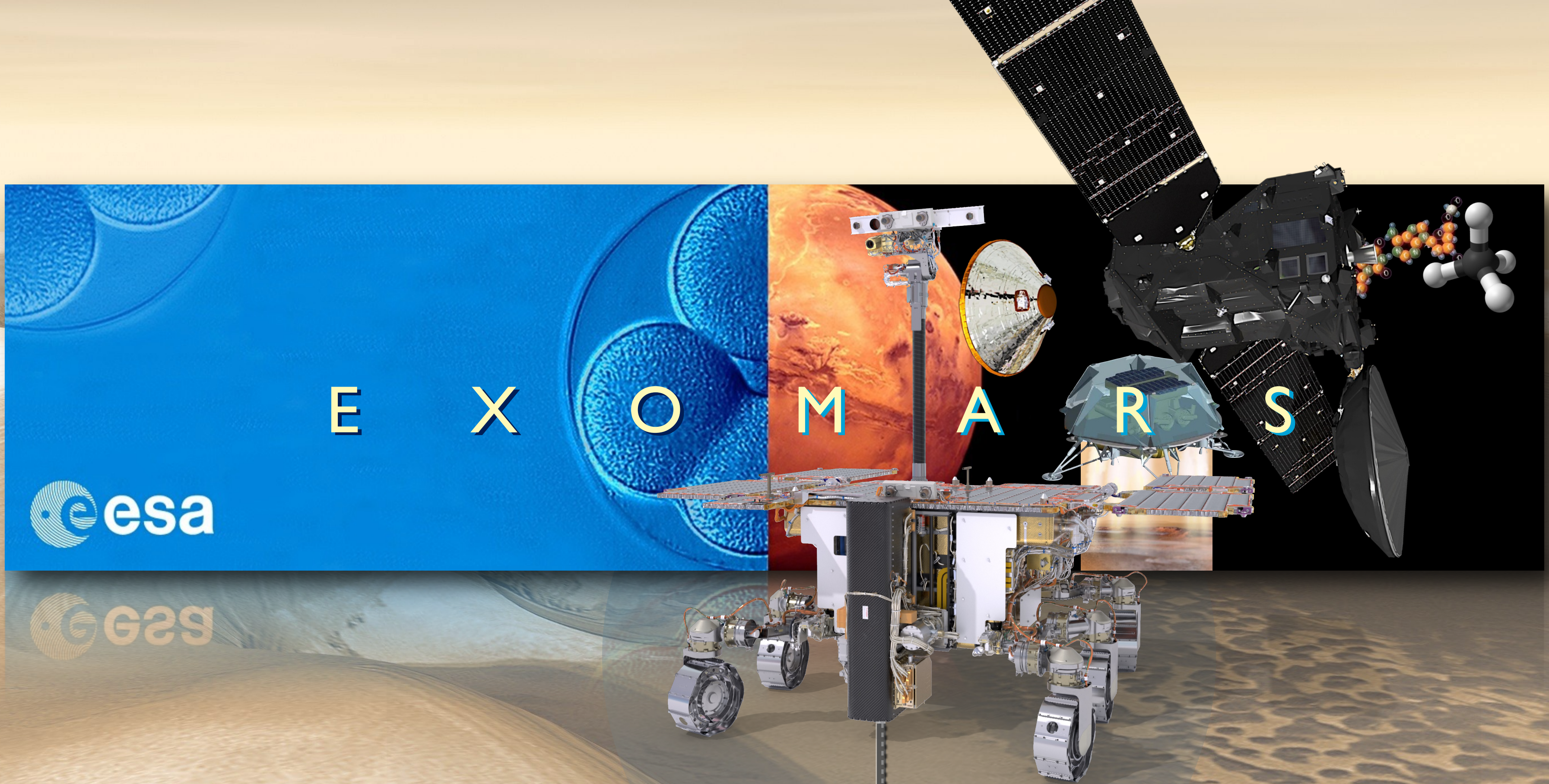
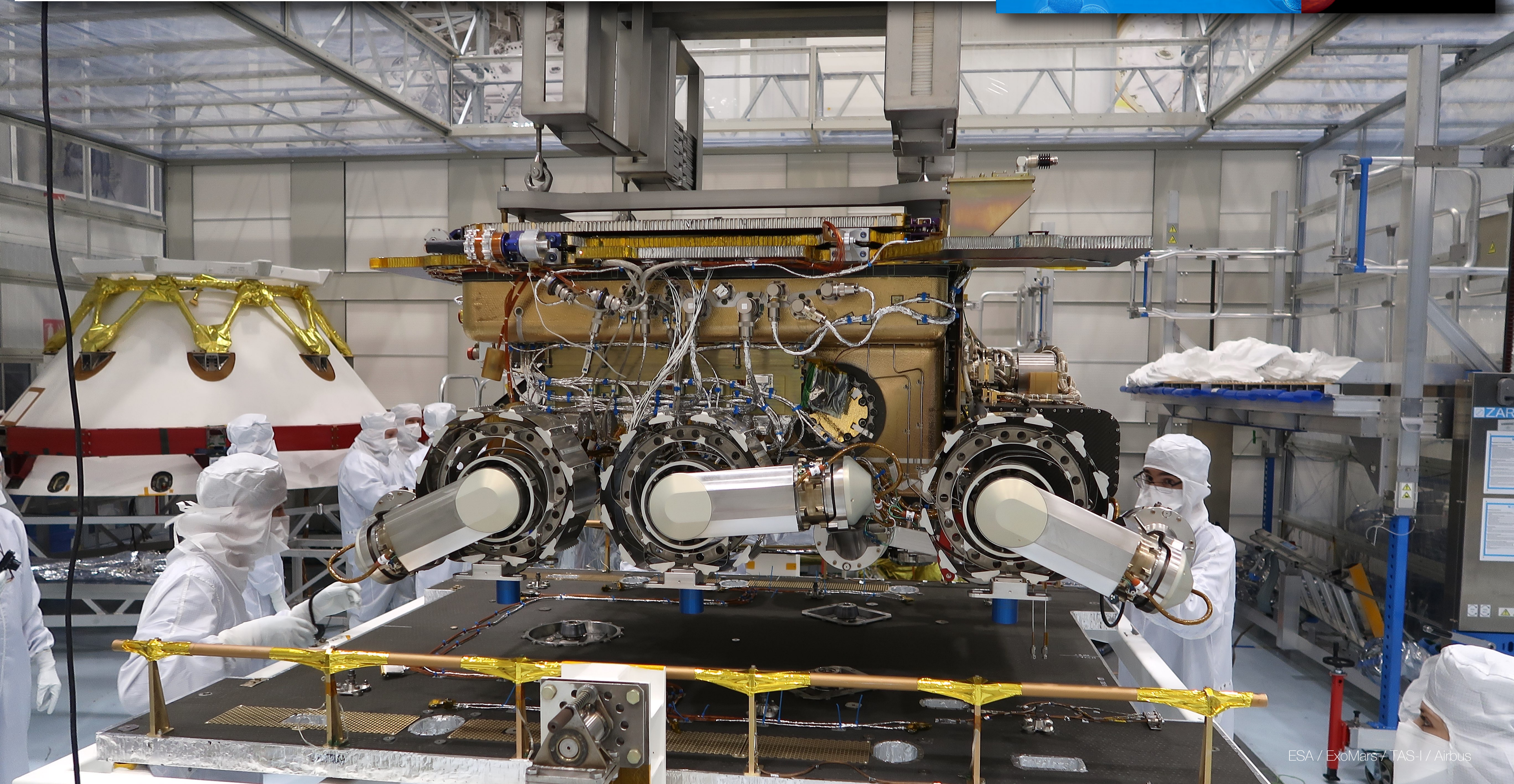


Search for Life on Mars

Jorge L. Vago, E. Sefton-Nash, P. Baglioni,
ExoMars project and ExoMars science working teams

