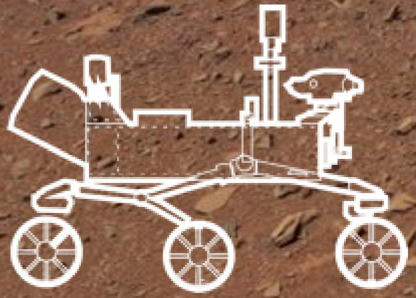
EXCELENCIA
MARÍA
DE MAEZTU

#JOURNEYTOMARS

Recent advances in in-situ miniaturized Environmental, Geochemical and Life detection instrumentation.

CAB's developments.



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Centro de Astrobiología

Scientific objectives

Big questions:

- Are we able to detect Life out of the Earth, even if it is not as we know it?
- What is the level of chemical complexity in the SS?
- Is that chemical complexity the manifestation of life?
- How does a planetary environment condition that life, and the evolution from prebiotic complexity to life?

So, we **need**:

- To characterize the local [contextual] environment (geological, subsurface, hydrological, atmospheric)
- To search for evidence of ancient climates and/or extinct life
- To determine potential habitats for extant life
- To determine the presence of chemical precursors

… among others.

Scientific objectives

And under the tremendously limiting constraints:

- Very low concentration of biomolecules → very high sensitivity
- Extreme temperatures
- Extreme pressures
- Extremely high radiation
- Long dormant periods in transit
- Gravity
- High-g landing impacts
- Vibrations
- Reduced mass and size
- Low power draw

(Extreme temperatures through Vibrations) → endurance

Essential areas, from a technological perspective: challenges

- Sampling
  (including targeting, acquisition and handling)
- In-situ detection for possible biomarkers
  (such as isotopic and organic measurements)
- Access technologies
  (such as drilling into rocks, or deep drilling into subsurface –bedrock, soil, ice-)
- Platforms and landing systems
  (such as penetrators, impactors, "hydrobots", drones, flying platforms,…)
- Communications
- Power
- Planetary Protection

Approaches

- Compact Gas/Liquid Chromatography - Mass Spectrometry
- Raman Spectrometry
- Microscopy
- LiDAR / miniaturized environmental sensors
- Tunable Laser Spectroscopy
- Capillary electrophoresis [on-a-chip] + Laser-induced Fluorescence
- Complex molecules detector

Approaches

Combined techniques (an example)

1. Mineralogy and Geochemical analysis

- ❑ XRD
- ❑ ICP-MS
- ❑ Ion Chromatography
- ❑ Stable Isotopes (IRMS)

