SCIENTIFIC OBJECTIVES AND REQUIREMENTS

PSI#4:

Understand the exchange processes between the ice shell surface/subsurface and the aqueous interior environments

SCIENTIFIC INVESTIGATIONS

PSIs#4 are focused on both regional and local scales to **characterize the habitability**, so their investigations will combine measurements from orbiter and lander

All JEM investigations from the surface should be in agreement with the NASA Lander TM (this case is different to other PSIs that require only remote measurements)

Exchange processes between the surface and aqueous environment are mainly related to:

- Activity : geological process that permit the exchange are tectonics, volcanisms (including plume activity)

- Materials:

geochemistry of the compounds that could be transported and/or change between layers

physical properties of the surface/subsurface

SCIENTIFIC INVESTIGATIONS

From Hand presentation, August 2016

(OPAG update)

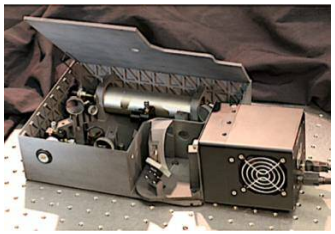
Goal	Investigation
Search for evidence of life on Europa	Detect and characterize any **organic indicator** of past or present life
	Identify and characterize **morphological and textural indicators** of life
	Detect and characterize any **inorganic indicator** of past and present life
	Determine the **provenance** of sampled material
	Determine if **living organisms persist** in sampled materials (Not part of the threshold)
Assess the habitability of Europa via in situ techniques uniquely available to a lander mission	Characterize the **non-ice composition** of Europa's near-surface material and determine whether there are indicators **of chemical disequilibrium** and other components essential for life.
	Determine the **proximity to liquid water** at the lander's location
	Detect whether Europa **is active today** and characterize any observable surface exchange processes to support sample context.
Characterize surface properties at the scale of the lander to support future exploration	Characterize the **biosignature preservation potential** (BPP) of accessible surface materials at the landing site
	Characterize the **surface dynamics** of Europa at the landing site in all 3D
	Characterize the **material properties** of Europa at the landing site

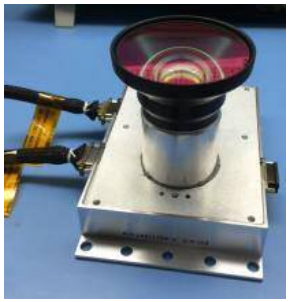
SCIENTIFIC INVESTIGATIONS

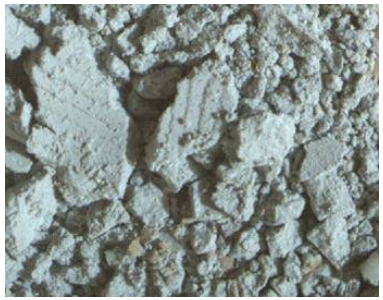
From Pappalardo presentation, March 2016

Model Payload (Total Mass 35 kg MEV)

- Centerpiece Instruments for Astrobiology
  - **GCMS**: VCAM GC + Ion Trap MS, 8.3 kg CBE
  - **Raman**: SHERLOC 5.4 kg CBE
- Auxiliary Instruments
  - **Context LanderCams (x2)**, 0.5 kg each CBE
  - **Microscopic SampleCam**, 0.5 kg CBE
- Baseline Instrument (not included in Threshold)
  - **3-axis Geophone**, 0.8 kg







