UCL

Looking for life on Mars

Andrew Coates & the Rosalind Franklin PanCam team

Mullard Space Science Laboratory, University College London

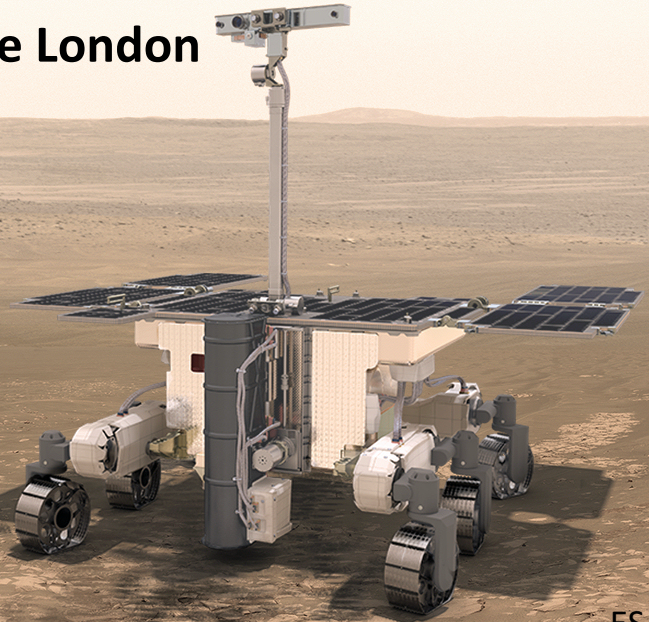
1. Mars 3.8 billion years ago & now
2. Water and life
3. ExoMars Rosalind Franklin rover

www.ucl.ac.uk/mssl

@exomarspancam

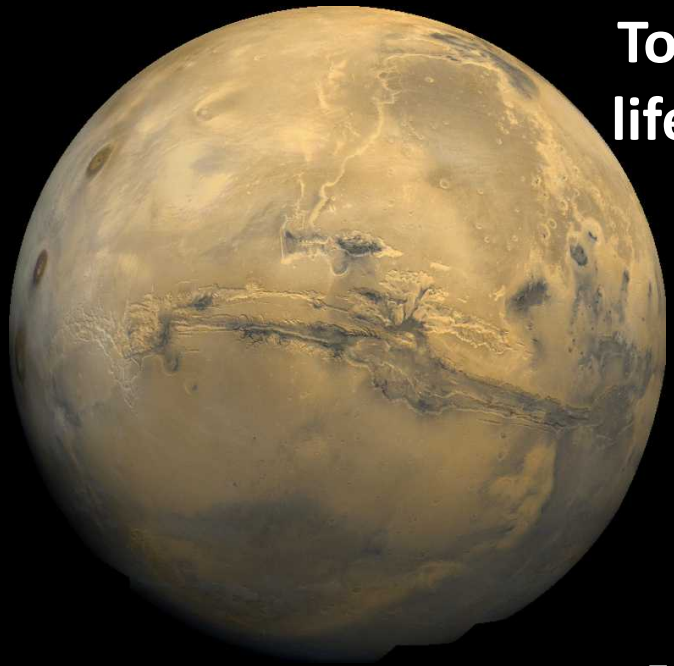
UK SPACE AGENCY

PANCAM



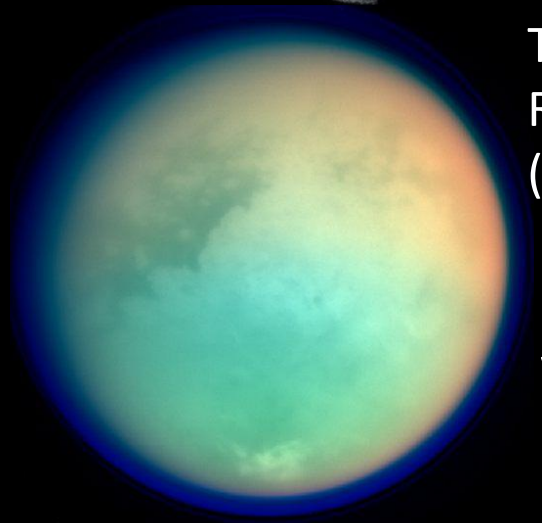
ESA

Top locations for life beyond Earth



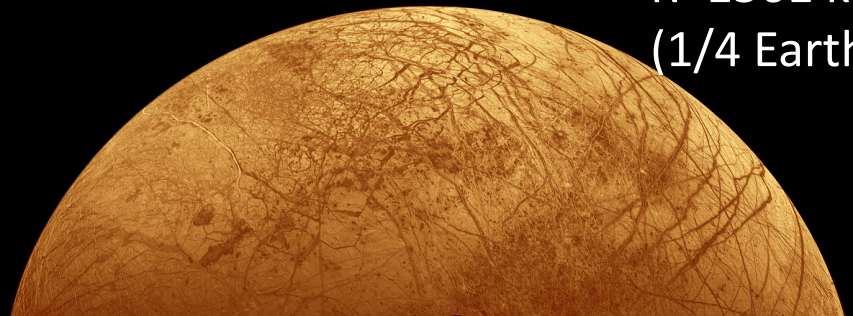
Mars
R=3390 km
(1/2 Earth)

Enceladus
R=252 km
(1/25 Earth)



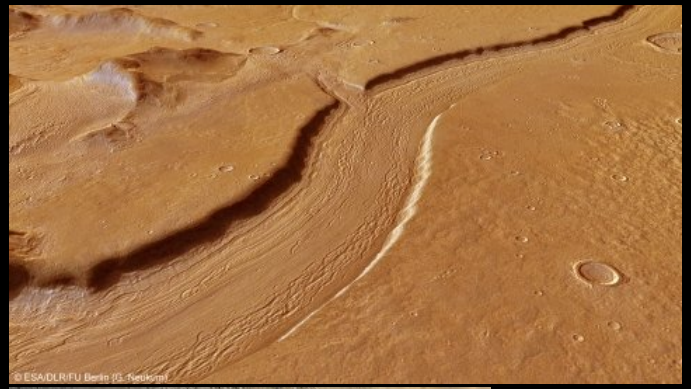
Titan
R=2575 km
(1/2.5 Earth)

Venus
R=6052 km
(95% Earth)



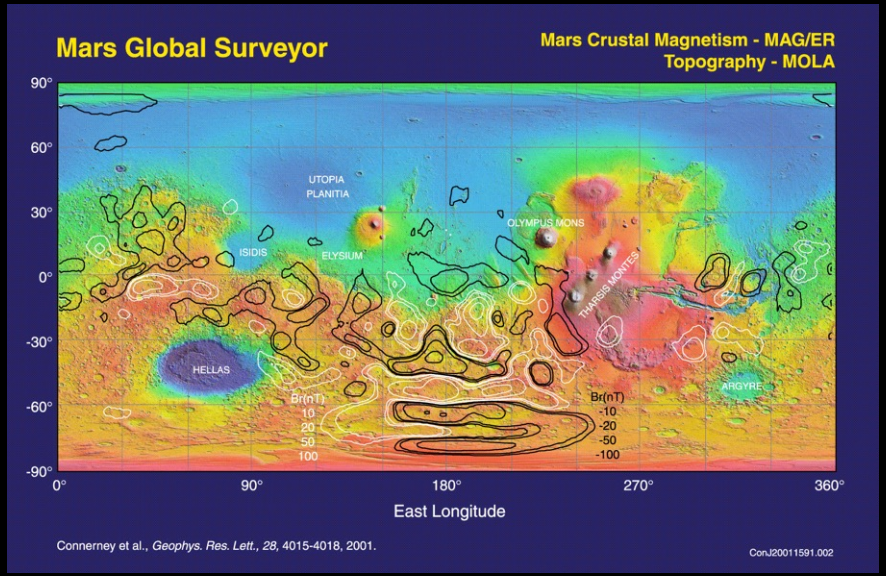
Europa
R=1561 km
(1/4 Earth)