2. Physicochemical parameters and organic matter

- ❑ pH
- ❑ TOC (Total Organic Carbon)
- ❑ Sugars and Proteins

3. Microbial diversity

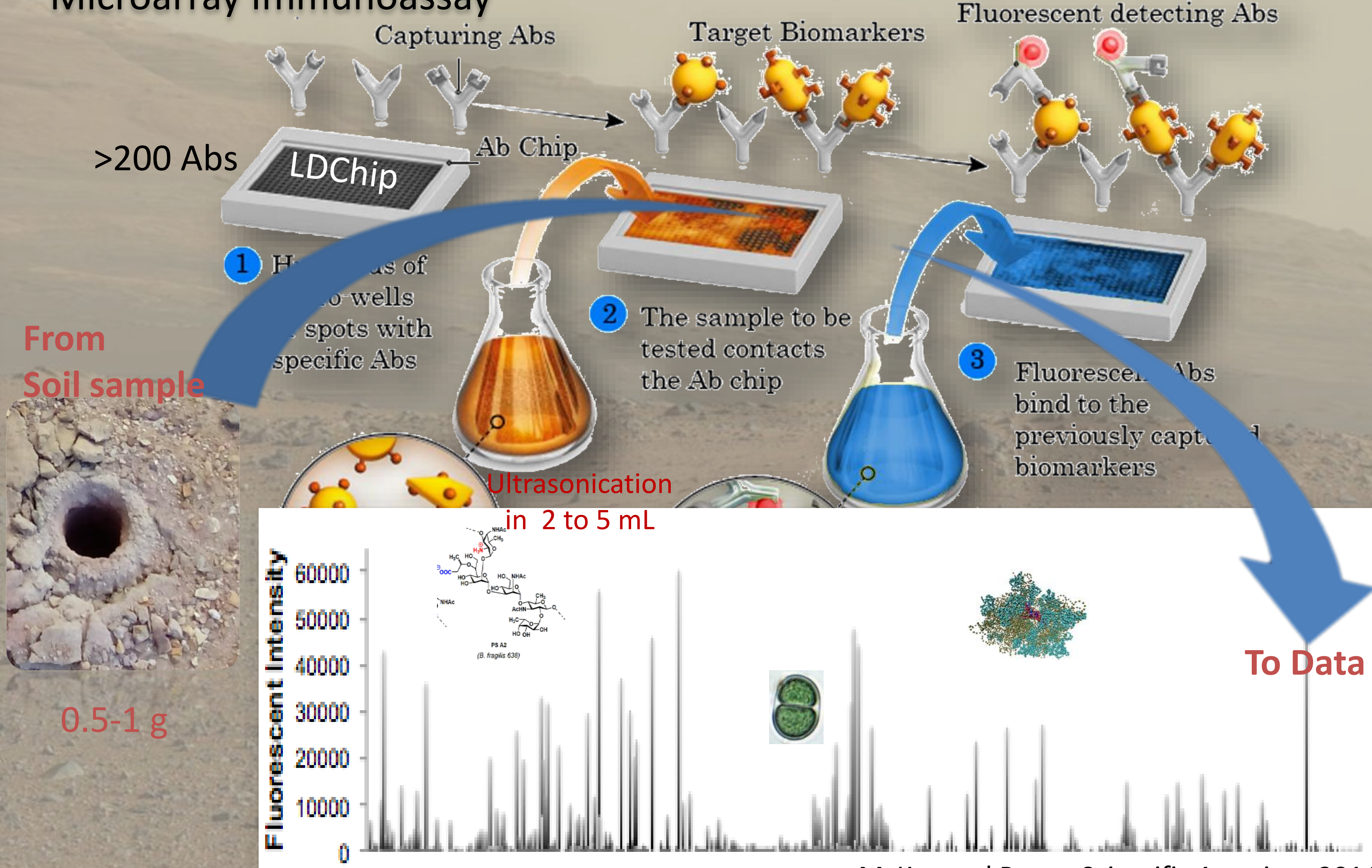
- ❑ DNA Sequencing
- ❑ Microarray immunoassay (FSMI)

4. Microbial markers and metabolism

- ❑ LDChip immunoassay

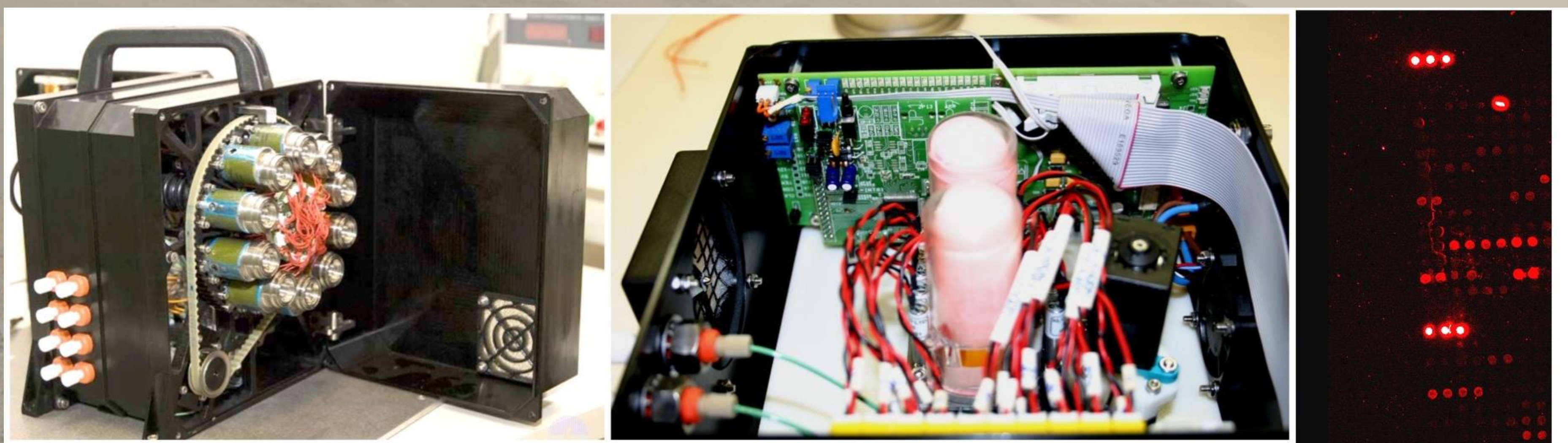
SOLID: Sign of Life Detector

SOLID's core is a Life Detector Chip (LDChip) by Multiplex Fluorescent Sandwich Microarray Immunoassay



