Characterizing the Martian surface and potential organics with ExoMars and MOMA

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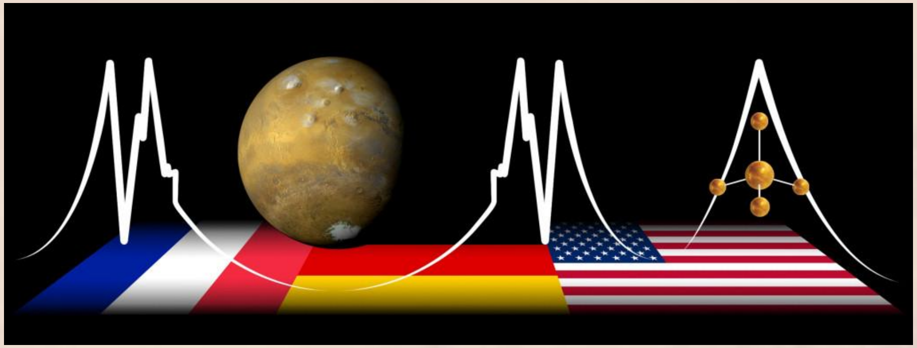
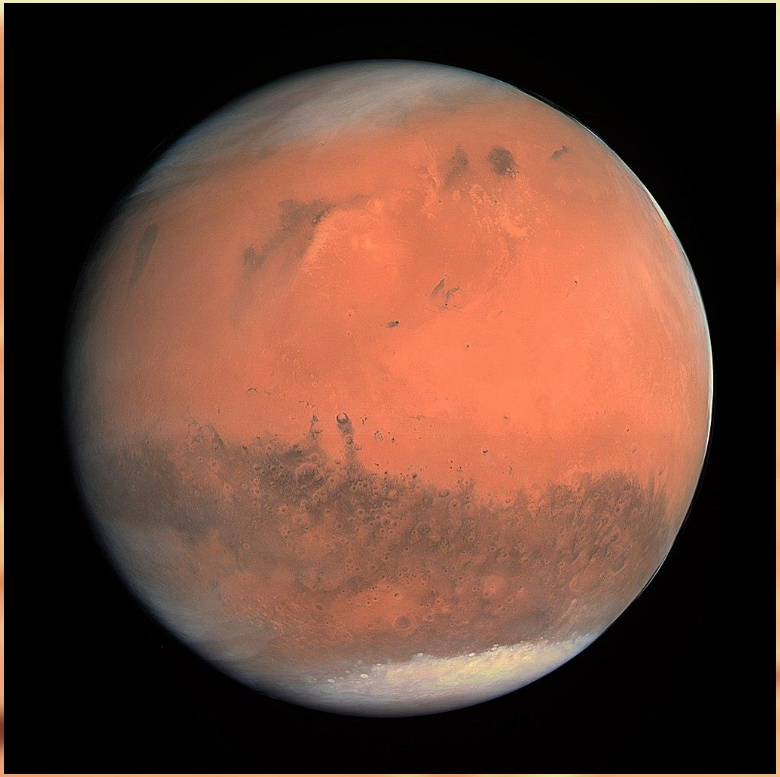
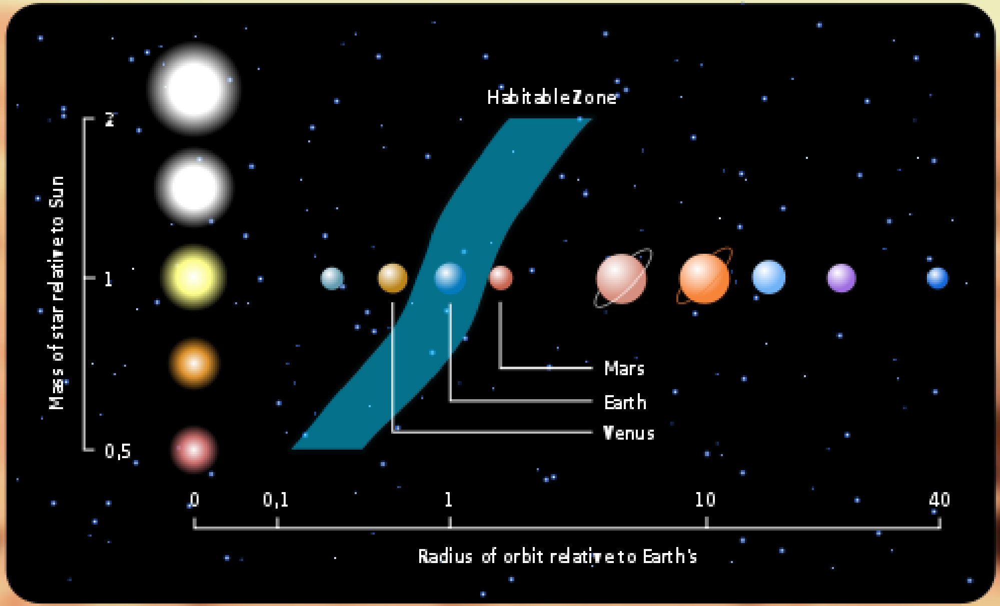
On behalf of the MOMA team



SRS meeting 2021, Lund

Mars

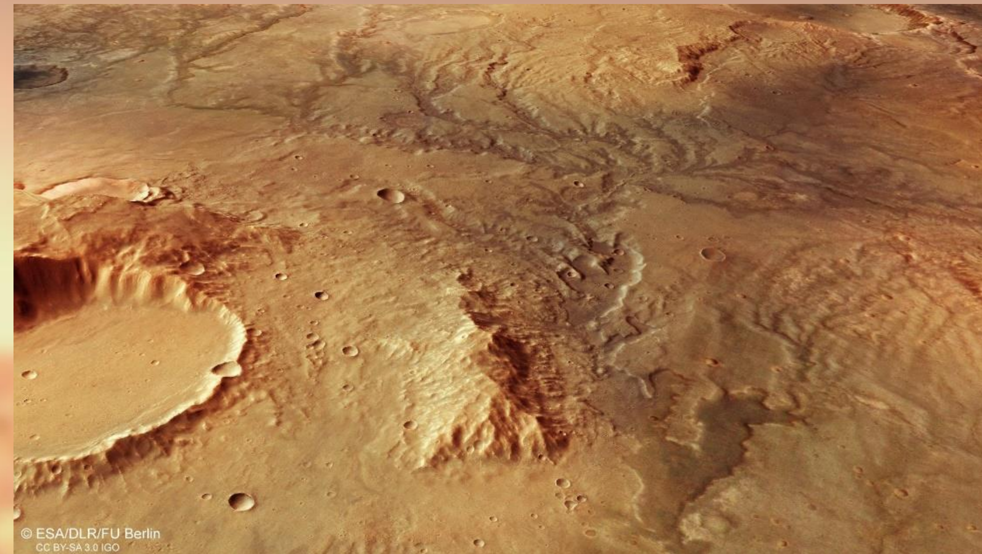


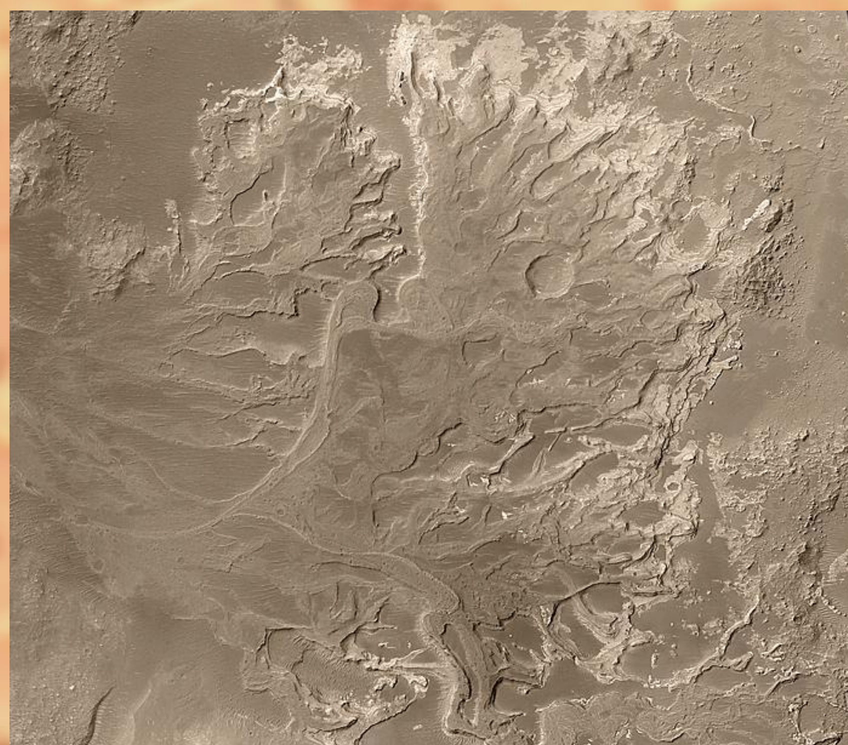


Source: ESA - European Space Agency & Max-Planck Institute for Solar System Research for OSIRIS Team ESA/MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA -

- **One of our closest neighbours.**
- In just outside habitable zone around our sun.
- Early Mars' history (4 Ga) similar to Earth.