Mars 3.8 by ago

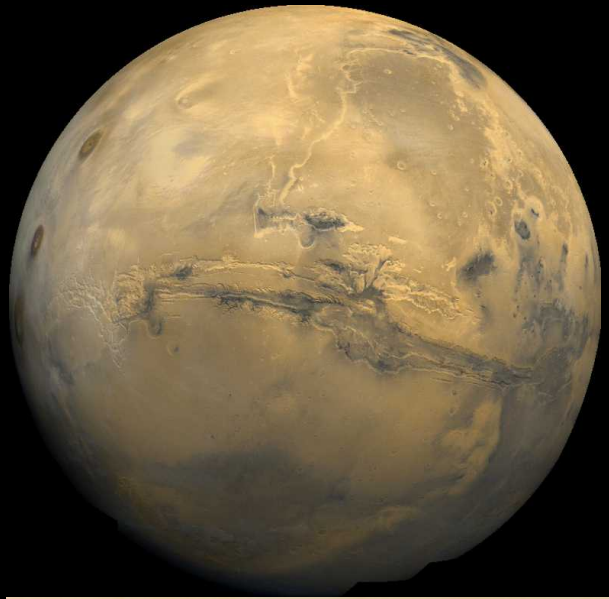


Water on surface

Volcanism

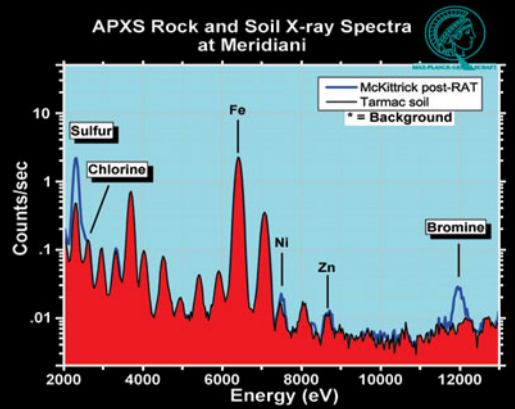


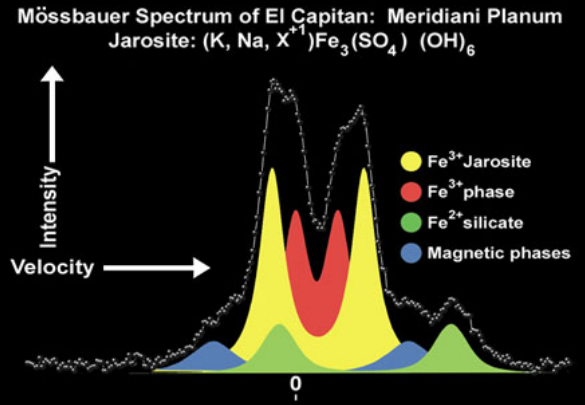
Magnetic field



Mars now

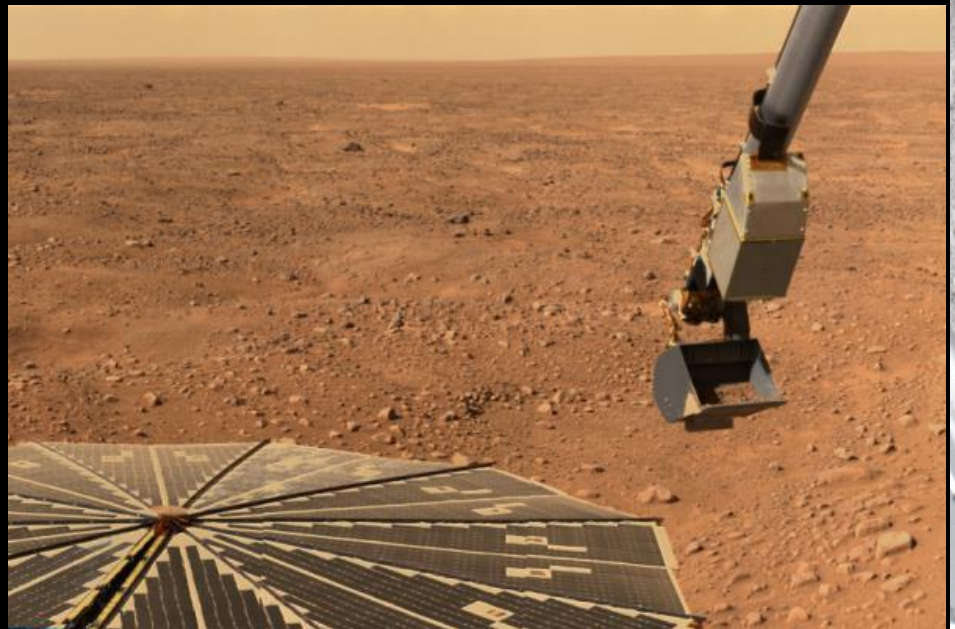
- Extinct volcanoes
- No large-scale magnetic field, only remanent regions
- 7 mbar, CO_2-rich atmosphere
- Cold, dry

