Mars Missions 2021: Early Discoveries

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www.ucl.ac.uk/mssl

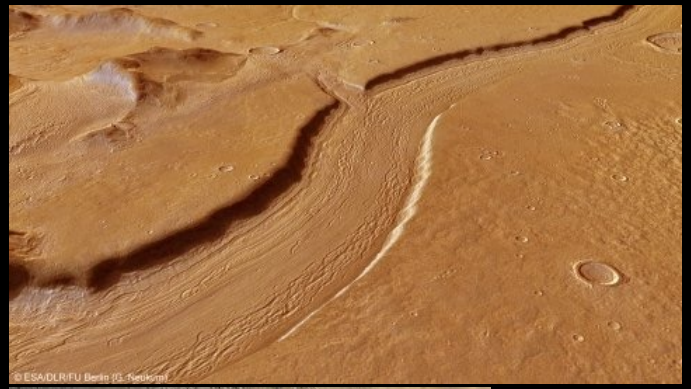
@exomarspancam

UK SPACE AGENCY

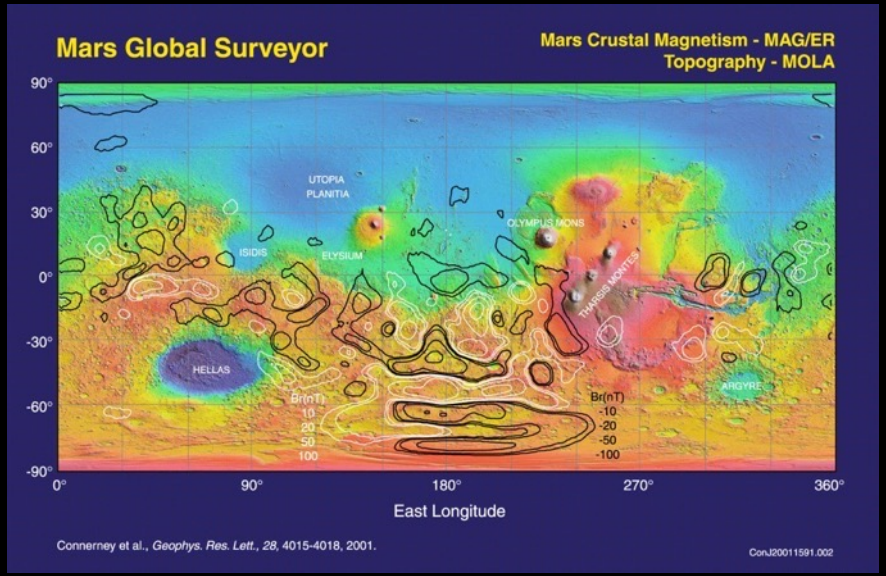
PANCAM

ESA

Mars 3.8 by ago

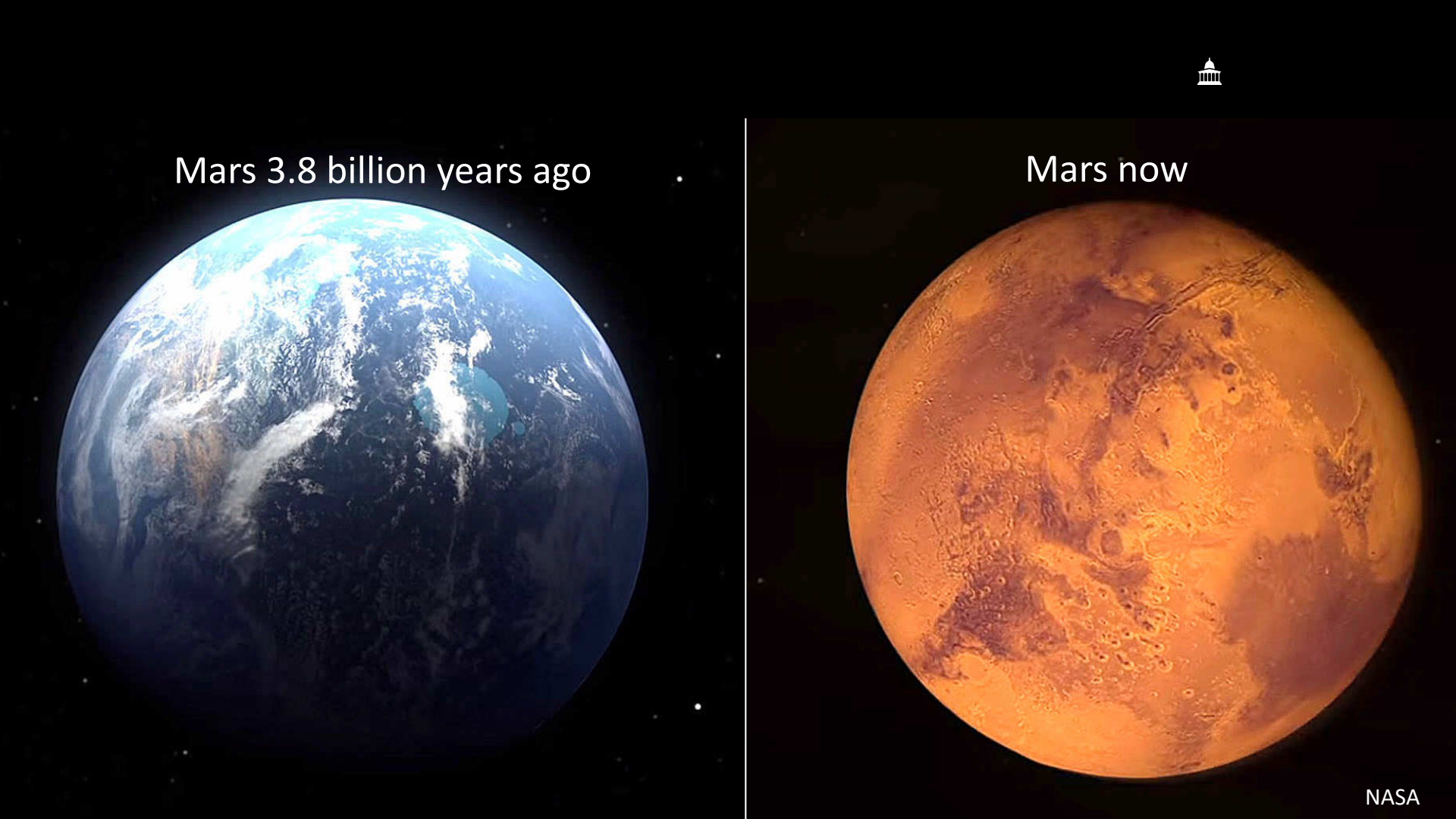


Water on surface



Magnetic field

Volcanism


Mars 3.8 billion years ago
Mars now
NASA

Requirements for life

Liquid water

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

Source of heat

Time

NASA

Early Mars?

Missions to Mars

UAE

Hope orbiter (2021)

China

Tianwen-1 orbiter

& Zhurong rover (2021)

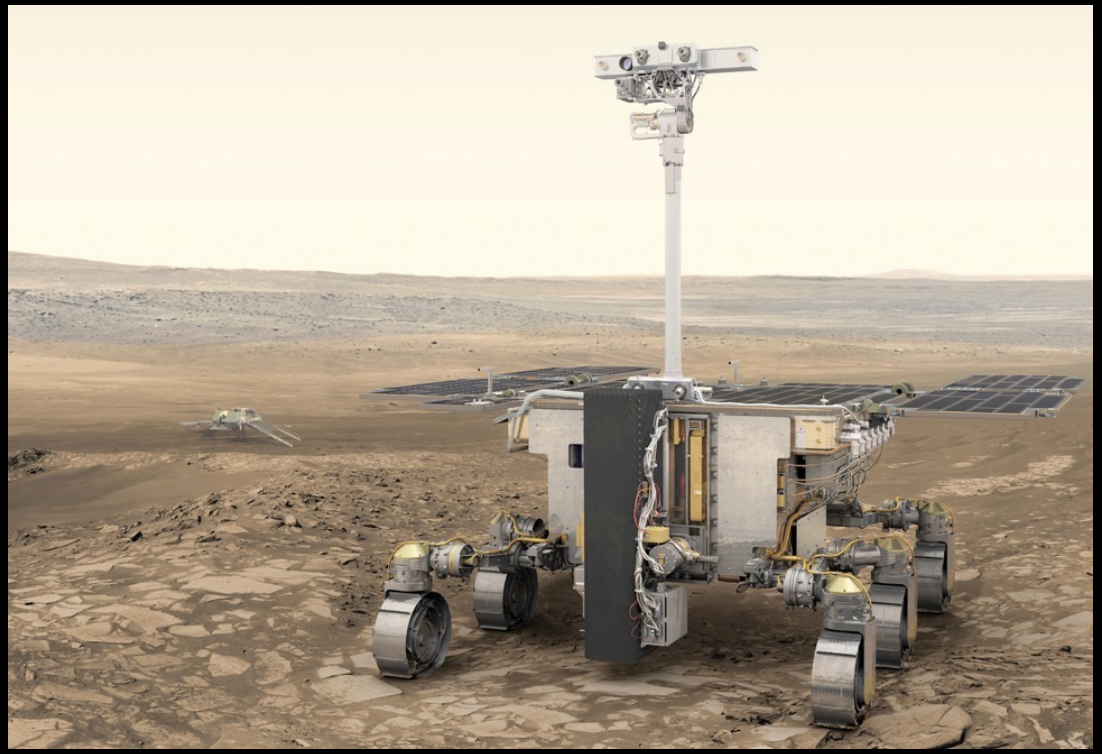
NASA

Perseverance + Ingenuity (2021)

