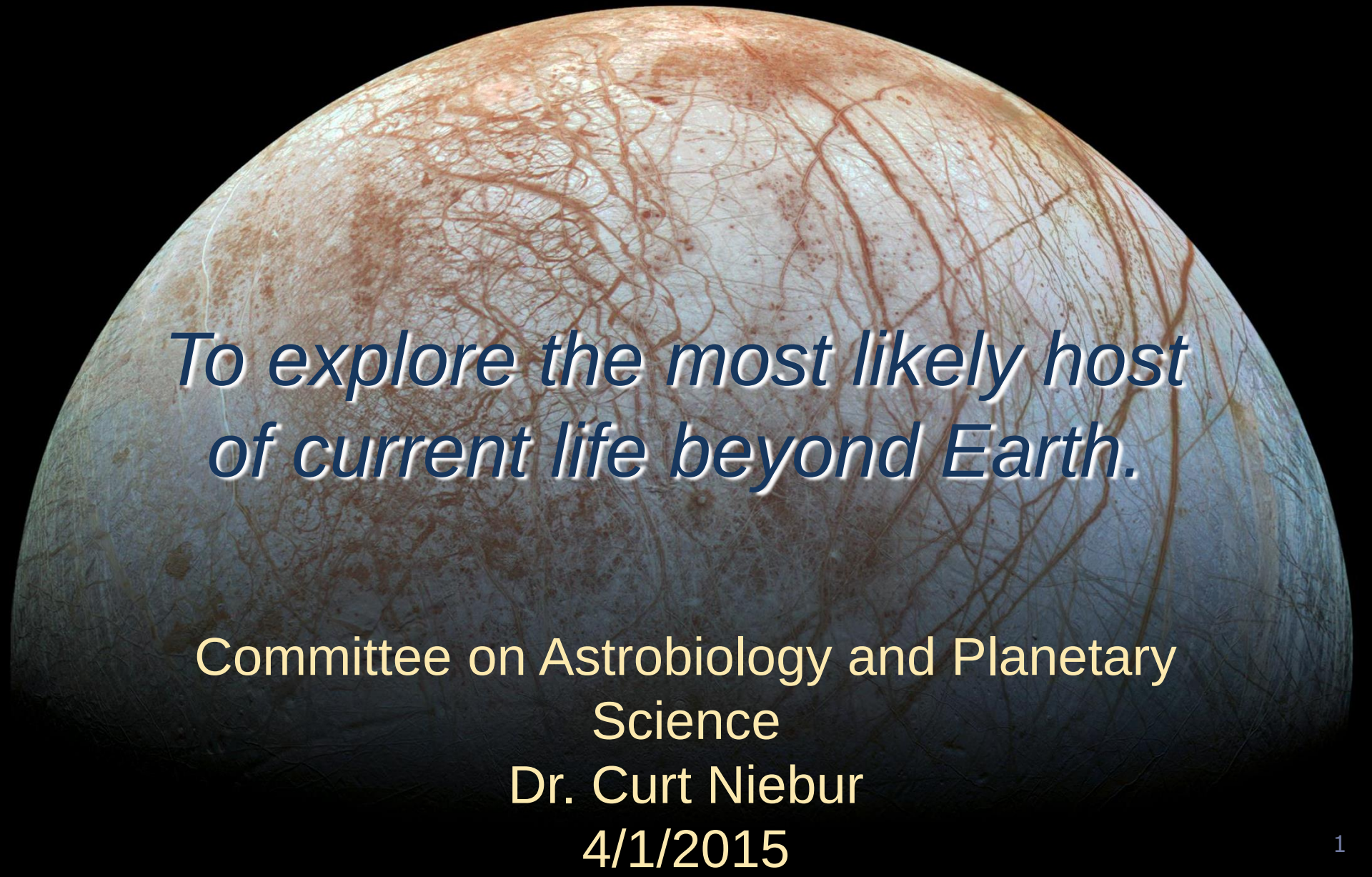
Europa Exploration



To explore the most likely host of current life beyond Earth.