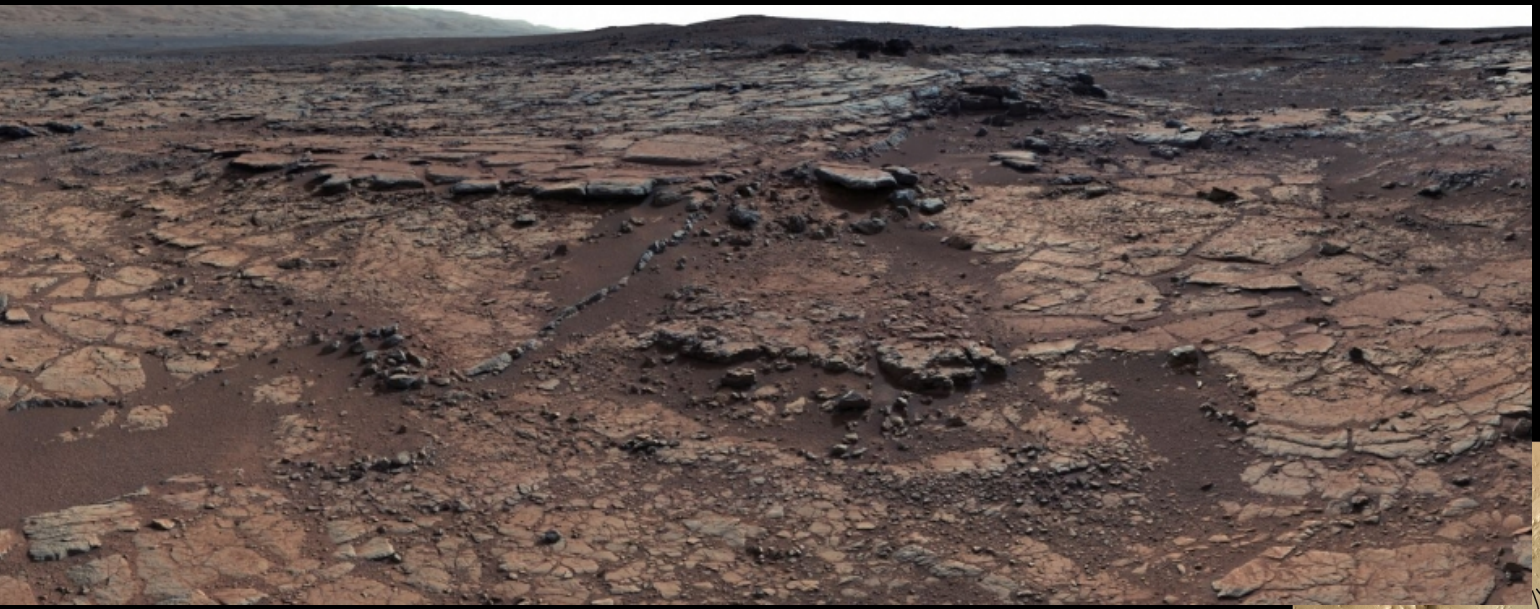


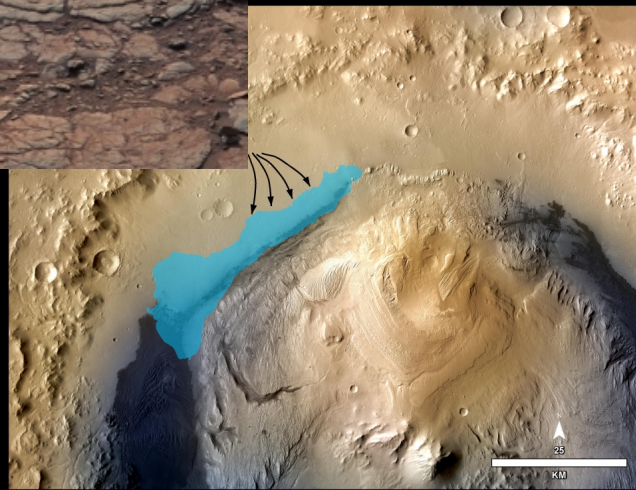


NASA Opportunity

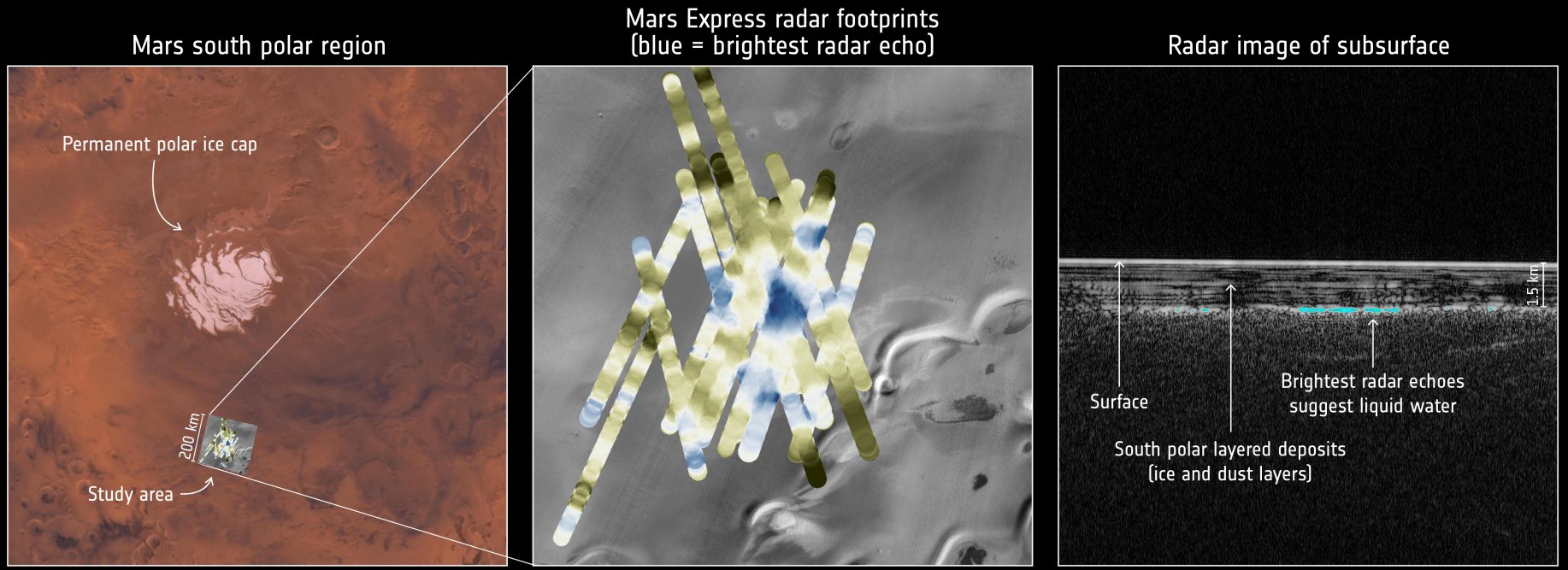
NASA Phoenix, 2008





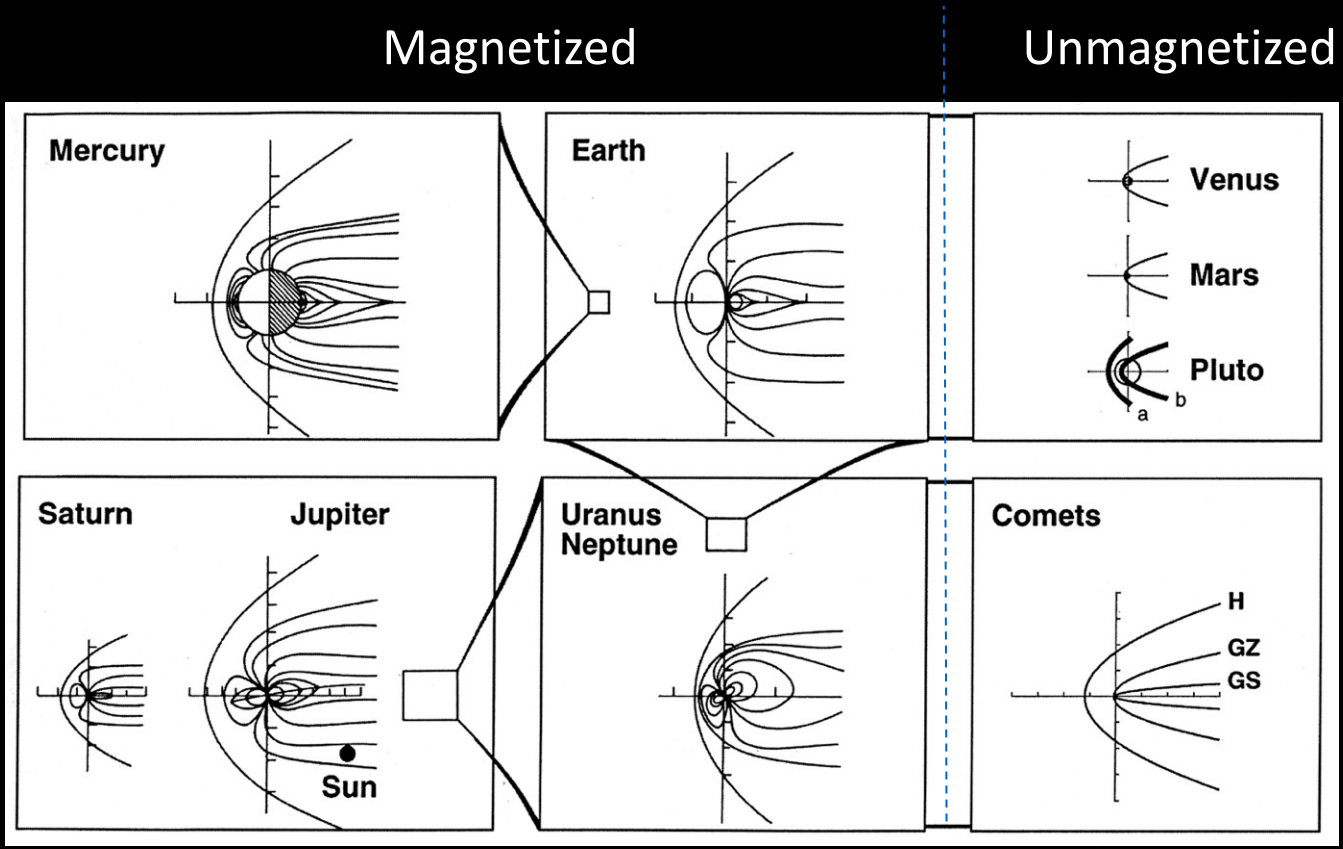


Evidence for ancient lake and stream deposits – conditions for microbial life
NASA Curiosity – Grotzinger +, 2014

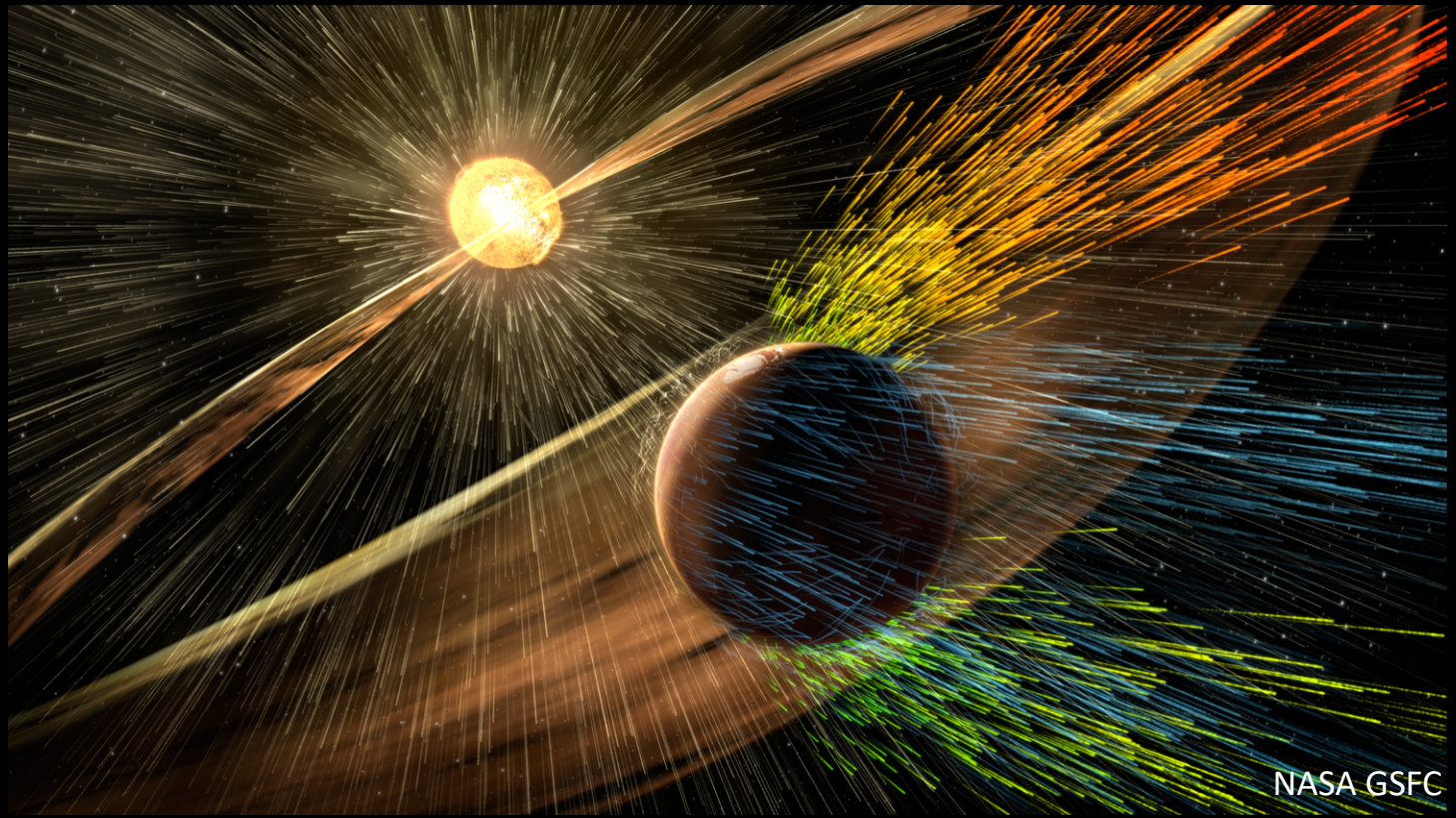


Context map: NASA/Viking; THEMIS background: NASA/JPL-Caltech/Arizona State University; MARSIS data: ESA/NASA/JPL/ASI/Univ. Rome; R. Orosei et al 2018

Solar wind interaction



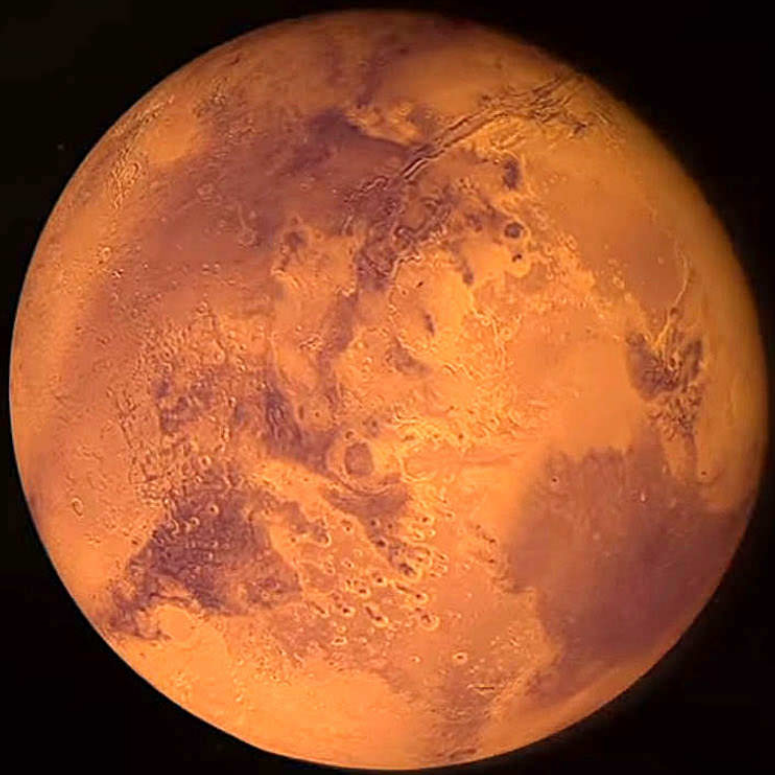
Coates, 2001



Solar wind pulling away Mars atmosphere: increased loss during solar activity
MAVEN mission, Science & Geophys. Res. Letters 2015