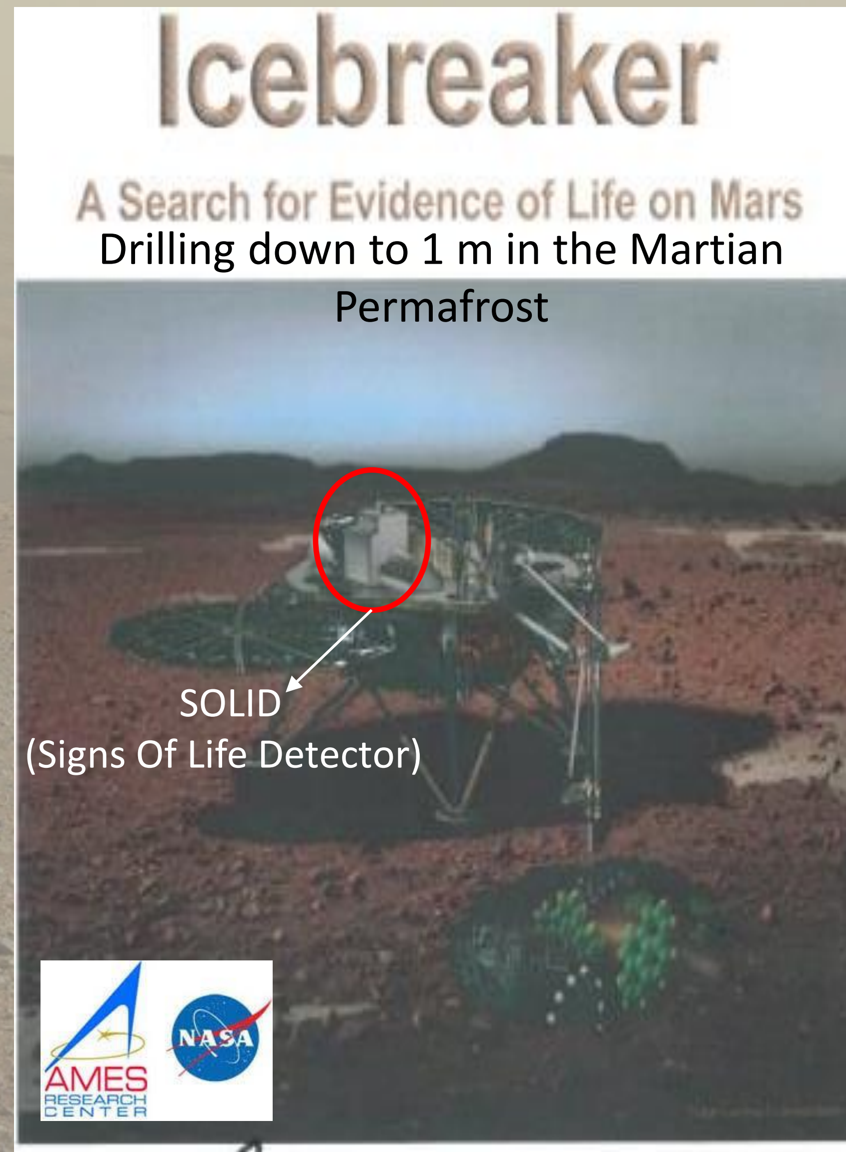
McKay and Parro, *Scientific American* 2014