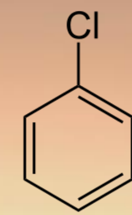
Past water on Mars

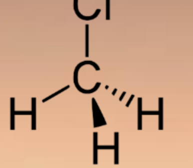


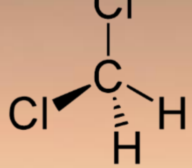


Source: NASA och ESA

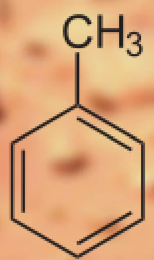
Organic molecules on Mars



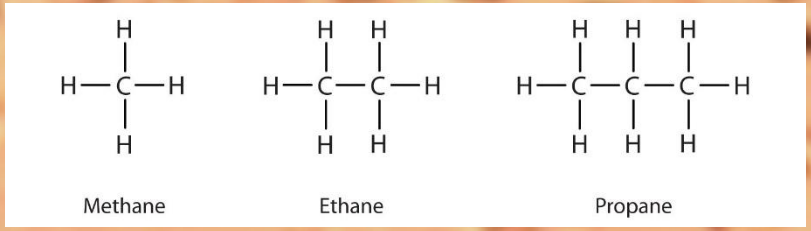


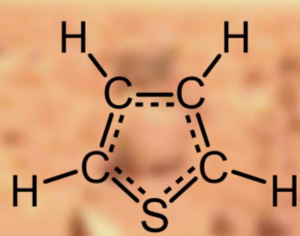


- NASA rover Curiosity has detected a range of chlorinated and non-chlorinated organic molecules in shallow subsurfaceof Mars.



Toluene





Thiophene

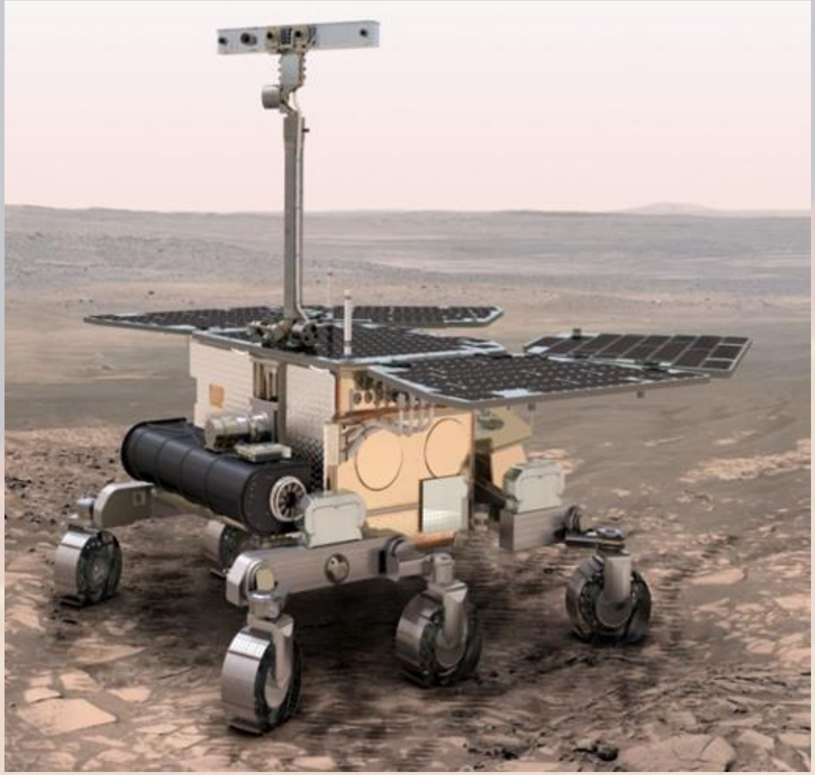
- No organic molecules important for life detected.

- **What is the source of the detected organic molecules.**
    - From space?
    - Abiotic production on Mars?
    - Life on Mars?

Freissinet, C., et al. 2015 Journal of Geophysical Research: Planets

Eigenbrode, J.L., et al. 2018 Science

ExoMars mission



Source: ESA

Launch 2016: ExoMars Trace Gas Orbiter. In orbit now and doing science. First results coming out.

Launch 2022: ExoMars lander (Kazachok) **and rover** (Rosalind Franklin; 218 sols).

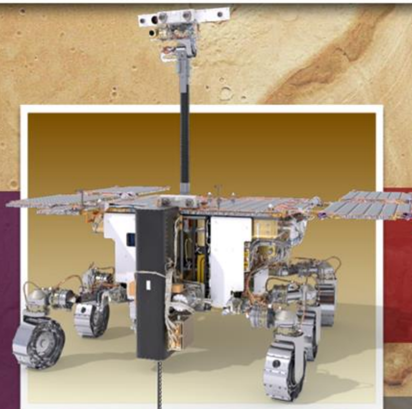
- **Landing June 2023**
- **Drill 2 m**.
- **9 instruments on rover**
- **10+ instruments on lander**

esa

Mission Objectives

E X O M A R S

2022



SCIENTIFIC OBJECTIVES

- To search for signs of past and present life on Mars;
- To investigate the water/subsurface environment as a function of depth.

TECHNOLOGY OBJECTIVES

- Surface mobility with a rover (having several kilometres range);
- Access to the subsurface to collect samples (with a drill, down to 2-m depth);
- Sample acquisition, preparation, distribution, and analysis.

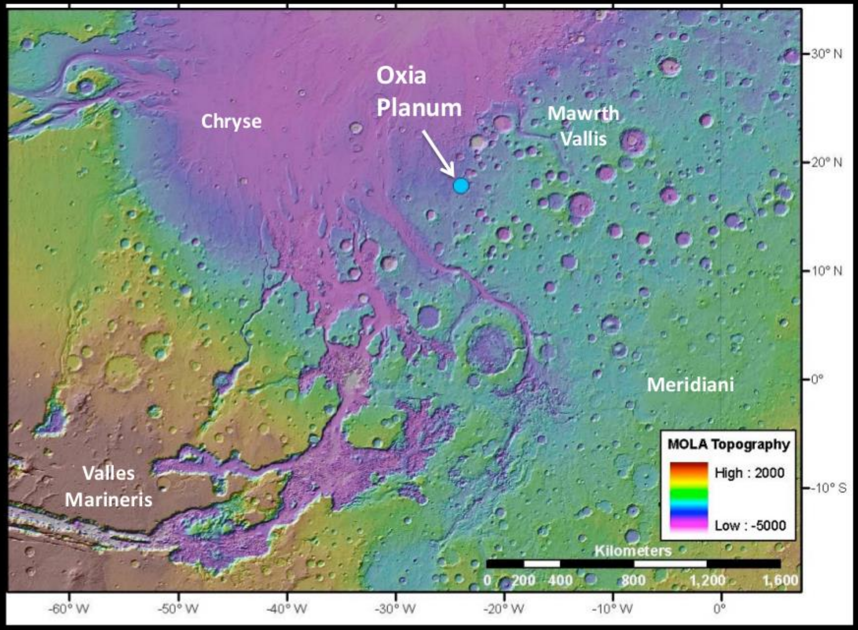
- To characterise the surface environment.

- Throttled braking engines for planetary landing;
- Russian deep-space communications stations working in combination with ESA's ESTRACK.