ESA-Russia

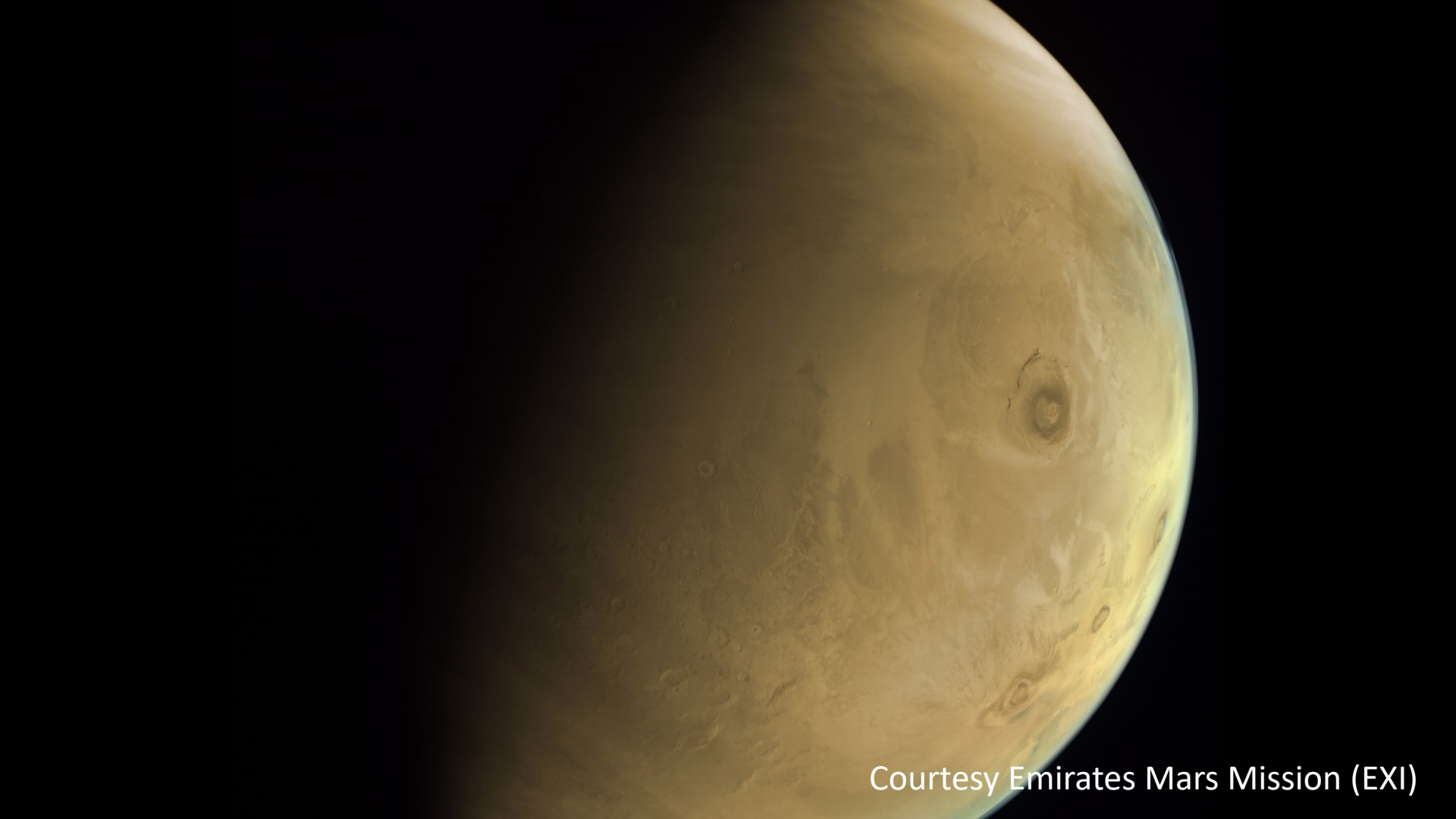
Rosalind Franklin

(ExoMars) rover (launch 2022)

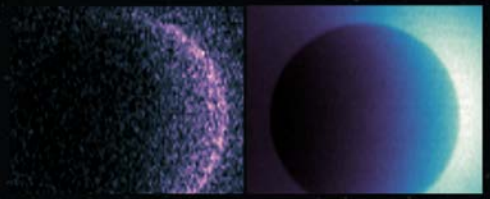


ESA

Also operating: Mars Odyssey, Mars Express, MRO, MSL (Curiosity), Mars Orbiter Mission, Maven, ExoMars TGO, Insight

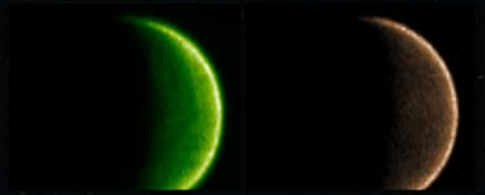

Courtesy Emirates Mars Mission (EXI)