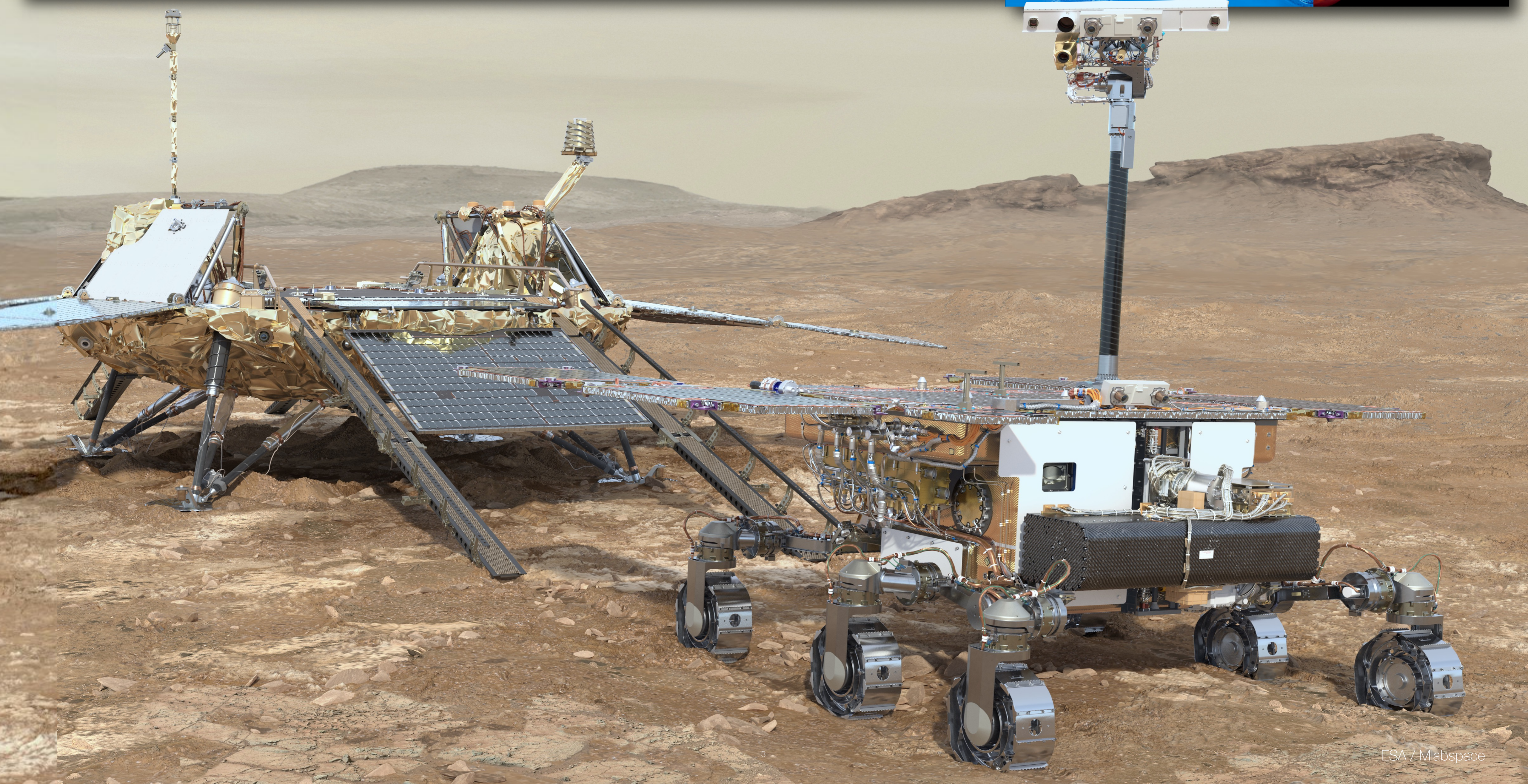
NASA Planetary Science Advisory Committee Meeting
28 February 2023, NASA HQ, Washington (USA)

Rover FM



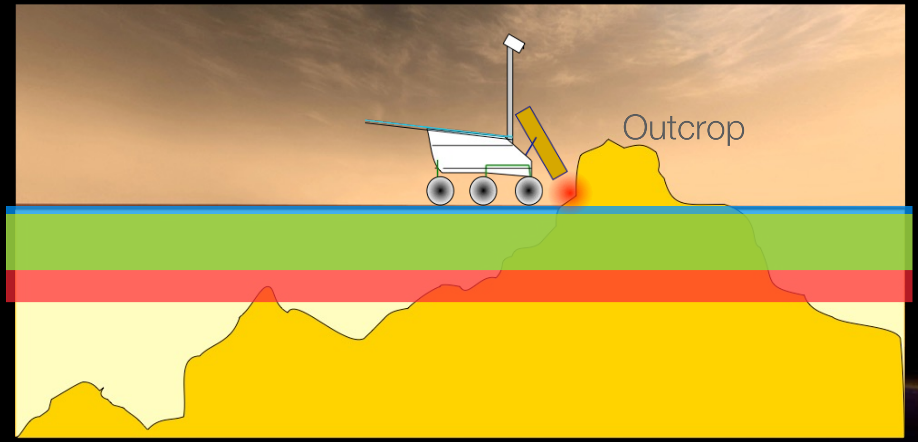
ESA / ExoMars / TAS-I / Airbus

We Are Building a New Lander



ESA / Mlabspace

Mobility + Subsurface Access



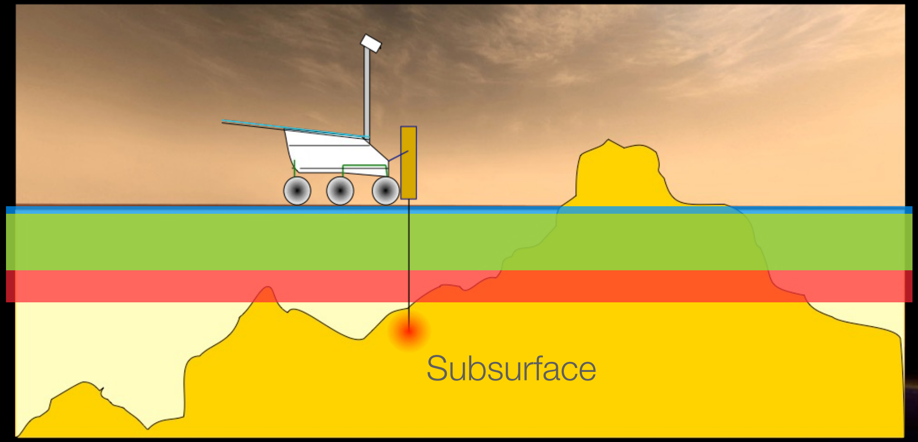
Penetration of Organic Destructive Agents

UV radiation	~ 1 mm
Oxidants	~ 1 m
Ionising radiation	~ 1.5 m

ExoMars exobiology strategy:

- Identify and study the appropriate type of outcrop;

Mobility + Subsurface Access



Penetration of Organic Destructive Agents

UV radiation	~ 1 mm
Oxidants	~ 1 m
Ionising radiation	~ 1.5 m

ExoMars exobiology strategy:

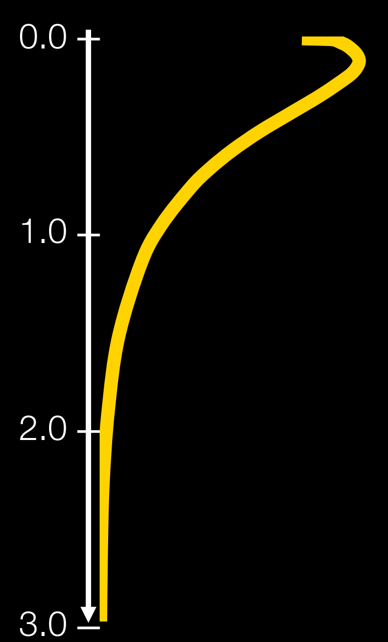
- Identify and study the appropriate type of outcrop;
- Collect samples below the degradation horizon and analyse them.

