

The Team

P-I Team, DLR-Berlin:
P-I: Dr. J.-P. de Vera, Dr. U. Böttger, Dr. Mickael Baqué



**IN TOTAL
27 INSTITUTES**

**12 NATIONS
3 CONTINENTS**

**About 40
people working
for the project!**

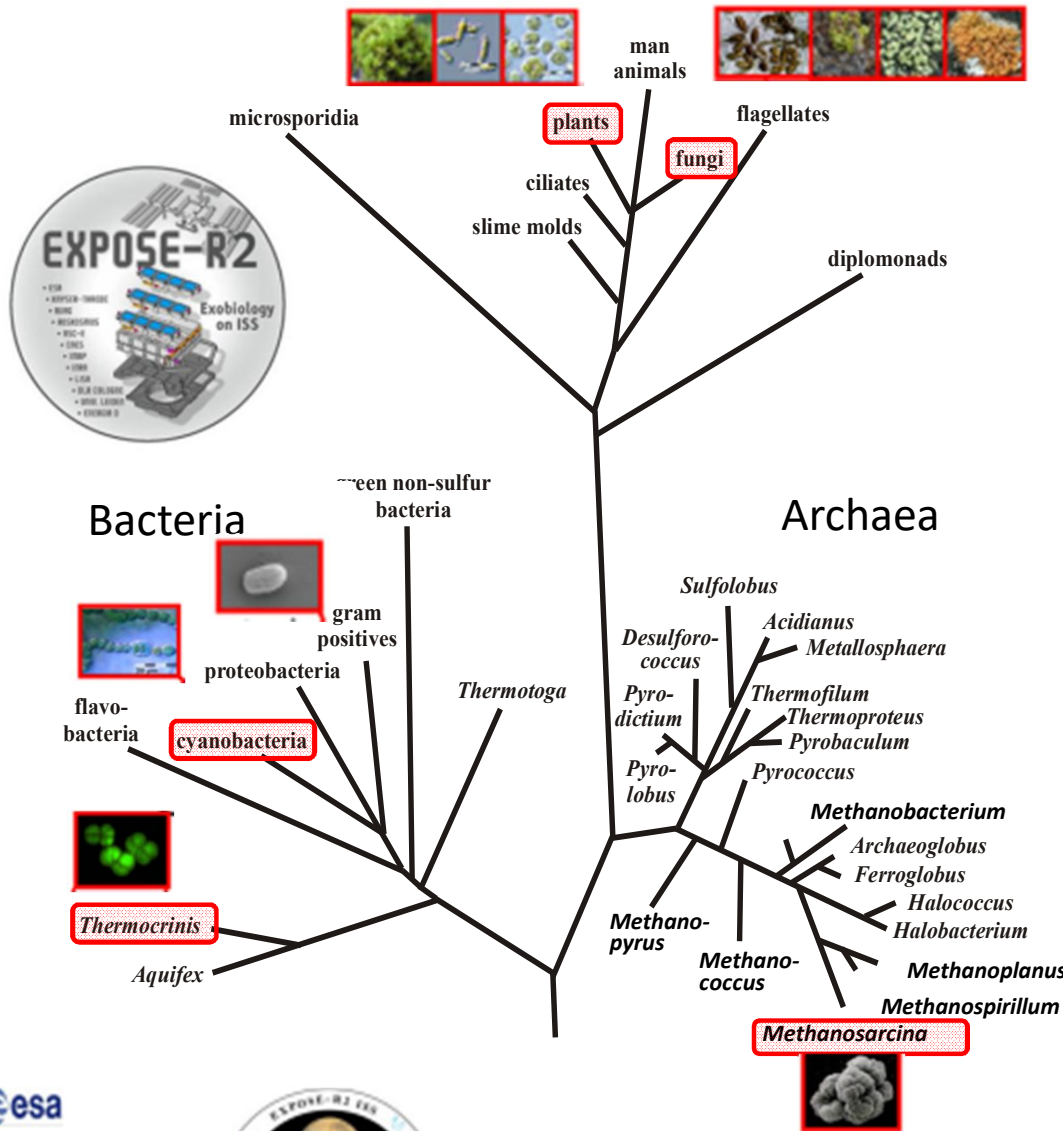
Institute of Plant
Biology, University of
Zürich
&
INFN Frascati
&
Uni. of Pretoria
&
Umeå University, SE
are cooperating!



Co-I	Institute	Logo	Foto
Prof. H.G.M. Edwards	University of Bradford		
Prof. C.S. Cockell	University of Edinburgh		
Dr. K. Olsson-Francis	Open University of Milton Keynes		
Prof. S. Onofri + Prof. Selbmann + Prof. Zucconi	Università degli Studi della Tuscia		
Dr. D. Billi	Università „Tor Vergata“ Roma		
Dr. R. de la Torre Noetzel	INTA, Spanish Aerospace Research Center Madrid		
Prof. S. Ott + Dr. J. Meeßen	Heinrich-Heine-Universität Düsseldorf		
Dr. A. Hermelink + Dr. P. Lasch	Robert Koch Institute Berlin		
Dr. T. Leya	Fraunhofer IBMT, Potsdam Golm		
Dr. J. Jänchen	Technische Hochschule (TH) Wildau		
Dr. J. Fritz + C. Meyer	Museum für Naturkunde Berlin		
Prof. J. Joshi + B. Huwe + S. Moritz	Universität Potsdam		
Prof. D. Wagner + P. Serrano	Geo-Forschungs-Zentrum (GFZ) Potsdam and Alfred Wegener Institute for Polar and Marine Research (AWI), Uni. Potsdam		
Prof. U. Szewzyk + N. Feyh	Technische Universität (TU) Berlin		
Prof. B. Foing	ILEWG / ESA / ESTEC, Noordwijk		
Dr. R. Demets + Dr. J. Hatton + Dr. J. Dettmann	ESA / ESTEC (coordination) Noordwijk		
Prof. P. Ehrenfreund + Dr. A. Elsaesser	University of Leiden		
Prof. N. Kozyrovska	Ukrainian Academy of Science, Inst. of Molecular Biology & Genetics, Kiev		
Dr. F. Westall	Université d'Orléans		
Prof. D. Schulze-Makuch Lynn Rothschild	Washington State University / TU Berlin NASA		
Dr. G. Reitz + Dr. P. Rettberg + Dr. R. Möller + Dr. S. Leuko + Dr. Berger + Dr. G. Horneck	DLR Köln, Institute of Aerospace Medicine, Division of Radiation Biology		

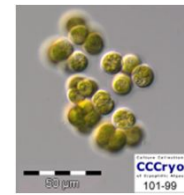
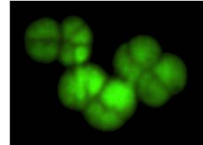
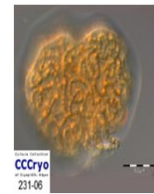
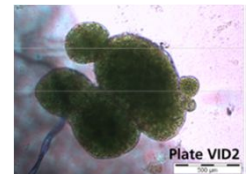


Eukarya



Sample coverage in the tree of life

- *Methanosarcina*
- *Thermocrinis*
- Cyanobacteria (*Nostoc*)
- Bacteria
- Fungi (*Cryomyces, Aspicilia, Buellia*)
- Plants (*Sphaerocystis, Grimmia*)



Source: De Vera et al. (2012)