MARS AS VIEWED BY THE
EMIRATES MARS ULTRAVIOLET SPECTROMETER



Hydrogen

102.6 nm 121.6 nm



Oxygen

130.4 nm 135.6 nm

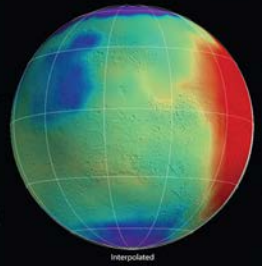
Carbon Monoxide

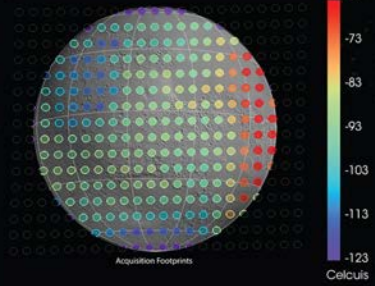
140 -160 nm

EMIRATES MARS MISSION / EMUS

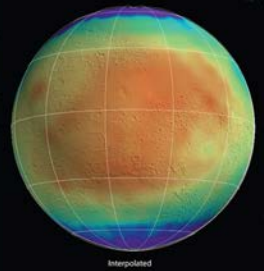
MARS AS VIEWED BY THE
EMIRATES MARS INFRARED SPECTROMETER

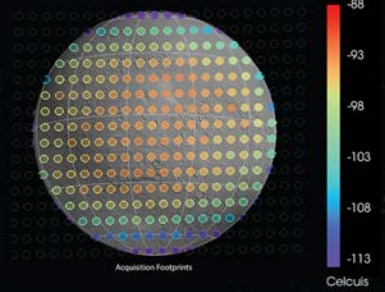
Surface temperature



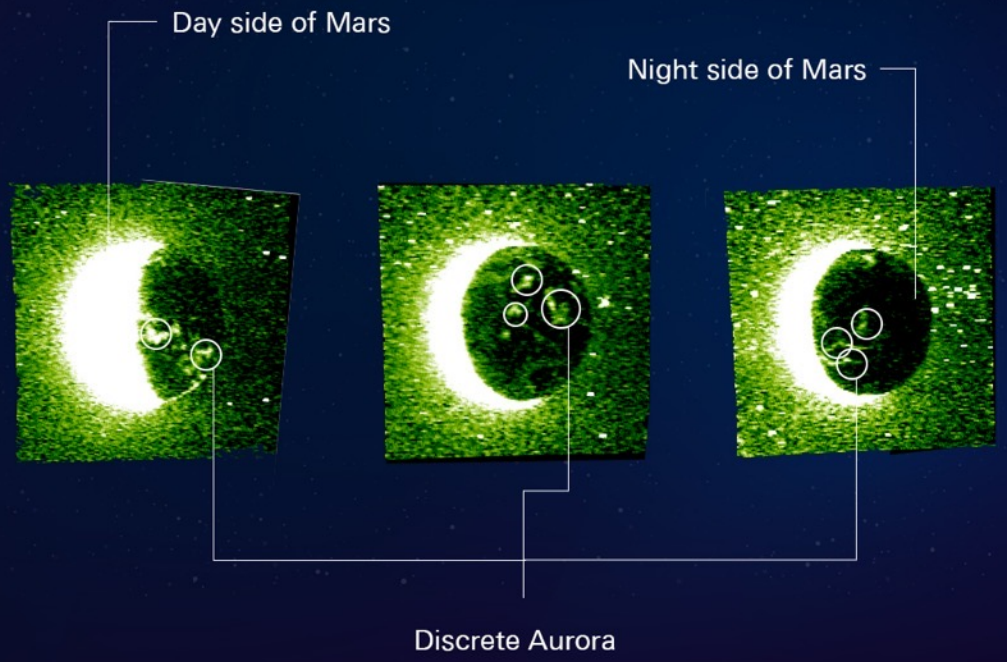


Atmospheric temperature



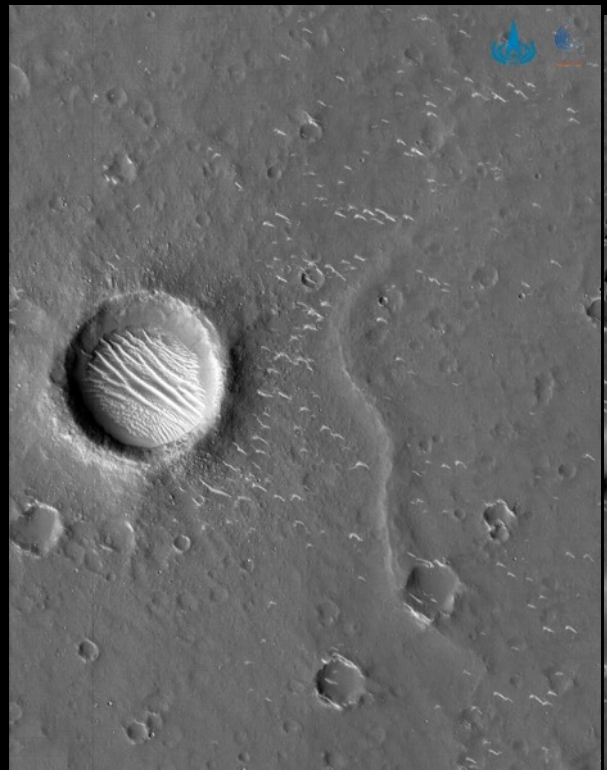


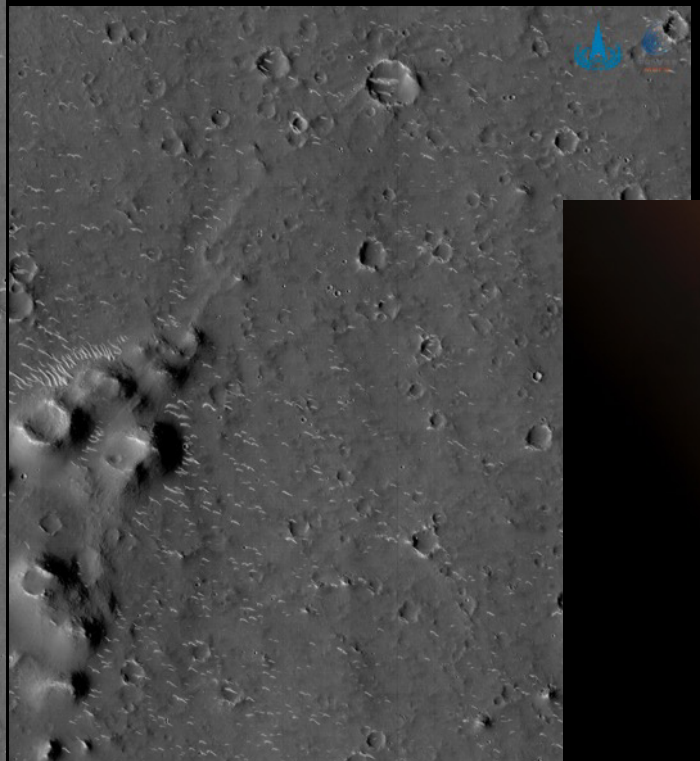
EMIRATES MARS MISSION / EMIRS

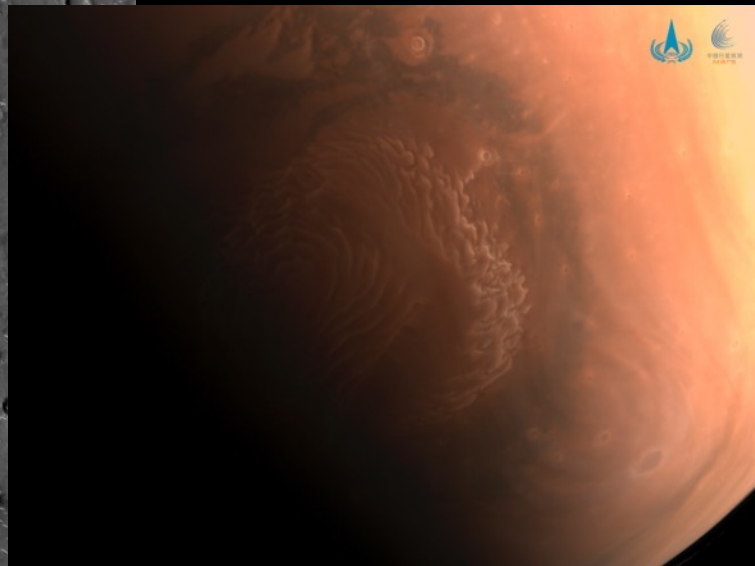

Day side of Mars
Night side of Mars
Discrete Aurora

•Images from Tianwen-1 at Mars

Courtesy CNSA, 4 March 2021

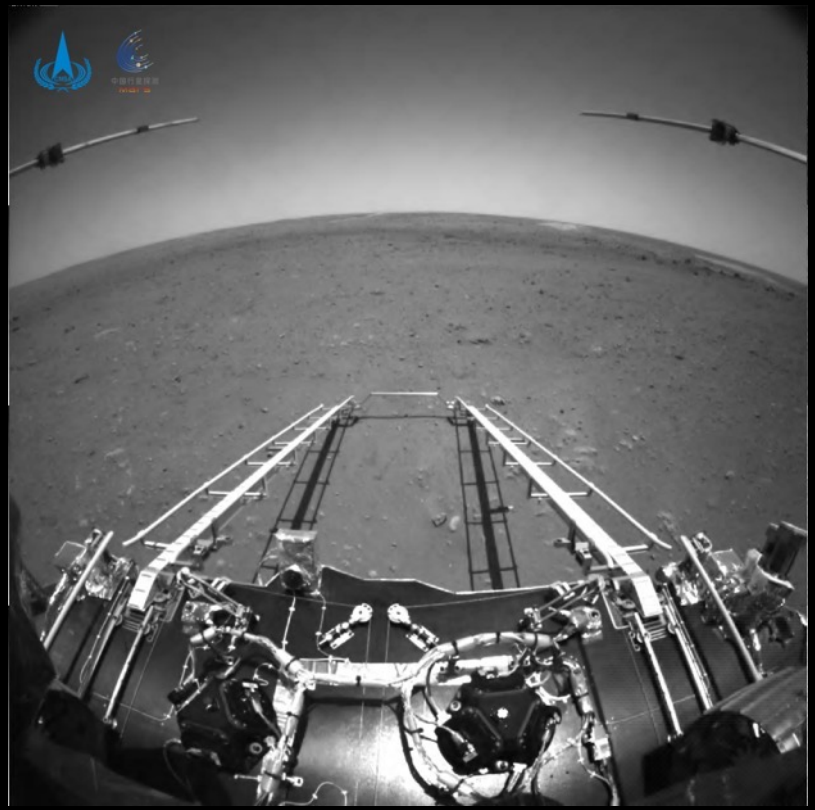


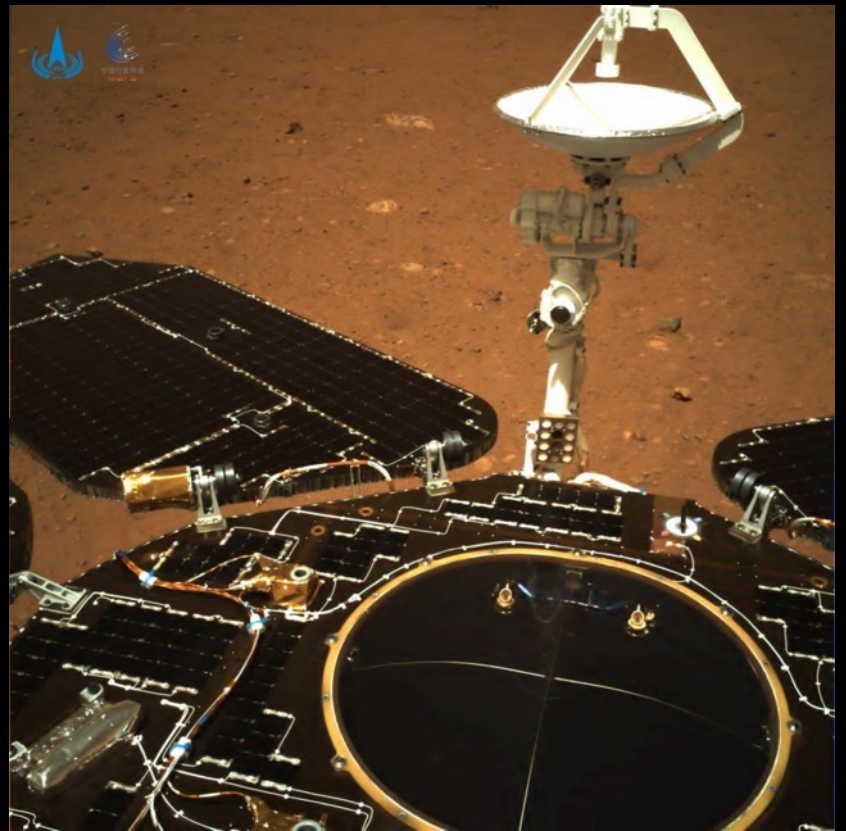


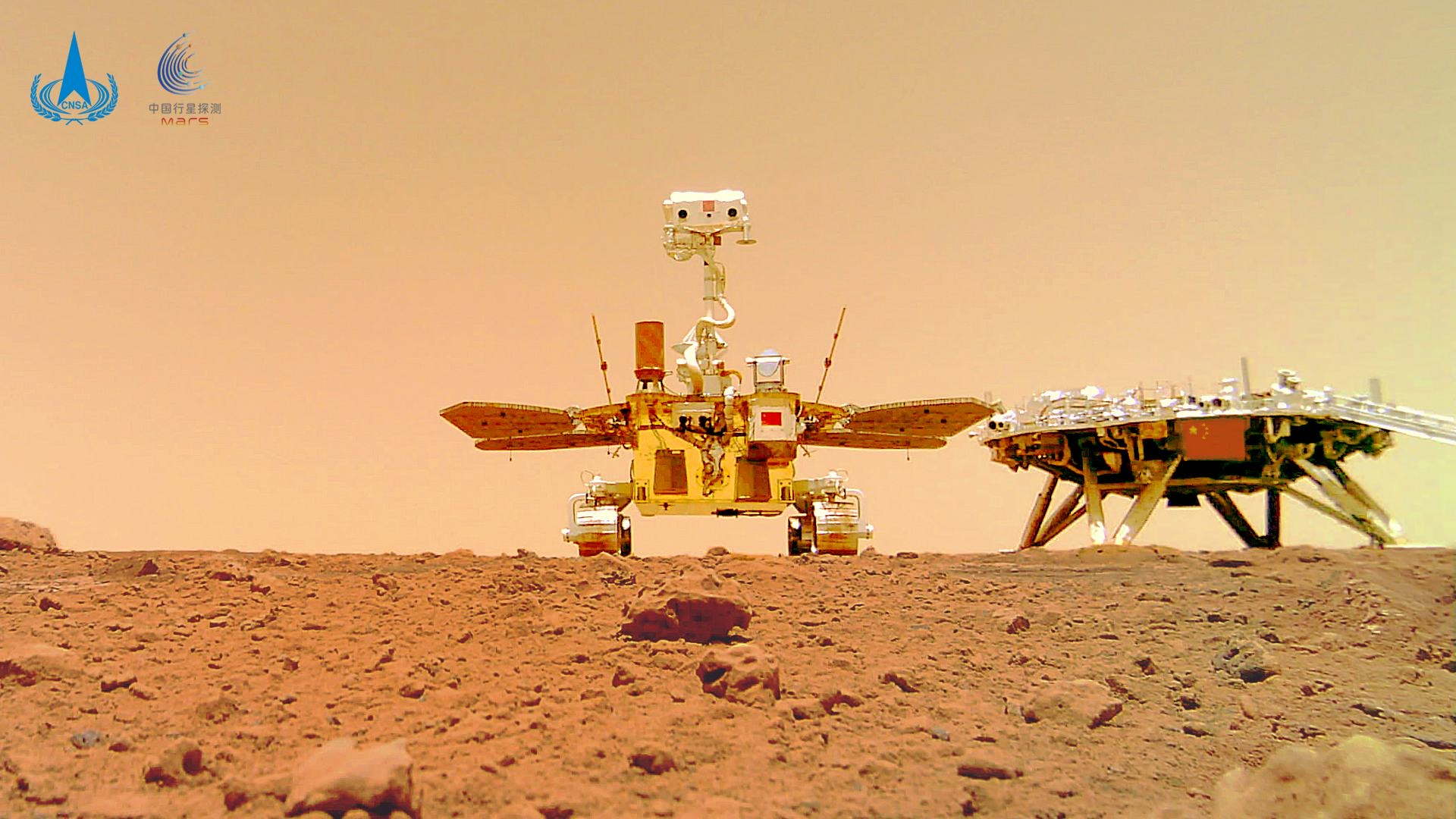


•Images from Zhurong rover on Mars

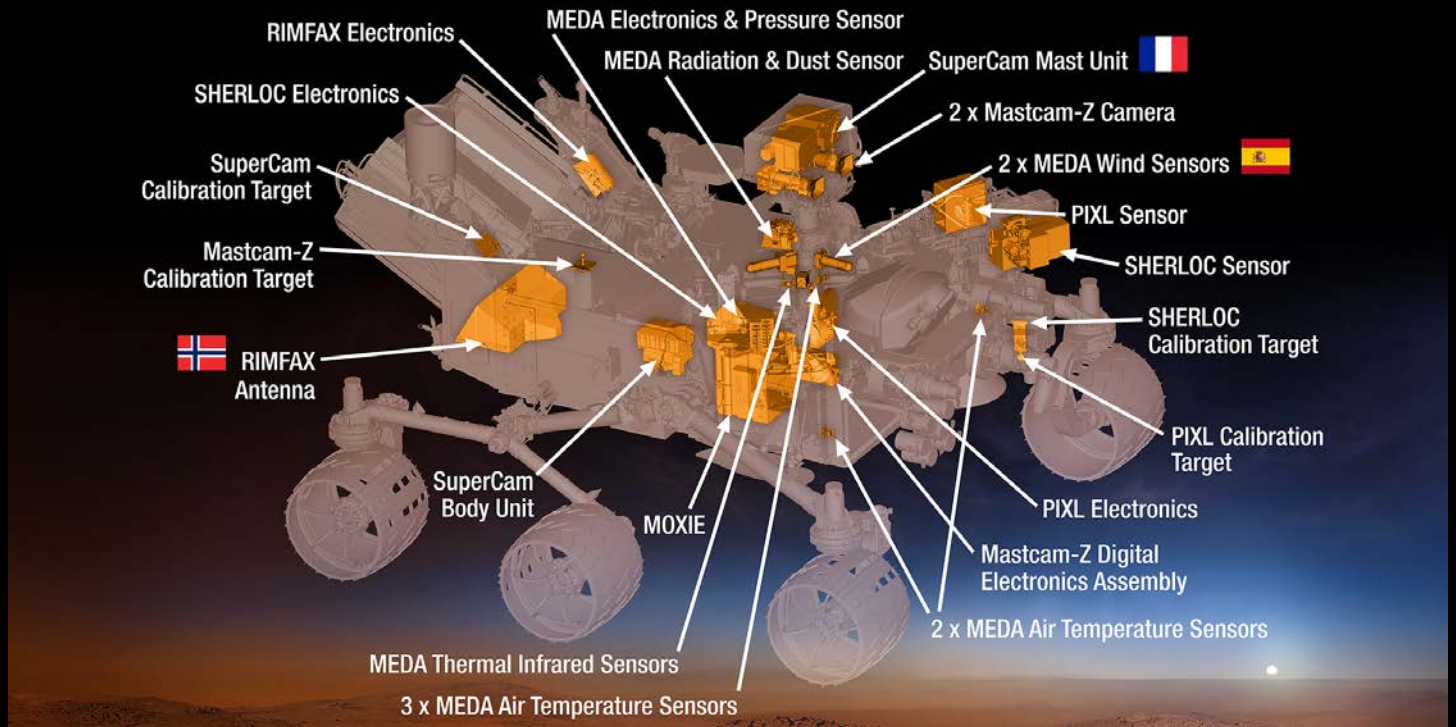
Courtesy CNSA, 19 May 2021 (landed 15 May 2021)