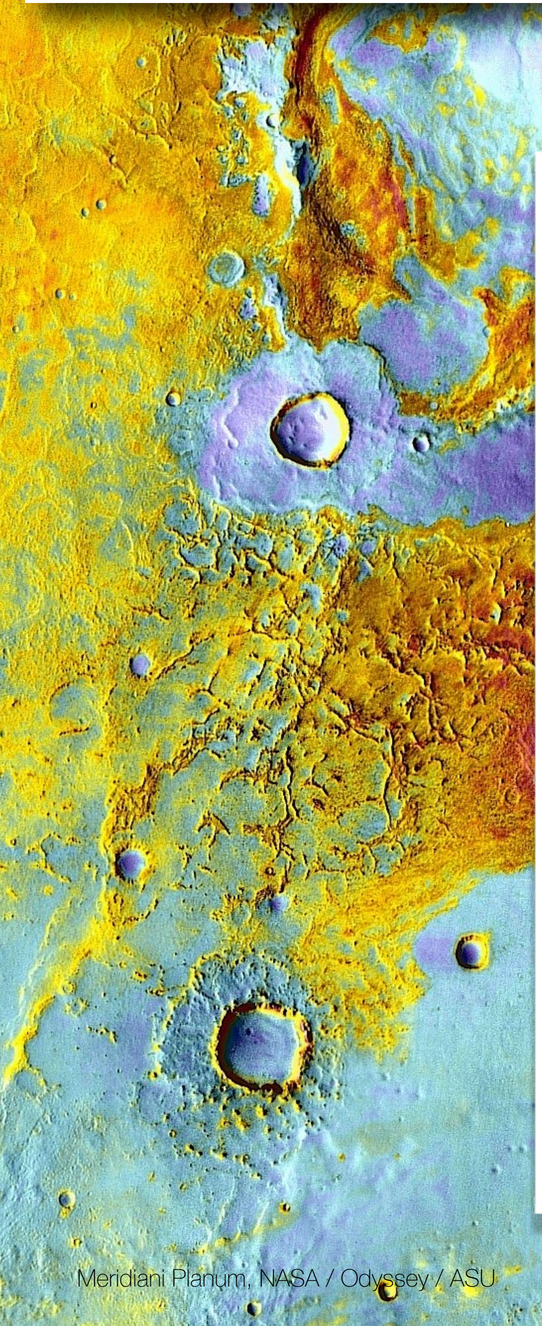
Ionising Radiation

Radiolysis destruction can be described by:

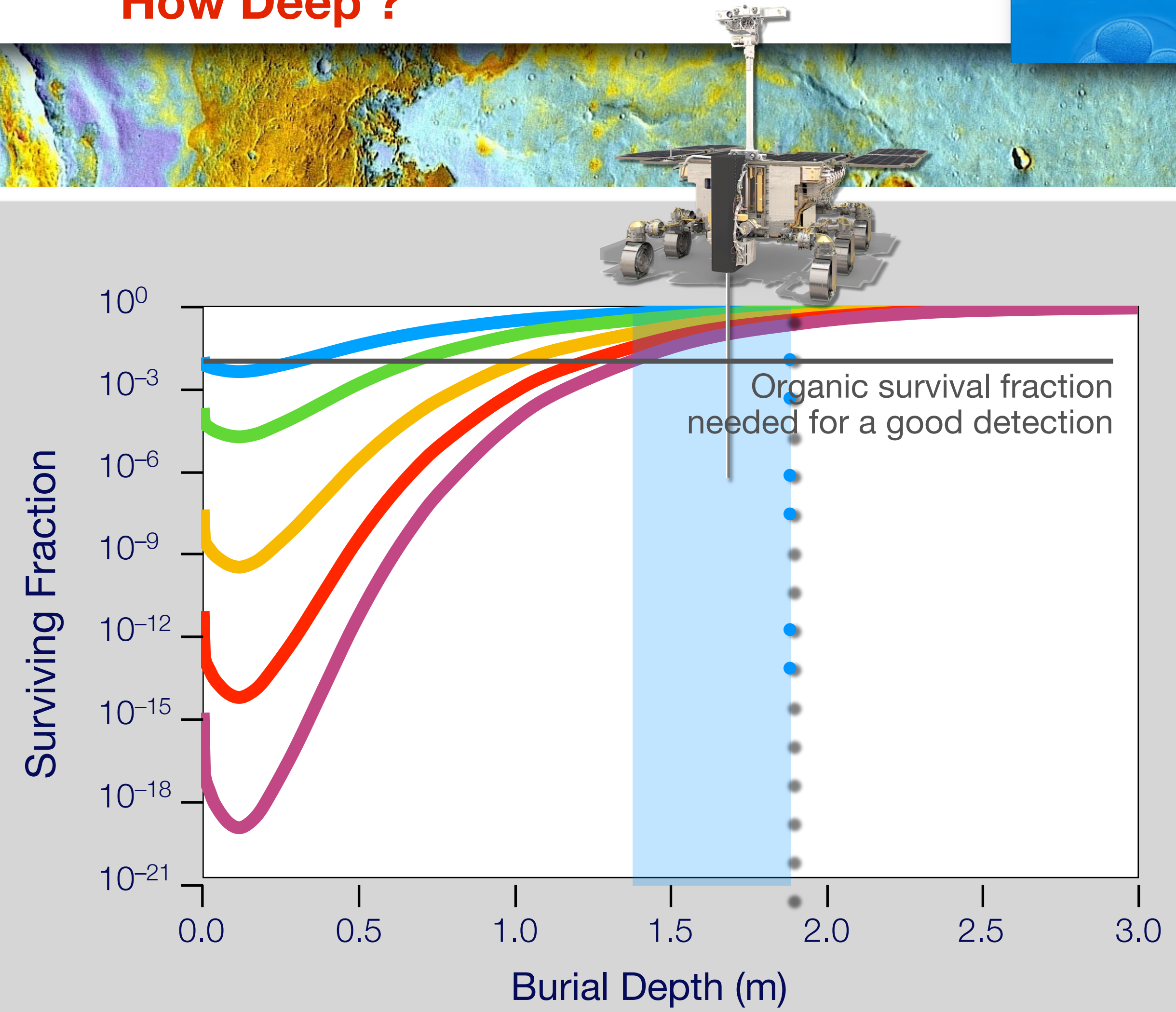
$$N / N_0 = e^{-k \cdot D}$$

N / N_0	Molecule surviving fraction
k	Radiolysis constant (scales with molecular weight)
D	As a function of subsurface depth on Mars



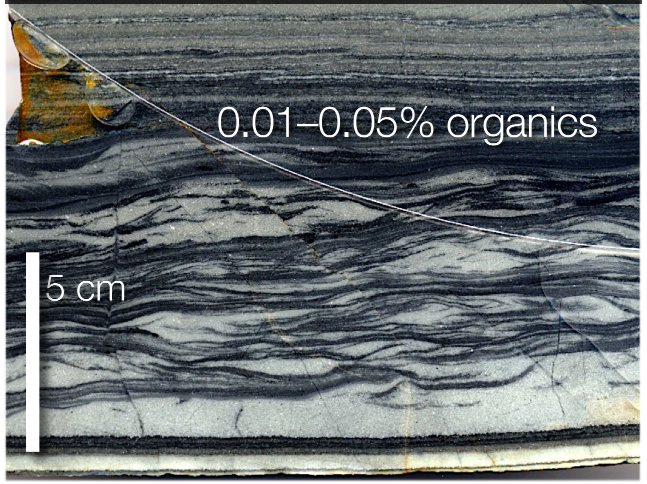

Meridiani Planum, NASA / Odyssey / ASU

How Deep ?



Survival rate of a 100% amino acid mixture vs. depth after being exposed to **0.5 (blue)**, **1.0 (green)**, **2.0 (yellow)**, **3.0 (red)** and **4.0 (purple)** billion years of Mars near-surface ionising radiation.

