Looking for life on Mars

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1. Mars 3.8 billion years ago & now
2. Water and life
3. ExoMars Rosalind Franklin rover

www.ucl.ac.uk/mssl

@exomarspancam
Top locations for life beyond Earth

- Mars
  - Radius: 3390 km
  - Relative to Earth: 1/2 Earth

- Enceladus
  - Radius: 252 km
  - Relative to Earth: 1/25 Earth

- Europa
  - Radius: 1561 km
  - Relative to Earth: 1/4 Earth

- Titan
  - Radius: 2575 km
  - Relative to Earth: 1/2.5 Earth

- Venus
  - Radius: 6052 km
  - Relative to Earth: 95% Earth
Mars 3.8 by ago

Water on surface

Volcanism

Magnetic field
Mars now

- Extinct volcanoes
- No large-scale magnetic field, only remanent regions
- 7 mbar, CO$_2$-rich atmosphere
- Cold, dry
NASA Phoenix, 2008
Evidence for ancient lake and stream deposits – conditions for microbial life
NASA Curiosity – Grotzinger +, 2014
Mars south polar region

Permanent polar ice cap

Study area

Mars Express radar footprints (blue = brightest radar echo)

Radar image of subsurface

Surface

Brightest radar echoes suggest liquid water

South polar layered deposits (ice and dust layers)

Context map: NASA/Viking; THEMIS background: NASA/JPL-Caltech/Arizona State University; MARSIS data: ESA/NASA/JPL/ASI/Univ. Rome; R. Orosei et al 2018
Solar wind interaction

Magnetized

Mercury
Earth
Saturn
Jupiter
Uranus
Neptune
Sun

Unmagnetized

Venus
Mars
Pluto
Comets

Coates, 2001
Solar wind pulling away Mars atmosphere: increased loss during solar activity
Mars 3.8 billion years ago

Mars now
Was there life on Mars?

Maybe, when Mars was warmer and wetter, 3.8 billion years ago
Many now find evidence from meteorite ALH84001 (announced in 1996) unconvincing
Must go to Mars to find out!
Requirements for life

Liquid water
Essential elements (C, H, N, O, P, S)
Source of heat
Time

Early Mars?
...in the atmosphere...

...and escaping to space
Methane on Mars!

Mars Express: trace concentrations of methane (11.5 parts per billion – Formisano+ 2004)

Confirms telescope observations (Mumma+, 2004, 2009)

Methane short lived in Mars atmosphere (hundreds of years)

Must be a source now (Geothermal activity? Life?)

Tantalising results

Also seen by Curiosity sporadically (Webster et al., 2013, 2014, 2018)

Oxygen recently detected also (Trainer et al., 2019)
Missions to Mars

ESA-Russia
Trace gas orbiter (2016)
Rosalind Franklin (ExoMars) rover (2022)

NASA
InSight (2018)
Perseverence (2020)

UAE
Hope orbiter (2020)

China
Tianwen-1 orbiter, rover (2020)
### Analytical Laboratory Drawer

**PanCam**
- Wide-angle stereo camera pair
- High-resolution camera
- WAC: $35^\circ$ FOV, HRC: $5^\circ$ FOV

**ISEM**
- IR spectrometer on mast
- $\lambda = 1.15 - 3.3 \, \mu m$, $1^\circ$ FOV

**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

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

**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 $\leq 6 \, \text{cm}^{-1}$

**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
The Rosalind Franklin rover

Looking for life on Mars
Launch 21 Sep 2022
Lands 10 June 2023
Drills up to 2m under surface
Context & analytical instruments
Some of PanCam team with rover model at ESTEC, Dec 2019
Parachute test, Oregon, 2019
Why Rosalind Franklin?

- Brilliant X-ray crystallographer
- Photograph (Photo 51) of a fibre of DNA
- Critical to Watson and Crick's discovery of the double helix
- Other important work on structure of carbon, viruses

Photo 51

Working notes on DNA

Wellcome library
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;
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.
Rosalind Franklin landing site - Oxia Planum

- Clay bearing rocks 3.9 bya
- Remnants of a fan or delta near the outlet of Coogoon Vallis

Fawdon et al., (2020) in prep.
PanCam: the science ‘eyes’ of the Rosalind Franklin rover

- Filter wheels (FWs)
- Wide angle cameras (WACs)
- High Resolution Camera (HRC)
- PanCam Interface Unit (PIU)
- DC-DC converter (DC-DC)
- Optical bench (OB)
- ‘Small Items’: PanCam Calibration Target (PCT), Fiducial Markers (FidMs), Rover Inspection Mirror (RIM)
- Stereo, colours, shapes and scales
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- Science team

MSSL
TAS-CH
DLR/OHB
MSSL
MSSL
Aberystwyth
PanCam’s filters

- 11 on each WAC
- Geology – water-rich minerals
- Atmosphere – water vapour
- Colour HRC provides rock texture

KEY: L01-L11/R01-R11 = filter wheel position number (home = 01); C01-C03 = red, green & blue broadband colour filters (both WACs); G01-12 = geology filters, HRC = solar filters; bbb = filter centre wavelength and FWHM bandwidth (in nm).
Examples of PanCam use and results

Many field tests
See Coates+ (2017)

Harris+ (Icarus 2015)
Trial in the Atacama desert, Feb 2019

WAC spectra
Courtesy Elyse Allender & PanCam team

MSL NASA JPL
JR/Imperial

3D geological analysis
e.g. Coates +, 2017

Courtesy PanCam team
PanCam integration at UCL-MSSL
PanCam

- delivered to Airbus May 2019
- installed August 2019

https://www.esa.int/spaceinimages/Images/2019/05/ExoMars_PanCam_filters
PanCam on the rover

Optical bench

Fiducial markers
Calibration target
Rover inspection mirror

Credit: M. de la Nougerede, UCL/MSSL

Credit: Airbus
PanCam mast installation, August 2019

Courtesy Airbus – M.Alexander
‘First light’ on the rover!
PanCam image, August 2019
Summary

Rosalind Franklin (ExoMars 2020) will provide an important new dimension on Mars: drill under surface

PanCam, with other context instruments, provides geological and atmospheric context

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