Mars 3.8 billion years ago

Mars now



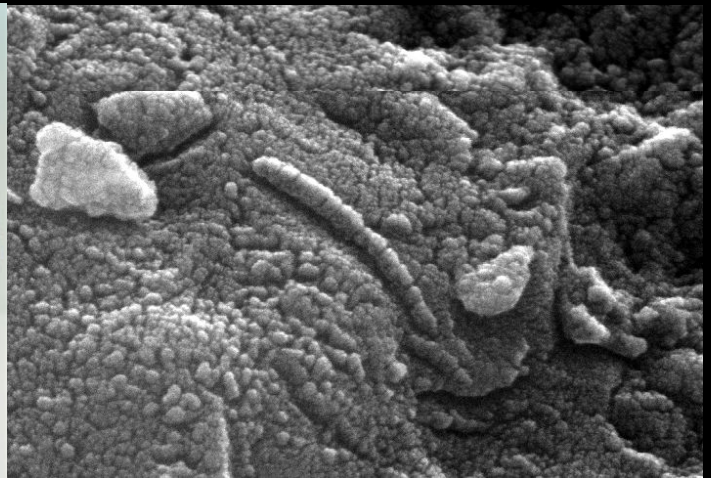
NASA

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

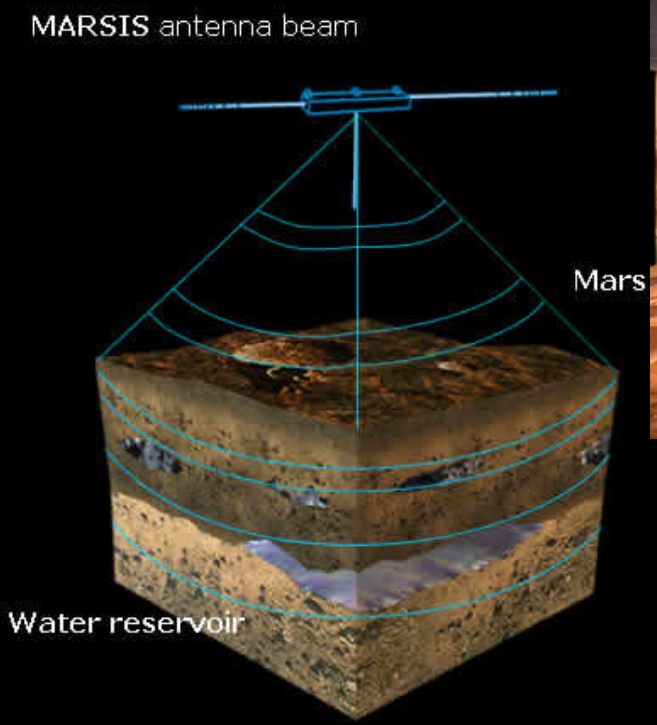
Essential elements (C, H, N, O, P, S)

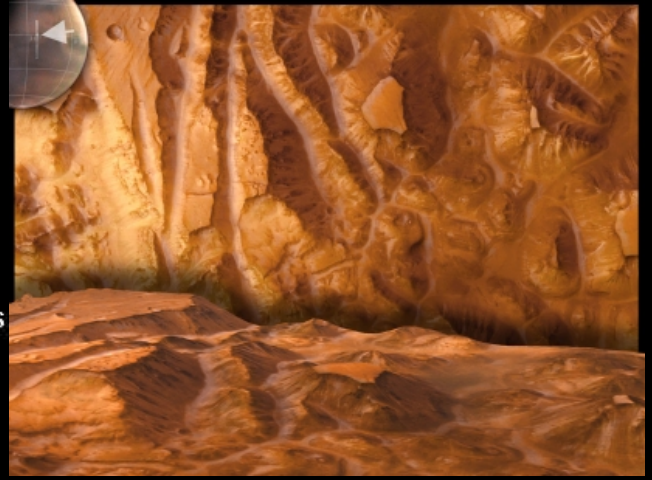
Source of heat

Time

NASA

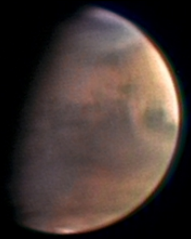
Early Mars?



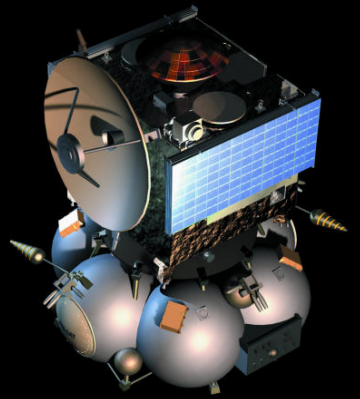


ESA Mars Express, orbit 28 Jan 04

…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

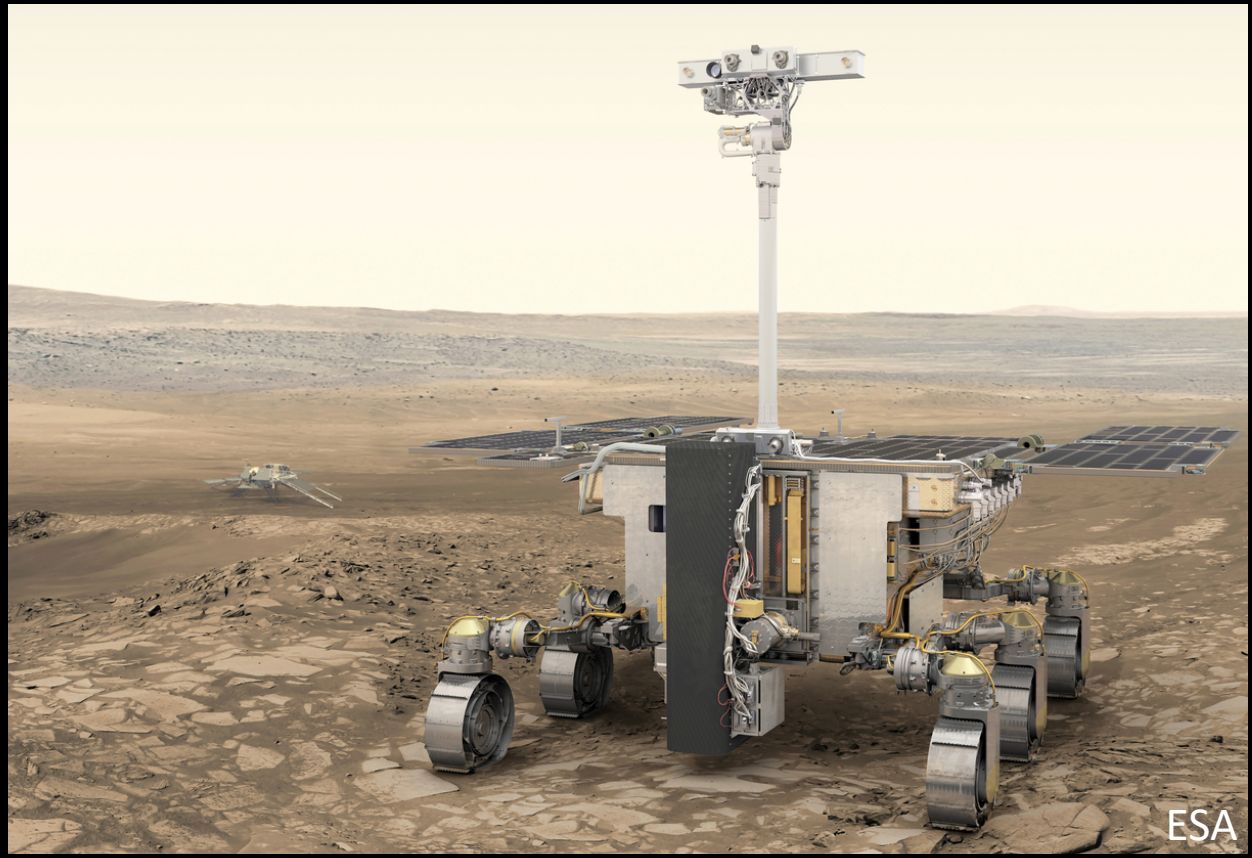
- InSight (2018)
- Perseverence (2020)

UAE

- Hope orbiter (2020)

China

- Tianwen-1 orbiter, rover (2020)



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

λ = 1.15 – 3.3 µm, 1° 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 ∞

Drill + Ma_MISS
In-situ mineralogy information

IR borehole spectrometer

λ = 0.4 – 2.2 µm

Analytical Laboratory Drawer

MicrOmega
VIS + IR spectrometer

Mineralogy characterisation of crushed sample material
Pointing for other instruments

λ = 0.9 – 3.5 µm, 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 ≤ 6 cm^{-1}

MOMA
LDMS + Pyr-Dev GCMS

Broad-range organic molecules with high sensitivity (ppb)
Chirality determination

Laser desorption extraction and mass spectroscopy

Pyrolisis extraction in the presence of derivatisation agents, coupled with chiral gas chromatography, and mass spectroscopy