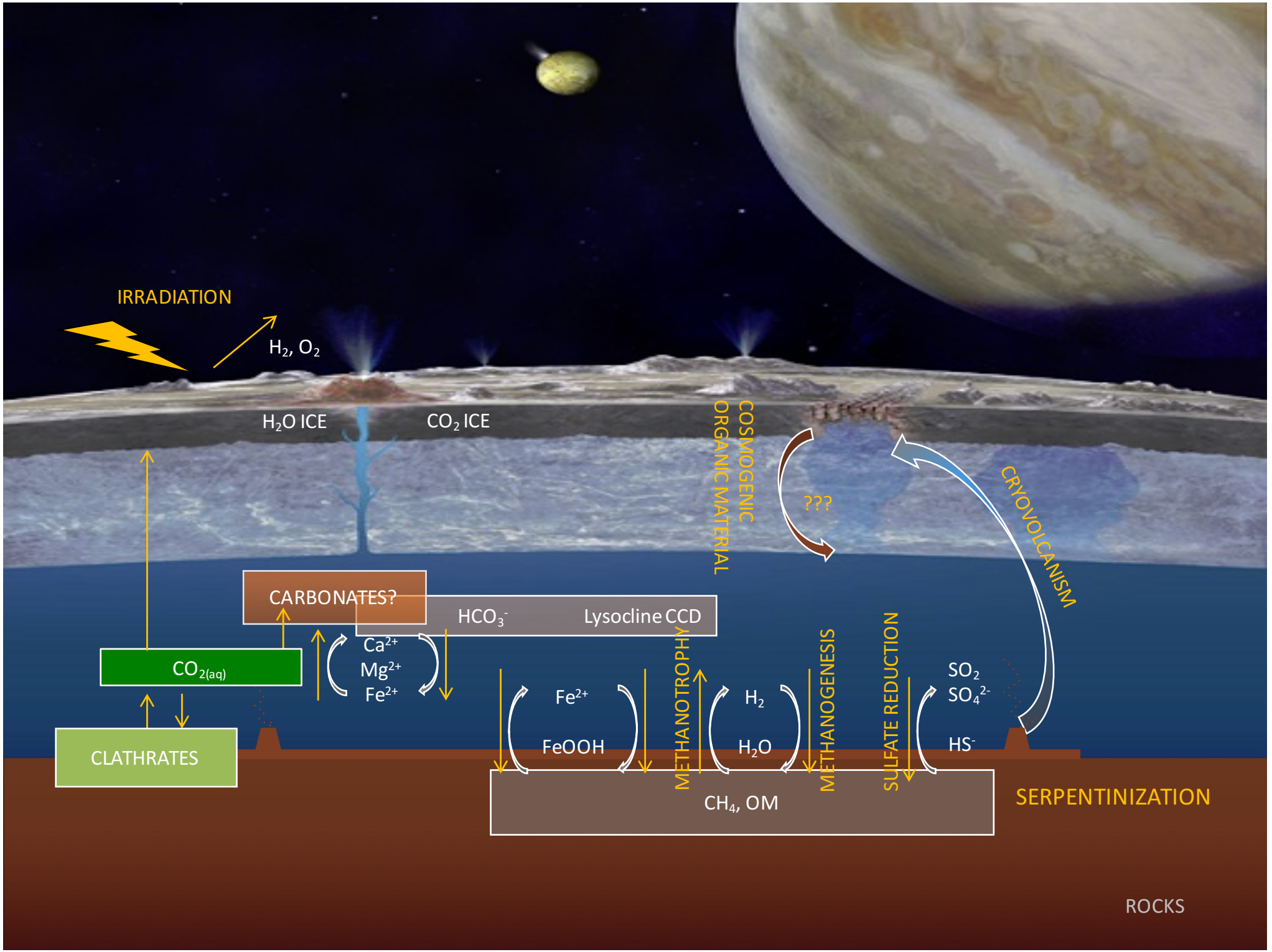
SCIENTIFIC INVESTIGATIONS

CONSIDERATIONS

- Characterization of habitability: solvent, bio-essential elements, chemical gradients
  - wet environment
  - organics and mineral sources o biochemistry
  - electrochemical gradients

Raman
GCMS

Parameters	Measurable	Relevant Information
Physico-chemical	pH	Environmental parameters, potential energy fluxes for life, minimal habitability conditions
	Conductivity	
	Redox potential	
	Temperature	
Chemical	Anions-inorganic: Cl-, SO4=, NO3-, PO4=, ClO4-, NO2-	Electron acceptors in microbial respiration, oxidants
	Anions-organic: acetate, formate, propionate	Electron donors for microbial energy supply, C sources
	Cations: Na+, K+, Fe=	Osmolites, nutrient and energy sources
	Volatiles: CH4, H2, NH3, O=	Energy sources, potential biomarkers