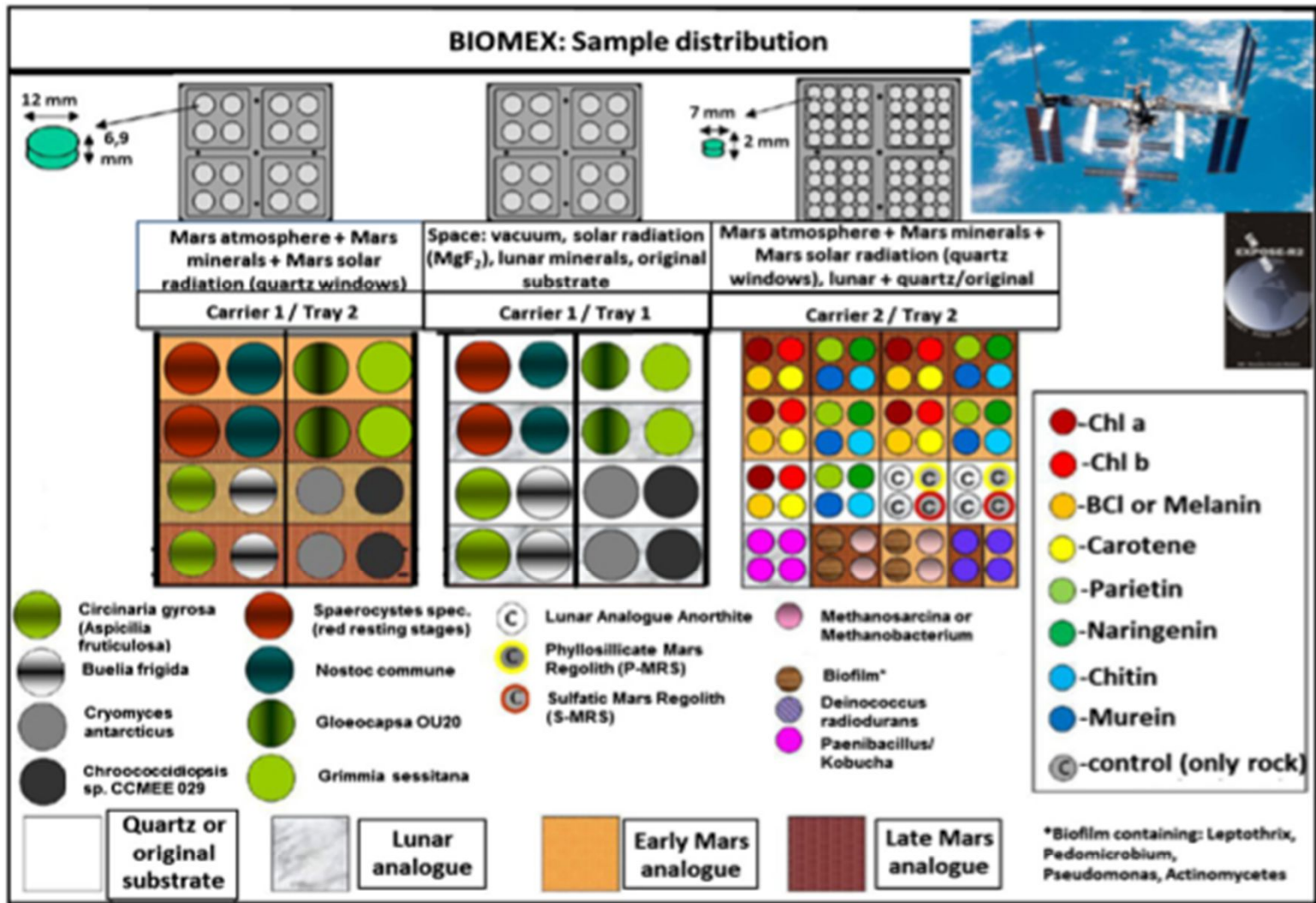


Fig. 3. Sample positions in hardware and parameter description.

Source: De Vera et al. (2012)



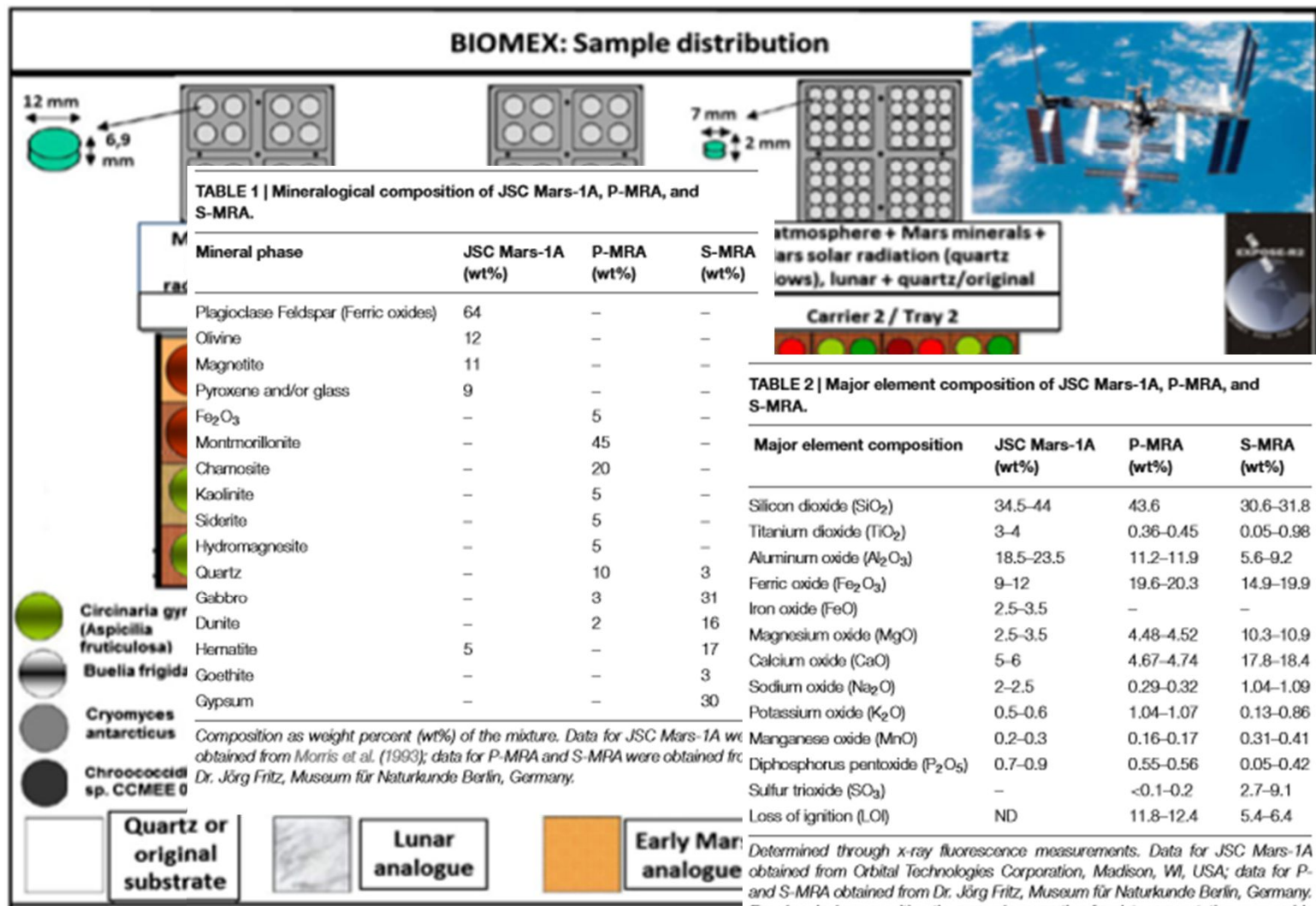


Fig. 3. Sample positions in hardware and

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Source Schiermack et al. (2015)