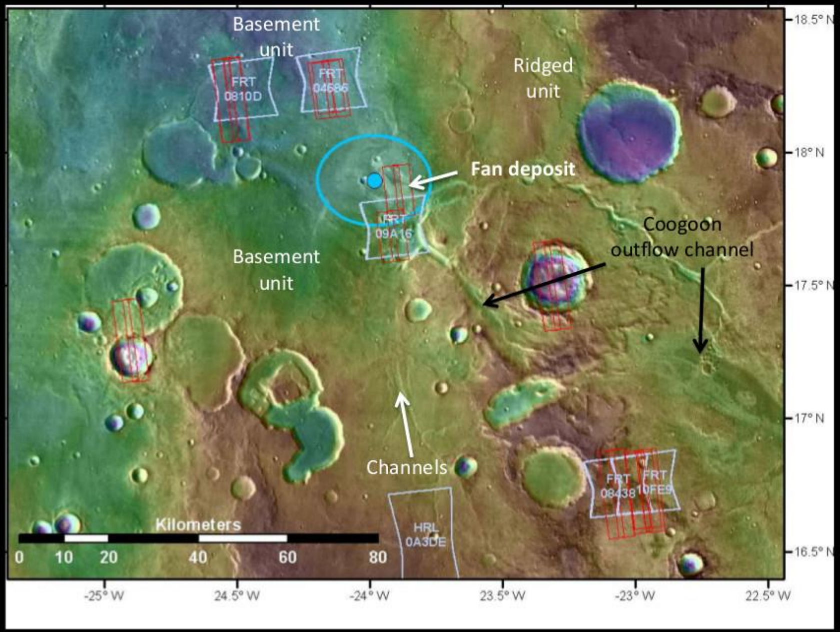
Mamers Valles, ESA / MEX / HRSC

Oxia planum

Oxia Planum location

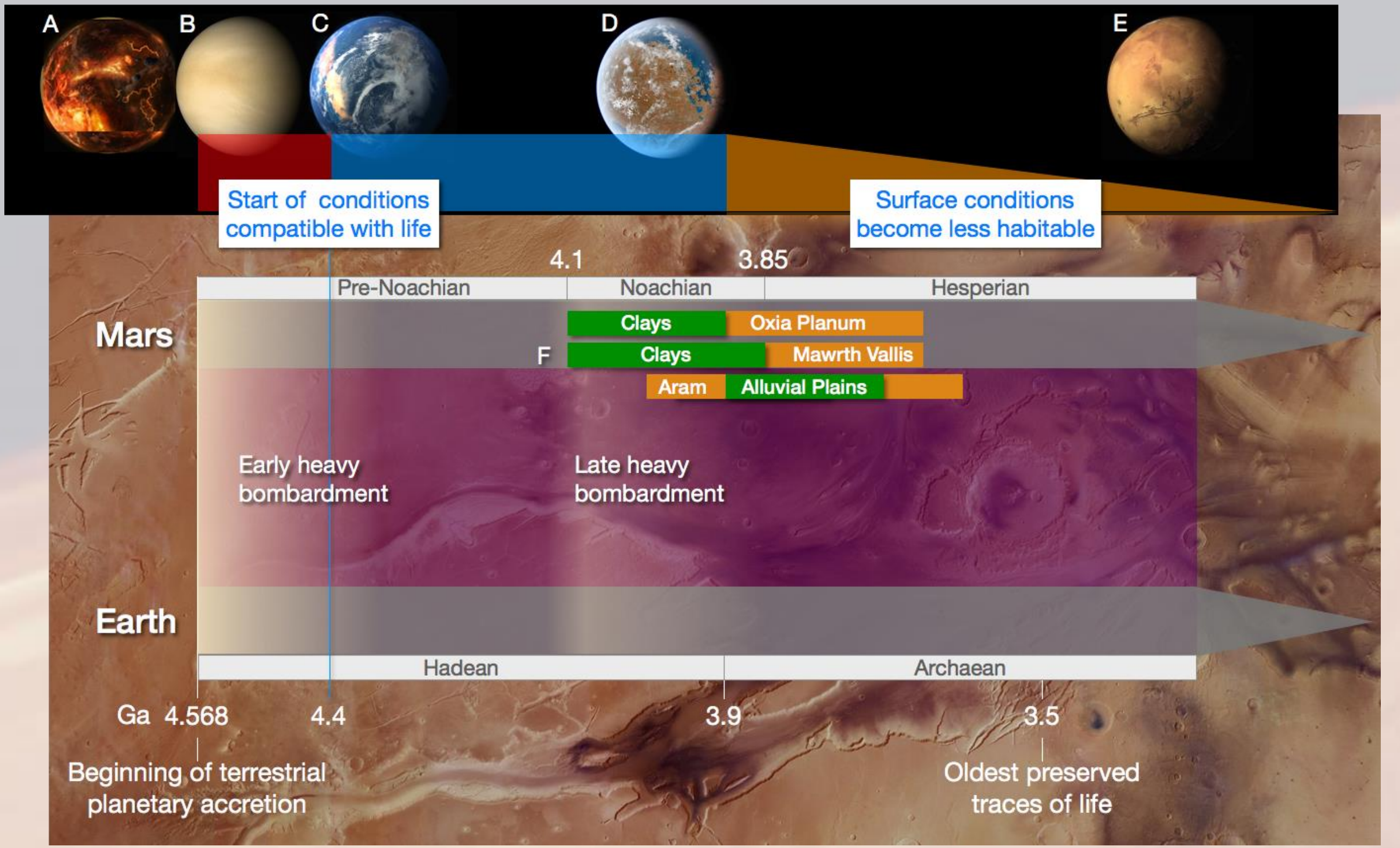


Geological context: morphology



http://marsnext.jpl.nasa.gov/workshops/2014_05/14_Oxia_Thollot_webpage.pdf

Oxia planum



Vago et al., 2017 Astrobiology

Oxia Planum contains some of the oldest rocks on Mars. It has a lot of clays which are good preservers of organic molecules.

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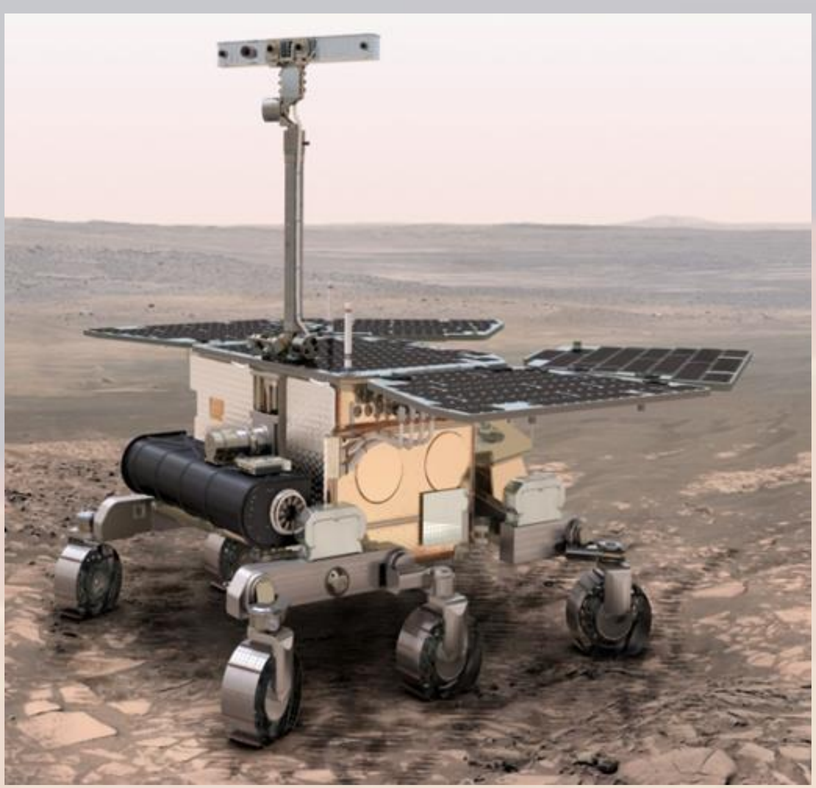
ExoMars 2022 rover