IRRADIATION
H_2, O_2
H_2O ICE
CO_2 ICE
COSMOGENIC ORGANIC MATERIAL
???
CRYOVOLCANISM
CARBONATES?
HCO_3^-
Lysocline CCD
Ca^{2+}
Mg^{2+}
Fe^{2+}
$CO_{2(aq)}$
CLATHRATES
Fe^{2+}
FeOOH
METHANOTROPHY
H_2
H_2O
METHANOGENESIS
SULFATE REDUCTION
SO_2
SO_4^{2-}
HS^-
CH_4, OM
SERPENTINIZATION
ROCKS

SCIENTIFIC INVESTIGATIONS

Modified from Hand's presentation, August 2016

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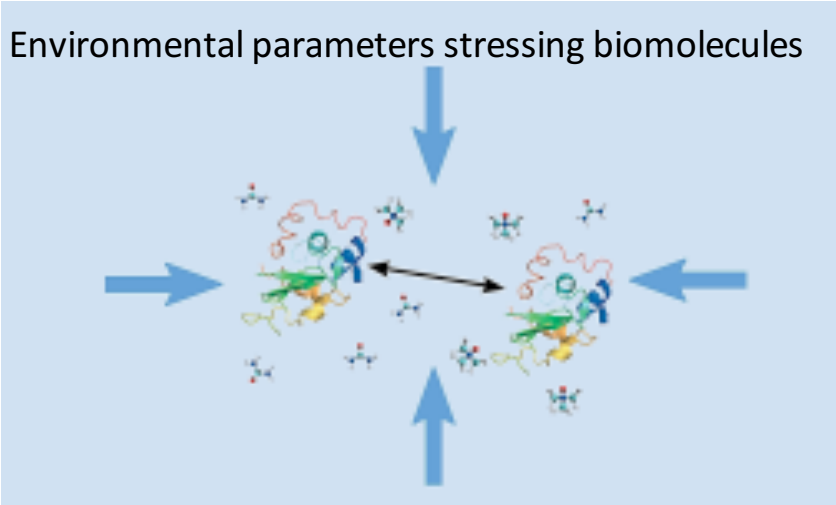
CONTRIBUTION TO THE INVESTIGATIONS