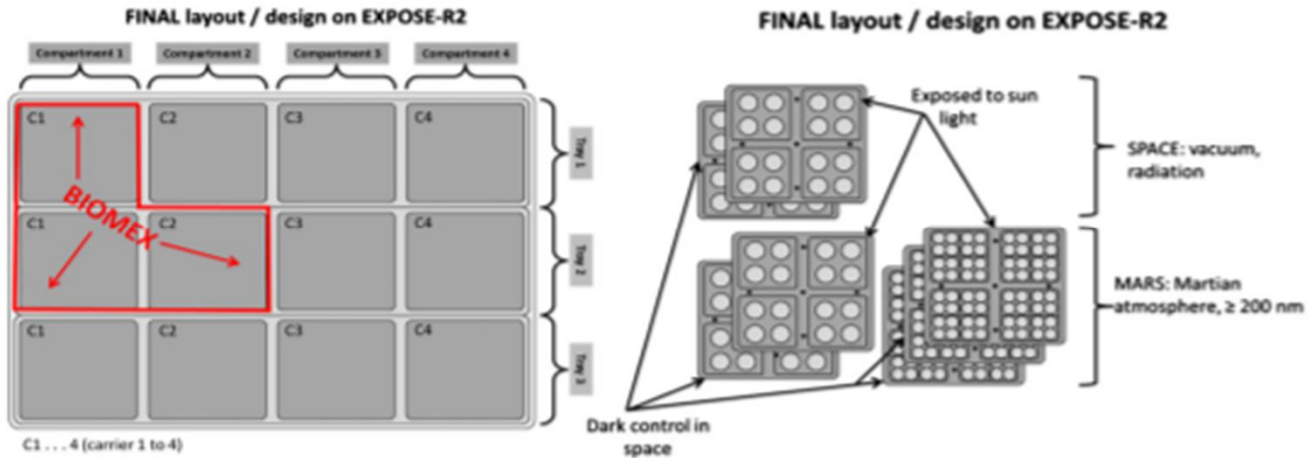
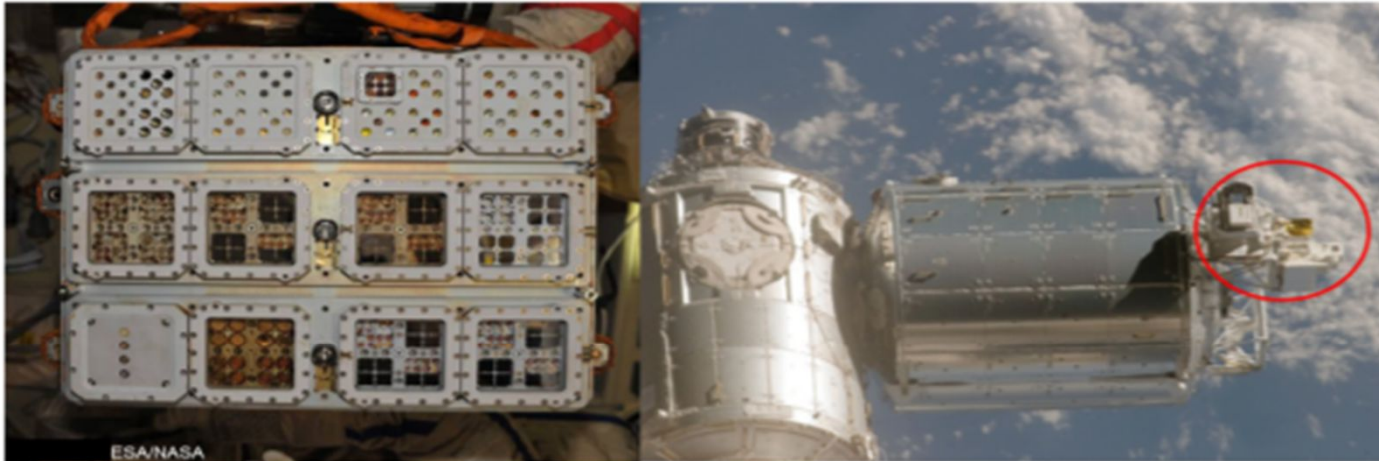


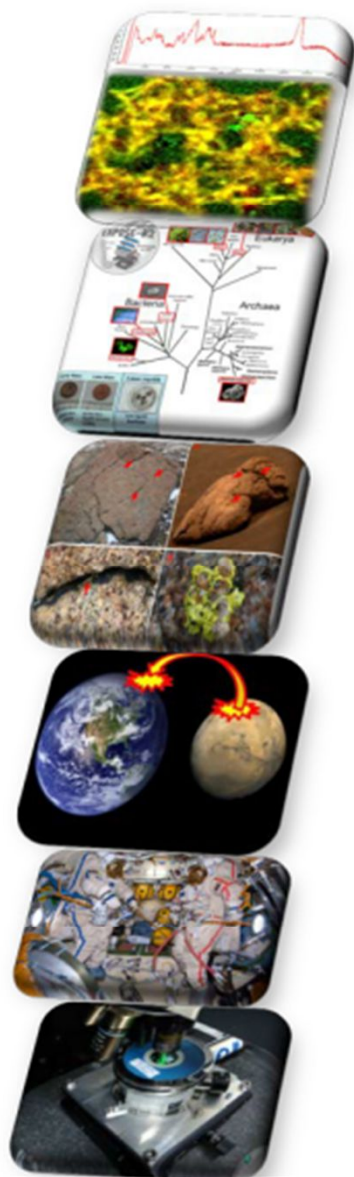
Fig. 1. EXPOSE R (Zvezda module/ top left) and EXPOSE-E on racks of Columbus module (top right, red circle); position of BIOMEX experiment in the EXPOSE-R2 hardware (bottom left) and sample holders (bottom right).

Source: De Vera et al. (2012)



Topics of BIOMEX

- **Stability and detection of biosignatures / bio-traces**
- **Limits of Life (using organisms of all 3 domains of the tree of life)**
- **Habitability of Mars**
- **Lithopanspermia**
- **Support of immune system of astronauts**
- **Test instruments for future space exploration**



BIOMEX is combining field work, simulation and space experiments to support future exploration missions

From the field to the lab and into space



Field studies



Simulation experiments



Low Earth Orbit experiments



Experiments on the Moon

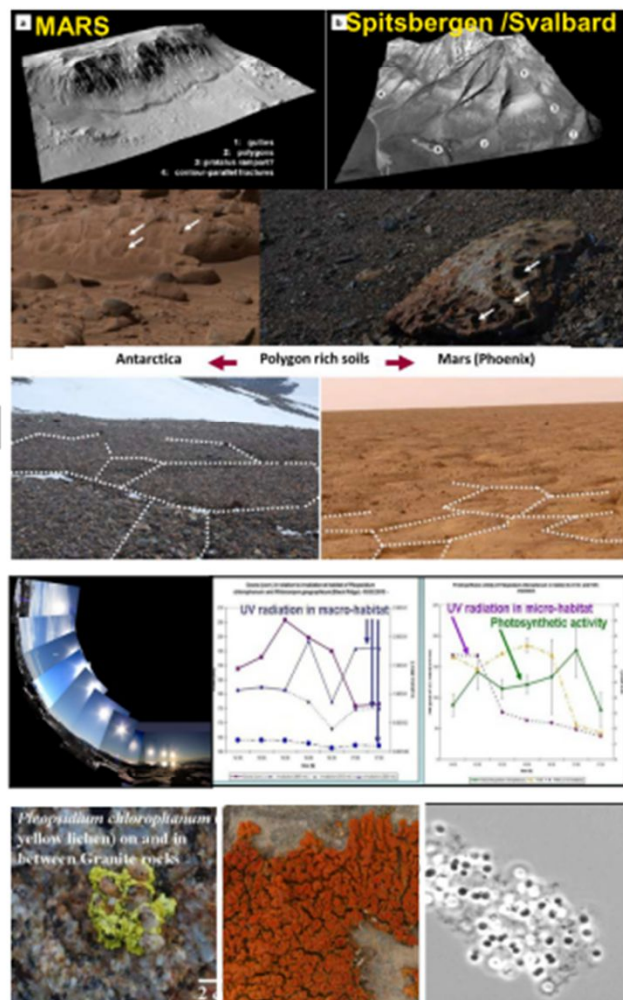


Exploration of Mars



Step 1: Mars analog research

- Characterization of Geomorphology to find Mars analog field sites
- Climatic and geological background in habitats
- Sample collection for Mars simulation experiments in the lab and in space



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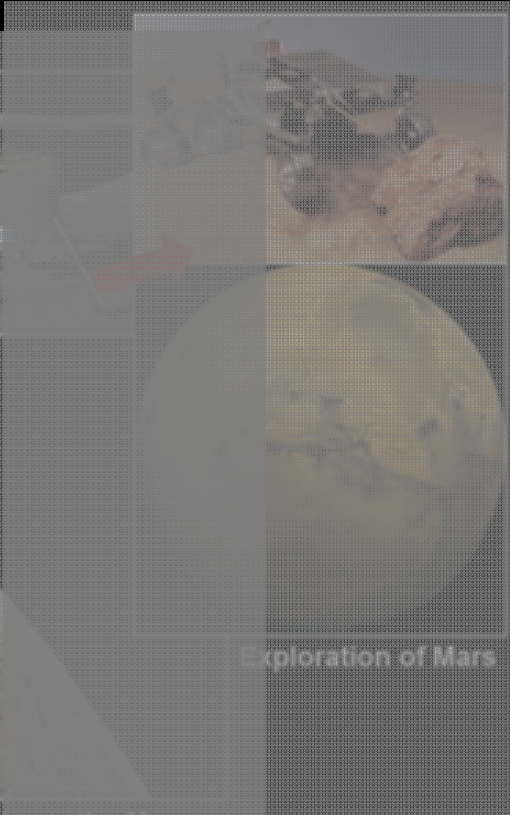
Simulation experiments