Committee on Astrobiology and Planetary Science
Dr. Curt Niebur
4/1/2015

Habitability: Ingredients for Life

√ Water

- Probable saltwater ocean, implied by surface geology and magnetic field
- Possible lakes within the ice shell, produced by local melting

√ Chemistry

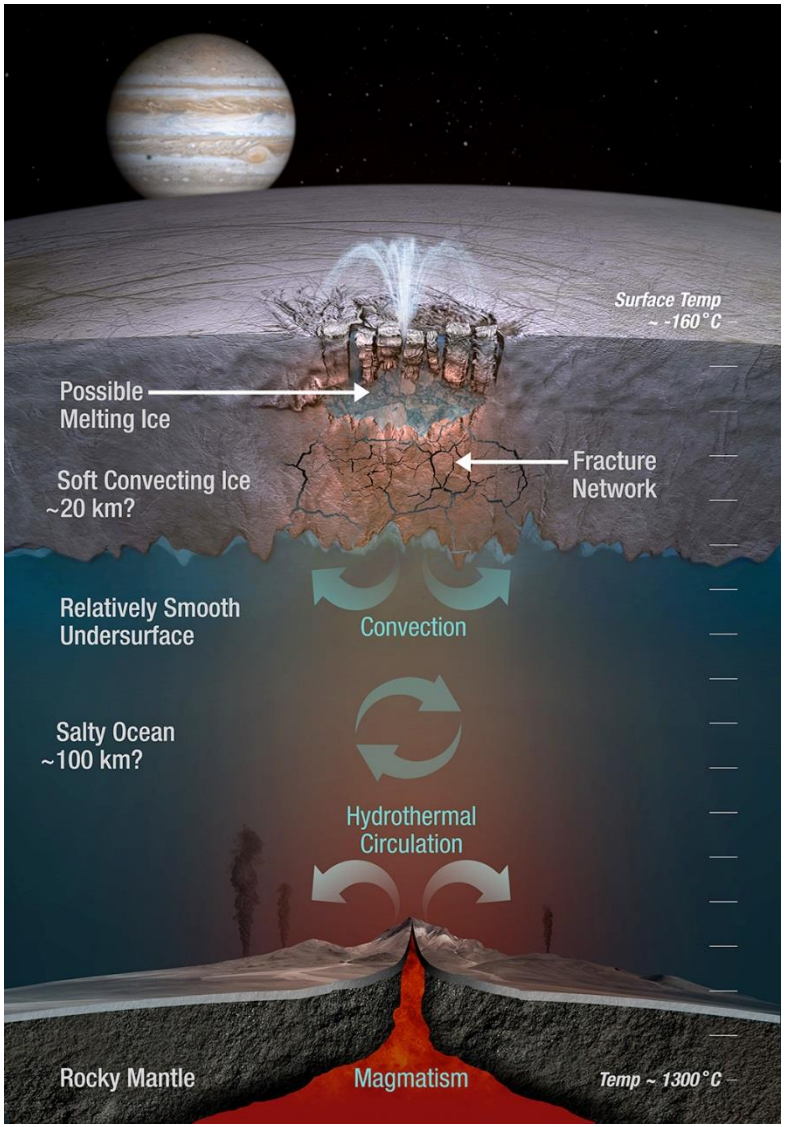
- Ocean in direct contact with mantle rock, promoting chemical leaching
- Dark red surface materials contain salts, probably from the ocean