SOLID: Sign of Life Detector

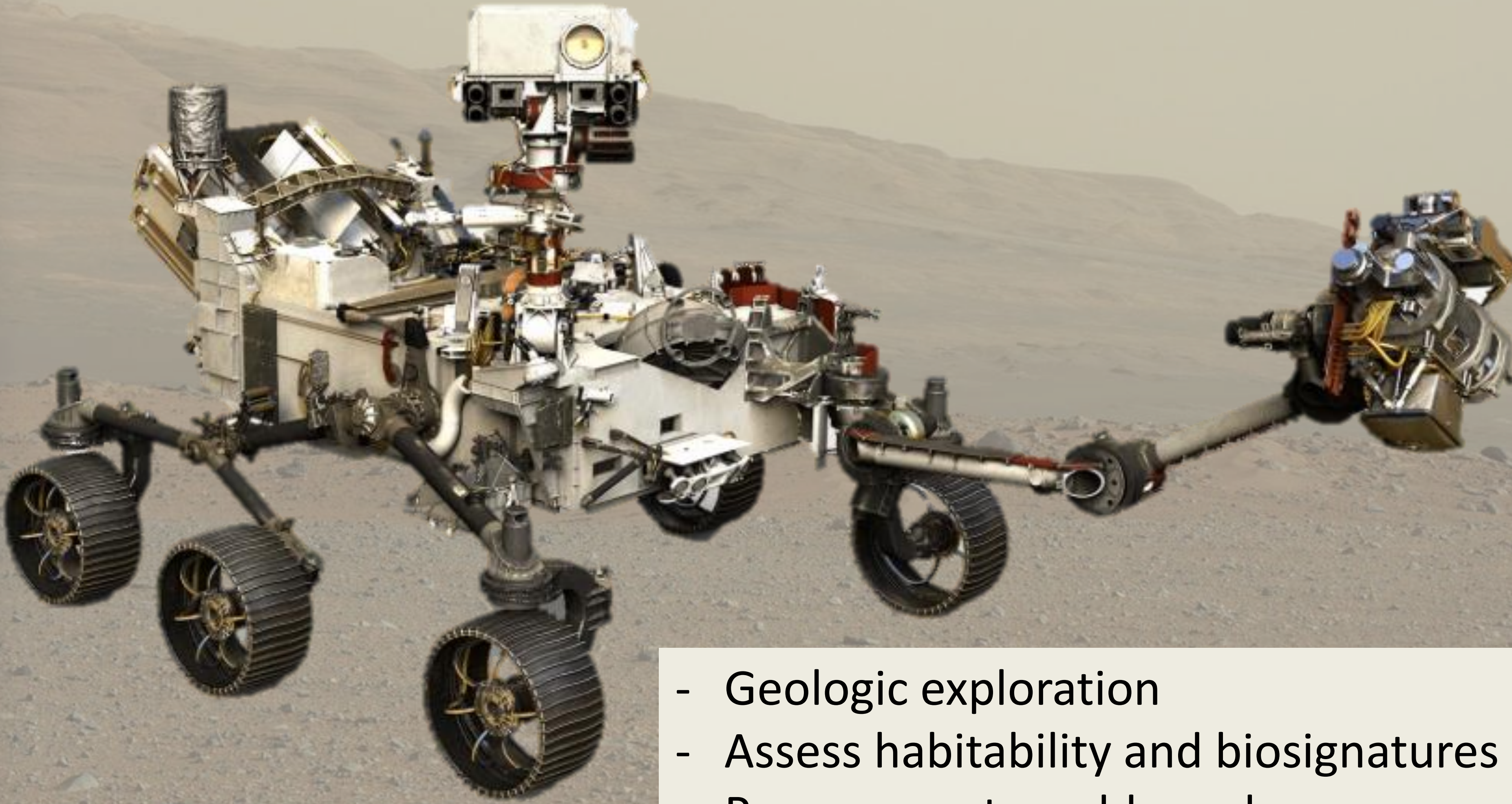


SOLID: Sign of Life Detector

Drilling the Martian Surface aiming at searching for signs of life



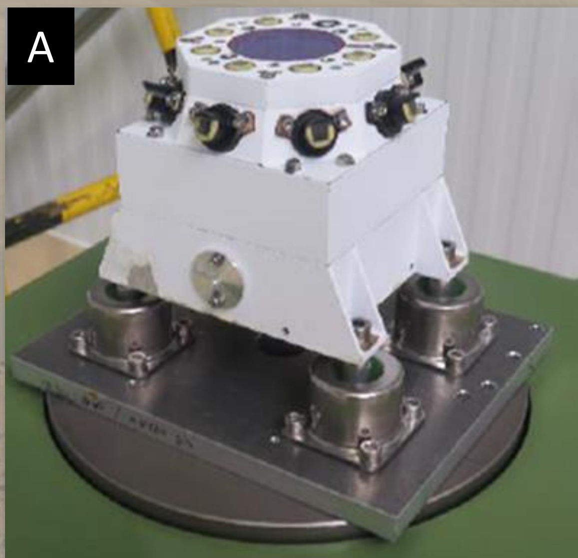
Mars 2020: Immediate future

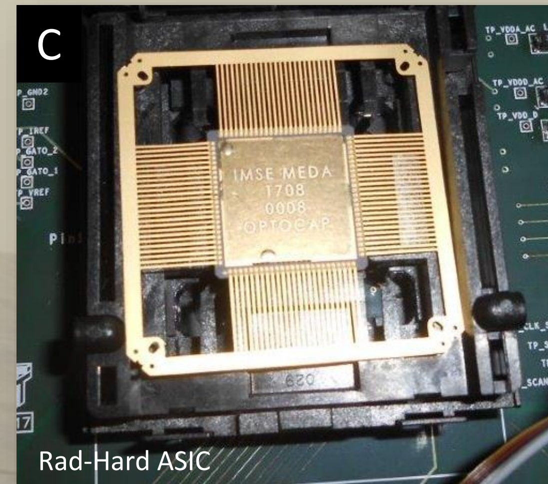


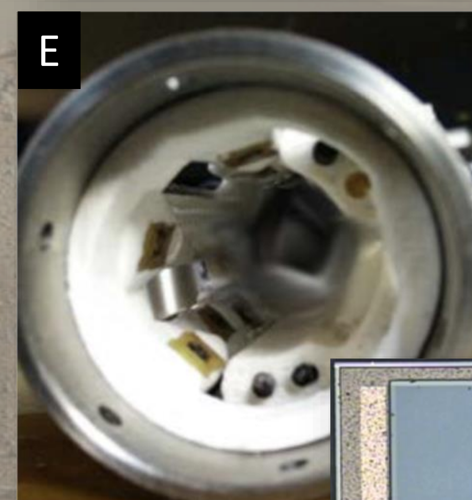
- Geologic exploration
- Assess habitability and biosignatures
- Prepare a returnable cache
- Prepare for human exploration

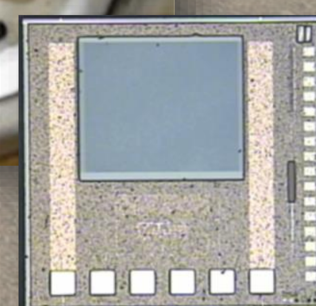
Environment characterization: mid-term future