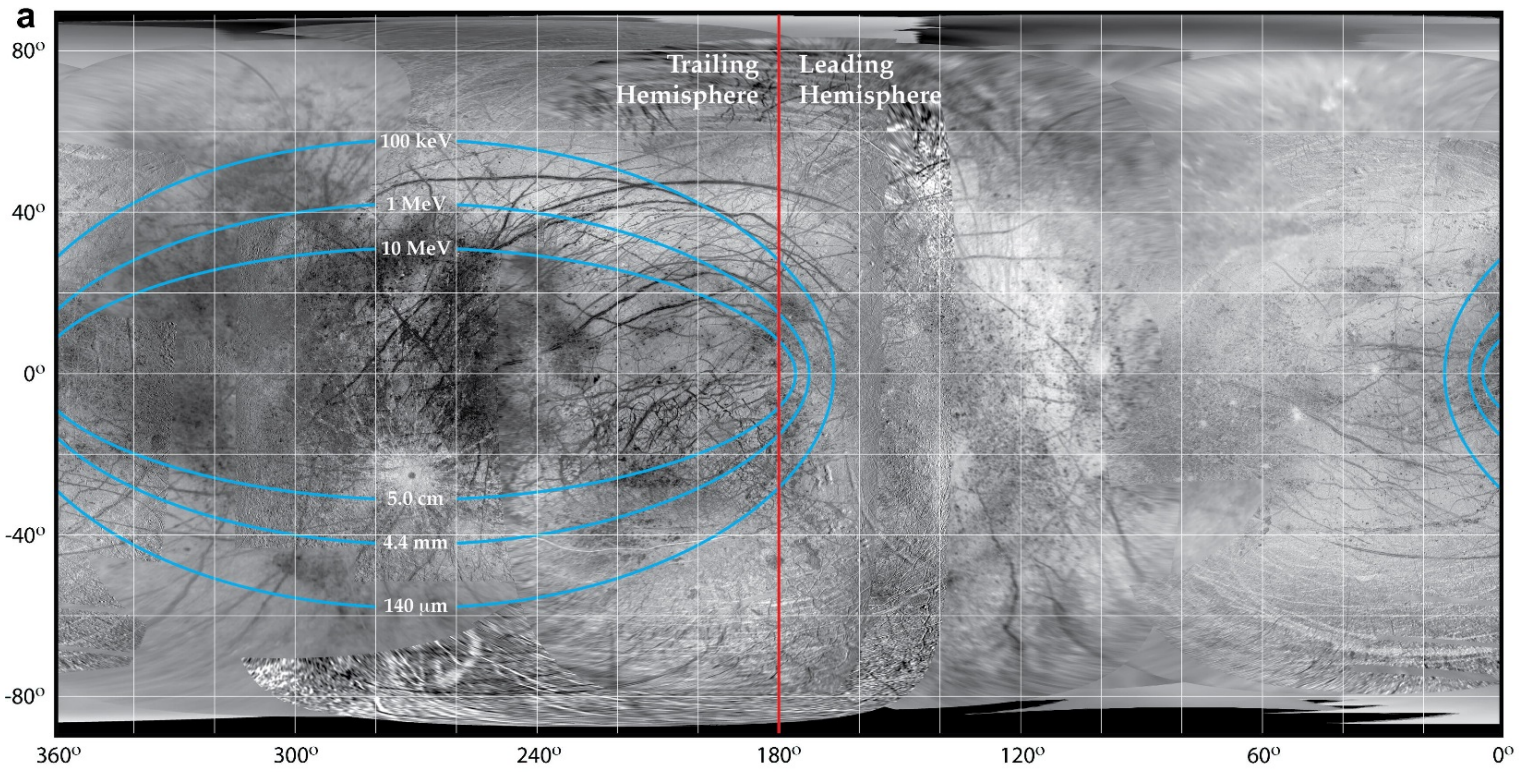
- WET CONTEXT
  - pH: influences the stability, reactivity and mobility of elements, inorganic and polar organic compounds
  - Redox: affect the behavior of many elements and chemical constituents in aqueous media and the living organisms. It is the main energy source for chemolithotrophic organisms. Redox reactions are electrochemical reactions that involve the migration of electrons from one species to another.
  - Conductivity: mostly influenced by salinity, which refers to the presence of dissolved inorganic ions such as Mg^{2+}, Ca^{2+}, K^{+}, Na^{+}, Cl^{-}, SO_4^{2-}, HCO_3^{-} and CO_3^{2-} in the aqueous solution. These ions can constitute redox couples that could provide energy for chemosynthetic life



SCIENTIFIC REQUIREMENTS

How to achieve this investigation:

- Surface science is imperative due to the access of samples
- Sampling the subsurface of Europa in order to measure fresh materials. Materials should be preserved from radiation and other destruction processes
- Selection of the landing site to minimize the risk, and maximize the options to search for endogeneous materials
- Multisite sampling to multiply opportunities of material analysis. Avoid potential contamination/alteration due to landing



SCIENTIFIC REQUIREMENTS

Investigation	Measurement	Requirement	Instrument
Characterize the hydrochemistry of endogenic fluids	Physical chemistry: Acidity, redox, conductivity and temperature of samples in liquid state	pH (to 1 unit) redox (TBC) conductivity (TBC) temperature (0.1 K)	Multiparametric electrode sensor
	Volatiles in ice (augmented capability if AWL)	O2, CH4 (TBC)	Multiparametric electrode sensor