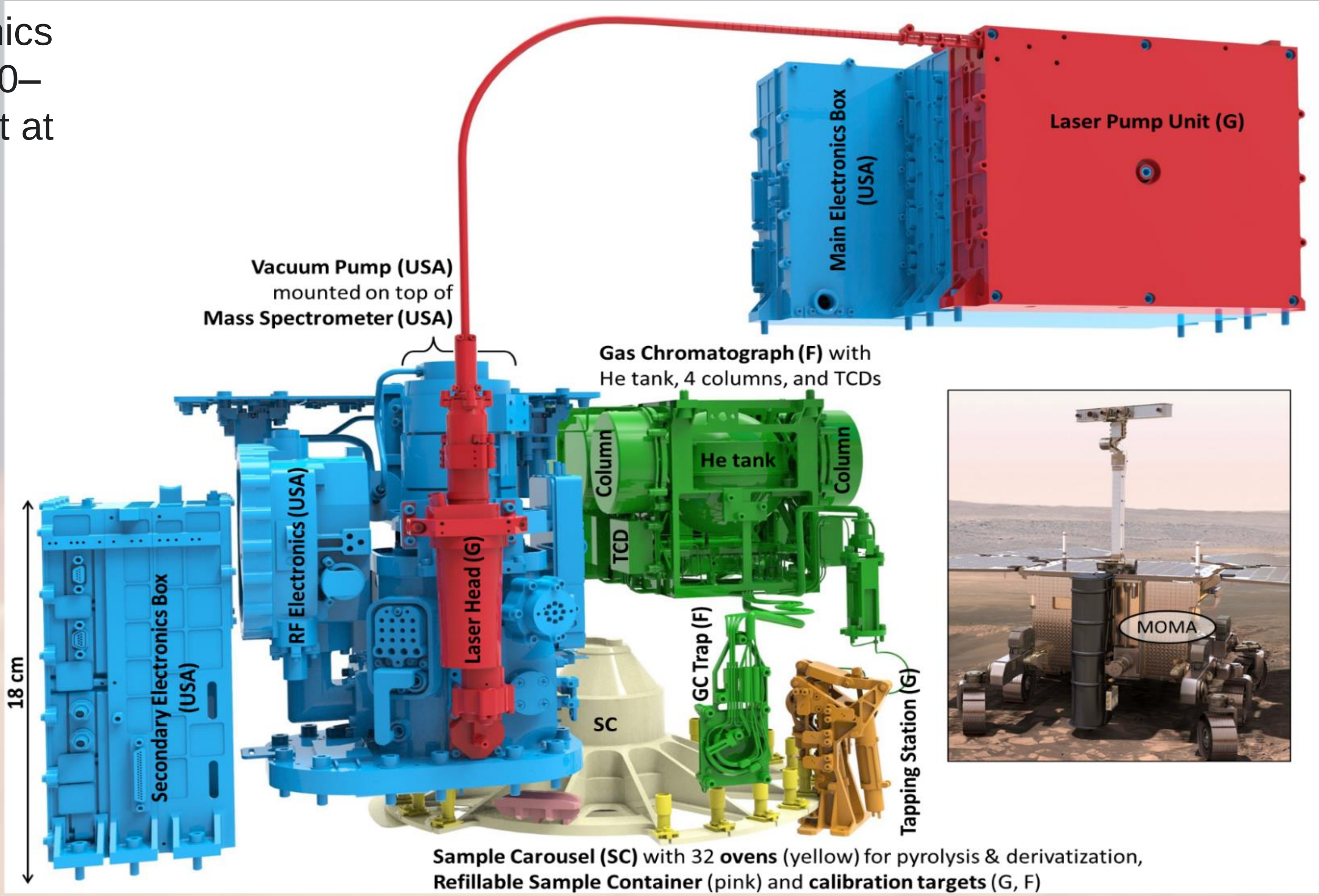
Source: ESA

Rosalind Franklin

- **218 sols**
- **Drill** will obtain samples from up to 2m below surface**.**
- **Sample handling system** will crush samples and present them to instruments inside rover.
- Instruments inside rover: Raman (RLS), UV-VIS (Micromega) and MOMA analyse same area of sample.
- **MOMA instrument**. Main instrument for looking for life (in form of organic molecules).

MOMA-Mars Organic Molecule Analyzer

Analyses organics (mass range: 50–1000 u) present at ≥10 ppb.



Goesmann et al., 2017 Astrobiology

Combines pyrolysis gas chromatography mass spectrometry (pyr-GC-MS) and laser desorption mass spectrometry (LDI-MS).

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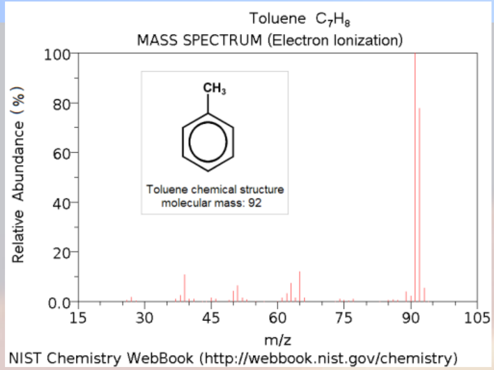
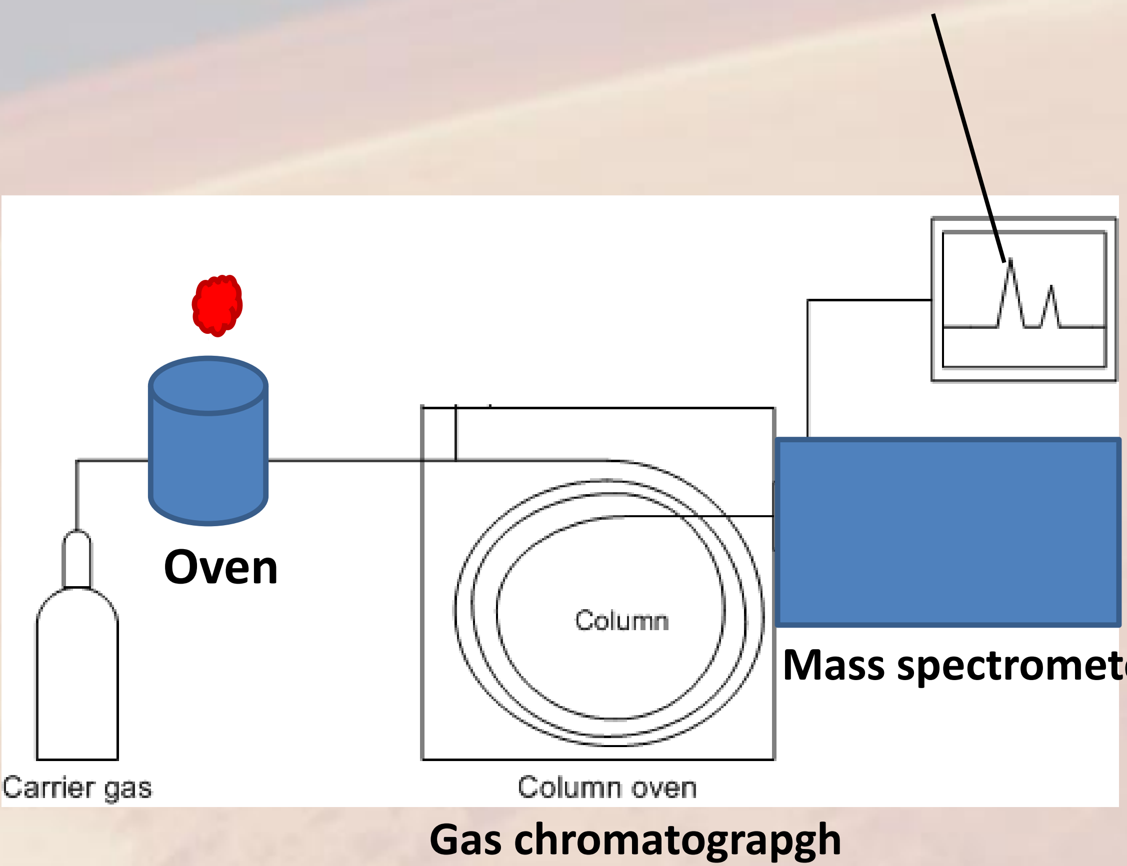
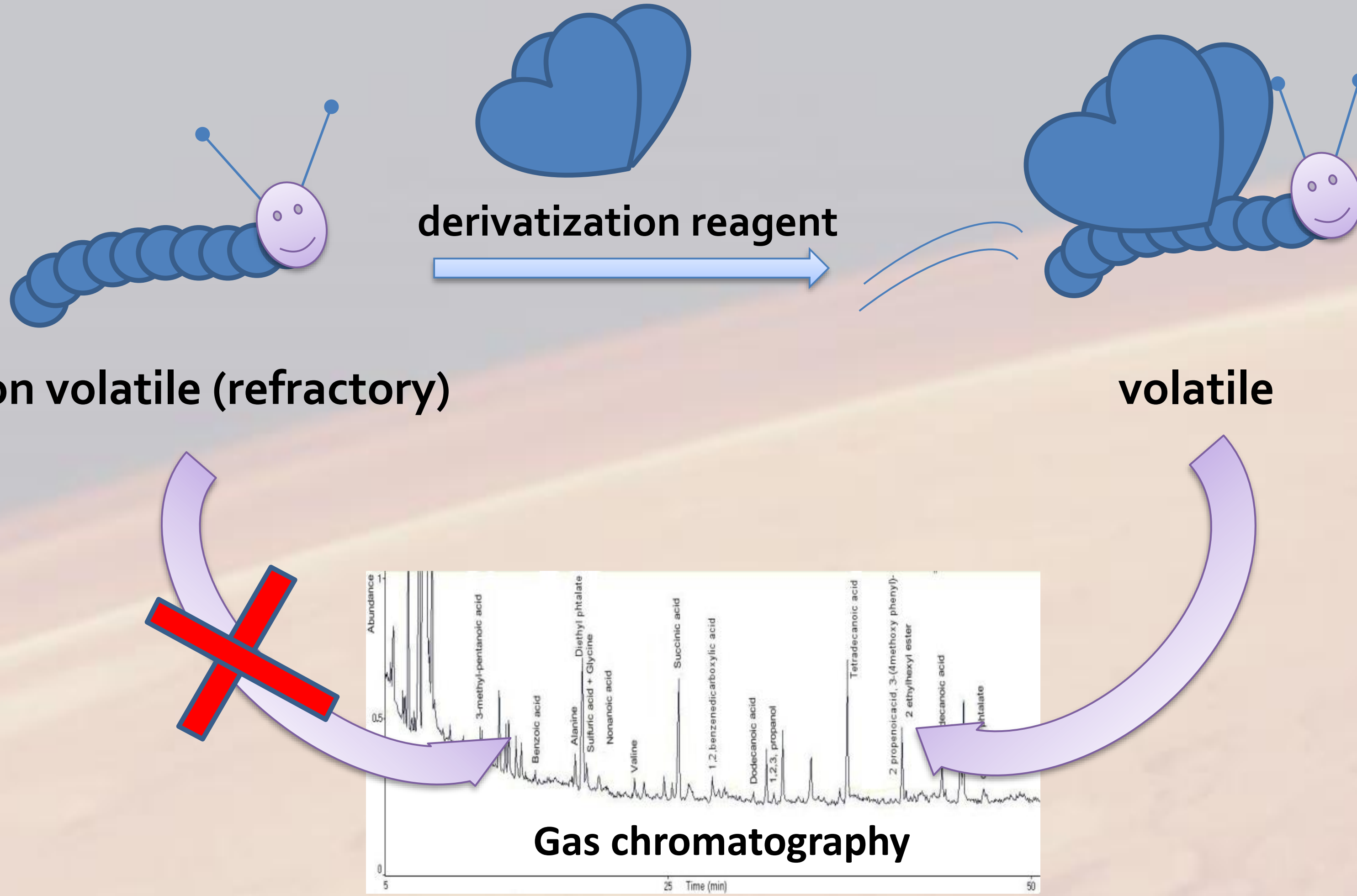
Pyrolysis gas chromatography mass spectrometry (pyr-GC-MS