Low Earth Orbit experiments



Experiments on the Moon



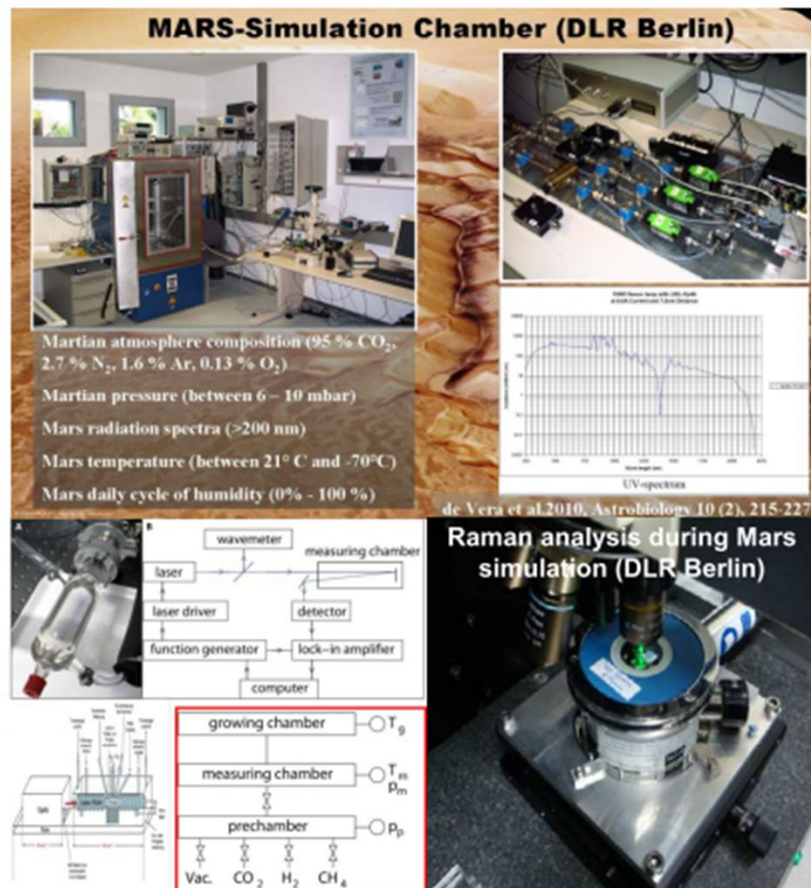
Exploration of Mars



Step 2: Mars simulation

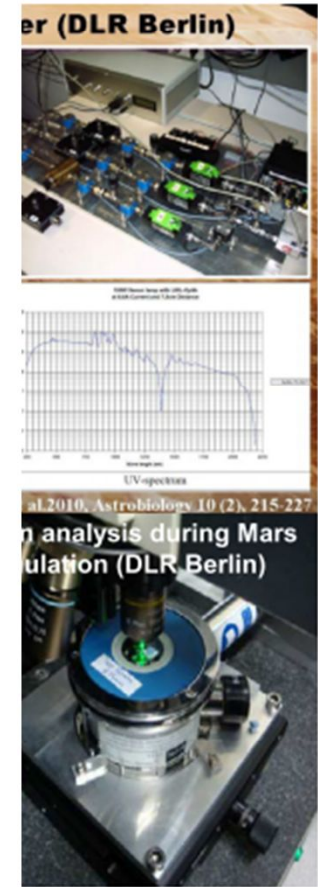
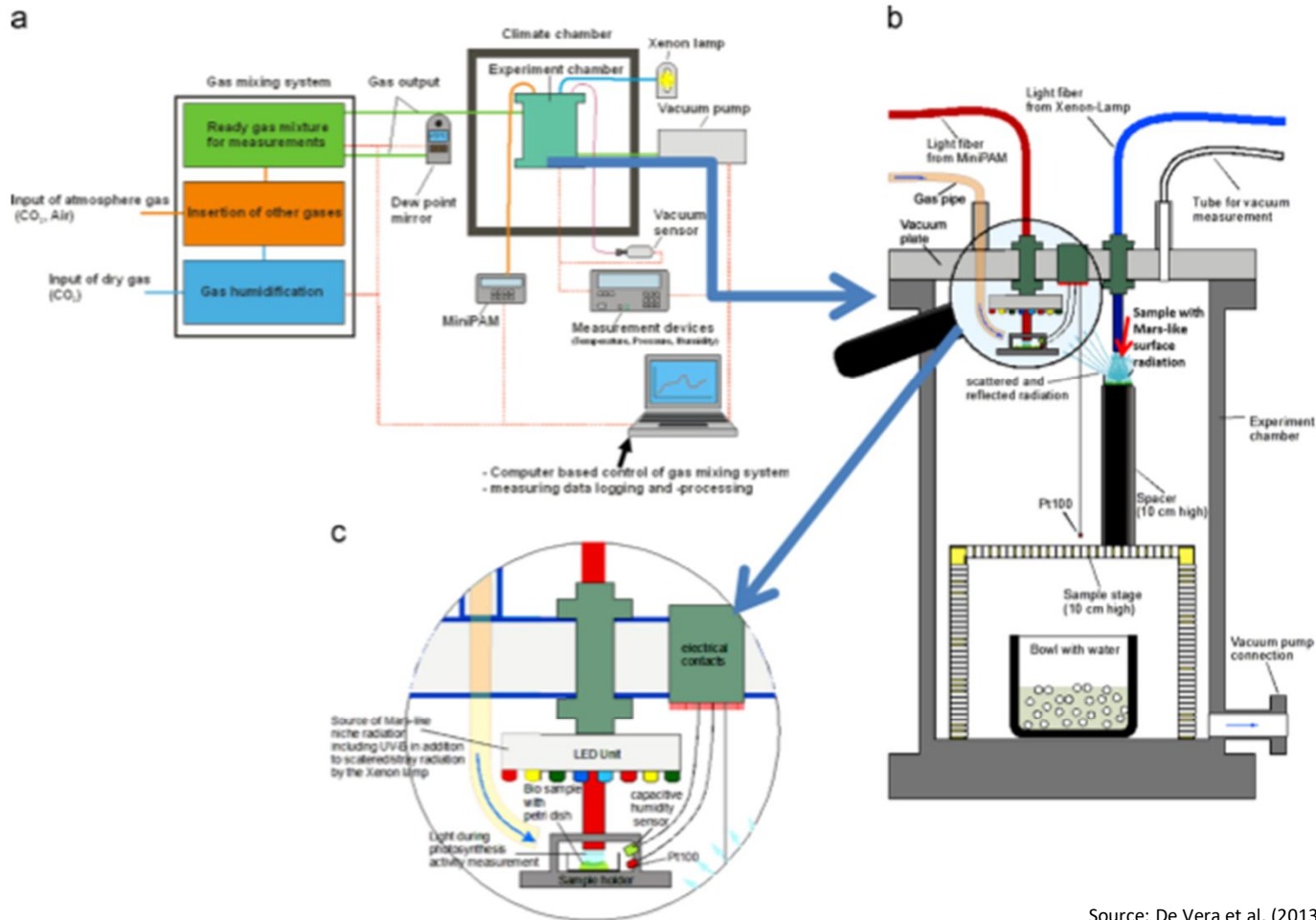
Mars simulation in the lab taken into account:

- Irradiation (including spectra of sunrise and sunset)
- Atmosphere composition / pressure
- Temperature
- Humidity
- Use of Mars analog minerals
- Diurnal cycles
- Sensor tests (monitoring of environmental conditions in simulation chamber)
- Raman spectroscopy analysis of samples before, during and after Mars simulation
- Life Activity / Metabolic activity of organisms before, during and after Mars simulation