Dose rate from MSL vs. depth, Hassler et al. (2014). Radiolysis constants *k* measured by Kminek and Bada (2006).



3.33 Ga Josefsdal sediments in Barberton (ZA)

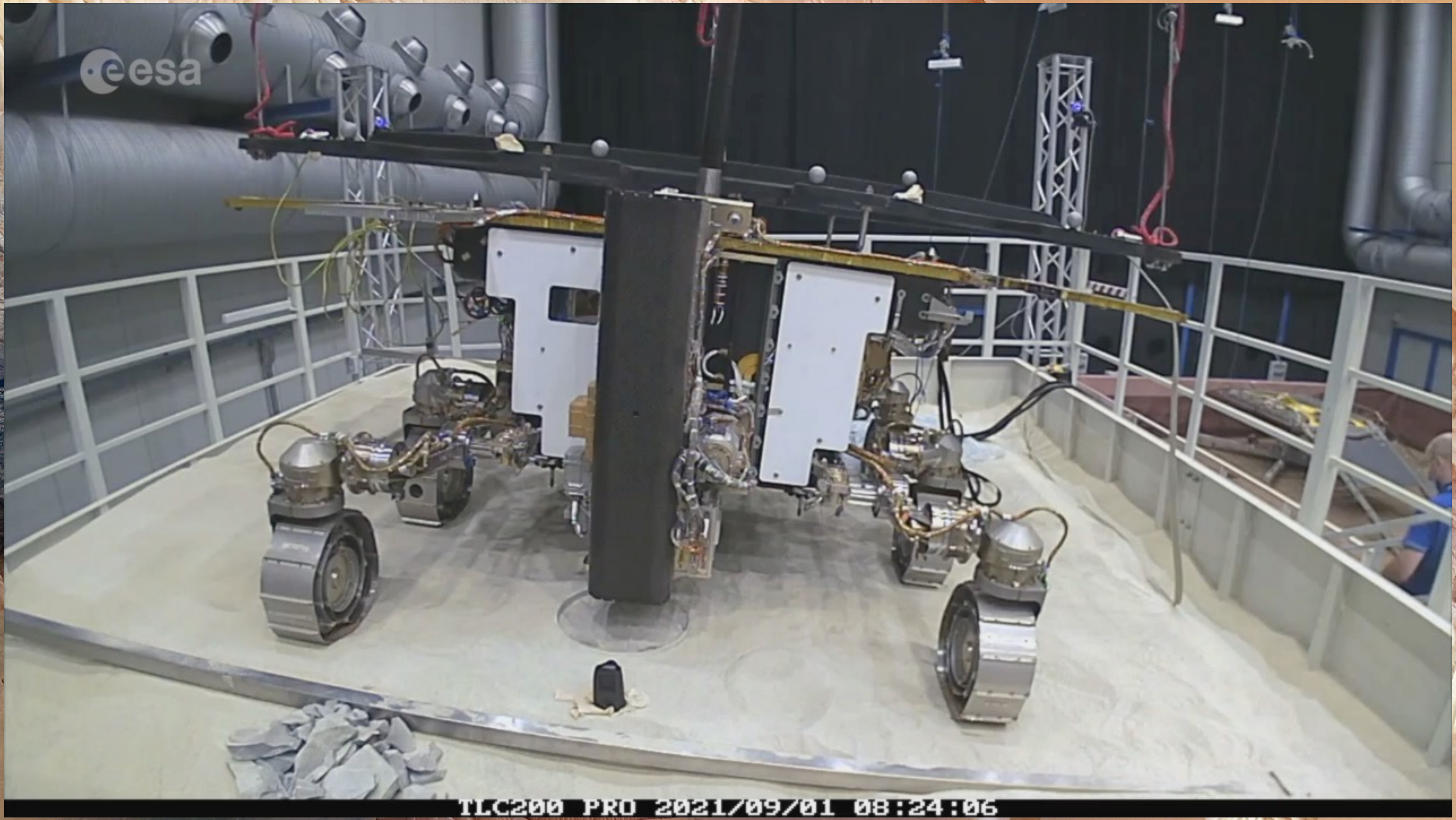
Westall et al. 2015

Why amino acids?

- 63% of cell by dry mass.
- They can preserve biochirality.
- Survive for billions of years in cold martian subsurface (if not destroyed by radiation).