√ Energy

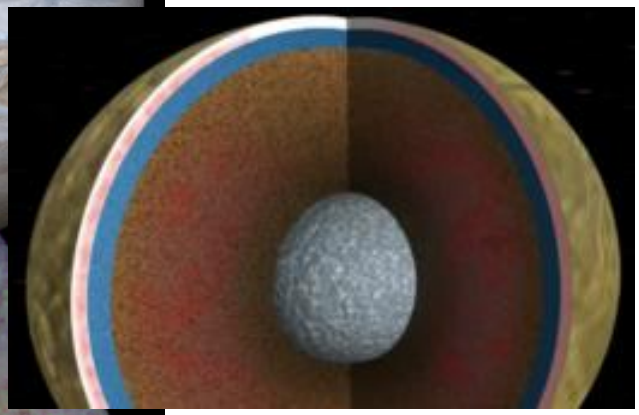
- Chemical energy could sustain life
  - Surface irradiation creates oxidants
  - Mantle rock-water reactions could create reductants

Geological activity “stirs the pot”

A Europa mission must verify key habitability hypotheses

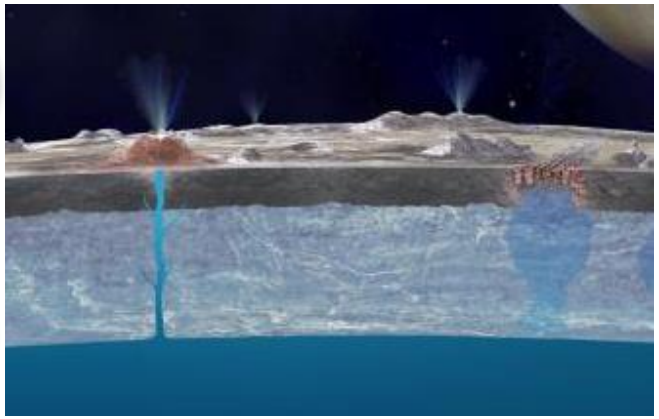


The Big Question: Is Europa Habitable?



How deep and salty is the ocean?
Gravity, Magnetometry
(GRAIL, GRACE)

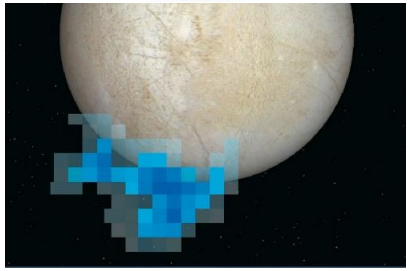
How thick is the ice shell?
Radar, Gravity
(MRO, Cassini)



How active is the ice shell?
Camera, Thermal Imager
(MRO, ICESat)

What's in the plumes?
Mass & Dust Spectrometers
(Cassini)

What's the brown stuff?
IR & Mass Spectrometers
(Landsat, MRO)



The drive to answer these questions has guided mission concepts for 15 years, drawing on our experience at Mars, Saturn and Earth

Evolution of Mission Concept

- Since 1999 NASA has studied over 18 mission concepts designed to answer the key habitability questions.
- Representative studies:

  Europa Orbiter (2001): small $1B orbiter mission with ~20 kg payload
  - Lesson: the radiation was worse and custom rad-hard parts more expensive than anticipated; cost increased

  Jupiter Icy Moons orbiter (JIMO) (2004): large orbiter mission with >200 kg payload
  - Lesson: increased science scope massively impacts mission design

  Europa Explorer & Jupiter Europa Orbiter (JEO) (2007-2011): $4-$5B orbiter mission with ~100 kg payload
  - Lesson: orbiting Europa strains mission and spacecraft design. Decadal recommended descoping the science to reduce costs.