Step 2: Mars simulation

Mars simulation in the lab taken into



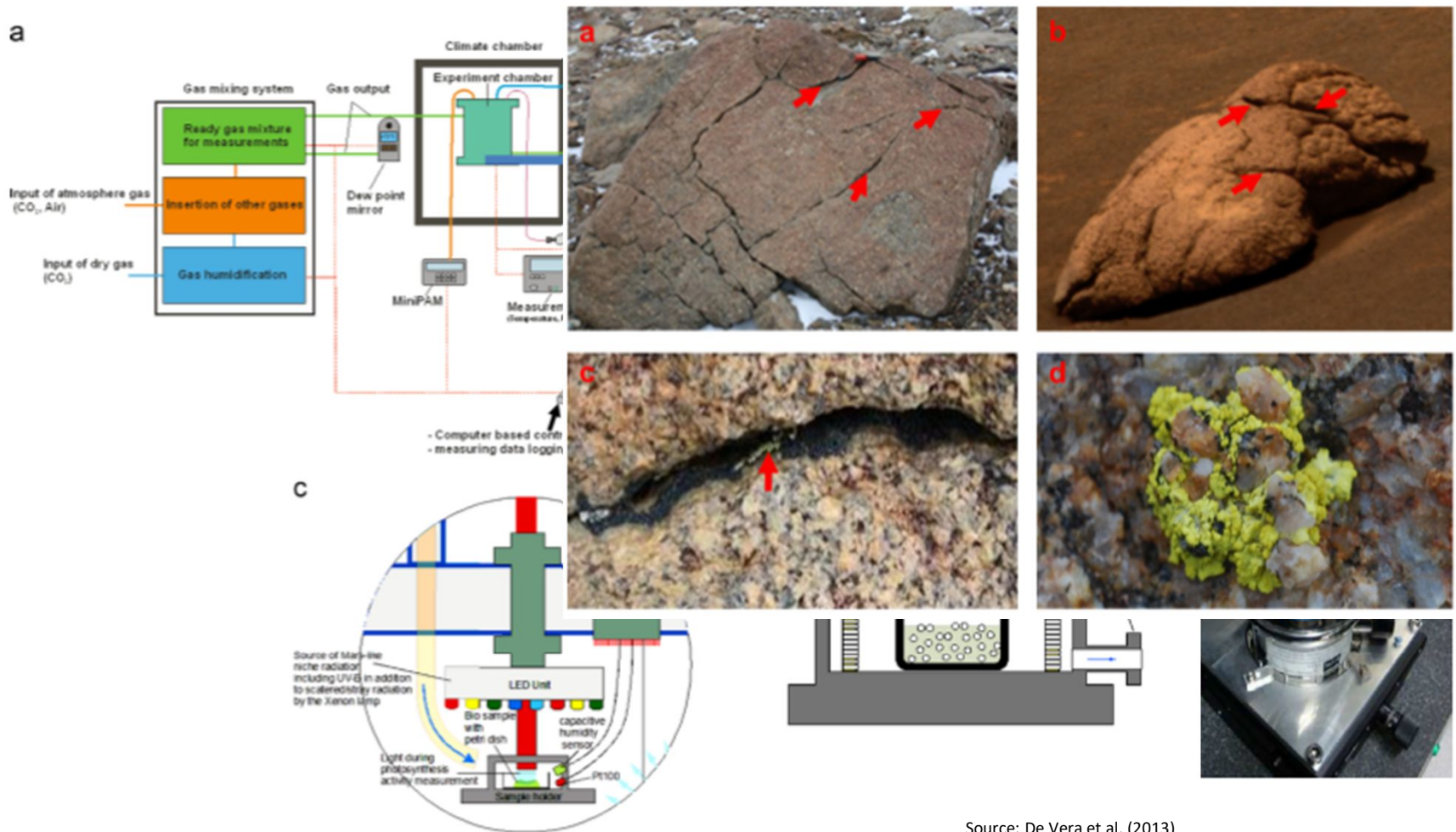
Source: De Vera et al. (2013)

Fig. 4. (a) Experiment configuration of the biological experiment. (b) Experiment arrangement inside the experiment chamber showing sample areas with Mars-like surface conditions and samples placed in Mars-like niche conditions. (c) Magnified insert from (b) showing the area of simulation realizing Mars-like niche conditions.



Step 2: Mars simulation

Mars simulation in the lab taken into



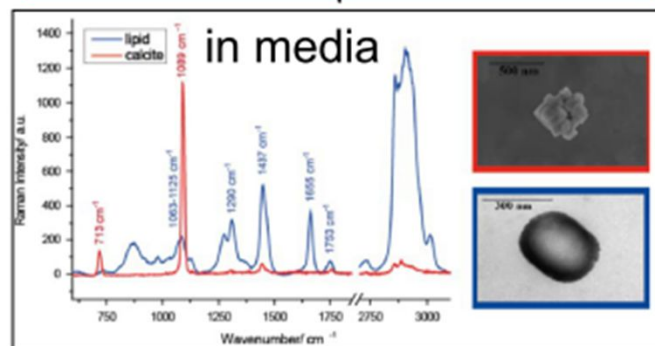
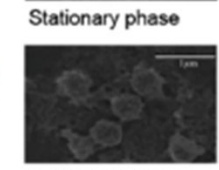
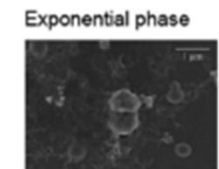
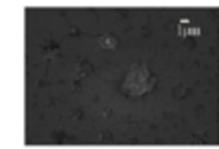
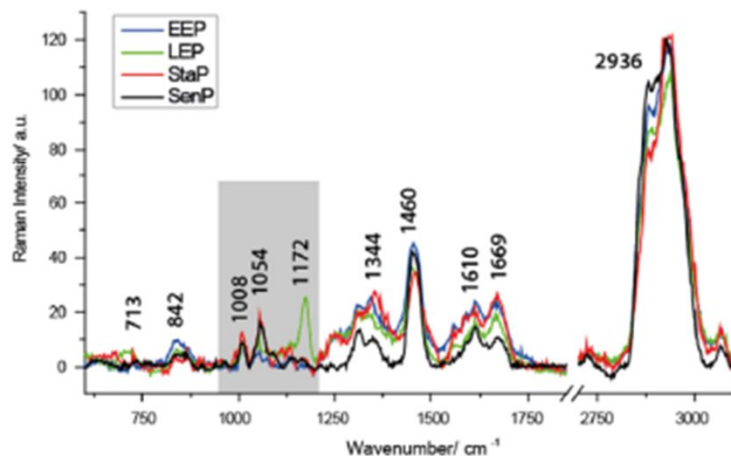
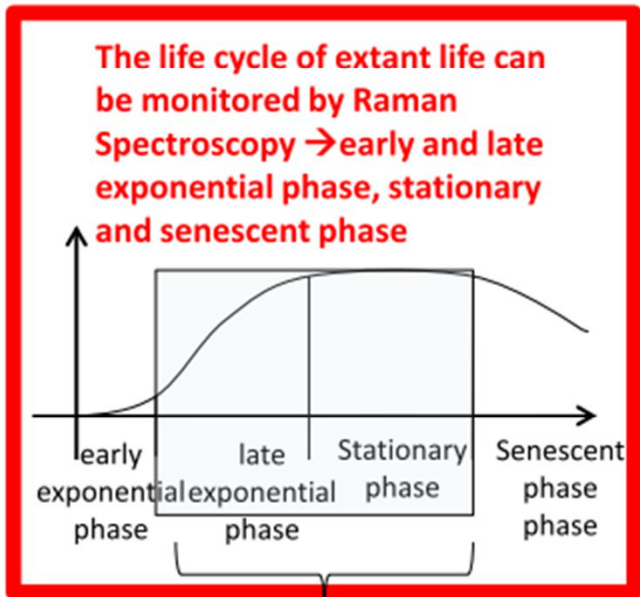
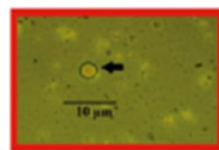
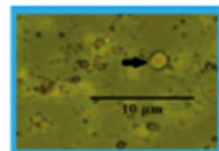
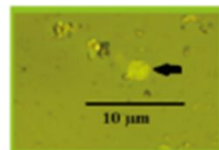
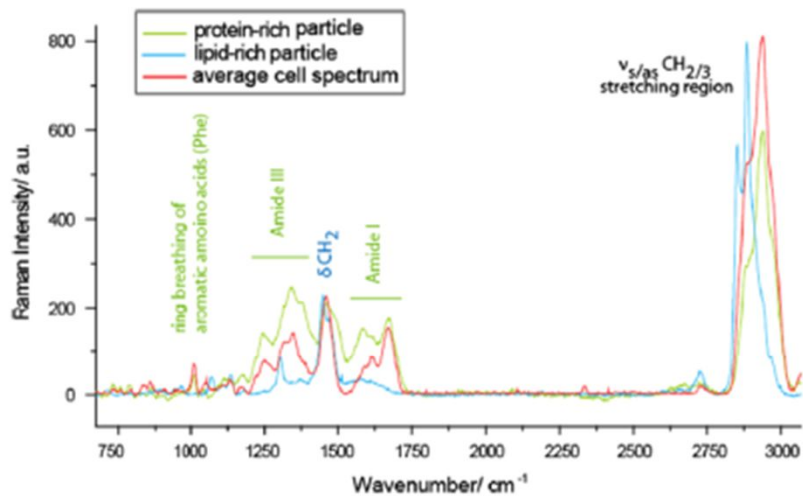
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Results of Pre-flight activities related to biosignatures: one example