Meridiani Planum, NASA / Odyssey / ASU

Clay Sample from 1.7 m Depth



Hebes Chasma, ESA / MEX / HRSC

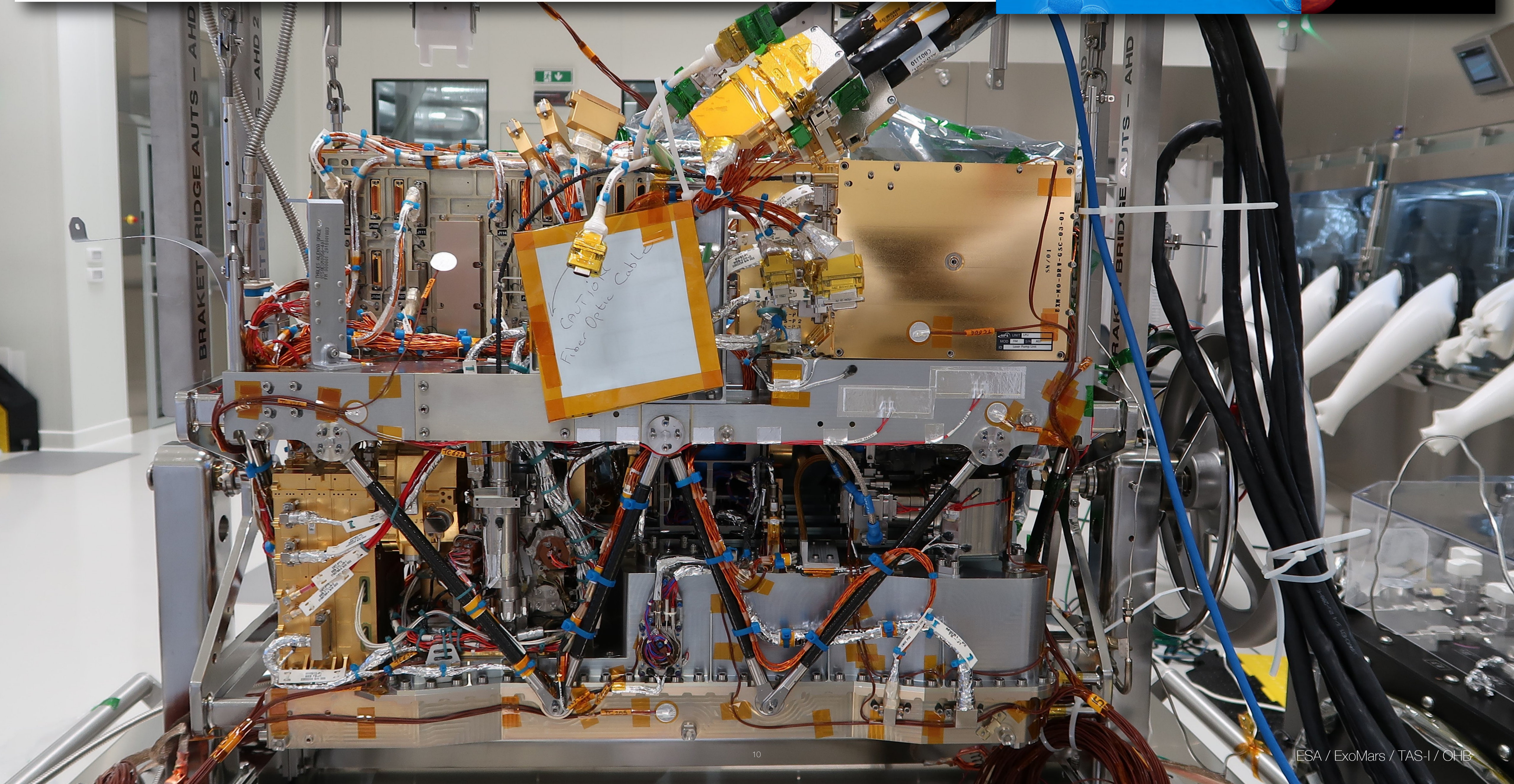
Analytical Laboratory Drawer

Mamers Valles, ESA / MEX / HRSC

Mamers Valles, ESA / MEX / HRSC

ESA / ExoMars / TAS-I / OHB

ALD FM Complete

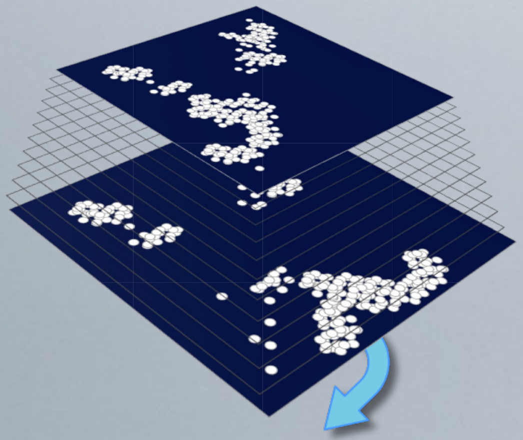


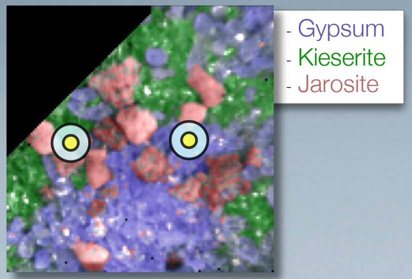
ESA / ExoMars / TAS-I / OHB

Sample Analysis

Use mineralogical + image information from µΩ to identify targets for Raman and MOMA-LDMS.

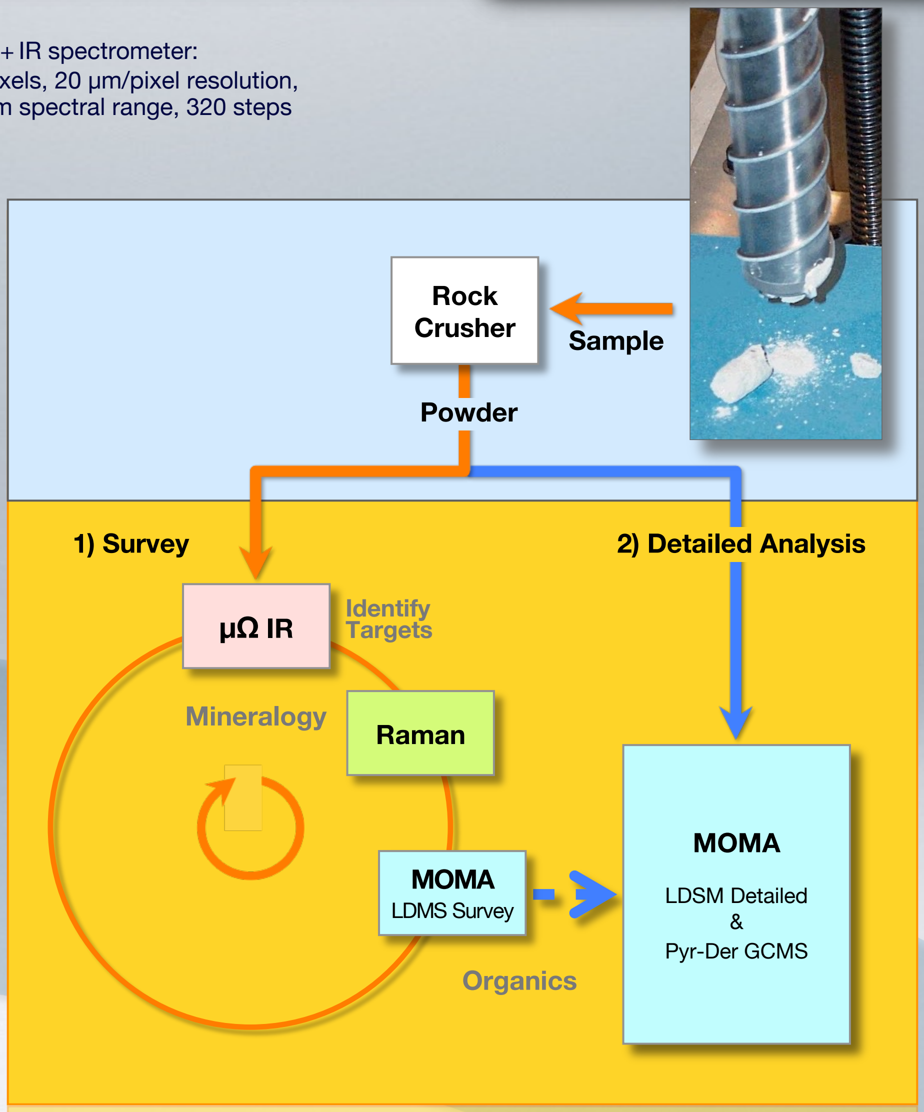
Imaging VIS + IR spectrometer:
256 x 256 pixels, 20 µm/pixel resolution,
0.95–3.65 µm spectral range, 320 steps





