ExoMars 2018 Mission

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2018 Mission Objectives

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

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

**2018**

- Russian deep-space communications stations to work with ESA's ESTRACK;
- Russian computer for ExoMars landed operations;
- Throttleable braking engines for planetary landing.

To characterise the surface environment.

Credit: MEX/HRSC

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Potential to Host Life

HABITABILITY
PRESERVATION
ExoMars exobiology strategy:

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

Nominal mission: 218 sols
Nominal science: 6 Experiment Cycles + 2 Vertical Surveys
EC length: 16–20 sols
Rover mass: 300-kg class
Mobility range: Several km
Determine the rover’s geological context:
- Survey site at large scales
- Examine surface outcrops and soils at sub-mm scales

Collect a subsurface (or surface) sample

Study sample:
- Survey analysis
- Detailed analysis

Credit: MEX/HRSC
Pasteur Payload

ANALYTICAL LABORATORY DRAWER

MicrOmega (VIS + IR Imaging Spectrometer)
MOMA (Organic Molecule Analyser)
RLS (Raman Spectrometer)

Credit: MEX/HRSC
**Site Characterisation**

**AT PANORAMIC SCALE:** To establish the geological context

- **Panoramic Camera System + IR Spectrometer**
  - Two Wide Angle Cameras (WAC): Colour, stereo, 35° FOV.
  - One High-Resolution Camera (HRC): Colour, 5° FOV.

- **Ground Penetrating Radar**
  - ~3-m penetration, with ~2-cm resolution (depends on subsurface EM properties)

- **Neutron Spectrometer**

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AT ROCK SCALE: To ascertain the past presence of water
For a more detailed morphological examination

High-Resolution Camera
Close-Up Imager
Colour, 10-µm/pixel resolution, 19° FOV,
Focusing range: 10 cm to ∞

Next step: ANALYSIS
Use the drill to collect a sample
From an outcrop
From the subsurface

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Subsurface drill includes a miniaturised IR spectrometer for borehole investigations.

Spectral range: 0.4–2.2 µm
Sampling resolution: 21 nm

OBTAIN SAMPLES FOR ANALYSIS: From 0 down to 2-m depth
DRILL discharges sample into Core Sample Transport Mechanism (CSTM). CLUPI images sample. PanCam HRC provides a backup sample imaging capability.
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, 0.9–3.5 μm spectral range, 500 steps

- μΩ = 20 μm
- Raman = 50 μm
- LDMS = 400 μm

Raman: Spectral shift range 200–3800 cm⁻¹
Spectral resolution: 6 cm⁻¹

GCMS = Gas Chromatograph Mass Spectrometer
What Phoenix Taught Us

- The Phoenix Wet Chemistry Laboratory (WCL) detected ~0.5 wt% perchlorate (ClO₄) in the soil.
- The Thermal and Evolved Gas Analyser (TEGA), TV-MS (without GC), did not detect any organic gases upon heating to ~1000 °C.
- WCL and TEGA data suggest that potential Martian organic compounds would be combusted by perchlorate during pyrolysis.

- Since Phoenix, a number of investigators have reviewed the Viking landers’ GCMS results (Navarro-Gonzalez et al. 2011).
- Viking had detected chloromethane and dichloromethane. At the time it was assumed they were cleaning agent residues.
- Lab results (Steininger et al. 2012) confirm that the presence of perchlorate complicates the detection of organics by TV-GC-MS:
  1. Partial or total oxidation, depending on organic molecule;
  2. Production of chlorinated compounds (as seen by Viking and now also MSL).
Broad identification range (50–2000 Da), including distribution, and chirality. High sensitivity (≤ 1 pmol/mol in TV-CGMS, ≤ 1 pmol/mol/mm² in LDMS). Resolution ≤ 1 Da over 50–500 Da range, ≤ 2 Da thereafter. Ability to perform MS-MS analysis on trapped fragments. LDMS mode appears not to be disturbed by perchlorates.
# Pasteur Payload

## PanCam
- Wide-angle stereo camera pair
- High-resolution camera
- Geological context
- Rover traverse planning
- Atmospheric studies
- WAC: 35° FOV, HRC: 5° FOV