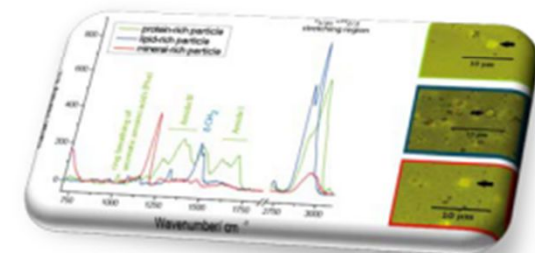
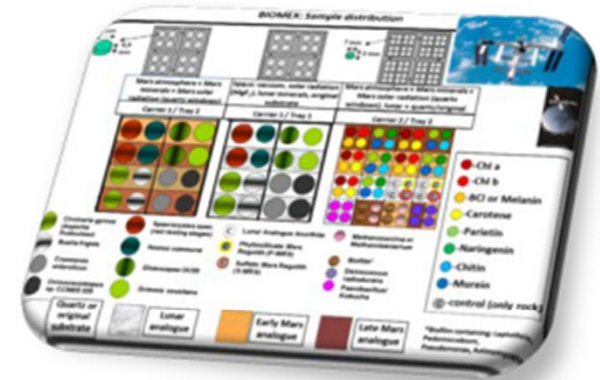
➔ The Raman biosignatures of *M. soligelidi* SMA-21 change over time as the archaeal cultures become older



Serrano et al. 2014, Planetary and Space Science 98 (2014), 191–197.

Overview about all Results

- **Biosignatures characterized by Raman spectroscopy of:**
 - **Methanogenes** (Serrano et al. 2014, 2015)
 - **Bacteria** (Baque et al. 2014, Böttger et al. 2013, Zaets, I. et al. 2014)
 - **Cyanobacteria** (Böttger et al. 2012, Baqué et al. 2014)
 - **Lichens** (Böttger et al. 2014, Meeßen et al. 2013)
- **Biosignatures and Biomineralization characterized by UV / VIS / IR / MS** (Meeßen et al. 2013, papers in prep.)
- **Mineral characterization of Mars-regolith analogs by Raman and analysis of water content by thermogravimetry** (Jänchen et al. 2014, 2015, 2016)
- **Survival of microorganisms after EVT and SVT such as:**
 - Methanogenes (**archaea**) – Schirmack et al. 2014
 - Cyanobacteria (**bacteria**) – Baqué et al. 2013
 - Iron bacteria and other bacteria (**bacteria**) – Zaets, I. et al. 2014, papers, Reva et al. 2015, and others in prep.)
 - Lichens (**eukaryotes**) – Meeßen et al. 2013a,b, Sánchez et al. 2012...
 - Micro-fungi (**eukaryotes**) – Pacelli et al. 2016
 - Mosses (**eukaryotes**) – Moritz et al. 2013, Fiedler et al. 2016 and in prep.



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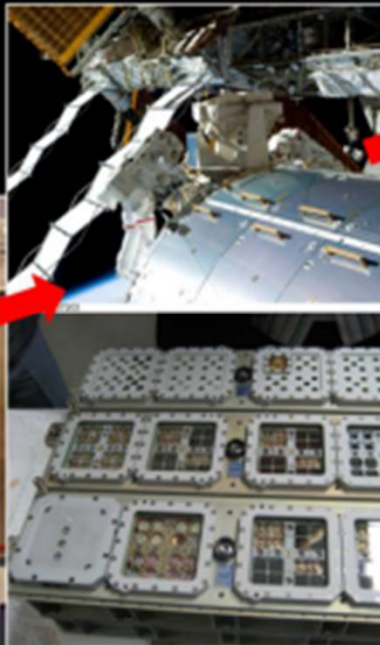
From the field to the lab and into space



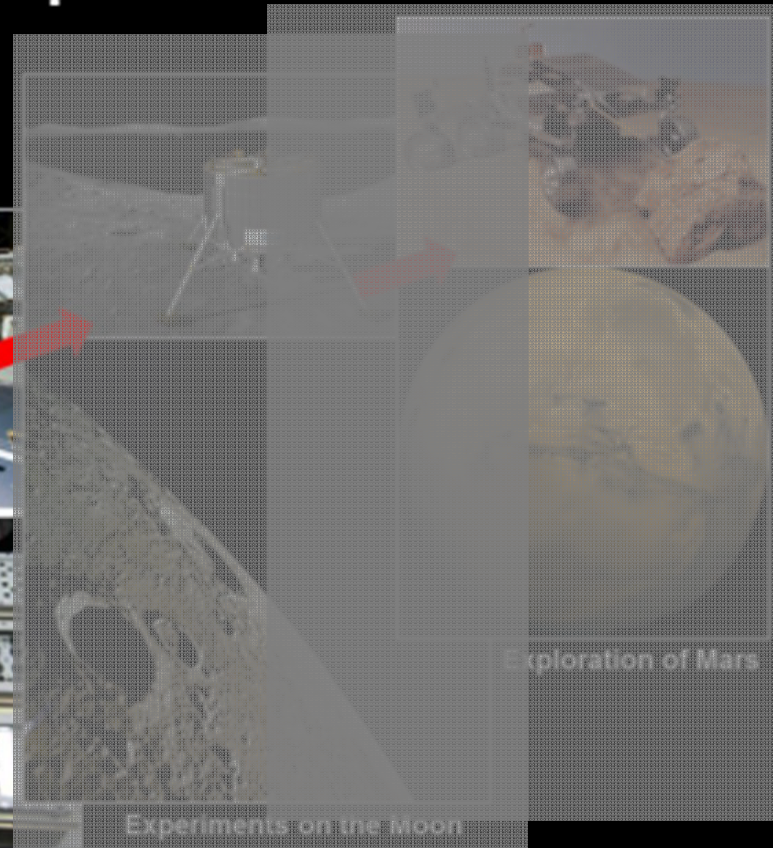
Field studies



Simulation experiments



Low Earth Orbit experiments

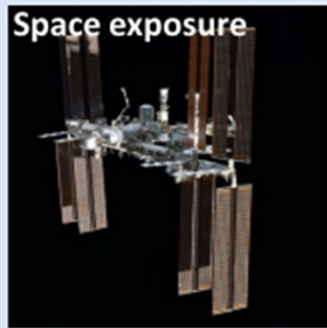


Experiments on the Moon

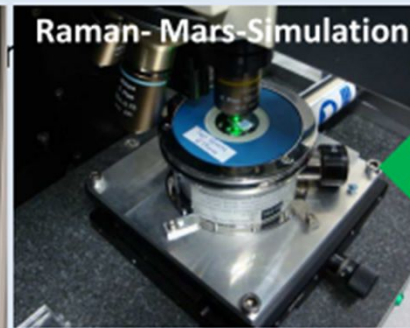
Exploration of Mars



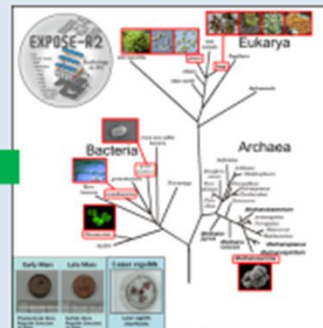
Differences of vitality / of Spectra of bio-signatures and Mars-analog minerals depending on the test-parameters