ESA

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

ESA/Miabspace

Some of PanCam team with rover model at ESTEC, Dec 2019

Parachute test, Oregon, 2019

ESA

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

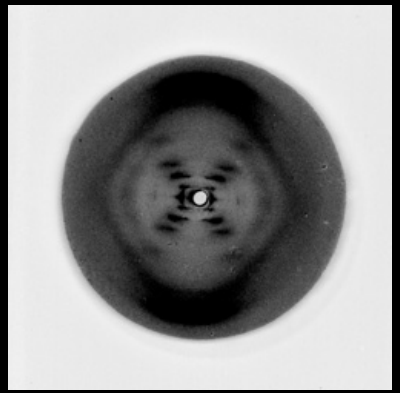
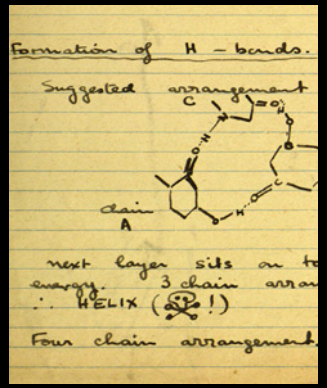
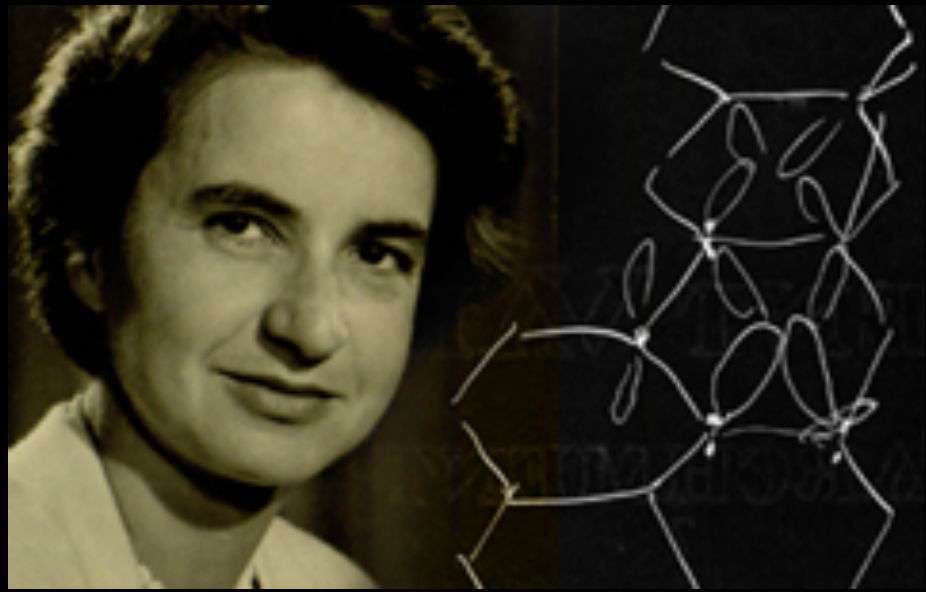


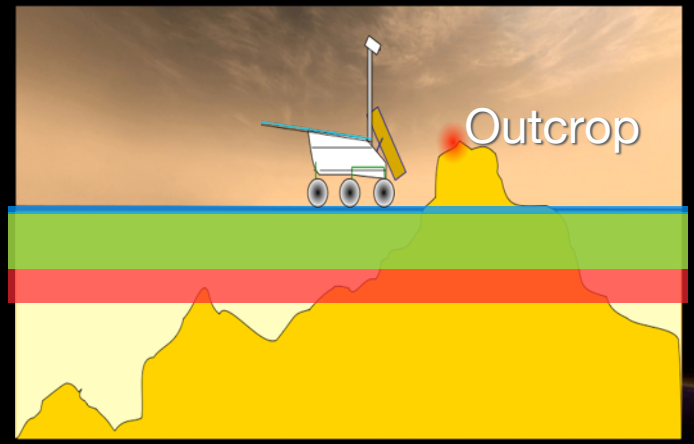
Photo 51



Working notes on DNA



Wellcome library

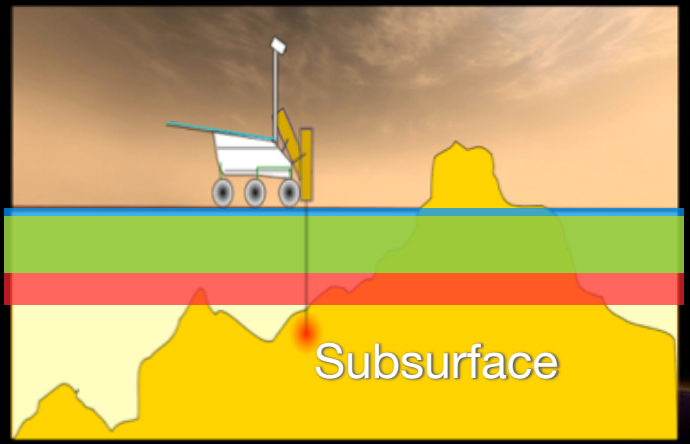


Penetration of Organic Destructive Agents

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

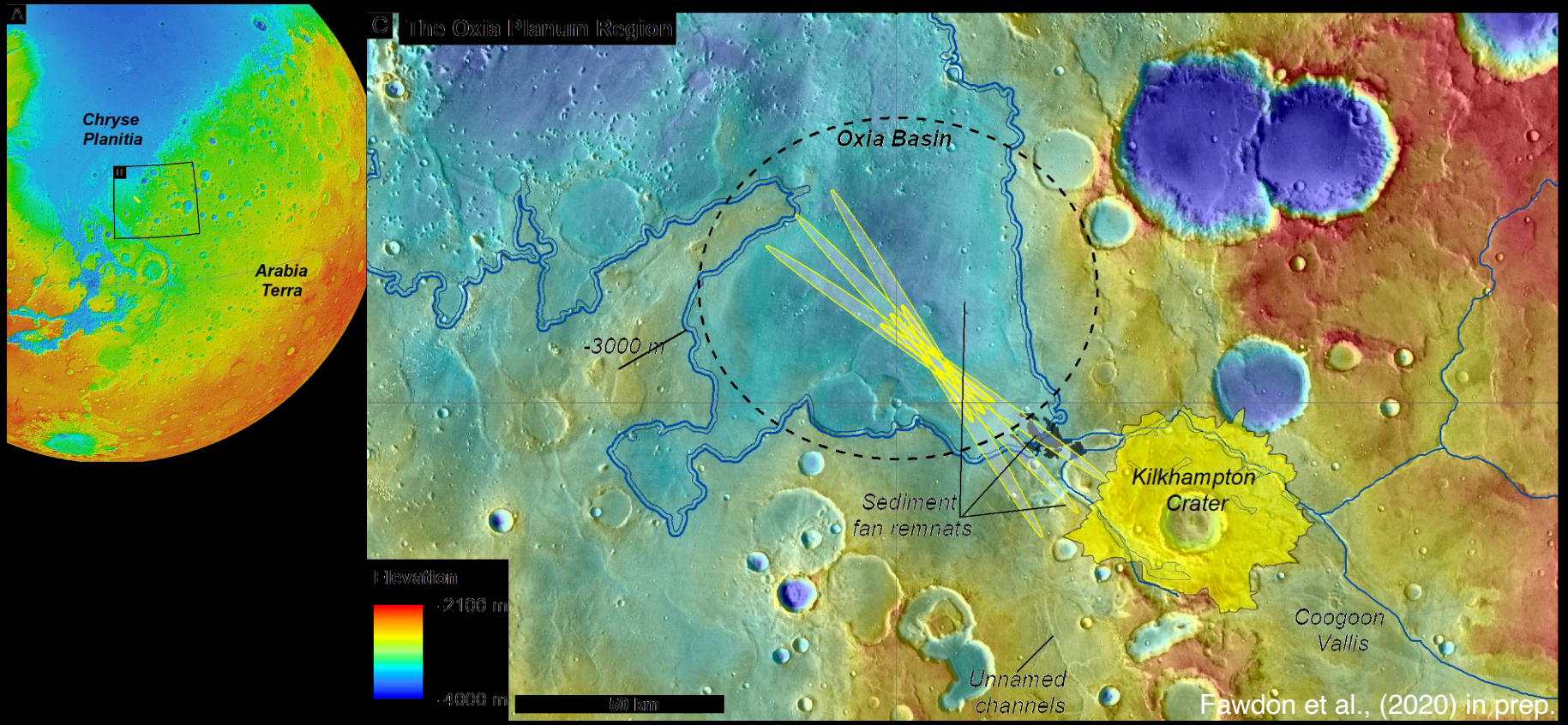
UV radiation	~ 1 mm
Oxidants	~ 1 m
Ionising radiation	~ 1.5 m

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

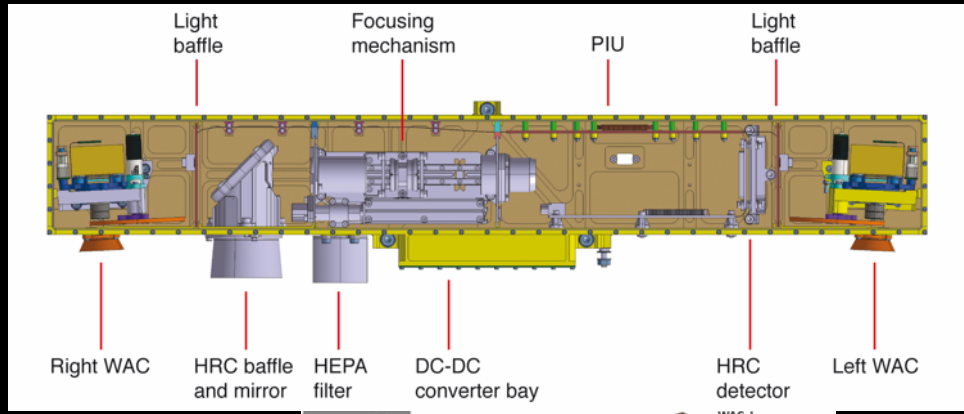
- Clay bearing rocks 3.9 bya
- Remnants of a fan or delta near the outlet of Coogoon Vallis

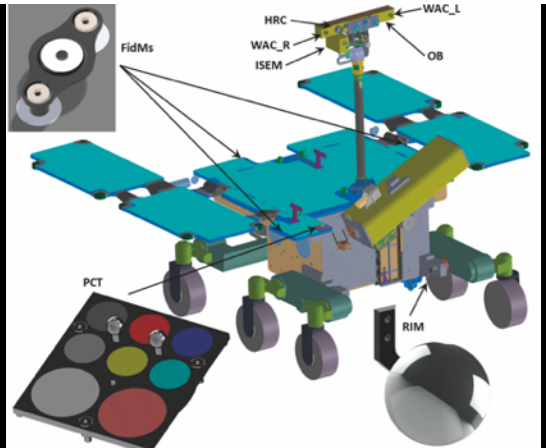


Fawdon et al., (2020) in prep.