New developments









Environment characterization: mid-term future

Sensor	Range	Resolution
pH	1 to 12 units	0.01 units
K^+	5 to 500pp	
Ca^{2+}	5 to 500pp	
Na^+	5 to 500pp	
Cl^-	5 to 400pp	

Sensor	Range	Resolution
NH_4^+	0.09 to 9000 mg/L	1 mg/L
NO_3-	0.6 to 31000 mg/L	
NO_2-	2.5 to 1000 mg/L	
Conductivity	0.02 to 20 mS/cm	
ORP	-999 to +999 mV.	

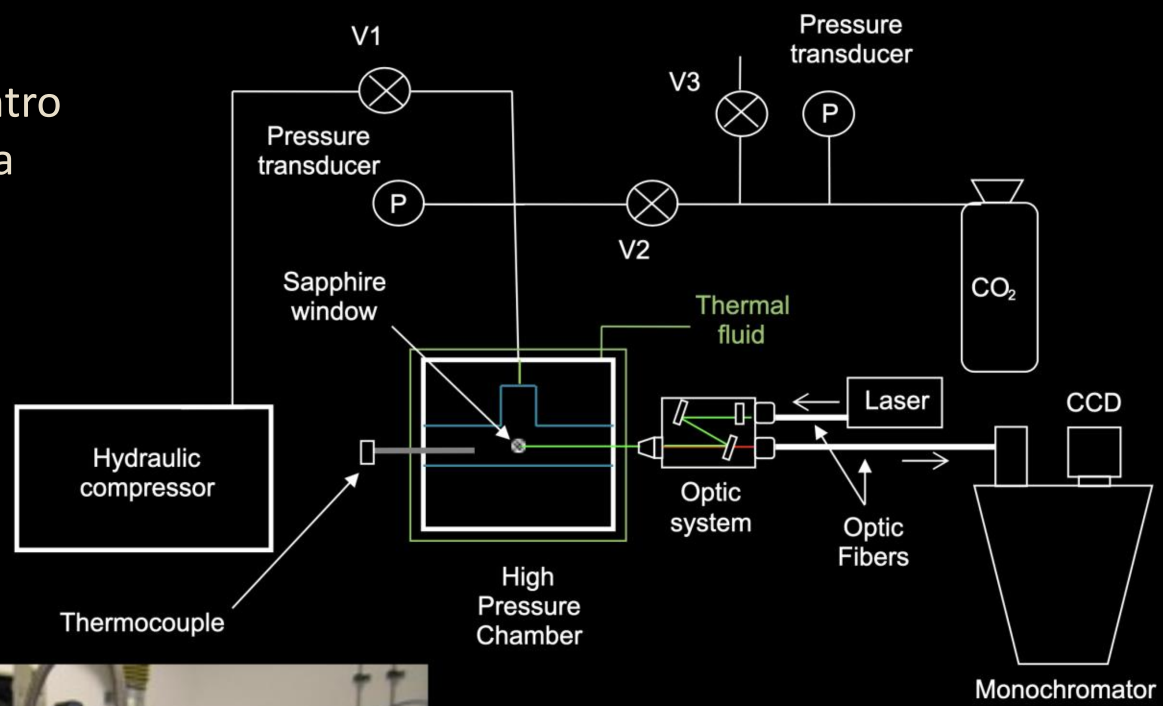
Sensor	Range	Resolution
Salinity	0 to 70 pps	0.01 pps
TDS	0 to 100g/L	0.1 g/
DO	0 to 20 ppm	0.01 p
Temperature	-20° to 60ºC	0.01 º
Pressure	0.6 to 600 bar	0.1 ba