## ISEM
- IR spectrometer on mast
- Bulk mineralogy of outcrops
- Target selection
- $\lambda = 1.15 - 3.3 \mu m$, 1° FOV

## CLUPI
- Close-up imager
- Geological deposition environment
- Microtexture of rocks
- Morphological biomarkers
- 20-µm resolution at 50-cm distance, focus: 20 cm to $\infty$

## WISDOM
- Ground-penetrating radar
- Mapping of subsurface stratigraphy
- 3 – 5-m penetration, 2-cm resolution

## ADRON
- Passive neutron detector
- Mapping of subsurface water and hydrated minerals

## Drill + Ma_MISS
- IR borehole spectrometer
- In-situ mineralogy information
- $\lambda = 0.4 - 2.2 \mu m$

## Analytical Laboratory Drawer

### MicrOmega
- VIS + IR spectrometer
- Mineralogy characterisation of crushed sample material
- Pointing for other instruments
- $\lambda = 0.9 - 3.5 \mu m$, 256 x 256, 20-µm/pixel, 500 steps

### RLS
- Raman spectrometer
- Geochemical composition
- Detection of organic pigments
- spectral shift range 200–3800 cm$^{-1}$, resolution $\leq 6$ cm$^{-1}$

### MOMA
- LDMS + Pyr-Dev GCMS
- Broad-range organic molecules with high sensitivity (ppb)
- Chirality determination
- Laser desorption extraction and mass spectroscopy
- Pyrolysis extraction in the presence of derivatisation agents, coupled with chiral gas chromatography, and mass spectroscopy
Posters

Pasteur Instruments:

• MOMA: Buch et al., #67, Thu
• MOMA: Steininger et al., #69, Thu

Landing Sites:

• All submitted: Flahaut et al., #58, Thu
• Simud Valles: Pajola et al., #56, Thu

Credit: Meridiani Planum–Odyssey
Driven by the search-for-life objectives:

› Age of landing site:
  Ancient (≥ 3.6 Ga)—from Mars’ early, habitable period: Pre- to late-Noachian (Phyllosian), possibly extending into the Hesperian;

› Geological setting:
  Abundant morphological and mineralogical evidence for long-duration, or frequently reoccurring, aqueous activity.

› Nature of deposits:
  Site must contain sedimentary rock outcrops.

› Prime target accessibility:
  Outcrops must be distributed on/over landing ellipse to ensure the rover can get to some of them (few km apart).

› Little dust:
  To guarantee access to subsurface sediments.
Landing Sites

Entry: Ballistic
Landing Ellipse: 104 km x 19 km
Max Elevation: ~2 km MOLA

- Oxia Planum 1
- Oxia Planum 2
- Hypanis Vallis
- Simud Vallis
- Mawrth Vallis 1 & 2
- Coogoon Valles
- Oxia Palus
- Southern Isidis

Elevation is acceptable
Elevation is too high
Too much dust

Credit: MEX/HRSC
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**Conclusions**

- **2016: ExoMars Trace Gas Orbiter**
  - Its science will improve our understanding of Mars and of key atmospheric processes of potential astrobiological relevance.
  - An excellent base for international collaboration.
  - Master landing technologies for future exploration missions.

- **2018: ExoMars Rover and SP**
  - A great exobiology mission.
  - The first ever to combine mobility with access to the subsurface.
  - The rover’s Pasteur payload contains next-generation instruments.
  - The rover will study for the first time:
    - Organics and biomarkers for past and present life at depth;
    - Vertical characterisation of geochemistry and water.
  - The SP will perform novel environmental measurements.
  - A step closer to Mars Sample Return.
Things to Check

Regional geological context:
- Where are the basins (containers)?
- Where could water have ponded for a long time?
- What types of sediments would have accumulated in the basins?

Burial, mineralogy, exhumation:
- What is the likely history of burial/compaction?
- Presence of clays, sulfates, silica.
- Duration of exposure to (modern) surface conditions.
- Where would burial, facies, and mineralogy provide the best isolation against surface destruction of organics?

Survival rate of amino acids vs. depth after being exposed for 0.5 (red), 1 (blue), and 3 billion years (green) to the ionising radiation in the near-surface of Mars. [Adapted from Sephton 2010, originally from Kminek & Bada, 2006].