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



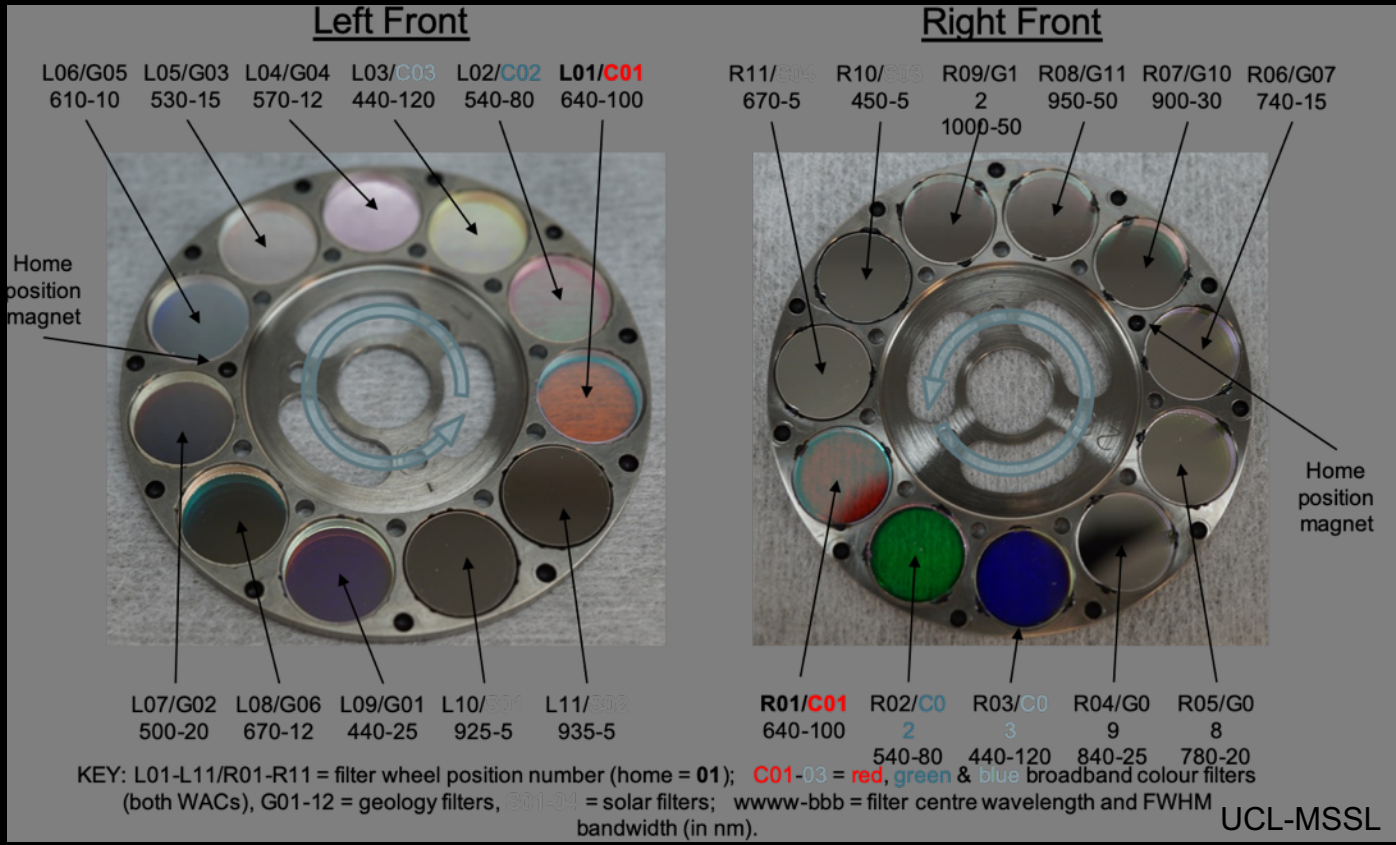


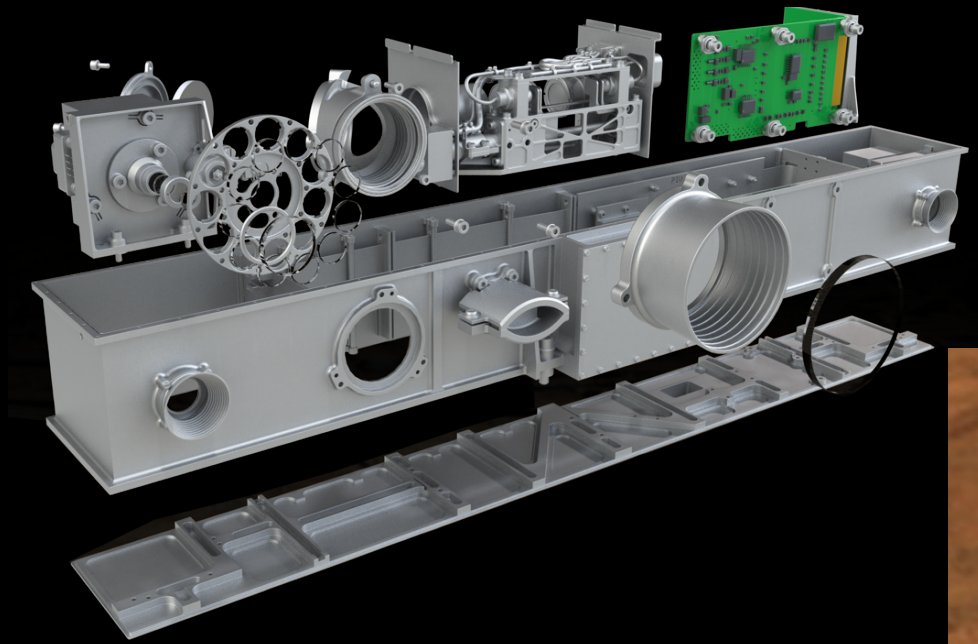
PanCam: the science ‘eyes’ of the Rosalind Franklin rover

- Filter wheels (FWs) — MSSL
- Wide angle cameras (WACs) — TAS-CH
- High Resolution Camera (HRC) — DLR/OHB
- PanCam Interface Unit (PIU) — MSSL
- DC-DC converter (DC-DC) — MSSL
- Optical bench (OB) — MSSL
- ‘Small Items’: PanCam Calibration Target (PCT), Fiducial Markers (FidMs), Rover Inspection Mirror (RIM) — Aberystwyth
- Science team