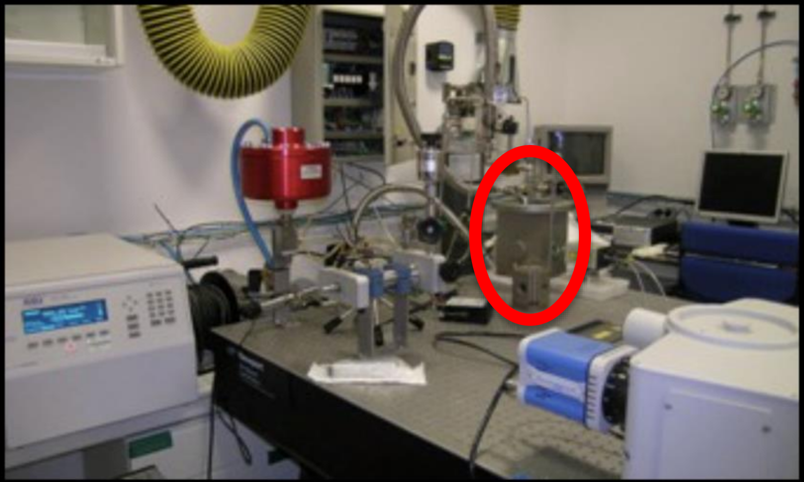
Br
Cu^{2+}
F
I^-
Li^+
Mg^{2+}
ClO_4^-
Ag^+
S^2
UV antifouling
Multispectral sensing