- ○ µΩ = 20 µm
- ● Raman = 50 µm
- ○ LDMS = 200 x 400 µm

Raman: Spectral shift range 200–3800 cm^{-1}
Spectral resolution: 6 cm^{-1}

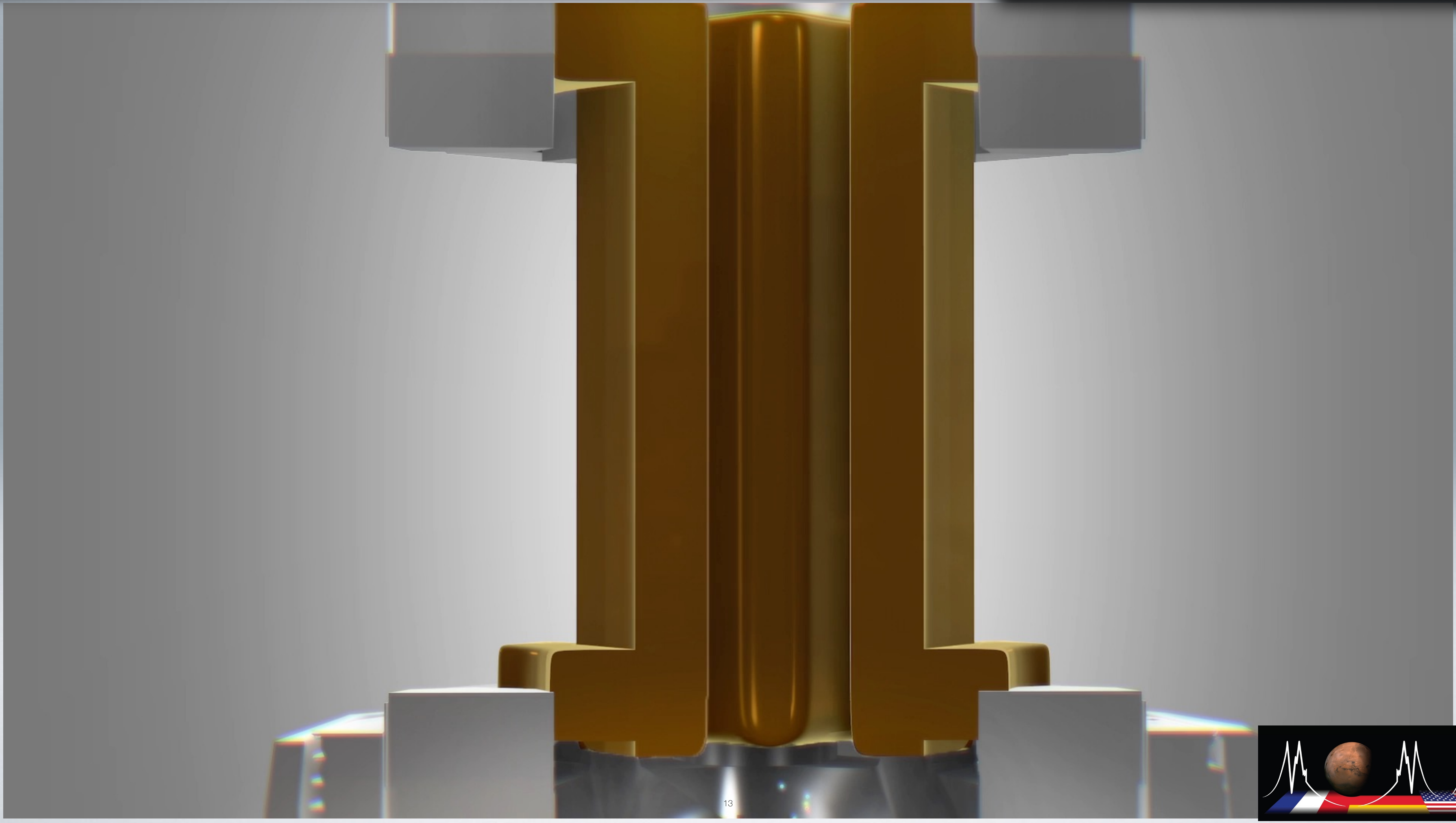


LDMS = Laser Desorption Mass Spectrometry
GCMS = Gas Chromatograph Mass Spectrometer

ESA / ExoMars / TAS-I / OHB

Characterisation of Organic Molecules

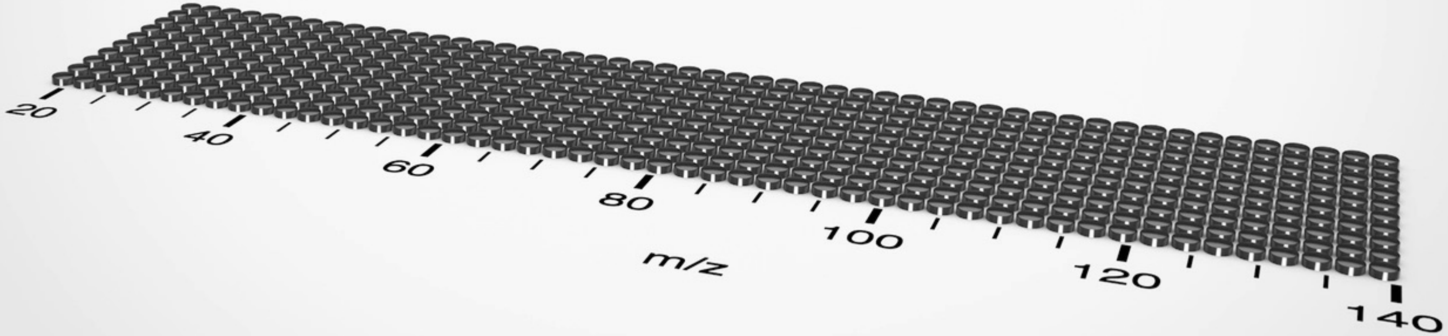
MOMA SWIFT to Enrich Molecules of Interest