Wet chemistry on Mars is difficult, due low pressure etc. Therefore, samples are pyrolyzed to get organic molecules into gas form.



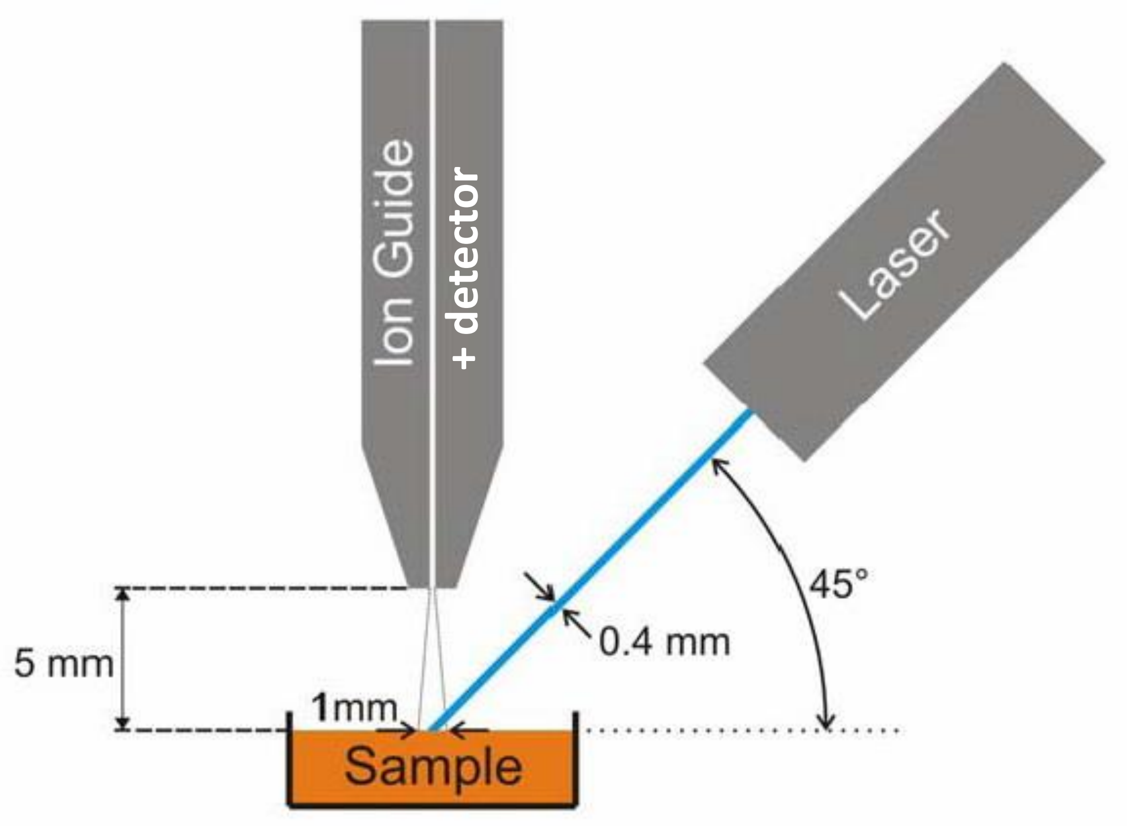
Derivatization



Arnaud Busch

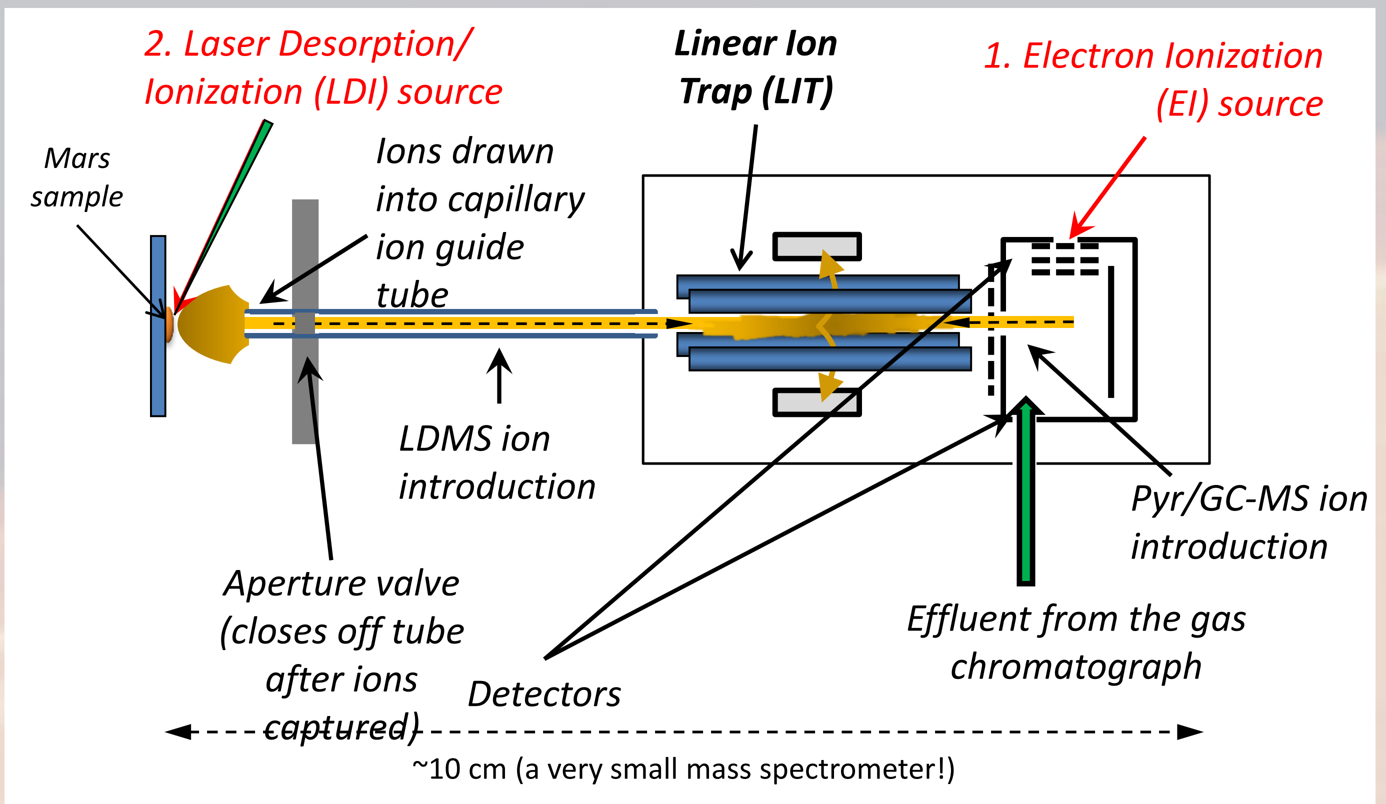
Expands types of molecules than can be analysed by MOMA.

Laser desorption mass spectrometry (LDI-MS)



Similar to pyrolysis but use laser to volatilze the organic molecules which then transported into a mass spectrometer.

