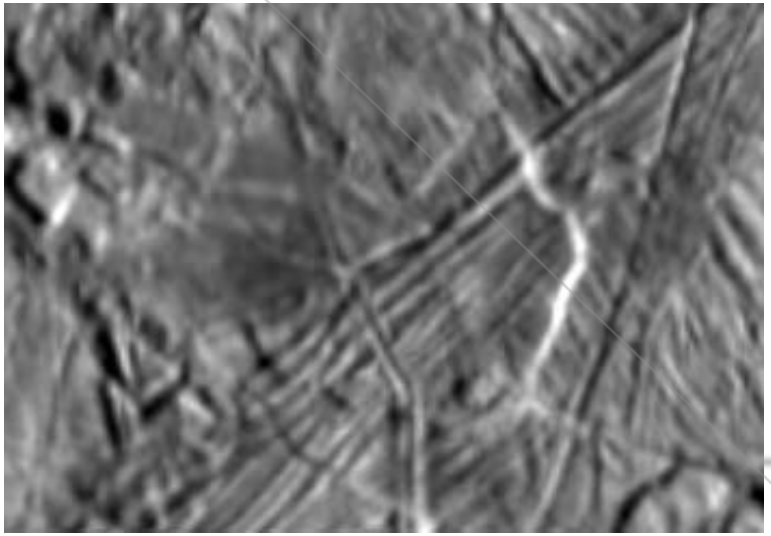
Location Constraints:
Tidal Amplitude

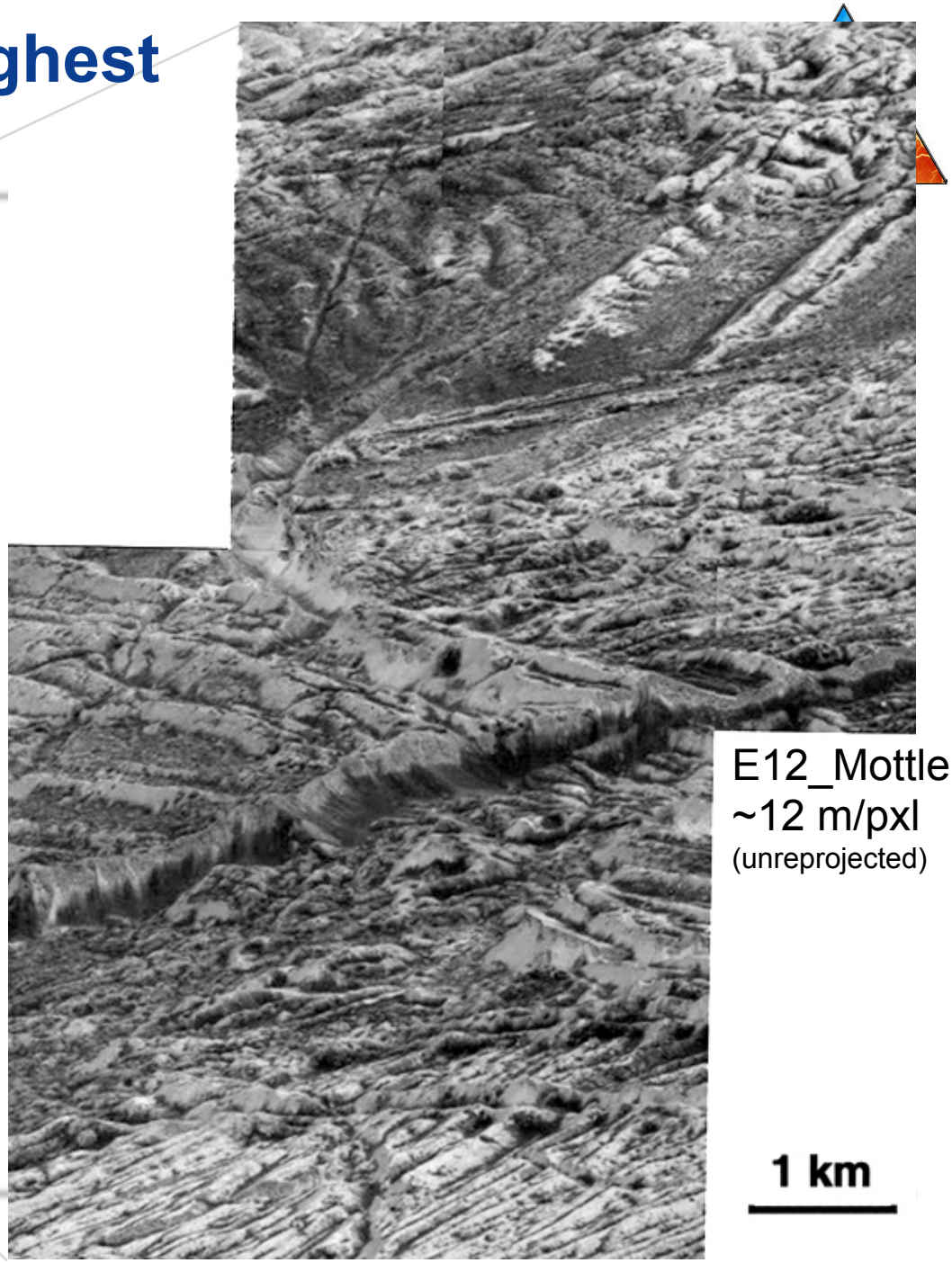