CNSA
中国行星探测
MARS

Mars 2020 Rover

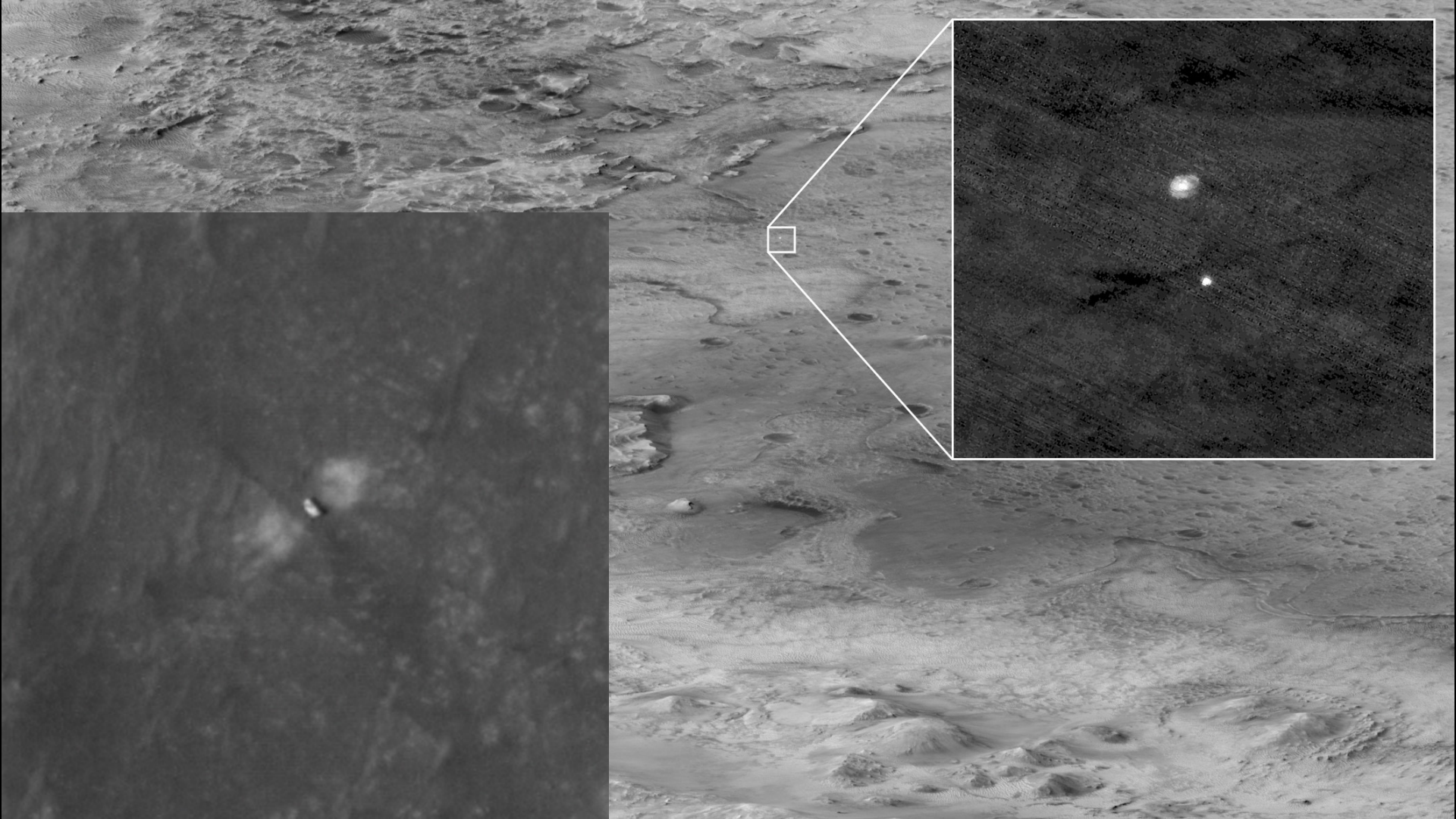


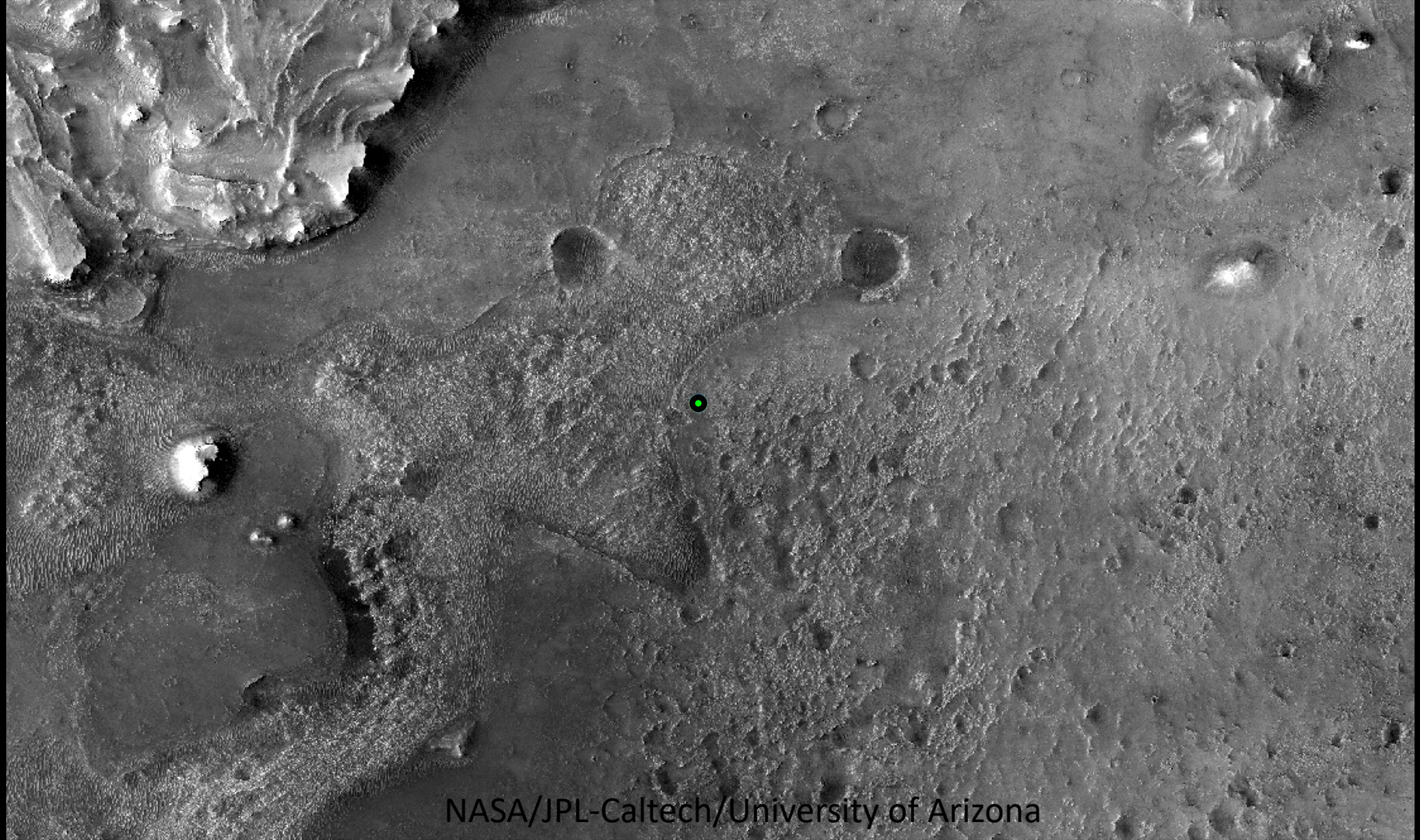
NASA/JPL-Caltech

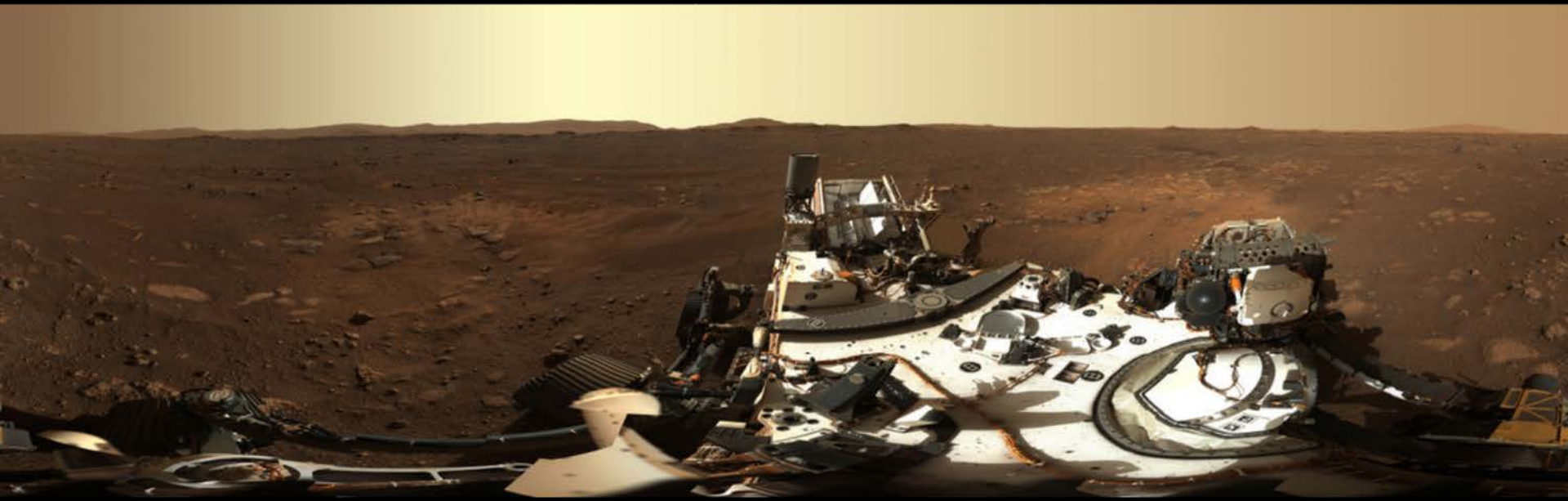

ESA/DLR/FU-Berlin

ESA/DLR/FU-Berlin/NASA/JPL-Caltech

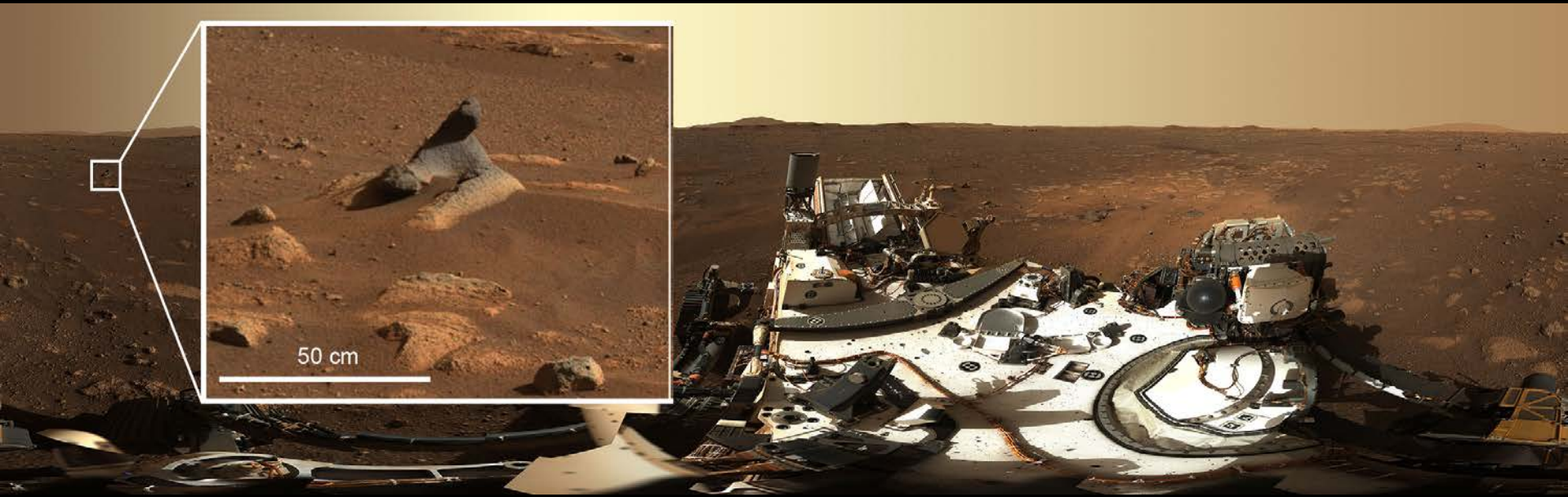
NASA/JPL-Caltech




NASA/JPL-Caltech/University of Arizona