Dual-Source Linear Ion Trap MS

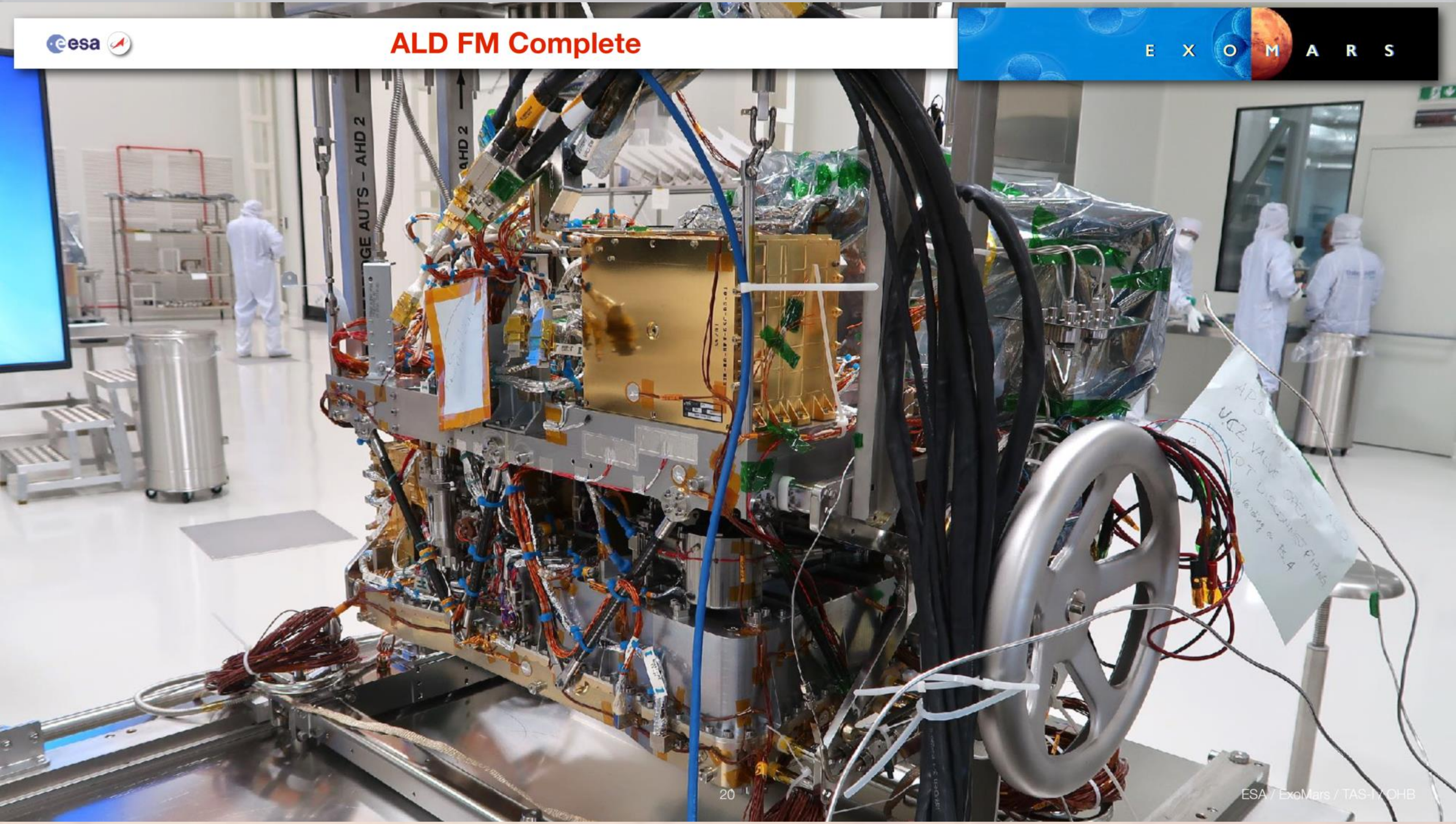


Same mass spectrometer for both LDI-MS and pyr-GC-MS. Pyr-GC-MS will be done in single ovens (32 cups) while LDI-MS will be done in refillable container.

Refillable container inside rover

Raman (RLS), UV-VIS (Micromega) and MOMA analyse same sample surface in refillable container.

Delivery of MOMA flight model (FM)



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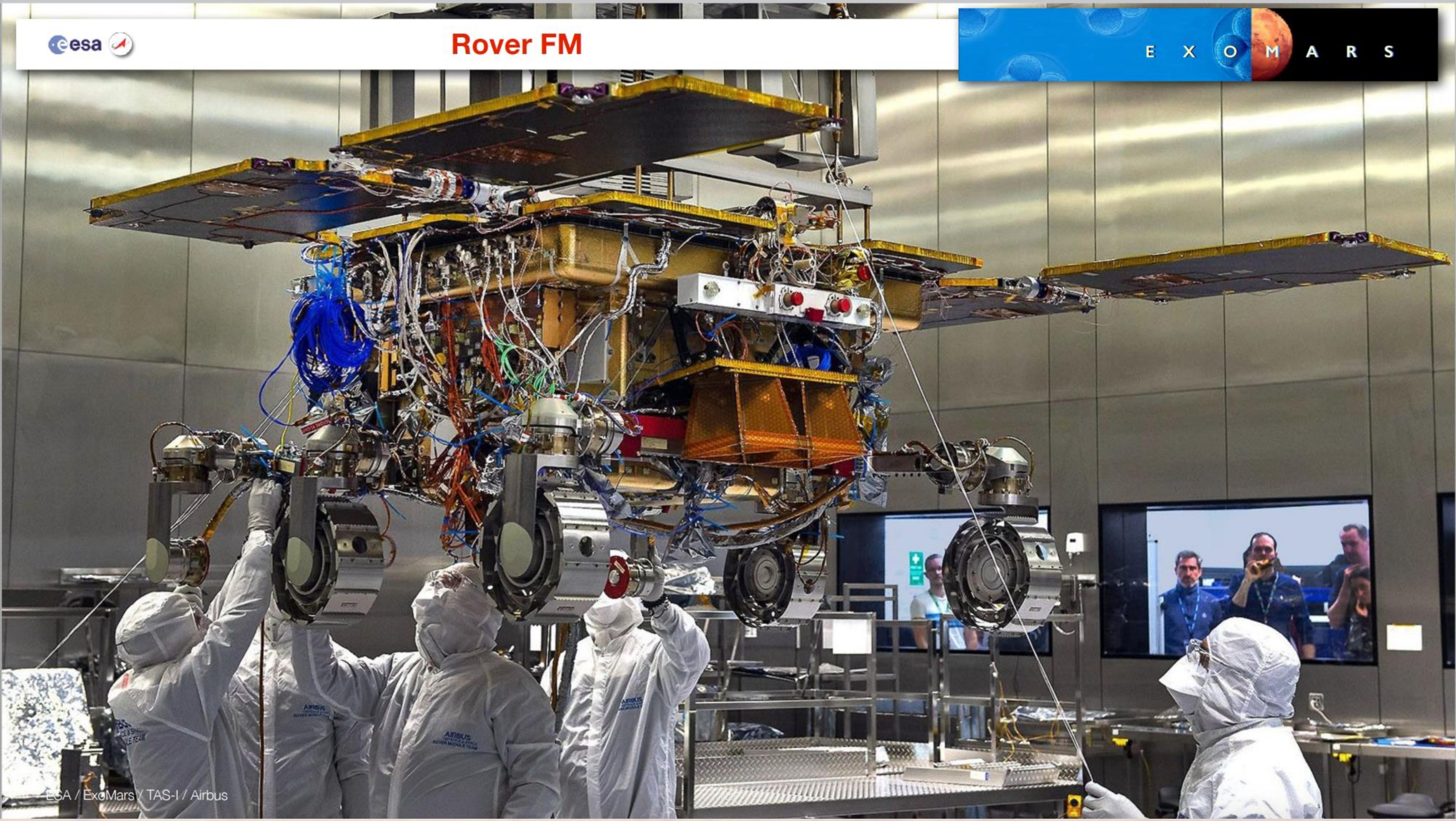