Simulation chambers

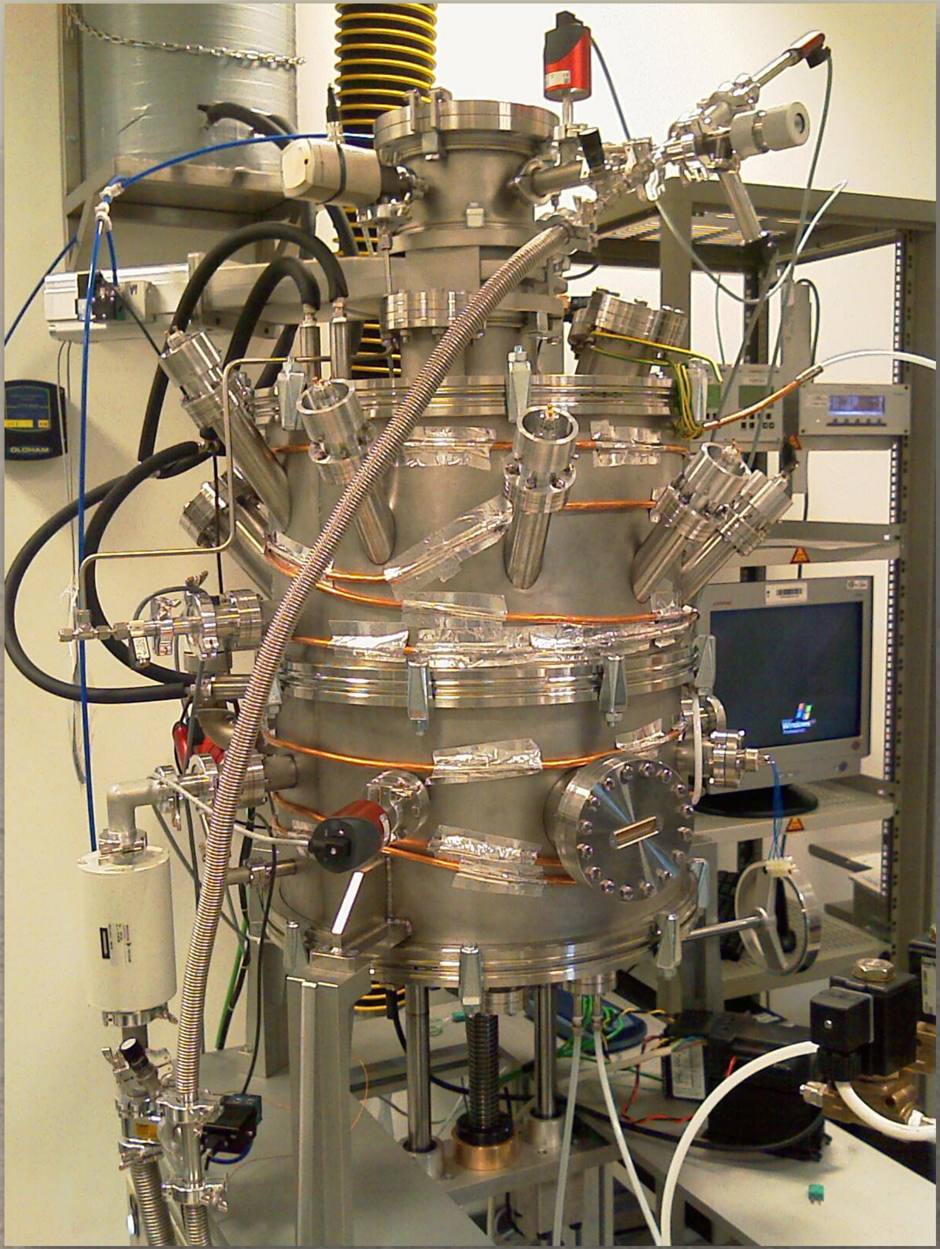
HPPSC

chamber at Centro de Astrobiologia





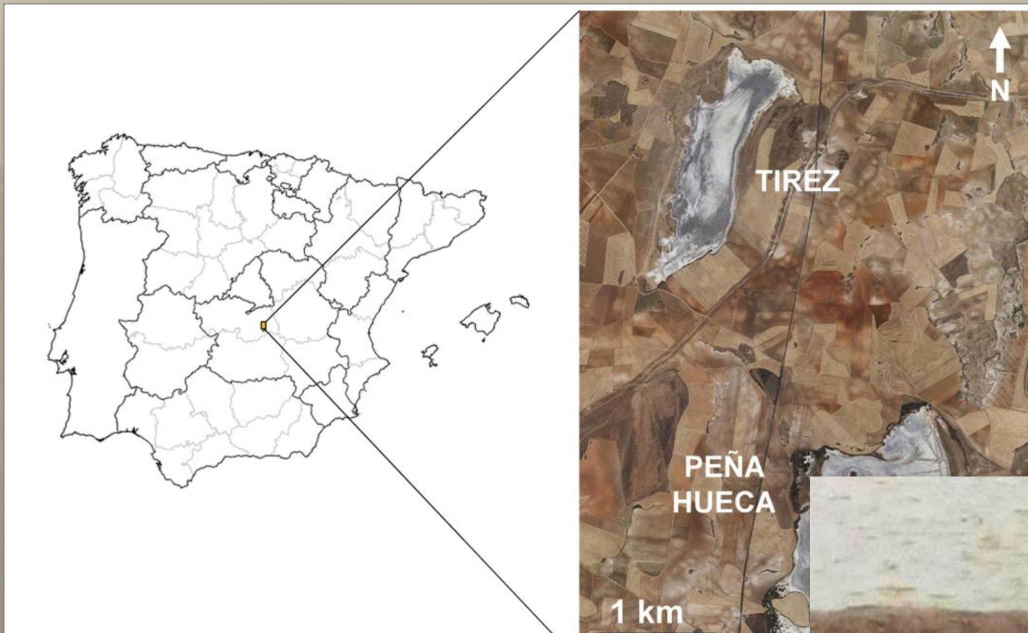
Simulation chambers



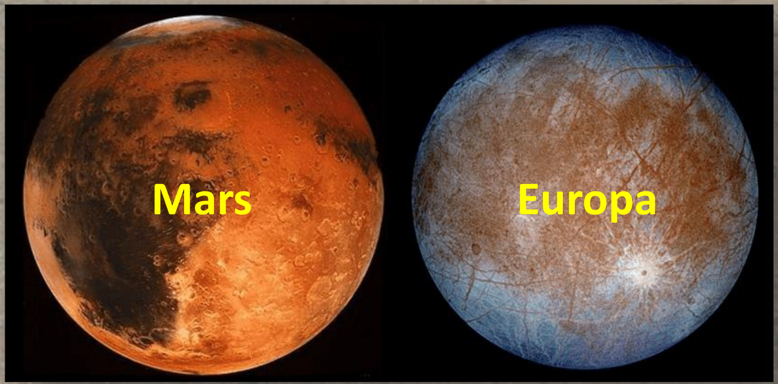
MARTE (Mars) chamber at
Centro de Astrobiologia

Field campaigns

Peña Hueca, an hypersaline ion-rich system in Spain, a good analogue for chloride deposits on Mars and Europa.