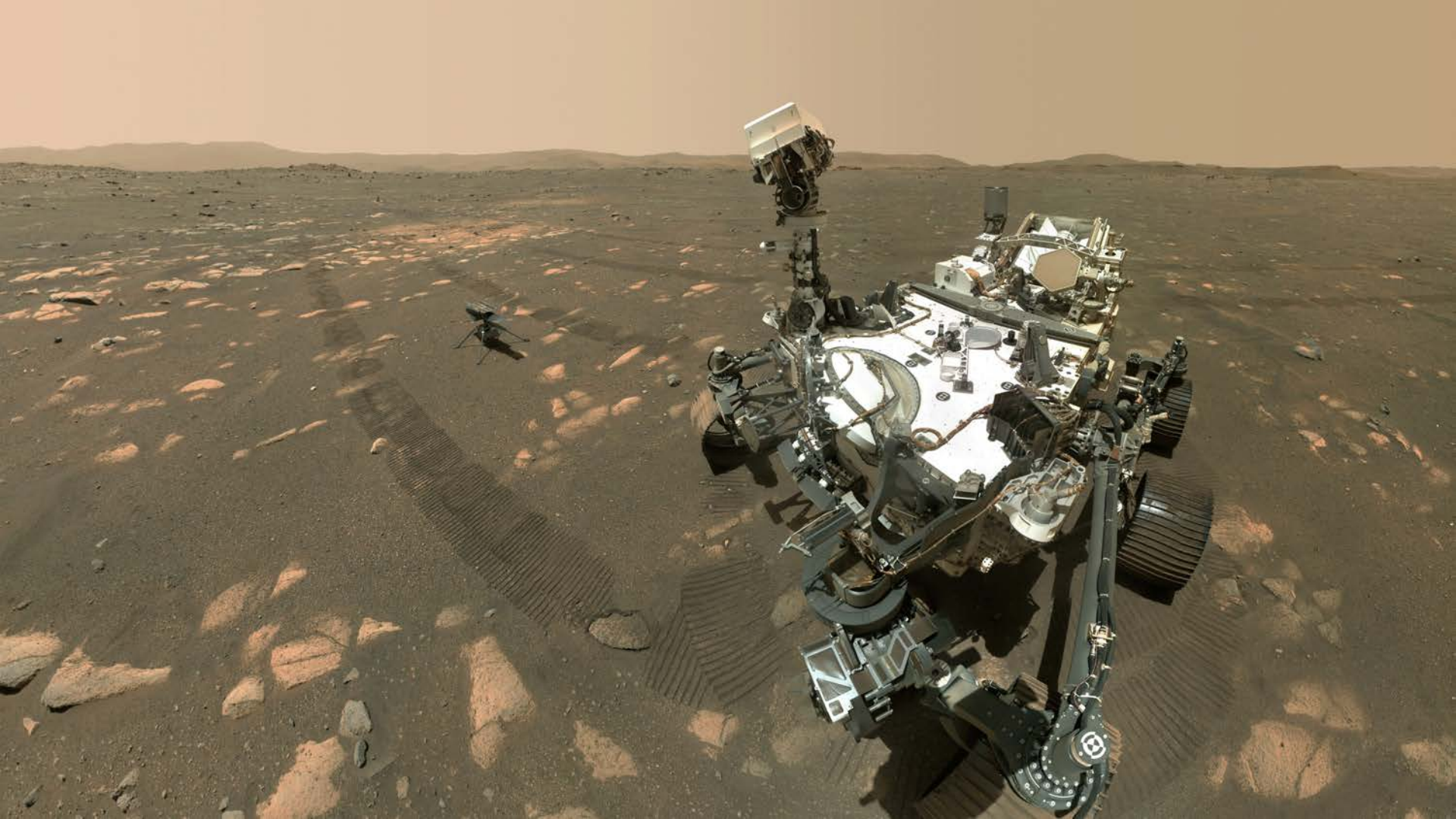
Mastcam-Z NASA/JPL-Caltech/ASU/MSSS



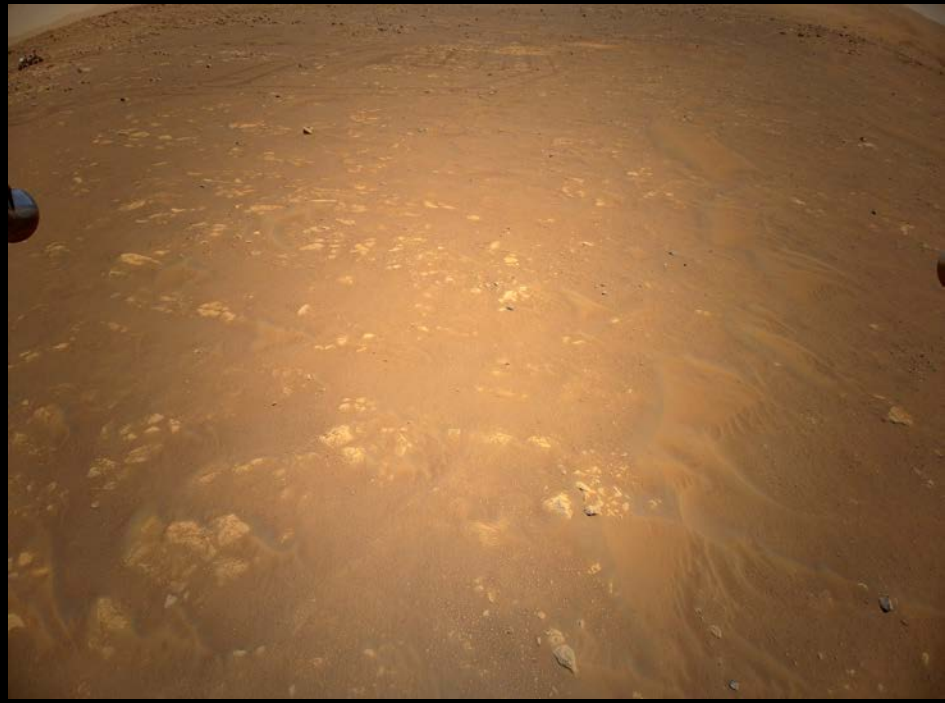
NASA/JPL-Caltech/MSSS/ASU

NavCam

Landed 18 February 2021
Mastcam-Z images
NASA/JPL-Caltech/ASU/MSSS



Credit: NASA/JPL-Caltech/ASU/MSSS



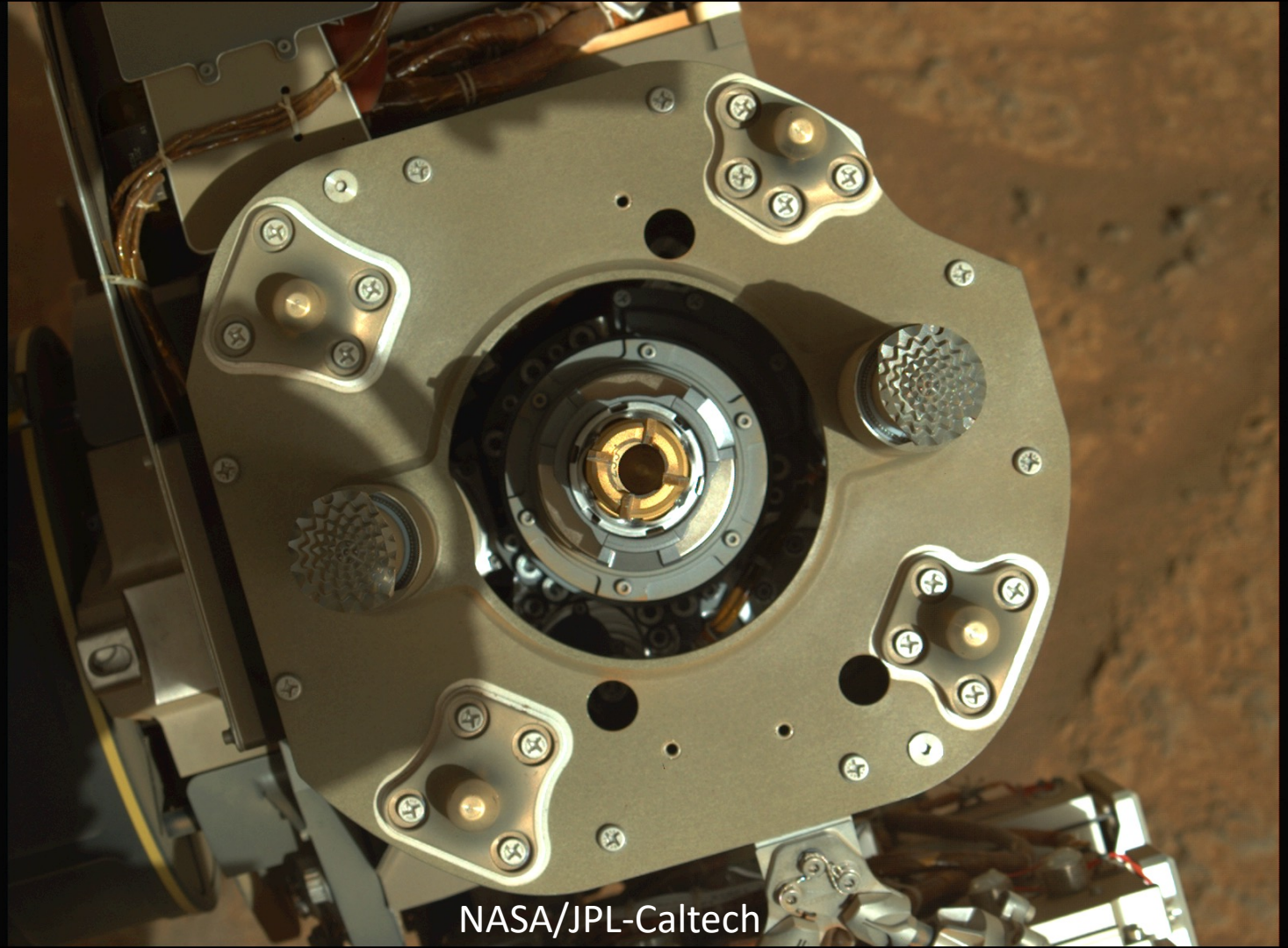
NASA/JPL-Caltech

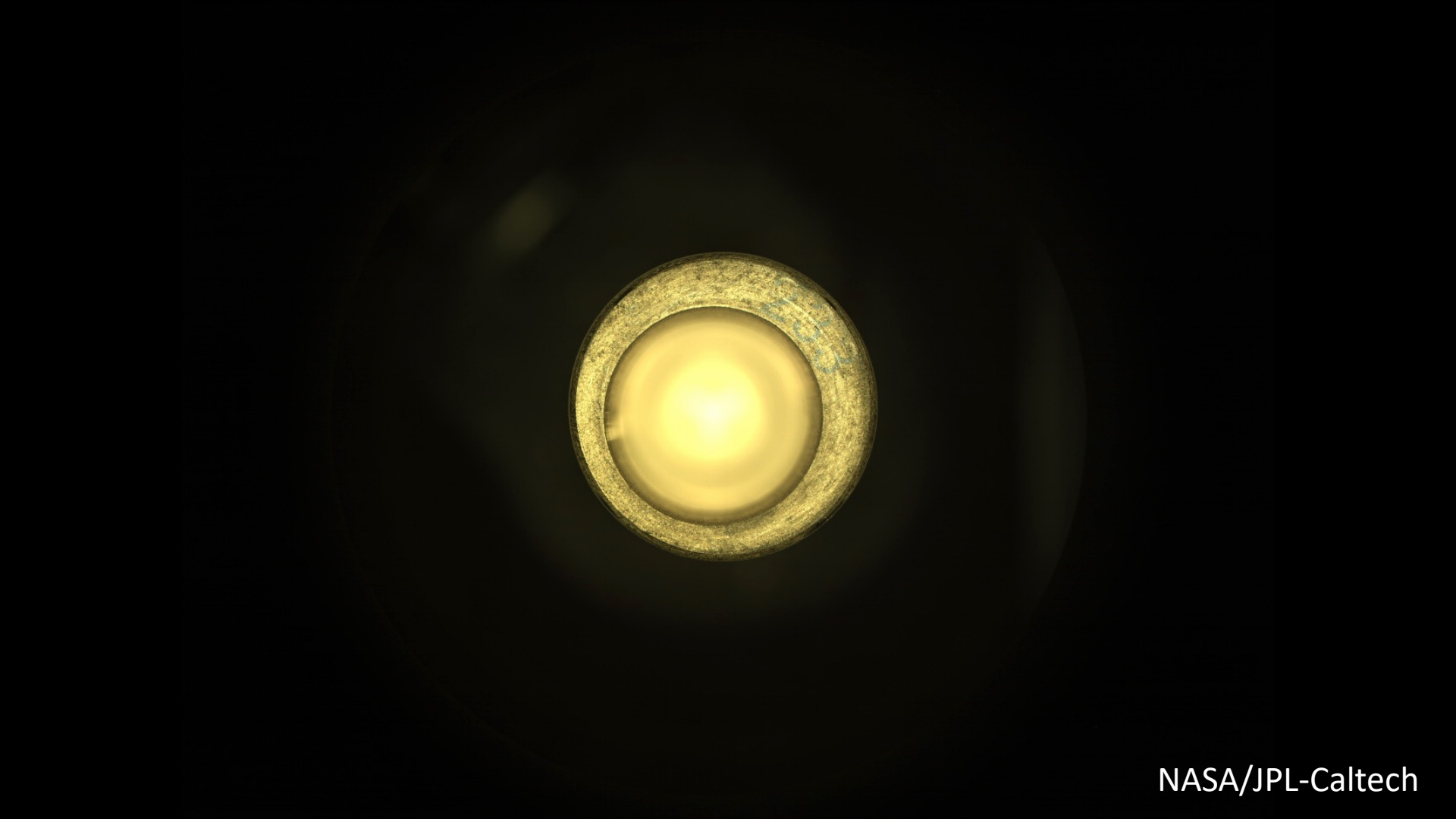