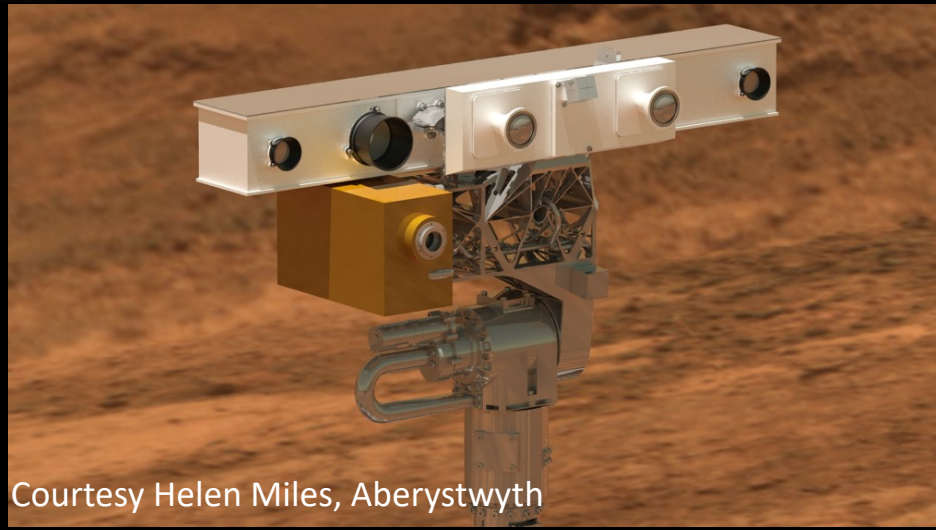
PanCam's filters

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



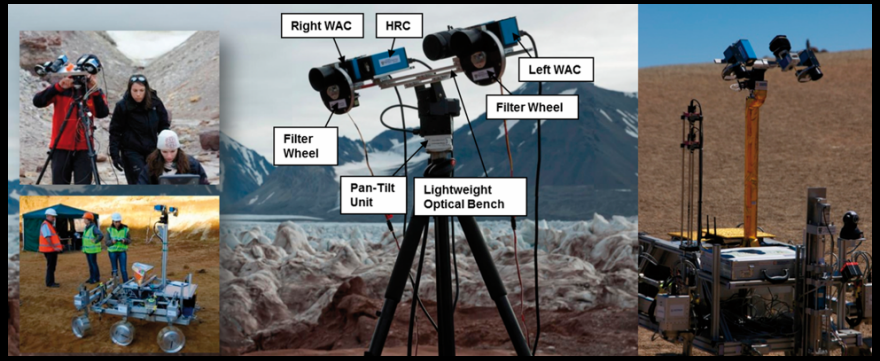


Courtesy Patrick Curry, MSSL



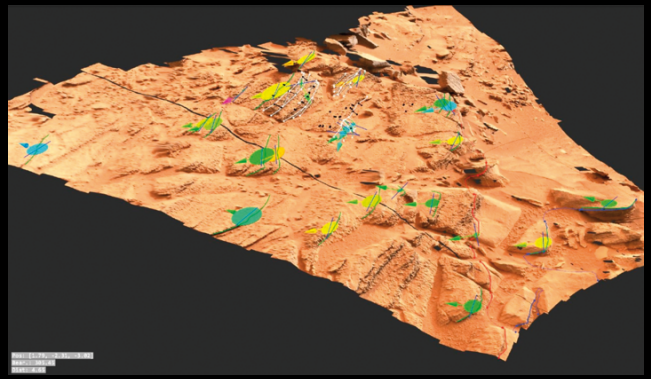
Courtesy Helen Miles, Aberystwyth

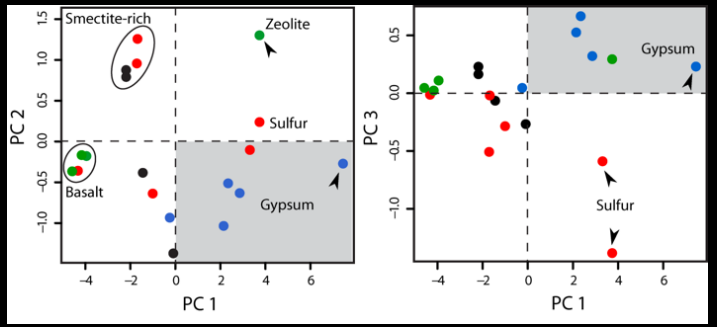
Examples of PanCam use and results



Many field tests

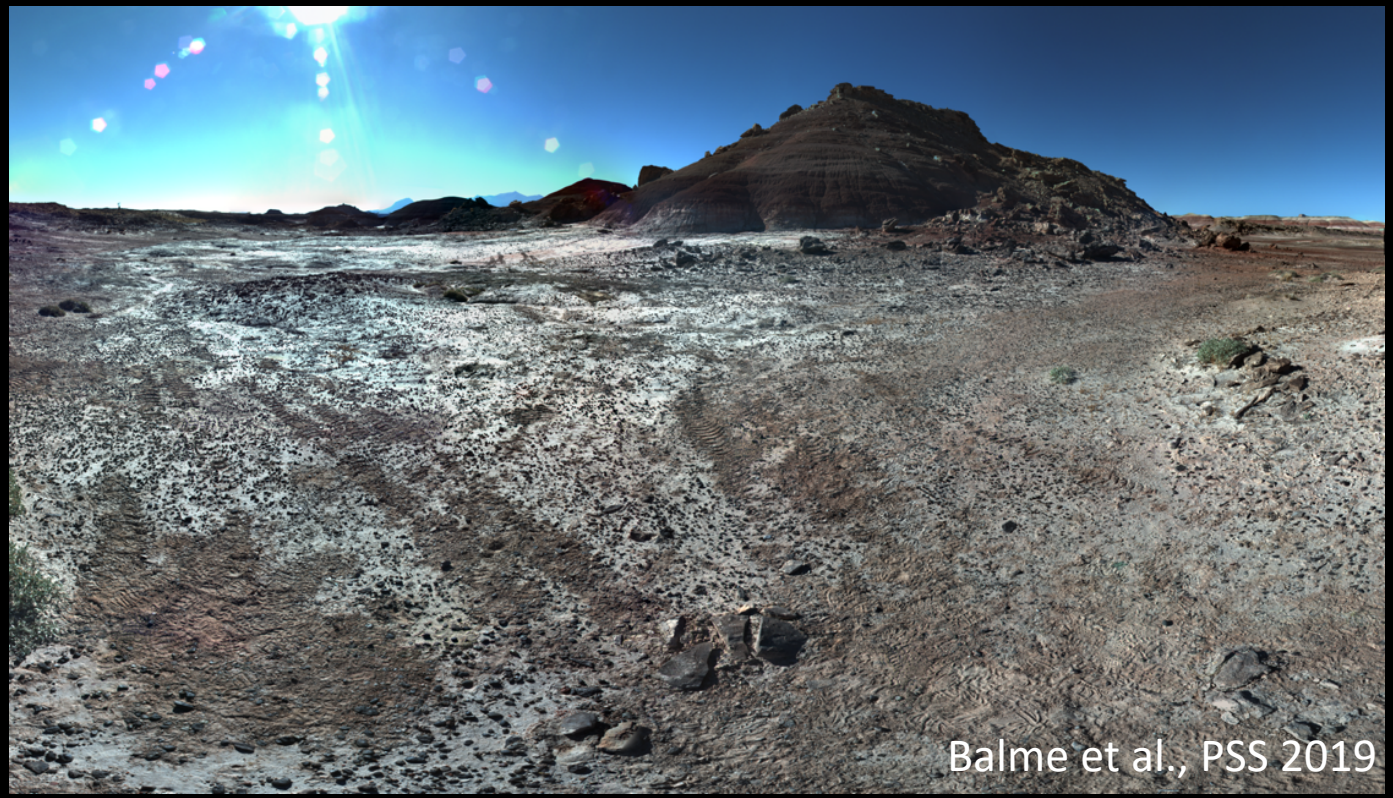
See Coates+ (2017)



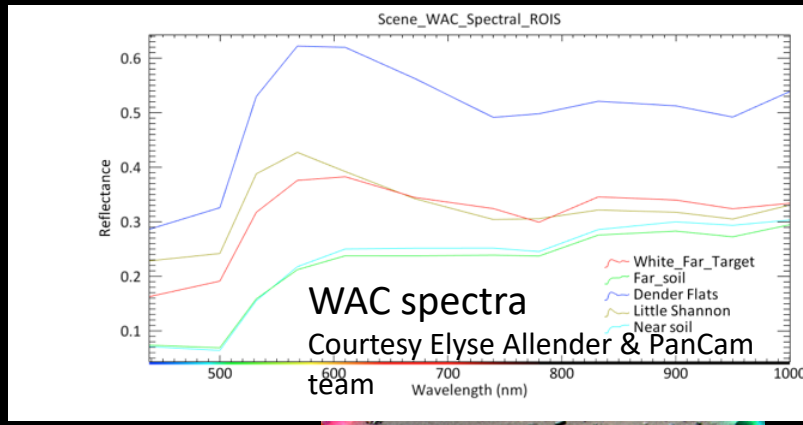


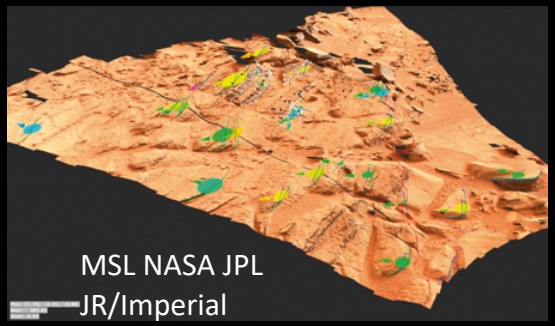
Harris+ (Icarus 2015)