Measurements before and after Exposure



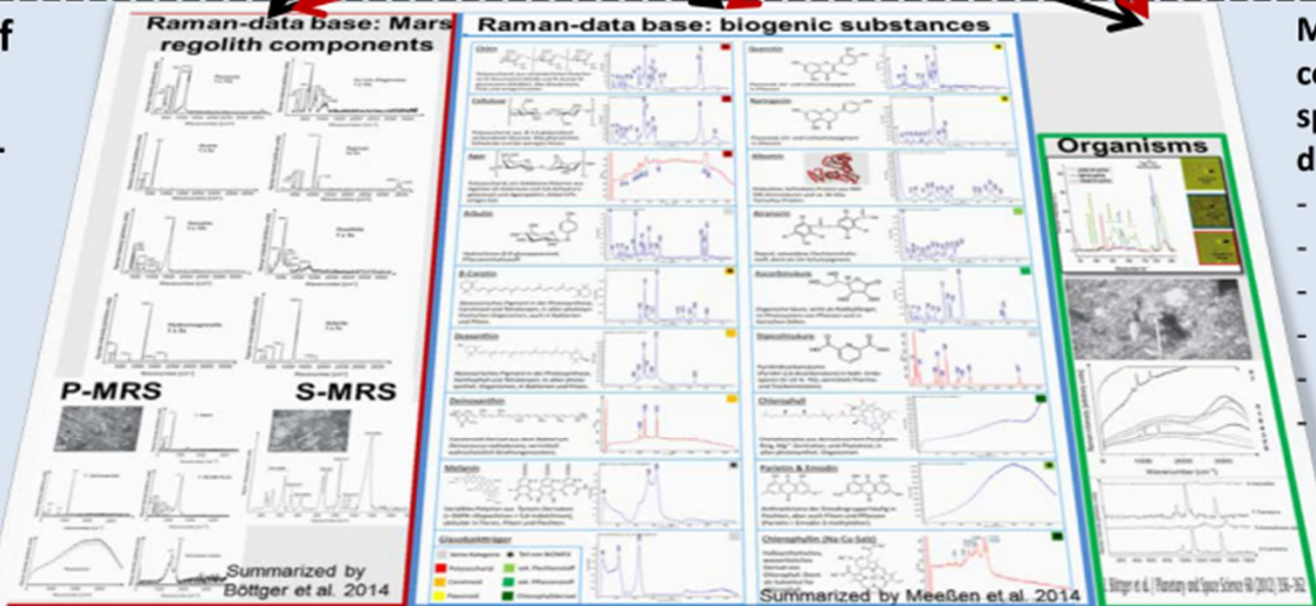
Measurements during Mars-Simulation



Mineral-/Bio-Samples



Production of a complete biosignature- and mineral-environment-dependent Database



Mars-analog regoliths

Biogenic substances

Organisms

Meta-Data: collection of spectra depending on:

- temperature
- humidity
- radiation
- pressure
- pH
- salinity



Launch and EVA: some impressions



23.07.2014



Transfer to Baikonur



Arrival at Baikonur



Integration on progress



Transfer to launch site

Last check before launch



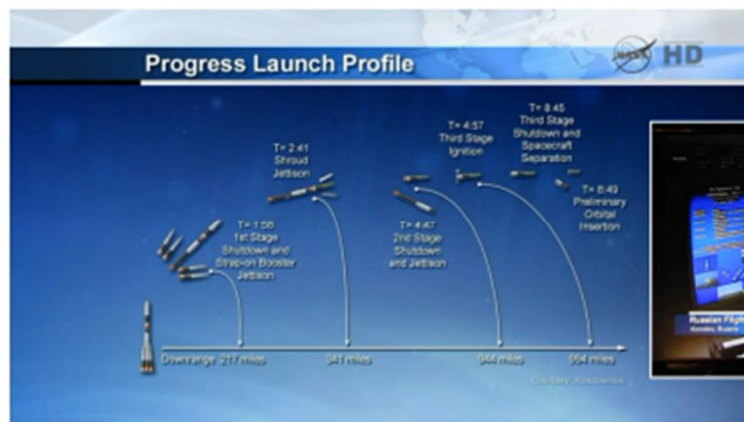
Launch



24.07.2014



Cheers!



Launch and EVA: some impressions



http://www.youtube.com/watch?v=IBKETorCqRw&list=UUOcpUgXosMCIIosreUfNFIA&feature=player_embedded#t=0



Arrival in the ISS:



Tray 1



Tray 2



Tray 3



Tray 1; compartment 1



Tray 2; compartment 1



Tray 2; compartment 2



Launch and EVA: some impressions



EXPOSE R2 in the ISS!



EXPOSE R2 with cover!

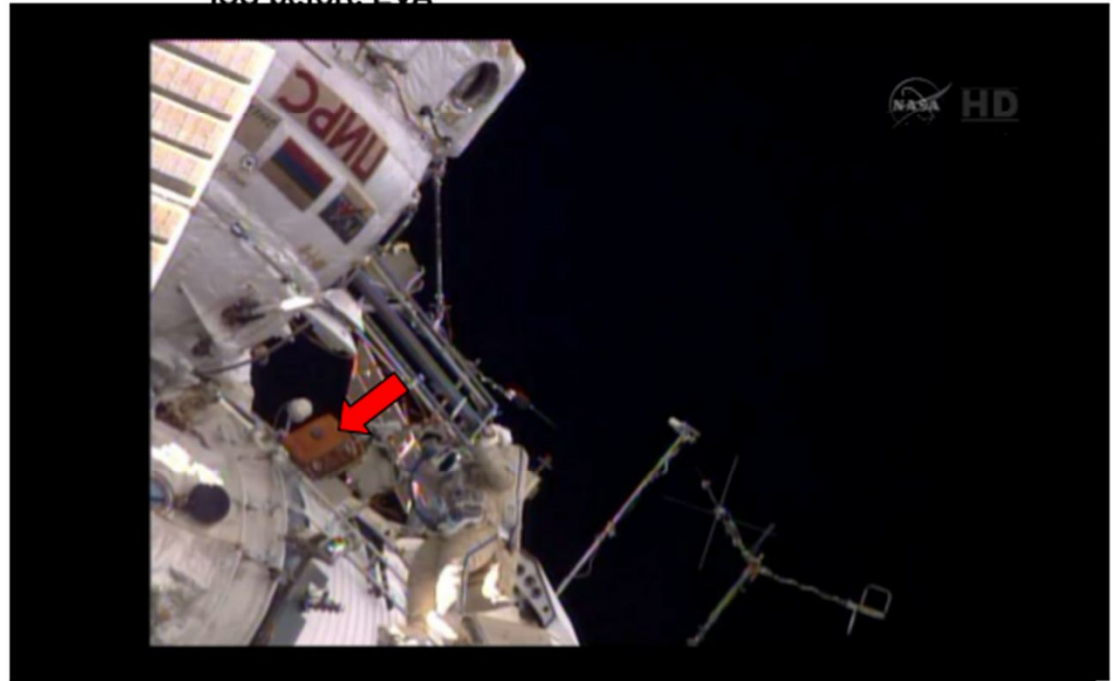


Astronauts in suits in the ISS before EVA



Astronaut installing EXPOSE R2

Ready!