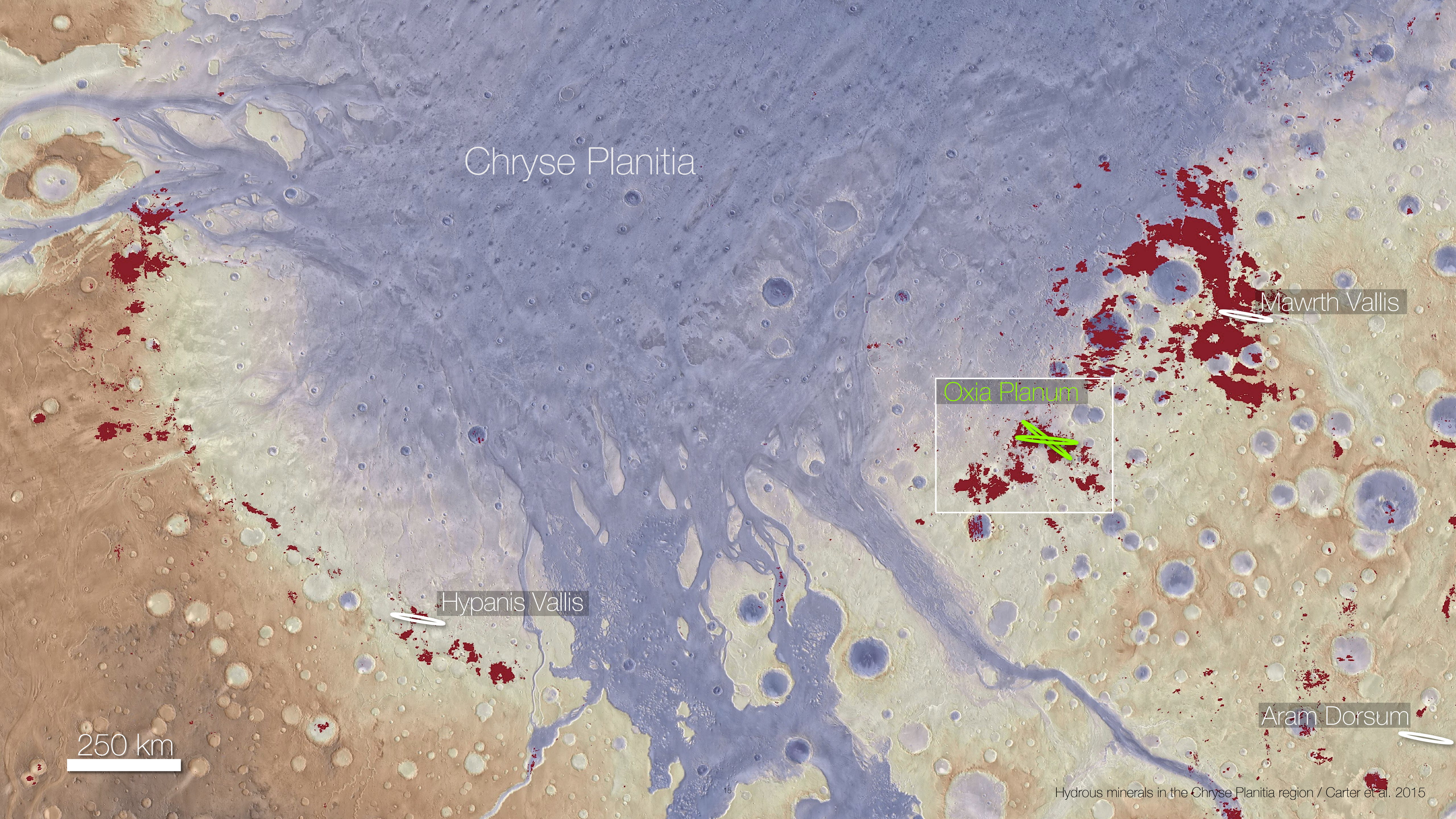


Identification of Molecules

BENZOIC ACID

$C_7H_6O_2$

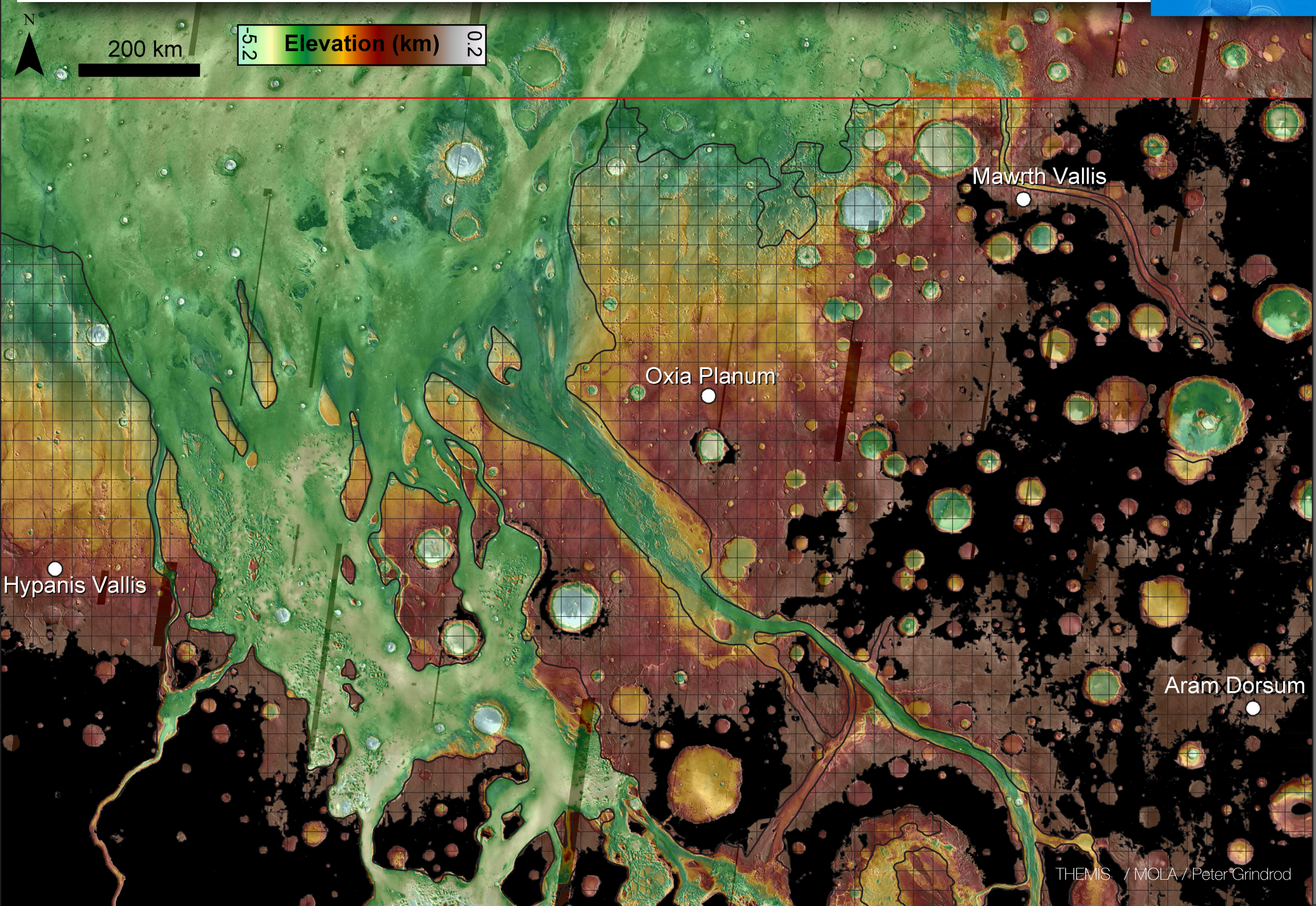




Hydrous minerals in the Chryse Planitia region / Carter et al. 2015 esa

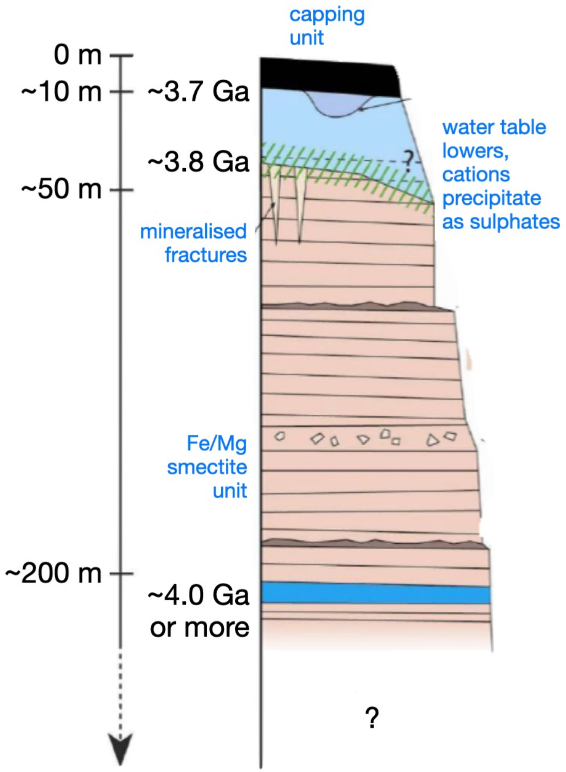
Candidate Landing Sites

EXOMARS



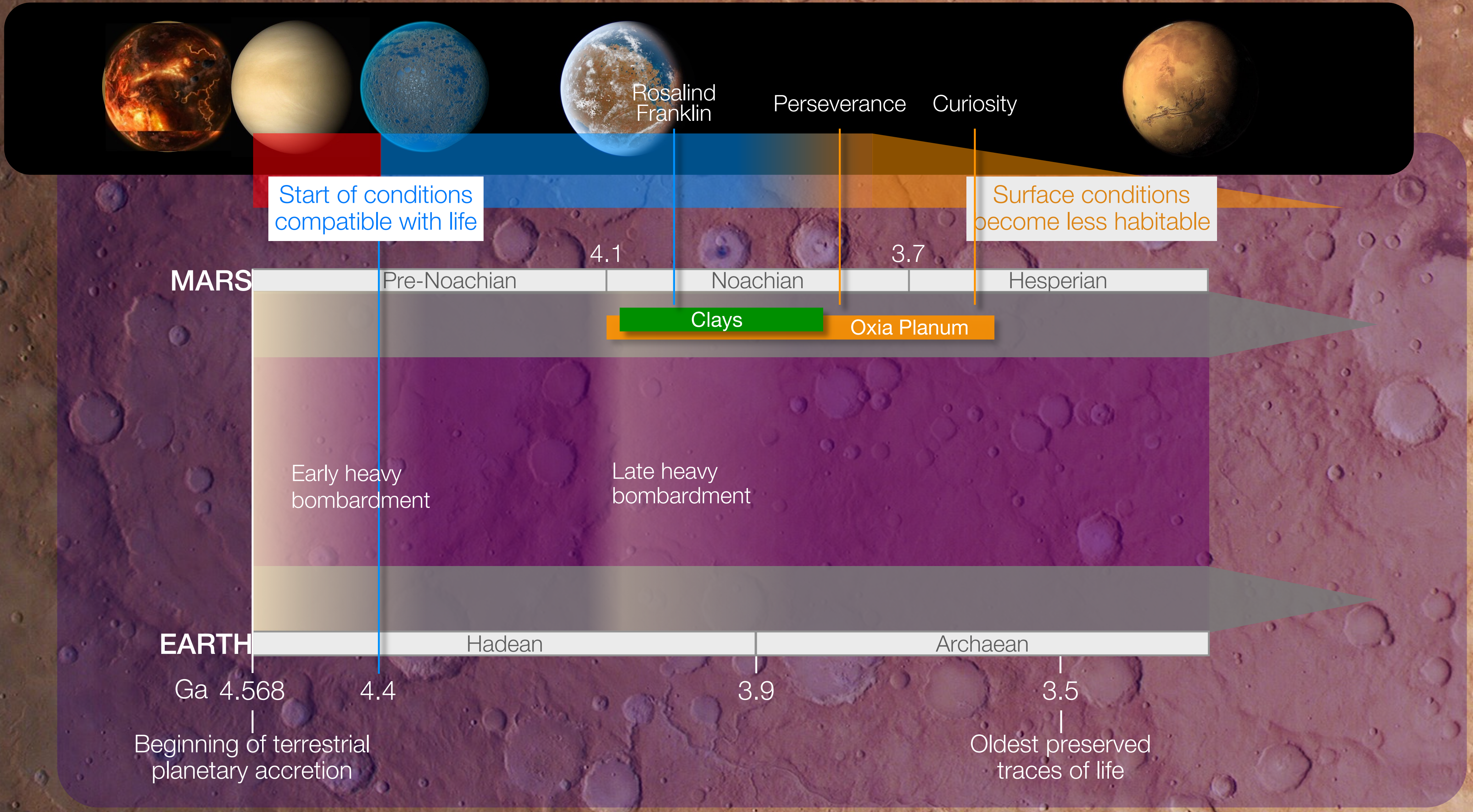
THEMIS / MOLA / Peter Grindrod

Candidate landing sites:
Oxia Planum
Mawrth Vallis



Oldest terrains to be targeted

Early Mars



Rosalind Franklin

Perseverance

Curiosity

Start of conditions compatible with life

Surface conditions become less habitable

4.1

3.7

MARS

Pre-Noachian

Noachian

Hesperian

Clays

Oxia Planum

Early heavy bombardment

Late heavy bombardment

EARTH

Hadean

Archaean

Ga 4.568

4.4

3.9

3.5

Beginning of terrestrial planetary accretion

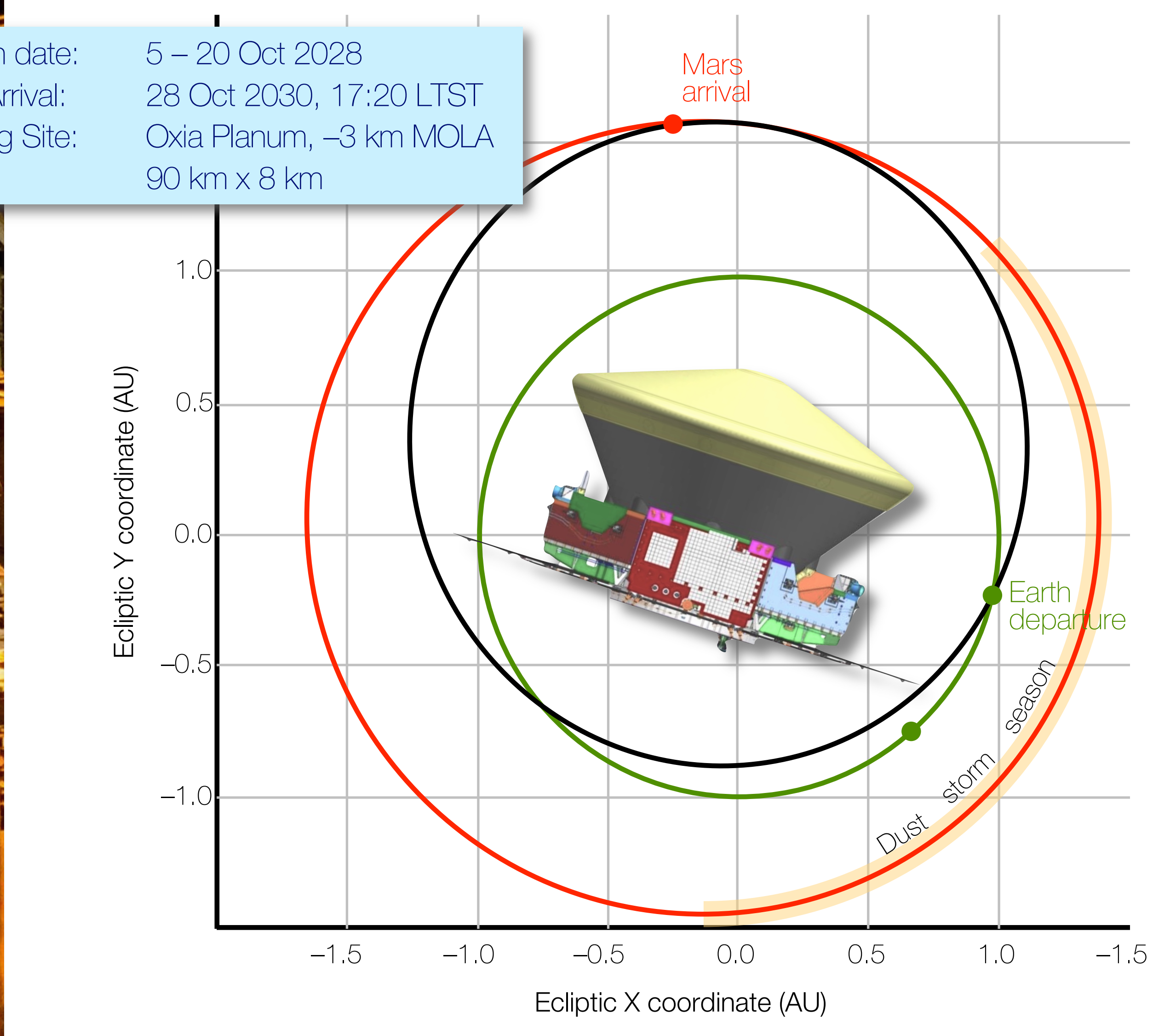
Oldest preserved traces of life

Cassini crater, ESA / MEX / HRSC

Launch

E X O M A R S

Launch date:	5 – 20 Oct 2028
Mars Arrival:	28 Oct 2030, 17:20 LTST
Landing Site:	Oxia Planum, –3 km MOLA
Ellipse:	90 km x 8 km



Rosalind Franklin Science

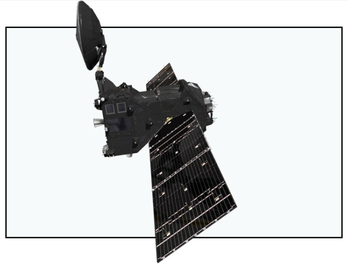
EXOMARS

The mission's science is compelling, timely, and of interest for Decadal Survey missions

- We will make a trip back in time to an epoch never explored, when Mars was more Earth-like.