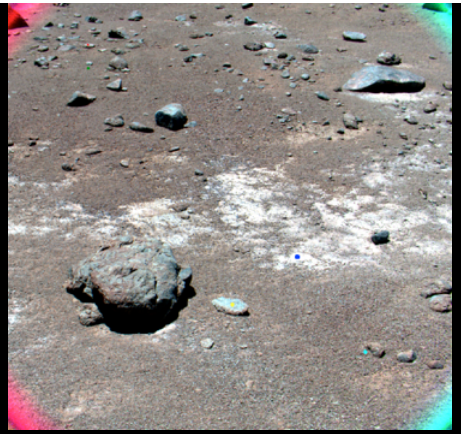
MURFI, Utah desert, 2016

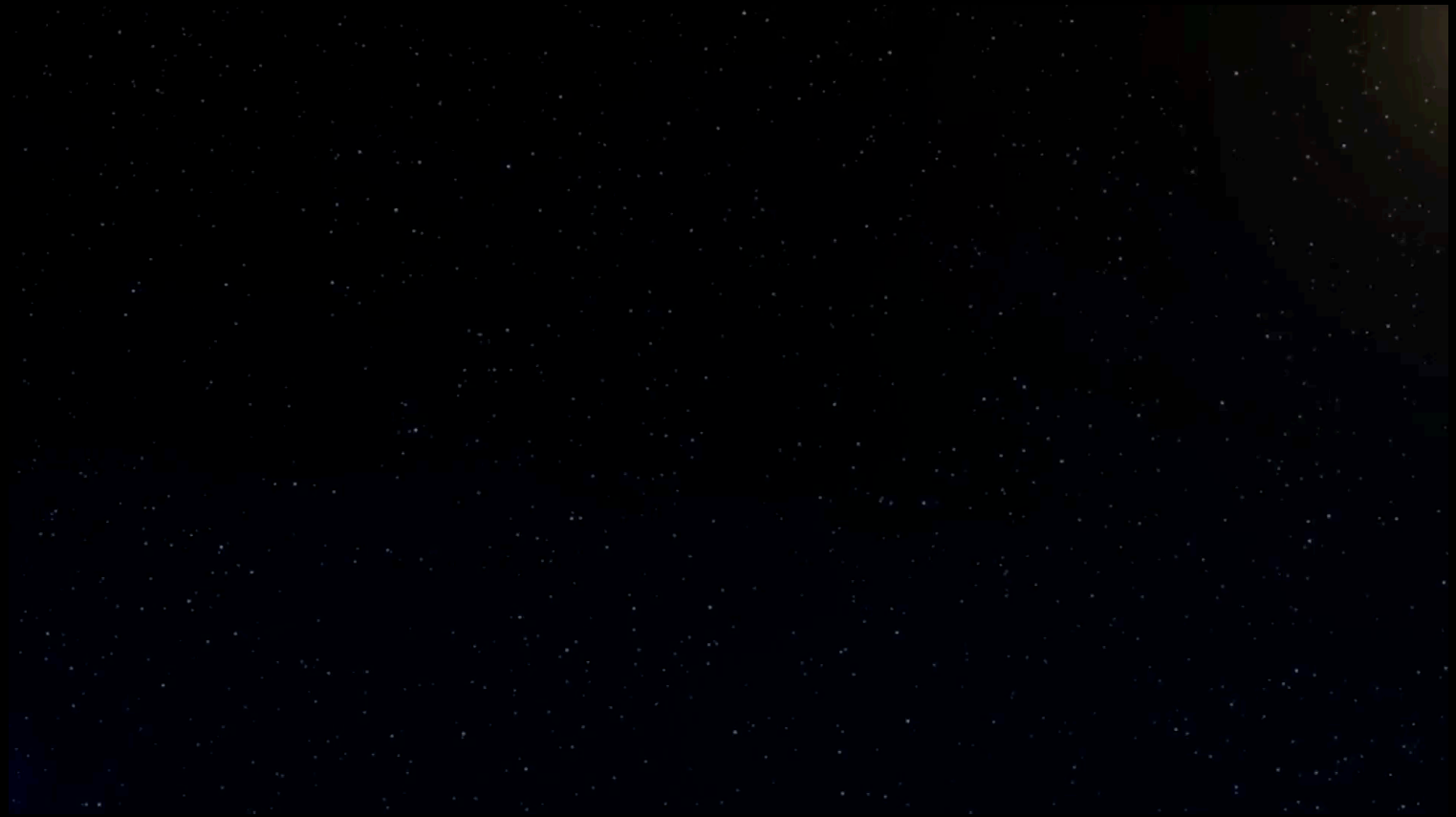


Trial in the Atacama desert, Feb 2019







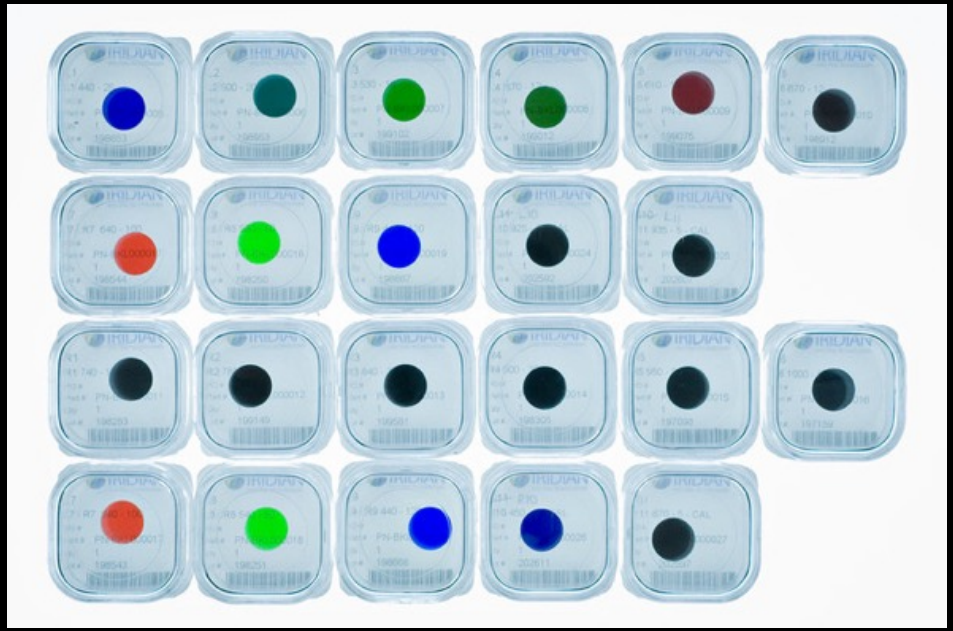


TAS-I

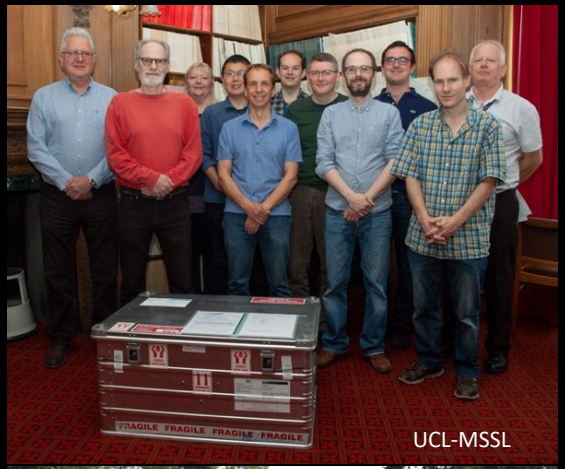
PanCam integration at UCL-MSSL

PanCam

- delivered to Airbus May 2019
- installed August 2019



https://www.esa.int/spaceinimages/Images/2019/05/ExoMars_PanCam_filters

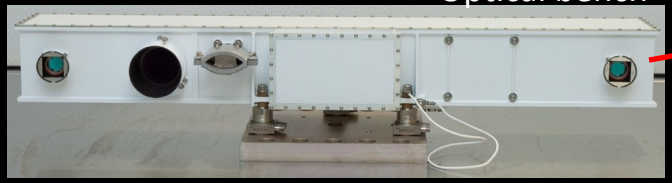


UCL-MSSL

UCL-MSSL

PanCam on the rover

Optical bench

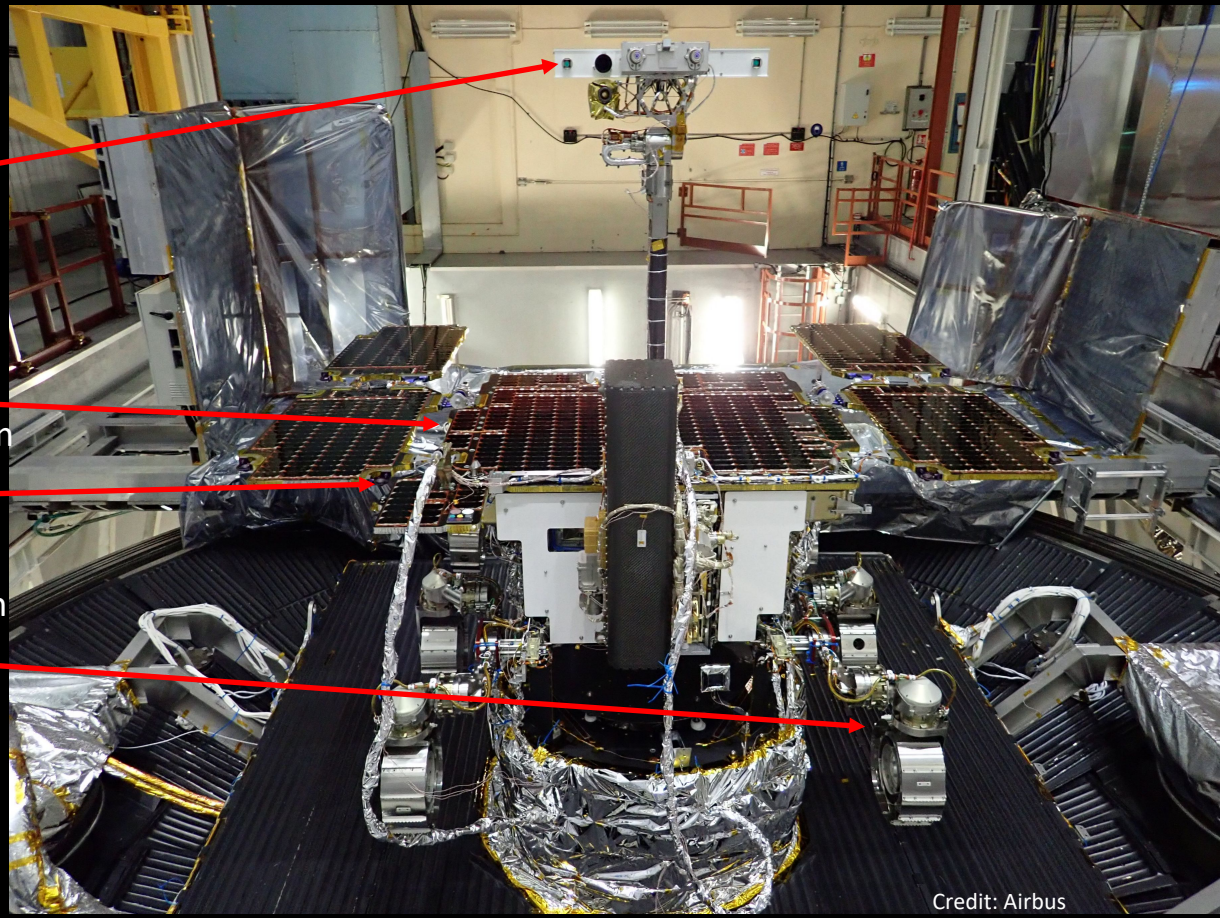


Credit: M. de la Nougerede, UCL/MSSL

Fiducial markers

Calibration target

Rover inspection mirror



Credit: Airbus

PANCAM

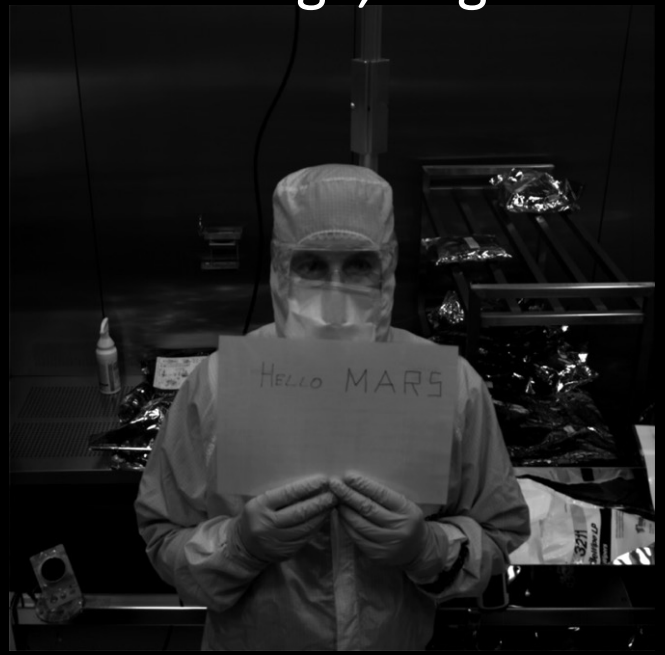
@exomarspancam

PanCam mast installation, August 2019

Courtesy Airbus – M.Alexander

Courtesy Airbus – M.Alexander

‘First light’ on the rover!
PanCam image, August 2019



ESA/ExoMars/PanCam team

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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exploration.esa.int

www.ucl.ac.uk/mssl

@exomarspancam

PANCAM