Europa at the Highest Resolution (1)



230 m/pxl

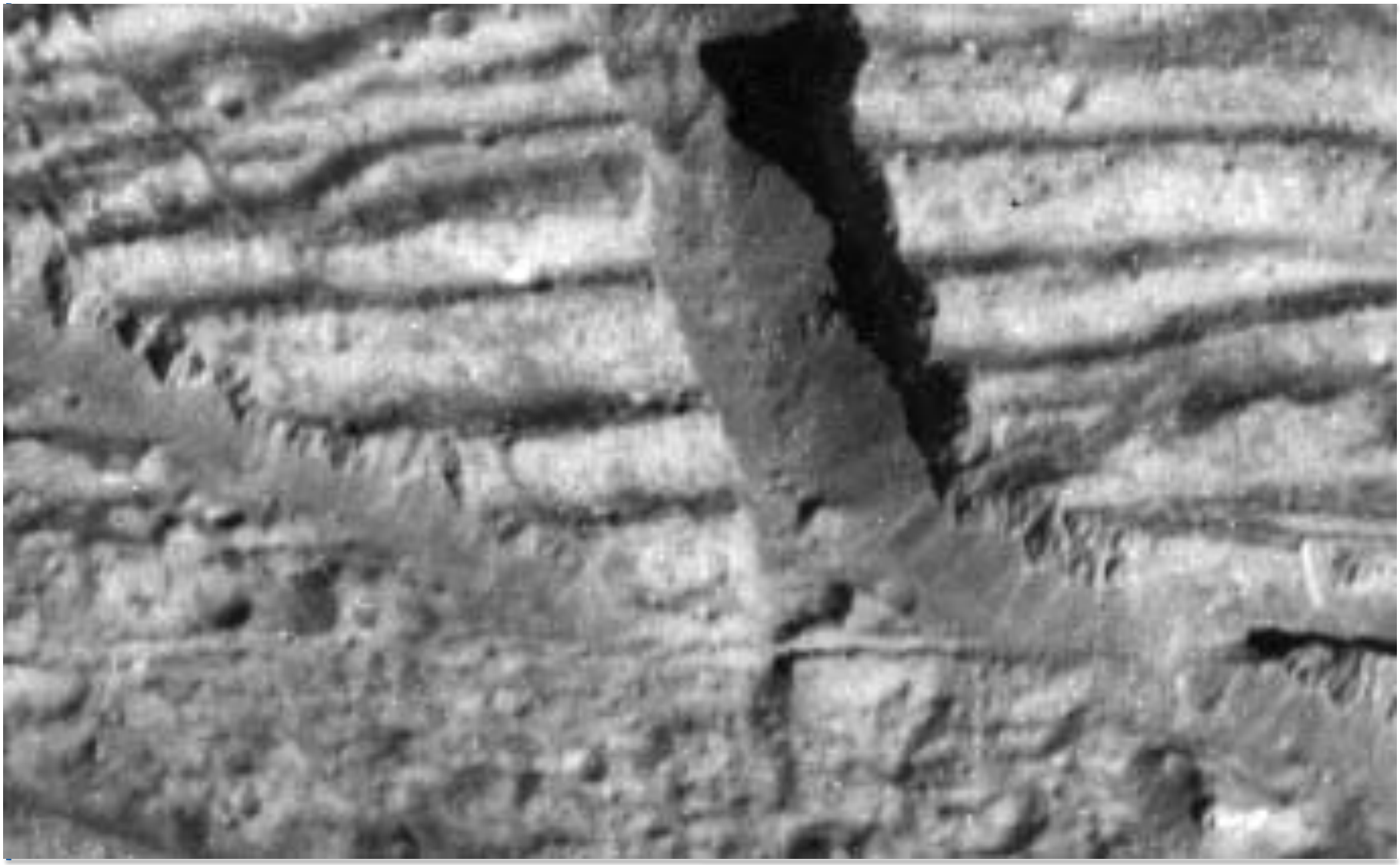




E12_Mottle
~12 m/pxl
(unreprojected)