R. Thombre & F. Gómez. EPSC 2018.



The Atacama desert: dry limit of life on Earth

- Low water availability
- Extreme temperatures
- High UV-radiation
- Oxidative Stress
- Saline Stress

Objective in the framework of this NASA-funded campaign:
To test and validate the SOLID-LDChip coupled to the IceBreaker prototype drilling system platform through:

1. **Studying the microbial biomarker profile with LDChip in two robotic drills**

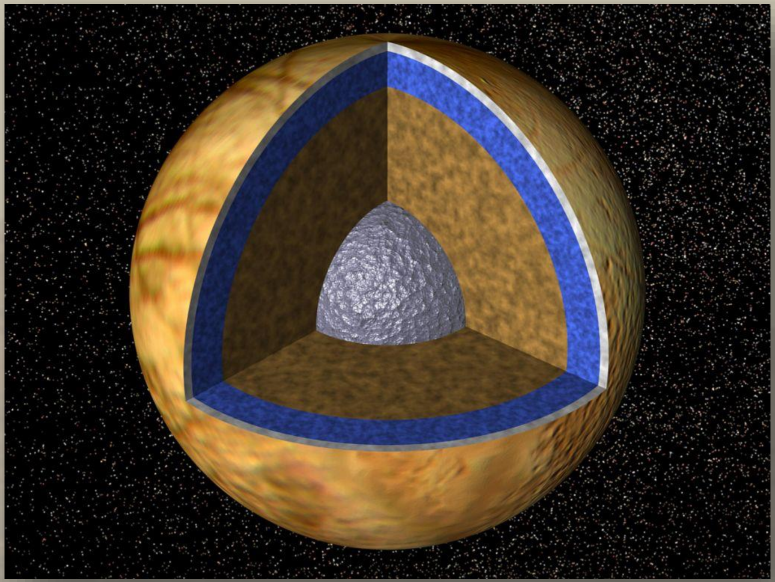
2. **Characterizing the biogeochemical and the geomicrobiological profiles as "ground-truth" analysis**

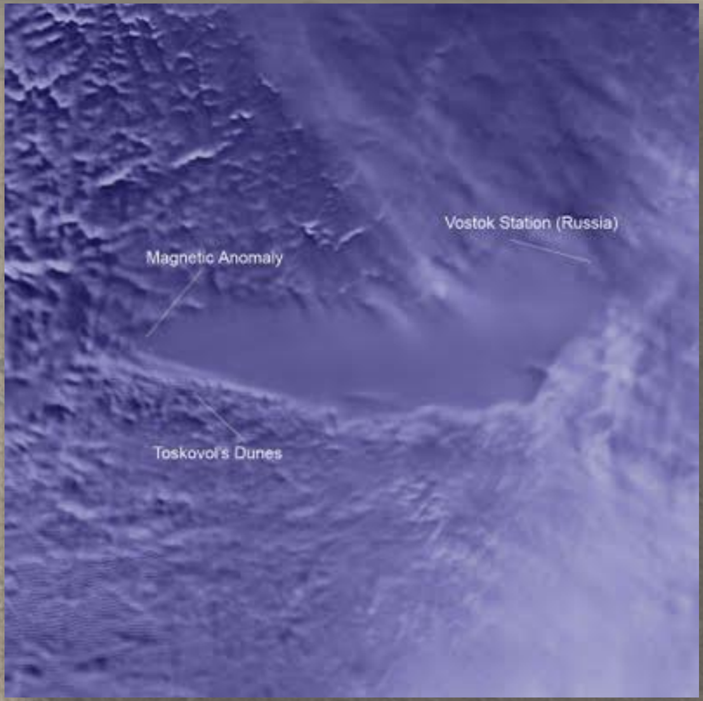
SOLID
LIFE DETECTION TECHNOLOGY BY CAB

Field campaigns

Hydrothermal system of Dallol

Field campaigns





Vostok Lake