- The unique landing site preserves the most ancient, water-altered deposits we know of.
- We will investigate the martian subsurface for the first time.
- We have a great payload to hunt for potential biomolecule relics and establish their geological context.
- Rosalind Franklin can make fundamental discoveries in organic chemistry, life sciences, and comparative planetology.
- Our findings will contribute to Mars Sample Return (MSR), Mars Life Explorer (MLE), and Dragonfly.

ESA/Mlabspace

ESA-NASA Mars Projects

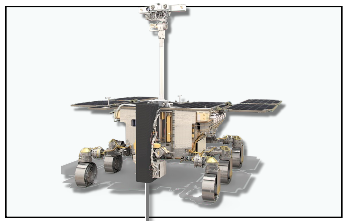


Trace Gas Orbiter 2016

- Study atmospheric trace gas species
- Provide communications relay for landers

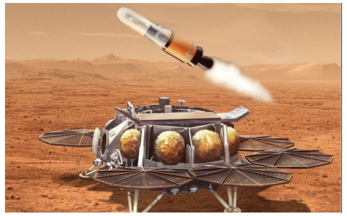
Mars 2020 Sample Caching

- Collect samples of rock, regolith, and atmosphere
- Cache samples on the surface for retrieval



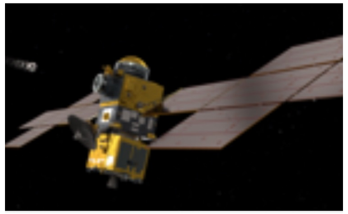
Rosalind Franklin 2028

- Search for signs of life in the subsurface
- Understand ancient Mars



Sample Retrieval Lander

- Retrieve samples caged by Mars 2020 rover
- Launch samples into Mars orbit



Earth Return Orbiter

- Capture and contain samples in Mars orbit
- Return samples safely to Earth

Mamers Valles, ESA / MEX / HRSC

Mamers Valles, ESA / MEX / HRSC