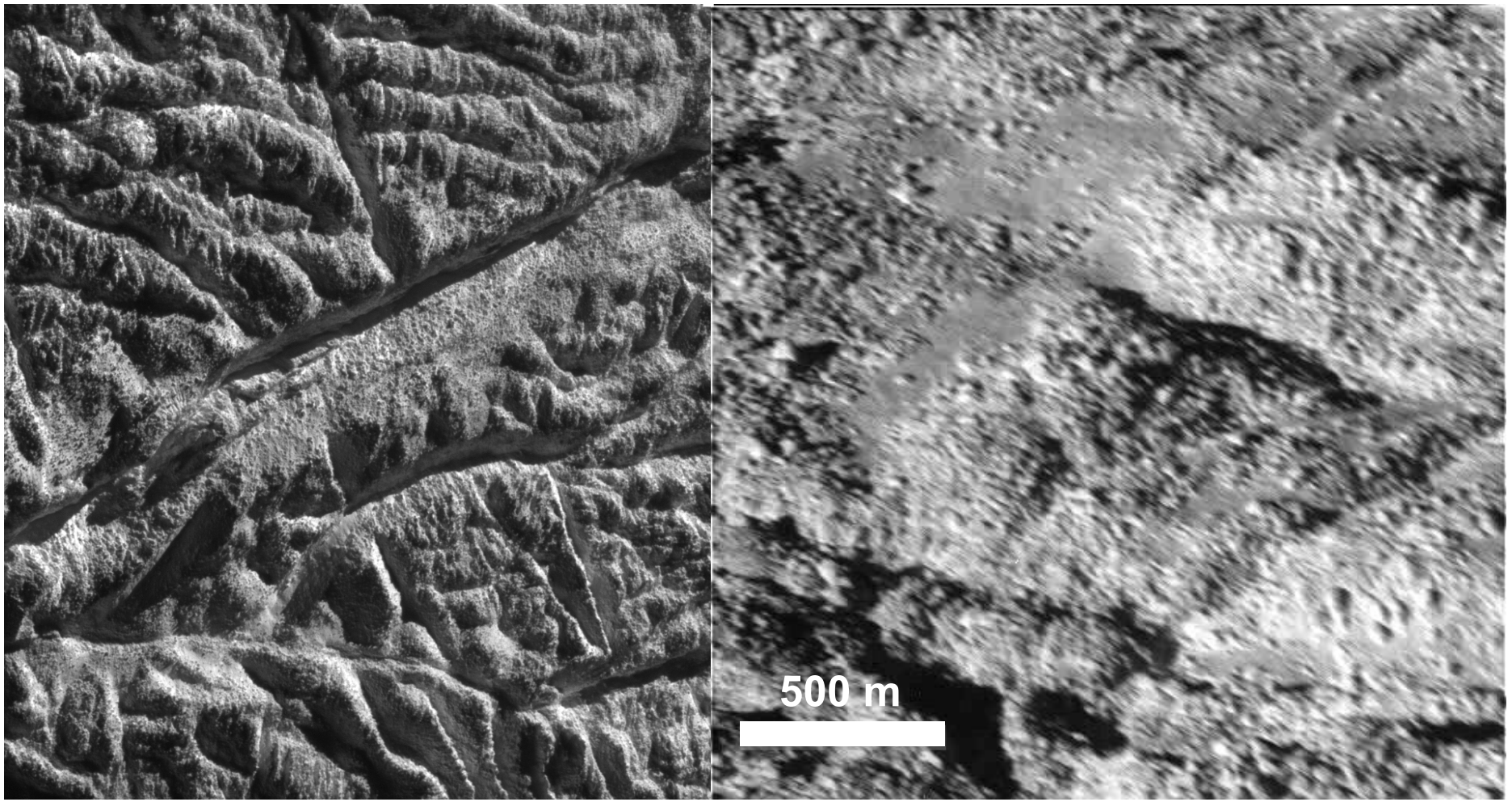
1 km

Europa at the Highest Resolution (2)



E12_Chaos ~11 m/pixel

Enceladus at the Highest Resolution



Devil's Golf Course, Death Valley, CA

Devil's Golf Course, Death Valley, CA