Europa Lander Studies
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Overview of Europa Lander Science Objectives

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Science Objectives*

- Characterize the near surface composition, especially organic chemistry, salts, and indicators of high temperature water-rock interactions particularly at depths below the critical radiation processing depth

- Determine the compositional, geophysical, and geological context for the surface site(s) on a global, regional, and especially local scale

- Search for indications of Europan biology, including chemical or isotopic signatures of potentially diagnostic non-equilibrium processes

* Space Studies Board, 1999. A Science Strategy for the exploration of Europa, National Academy Press, Washington, D. C.

How To Meet High-priority Science Measurement Objectives

- **Characterize Near-Surface Composition Below Radiated Layer**

  Employ lander/penetrator to access subsurface; Sample material ≥10 cm depth

  Measure materials of endogenic and exogenic origin

  - Endogenic
    - **Salts (e.g., epsomite, natron) and/or sulfuric acid**
    - **Hydrogen peroxide (H_2O_2), Na**
    - **Minerals (e.g., silicates, sulfides, iron/iron alloys)**
  - Exogenic
    - **SO_2, S, and Na from Io**
    - **Minerals (e.g., silicates, sulfides, iron/iron alloys) and carbonaceous materials**
  - H and O isotopic ratios
  - Measure $^{14}N/^{15}N$ and $^{12}C/^{13}C$ ratios to distinguish between chondritic vs. endogenic origin

How To Meet High-priority Science Measurement Objectives

- **Determining Compositional, Geophysical, and Geological Context**
  - Characterize local sites using high resolution spectral and spatial imaging/NIR remote sensing and mass analysis
  - Measure the seismicity
    - Characterize the frequency of Europaquakes and crustal noise
    - Measure quantity of liquids and thickness of ice (P and S waves)
    - Identify possible Crary waves
  - Measure the magnetic signature
    - Characterize induced and intrinsic fields, thickness of possible water layer
      - Orbiting magnetometer helps

How To Meet High-priority Science Measurement Objectives

- **Searching for Indications of Europan Biology**
  - Perform microscopic analysis and/or the equivalent (e.g., UV spectroscopy)
  - Measure concentrations/concentration ratios and chemical forms of C, H, O, N, S, P, Ca, Fe, and K
  - Measure anions, cations and pH
  - Measure redox compounds (Fe, H_2, CO, Mn, CH, S, NO_x, H_2S, NH_3, O_2, CO_2)

Science vs. Instrument Payload Matrix

Science Objective	Measurements	Instruments	Suggested Delivery System
1. Characterize near-surface composition	Salts/Sulfuric acid H_2O_2, Na Minerals SO_2, S and Na from Io H and O isotope ratios $^{14}N/^{15}N$ and $^{12}C/^{13}C$ ratios	Ion specific electrodes IR spectrometer GCMS	Surface lander w. ultrasonic drill and mast
2. Determine compositional/ geophysical/geological context for surface site (local scale)	High spectral/spatial resolution remote sensing Seismicity Magnetic signature Heat flow	Imager IR spectrometer Micro-seismometer Magnetometer Temperature sensor	Surface lander with mast Melt probe
3. Search for indication of Europan biology	Concentrations/ratios of chemicals (C,H,O,N, S,P, Ca,Fe,K) Anion, cations and pH Redox compounds ((Fe, H_2, Co,Mn, CH,S,NO_2,H_2S, NH_3,O_2,CO_2) Microscopic analysis	Ion specific electrodes GCMS UV laser/spectrometer Raman spectrometer 100 µm camera	Surface lander with ultrasonic drill Melt probe with imaging window and/or sample ingestion port
4. Prepare for deep ice shelf penetration	See objectives 2,3 above	Instrument sets as above	Melt probe configured to carry full suite of instruments and passive/ active heating, full array of state sensors, and mini-RF tranceivers