NASA/JPL-Caltech/ASU/MSSS

‘Paver rocks’ NASA/JPL-Caltech


NASA/JPL-Caltech

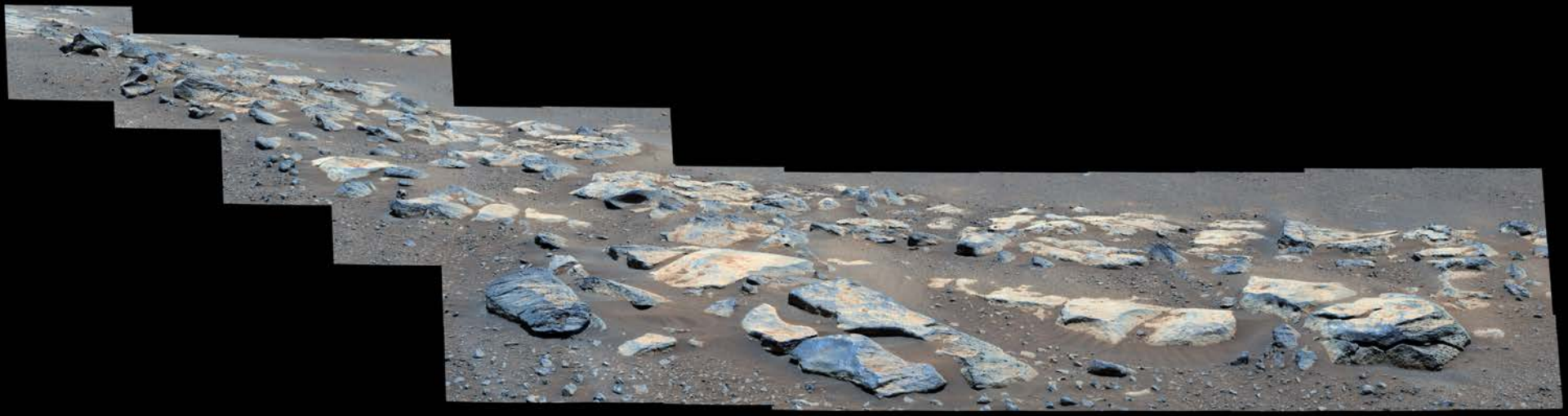
NASA/JPL-Caltech/LANL/CNES/IRAP


NASA/JPL-Caltech

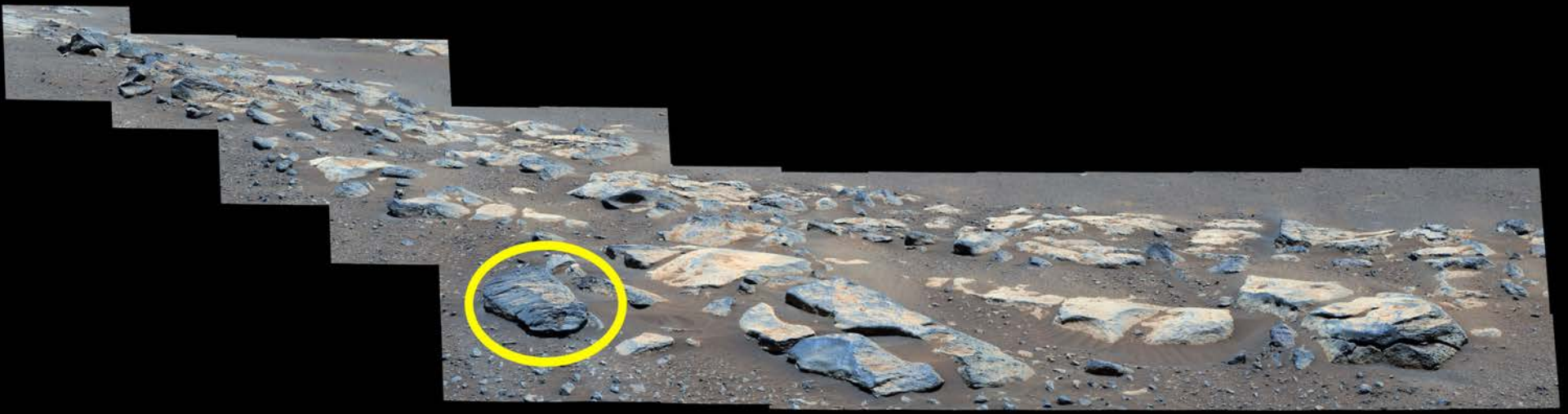


NASA/JPL-Caltech

NASA/JPL-Caltech/University of Arizona/USGS



NASA/JPL-Caltech/ASU/MSSS