Launch and EVA: some impressions



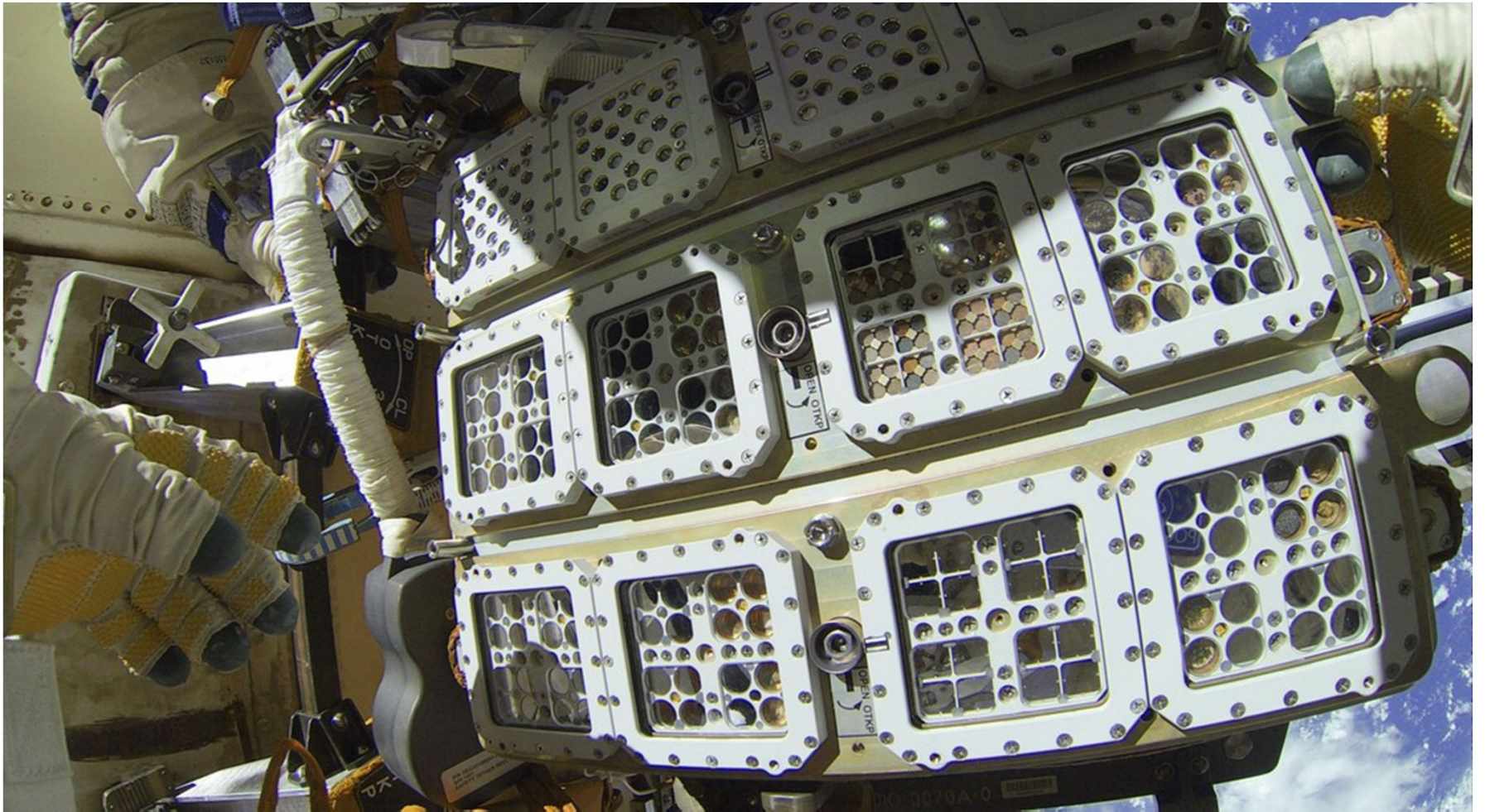
EXPOSE-R Experiment

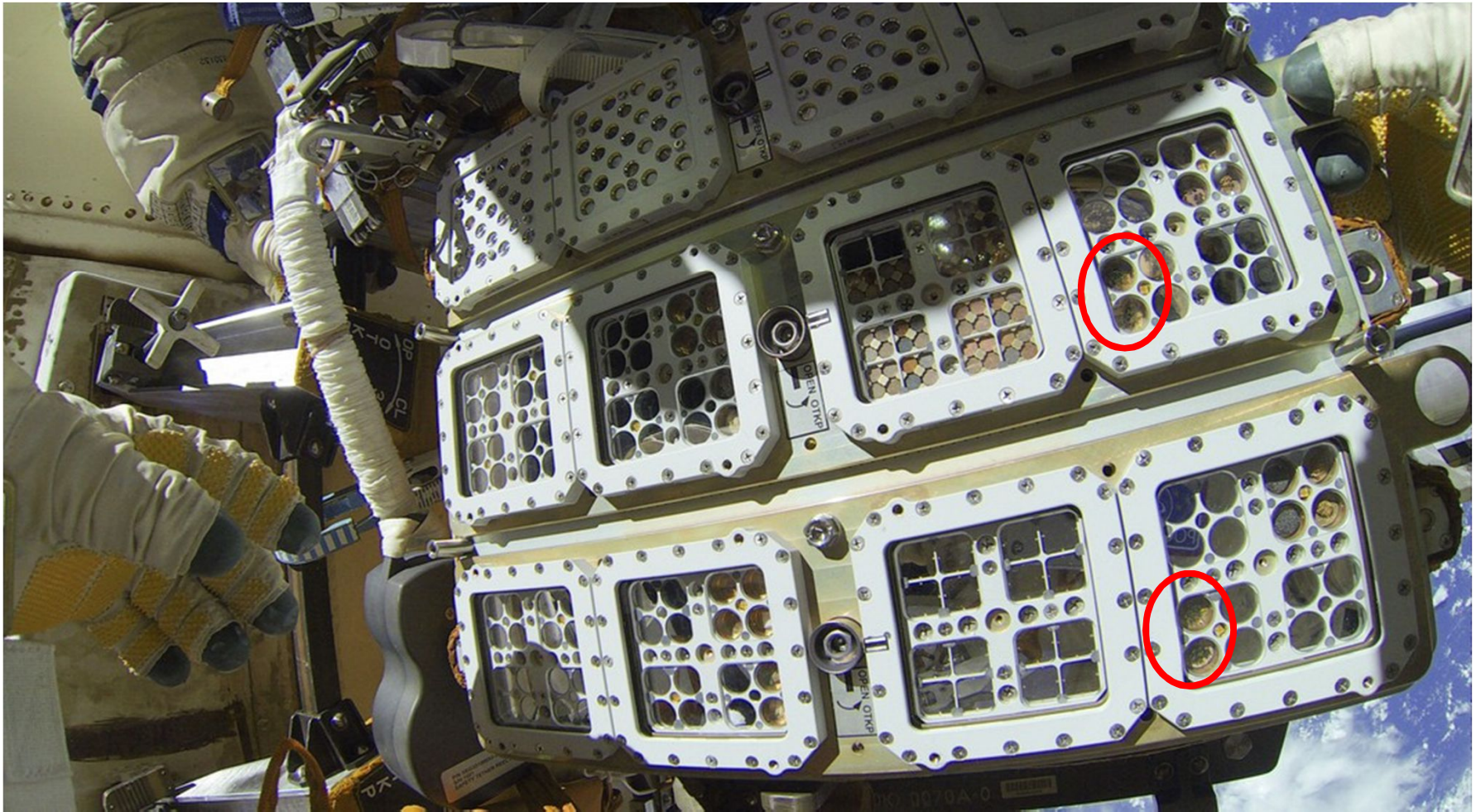


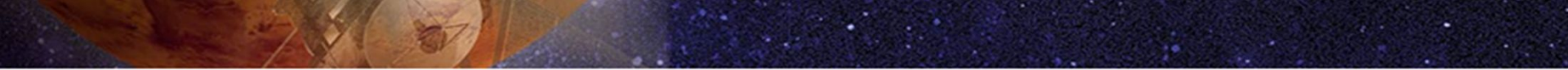
Zvezda Plane II
Universal Work Platform





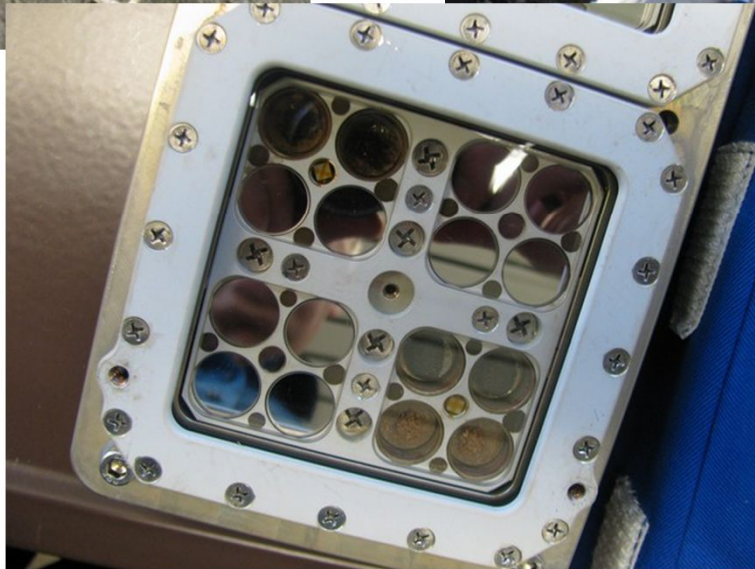






esa





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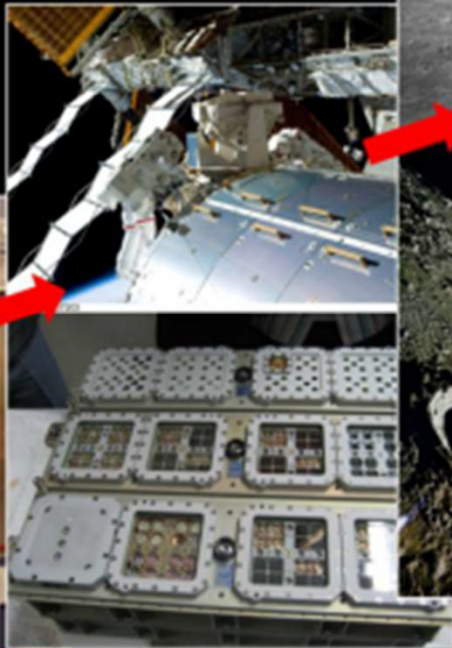
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