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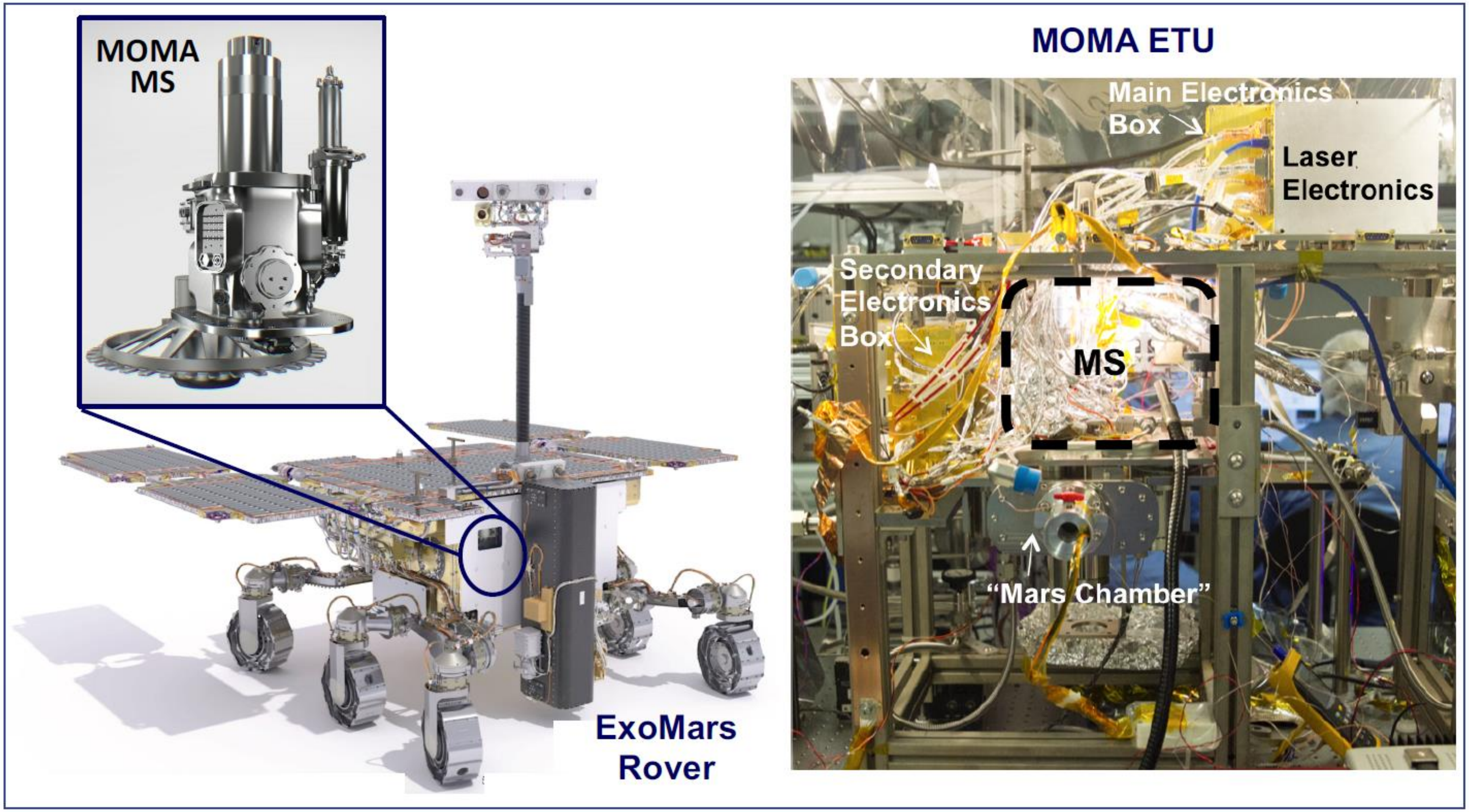
MOMA ETU (engineering test unit)



Siljeström et al., 2021 Astrobiology

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Testing and calibration of MOMA

- **Minerals**

- **Pure organic standards**

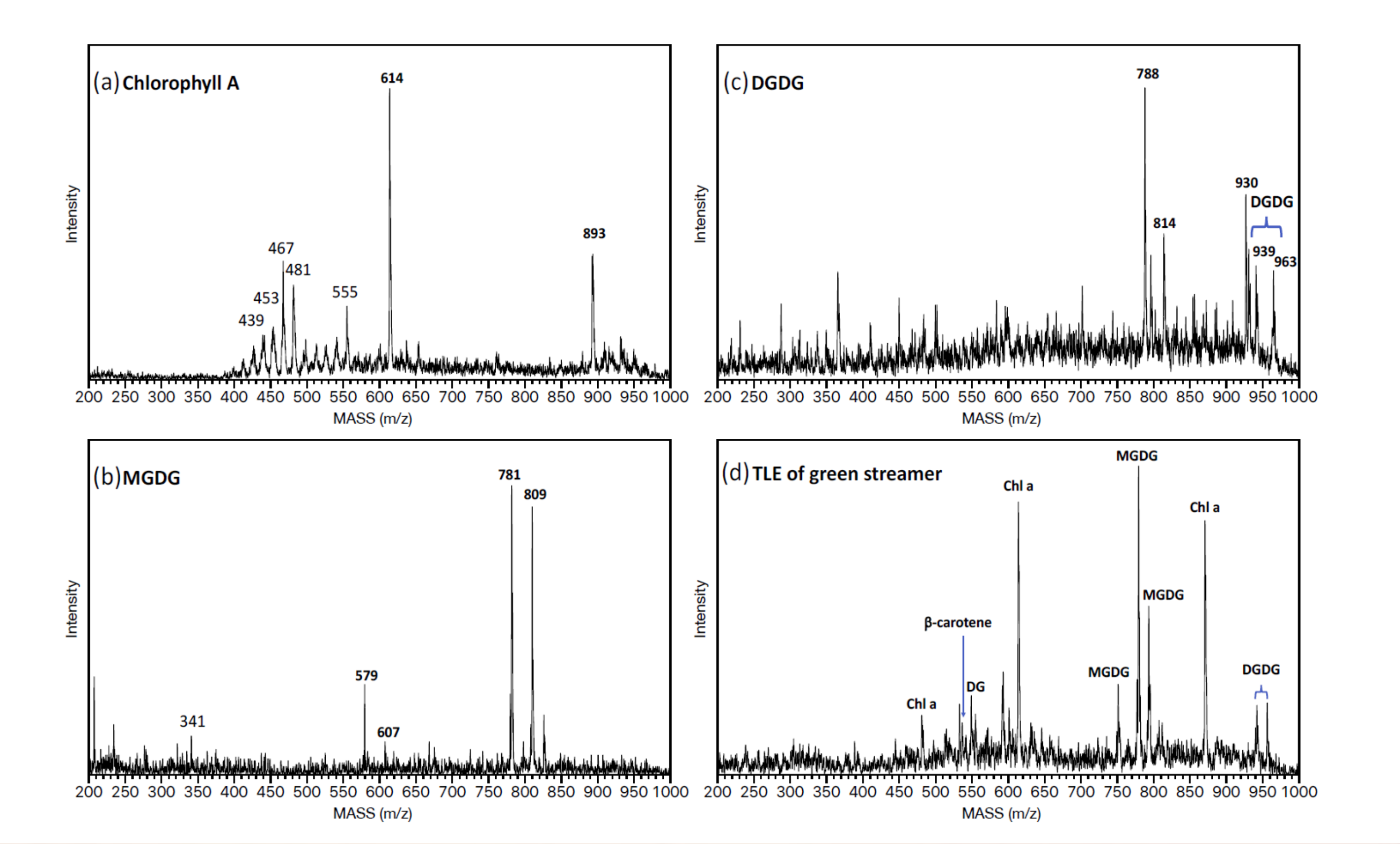
- **Spiked samples- mineral samples doped with organic molecules**

- **Mars analog samples**

Atacama, Svalbard, Yellowstone National Park, Green river shale, JSC Mars, meteorites etc.

LDI-MS of microbial mats from hot springs in Yellowstone National Park

- Freeze-dried green streamer mat
- Lipid extracts of green streamer mat such as total lipid extract (TLE)
- Standards of pigments and lipids identified in mat.