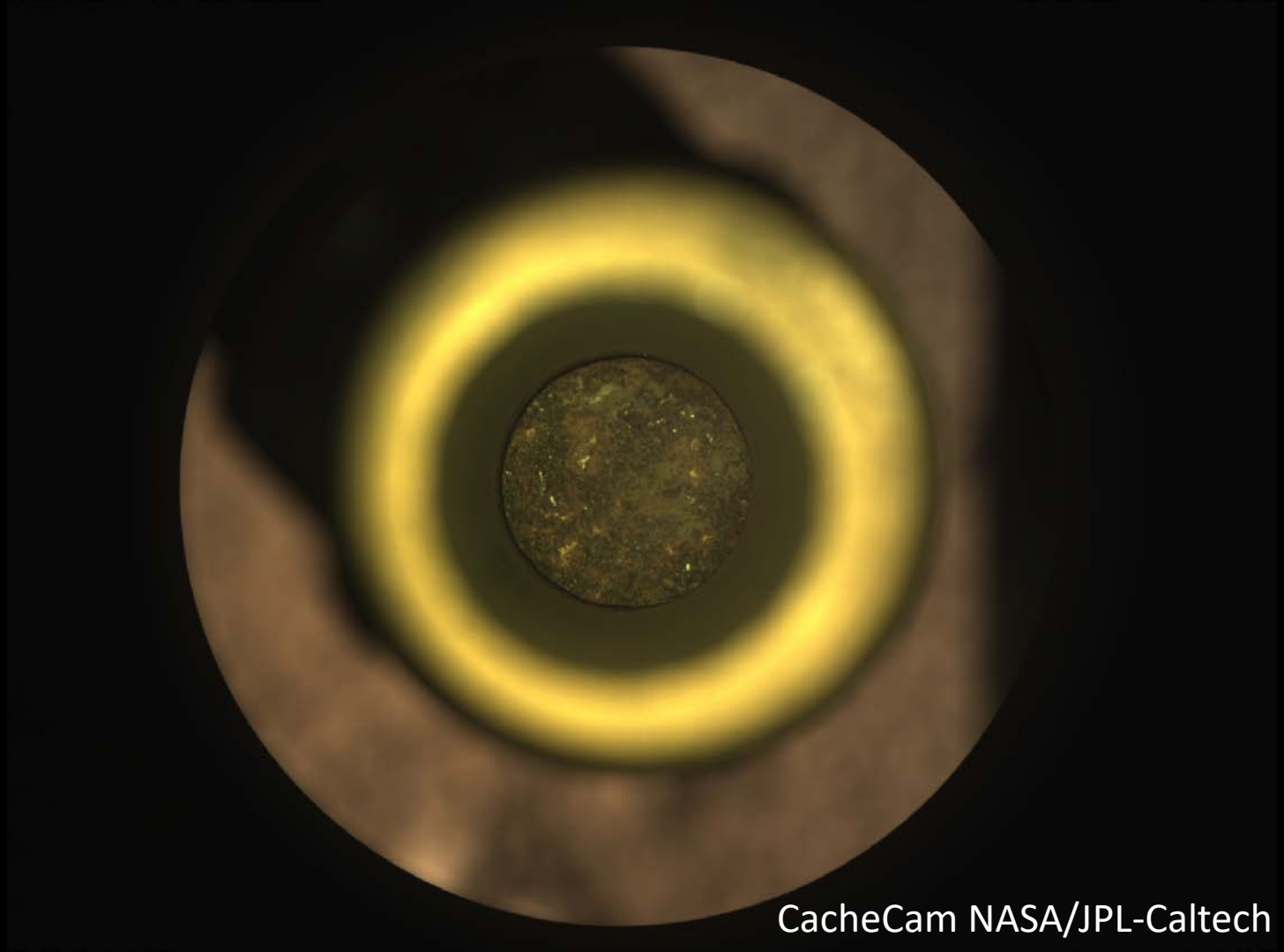
NASA/JPL-Caltech/ASU/MSSS

‘Rochette’ NASA/JPL-Caltech

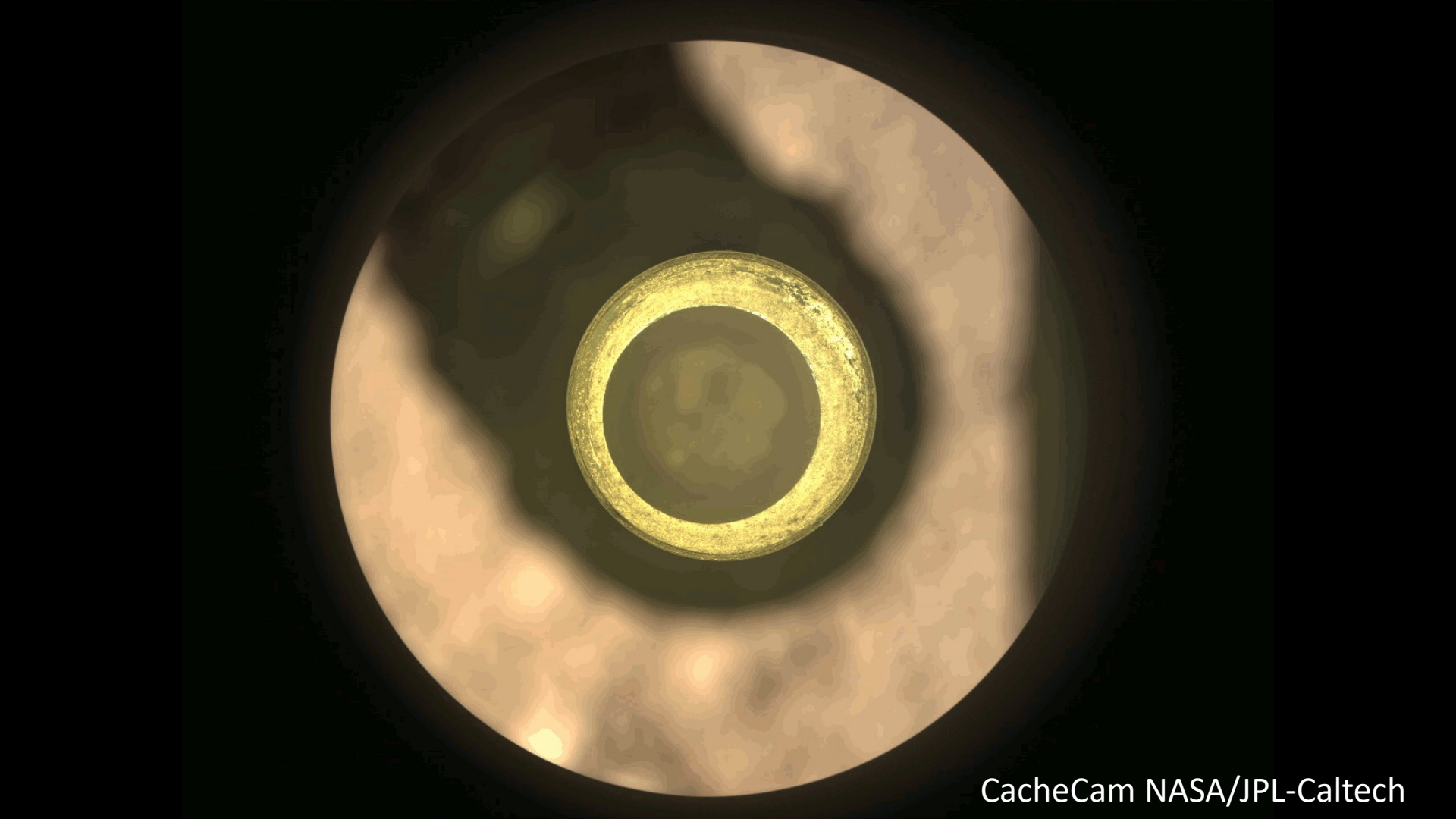

NASA/JPL-Caltech

NASA/JPL-Caltech

Before and after ‘processing’ NASA/JPL-Caltech/ASU/MSSS

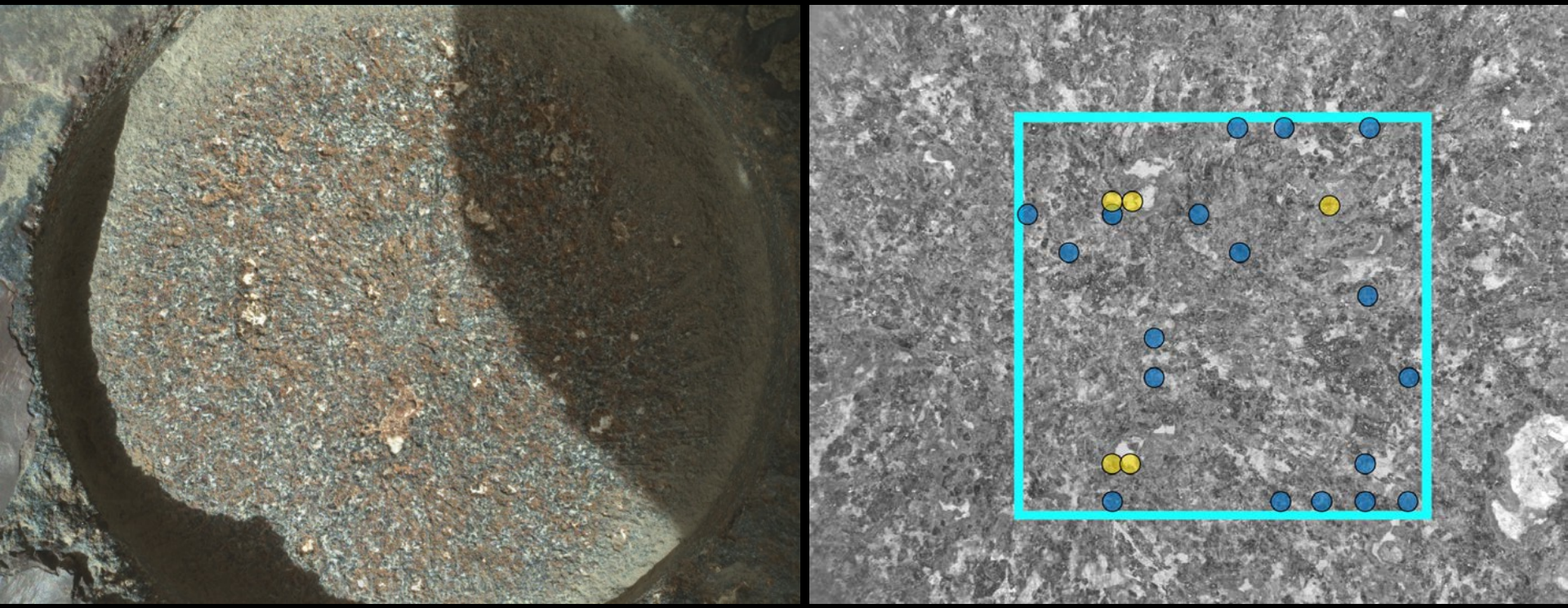


CacheCam NASA/JPL-Caltech

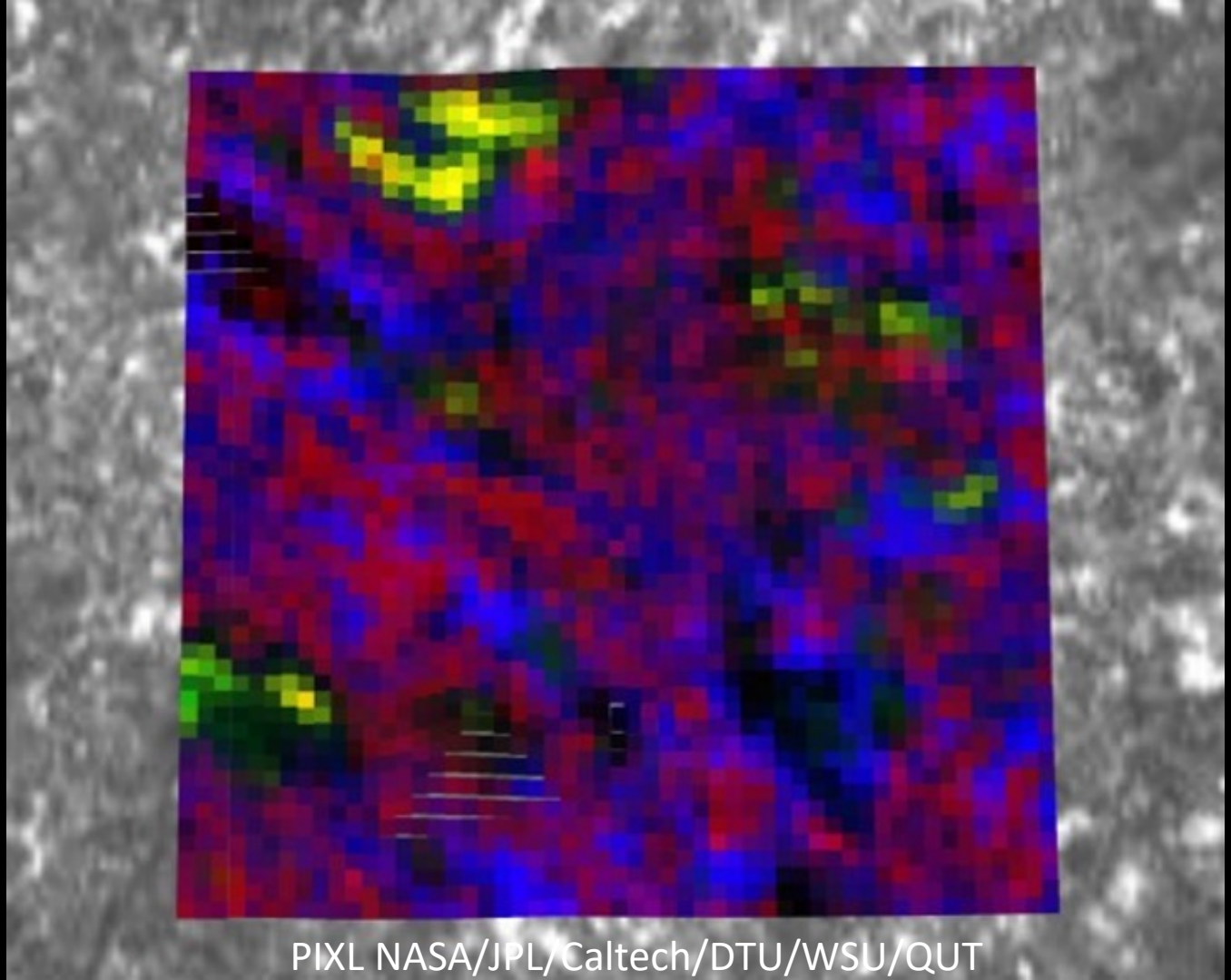

CacheCam NASA/JPL-Caltech