  Orbiter (2013): <$2B orbiter mission with ~90 kg payload
  - Lesson: trade science return and payload against need to orbit Europa

  Lander (2013): $4B soft lander lasting one month
  - Lesson: sample acquisition necessary, landing blind

Europa Mission Concepts < $1B

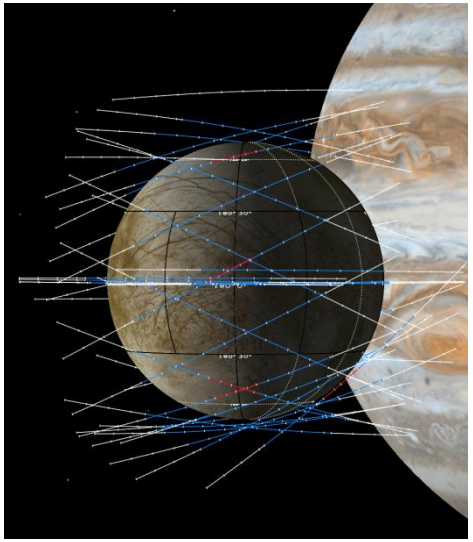
- In 2014, NASA issued an RFI for complete mission concepts for exploring Europa at less than $1B (FY$15, excluding launch vehicle), to see if sufficient science progress would be possible for smaller than flagship missions
  - Needed to meet the majority of the five Decadal Survey science goals, including characterizing scientifically compelling sites for a potential future lander mission, while dealing with radiation & planetary protection
- Six responses received
  - Independent costs estimates by Aerospace Corp. exceeded respondents' estimates by up to 200%
  - The cost for required technology development was generally not included in proposed estimates
  - Inadequate budgets for operations
- Missions close to the $1B target minimally addressed a fraction of the Decadal Survey science and required follow on missions, and missions that tried to address even half of the objectives were approaching Flagship class.

Mission Architecture

- Scientific desire for global coverage has invariably led to (terminated) Europa orbiter mission architectures in the past
- Europa orbiter mission:
  - Very expensive in propellant (ΔV) due to large orbit insertion maneuver
  - This maneuver takes away from mass that could be used for scientific instrumentation and radiation shielding
  - Limited lifetime due to continual immersion in harsh radiation (less data return, data return more susceptible to s/c or DSN anomalies)
- Experience at Saturn with Cassini provides an alternative approach:
  - With Europa mission investments and leveraging off previous research/experience on Cassini, the team has developed strategies to gain near global coverage via multiple flybys from a Jupiter orbit.

Europa Multiple Flyby Mission Concept

- Successful concept design allowed a paradigm shift from Orbiter ($4.7B Decadal CATE JEO estimate w/ LV) to Multiple Flyby concept (≈ $2B FY 15$, excluding launch vehicle).
- Achieves >80% of science for <50% of cost (SDT & Independent Board):
  - Limit science scope (focus on Europa, not Jovian System)
  - Builds on multiple Juno and Cassini developments
  - Achieve near global coverage without sustained very high radiation environment at Europa
    - Fly by close, collect science data, leave
    - Standard hi-rad parts replace custom hi-rad parts
  - Less propellant needed to enter Jupiter orbit, mass goes to shielding
  - Simplified Operational concept; same concept for each flyby
- Fly-by & collect science data, remaining Jupiter orbit used to recharge batteries & downlink data (capable of 5 times more data downlink)



Regional-Global coverage of Europa achieved through 45 flybys

Programmatic Status

- Europa mission is in the FY16 President's Budget Request
  - This new start formalizes the Europa mission and kicks off formulation
- Instrument selections for Europa mission expected in May 2015
  - Released SALMON 2 PEA in July 2014 to solicit instrument investigations for an unspecified Europa mission
  - 33 proposals recently completed evaluation and categorization
  - Potential for 1- or 2-step selection
- 57 Dedicated Hubble Observations with optimal lighting and orbital conditions underway to attempt to verify existence of Europa plumes
  - Not confirming their existence does not mean they don't exist. Variability factors are currently not understood.
- Hosted a workshop Feb. 18, 2015 with leading astrobiologists and Europa scientists to understand how to possibly interrogate the plumes, if they exist
  - Previous plume workshop fully endorsed mission concept and strawman payload
  - Identify potential instruments and mission concepts to maximize likelihood of detecting current life if it exists
- Evaluate feasibility of adding probe or small sats to interrogate the putative plumes.