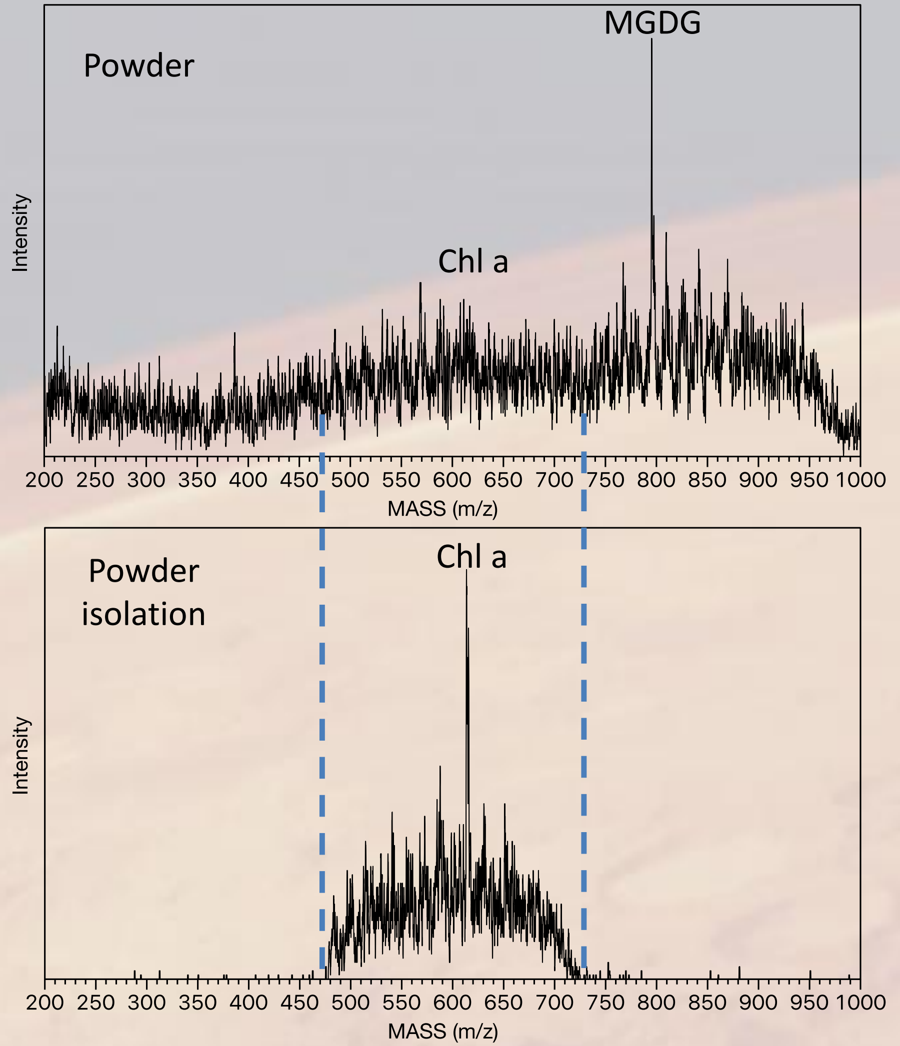


Siljeström et al., 2021 Astrobiology

LDI-MS of microbial mats from hot springs in Yellowstone National Park

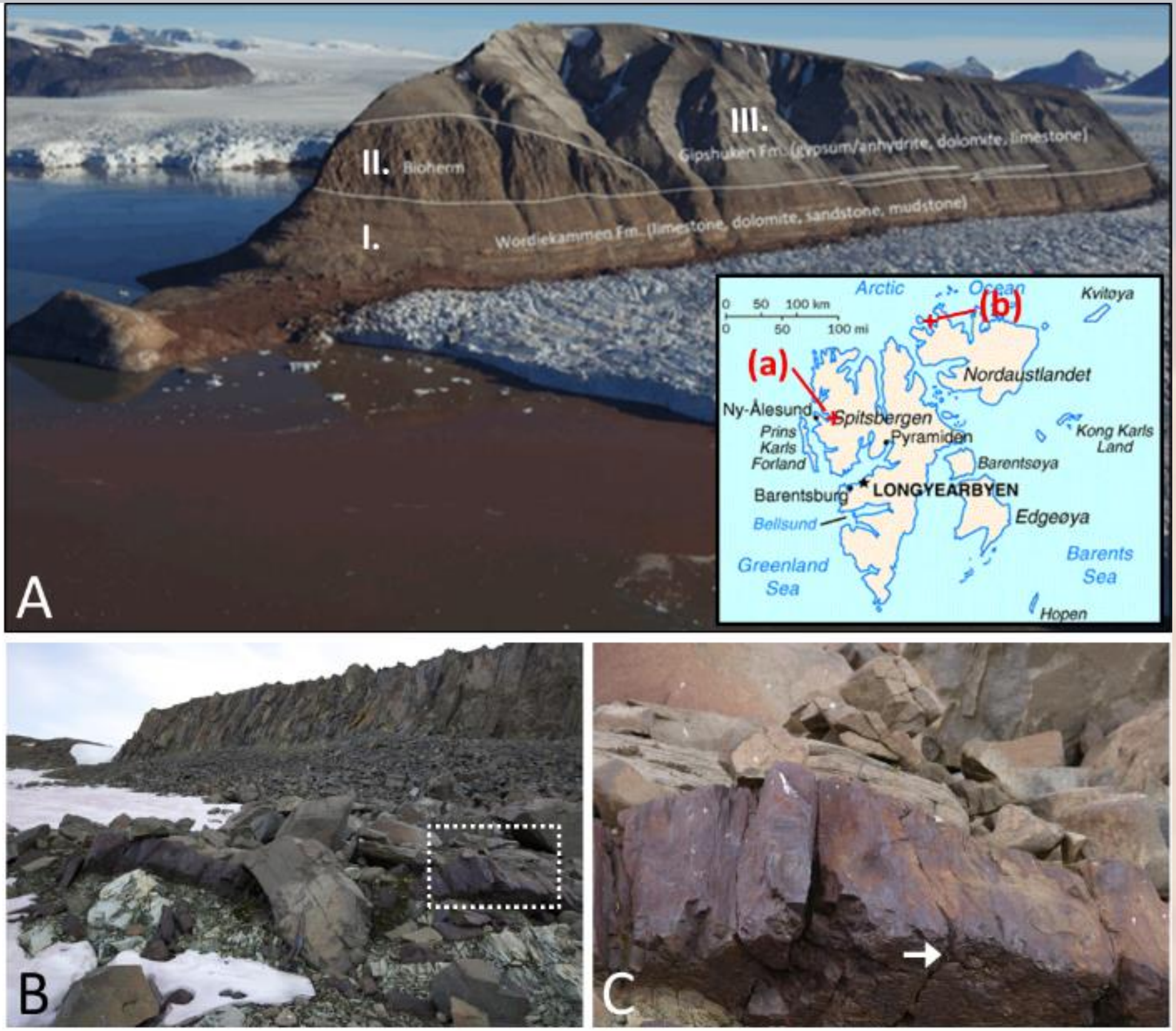
Green Streamer
powder, pos

Narrower mass range
isolation, 400-700Da



Siljeström et al., 2021 Astrobiology

MOMA prototype testing on Svalbard



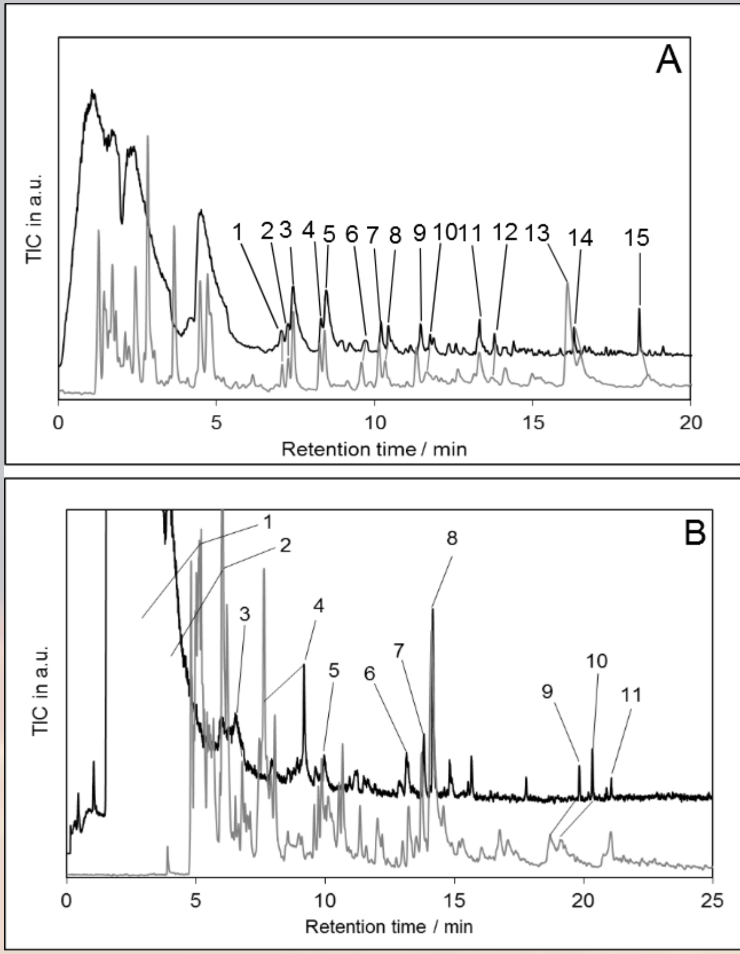
Analogue to Mars

A. CollethØgda (carbonates evaporites)

B. Botnia halvøya (Weathered basalt to clays)

Siljeström et al., 2014 Astrobiology

Pyrolysis and derivatization



Comparision of MOMA prototyp (gray) and an commercial instruments (black)

A. Sample from CollethØgda

B. Sample from Botniahalvøya.

Results indicate BotniahalvØya sample contain traces of recent life in the form of amino acids, sugars and fatty acids.

Siljeström et al., 2014 Astrobiology

Acknowledgement

MOMA team

Funding: Swedish National Space Agency

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