NASA/JPL-Caltech

Before & after sealing NASA/JPL-Caltech



WATSON (L) and SHERLOC (R) at Bellegarde – sulphates, phosphates
JPL-Caltech/MSSS/LANL/Photon Systems/CIW/University of Pittsburgh



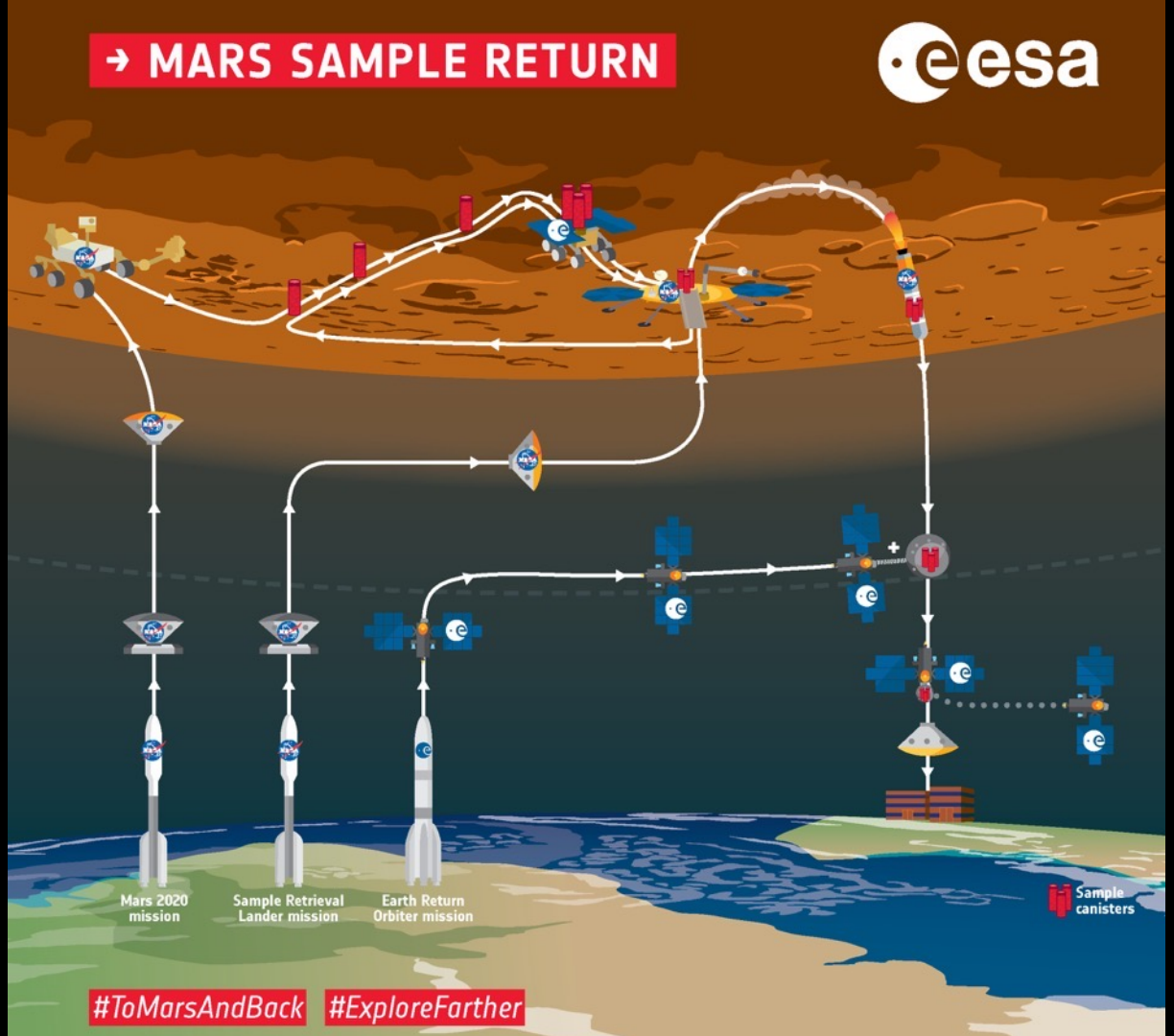
PIXL NASA/JPL/Caltech/DTU/WSU/QUT

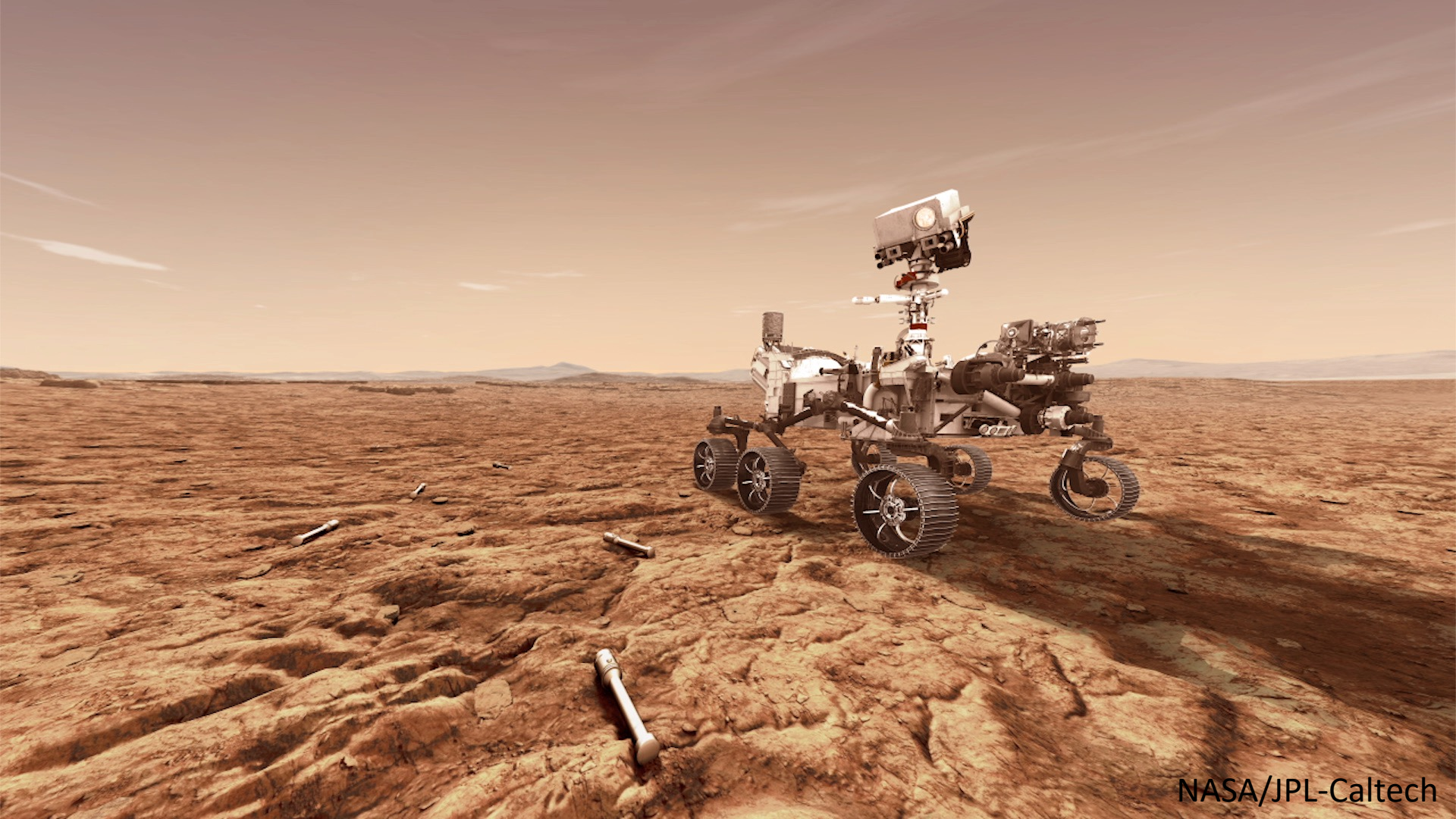

NASA/JPL-Caltech

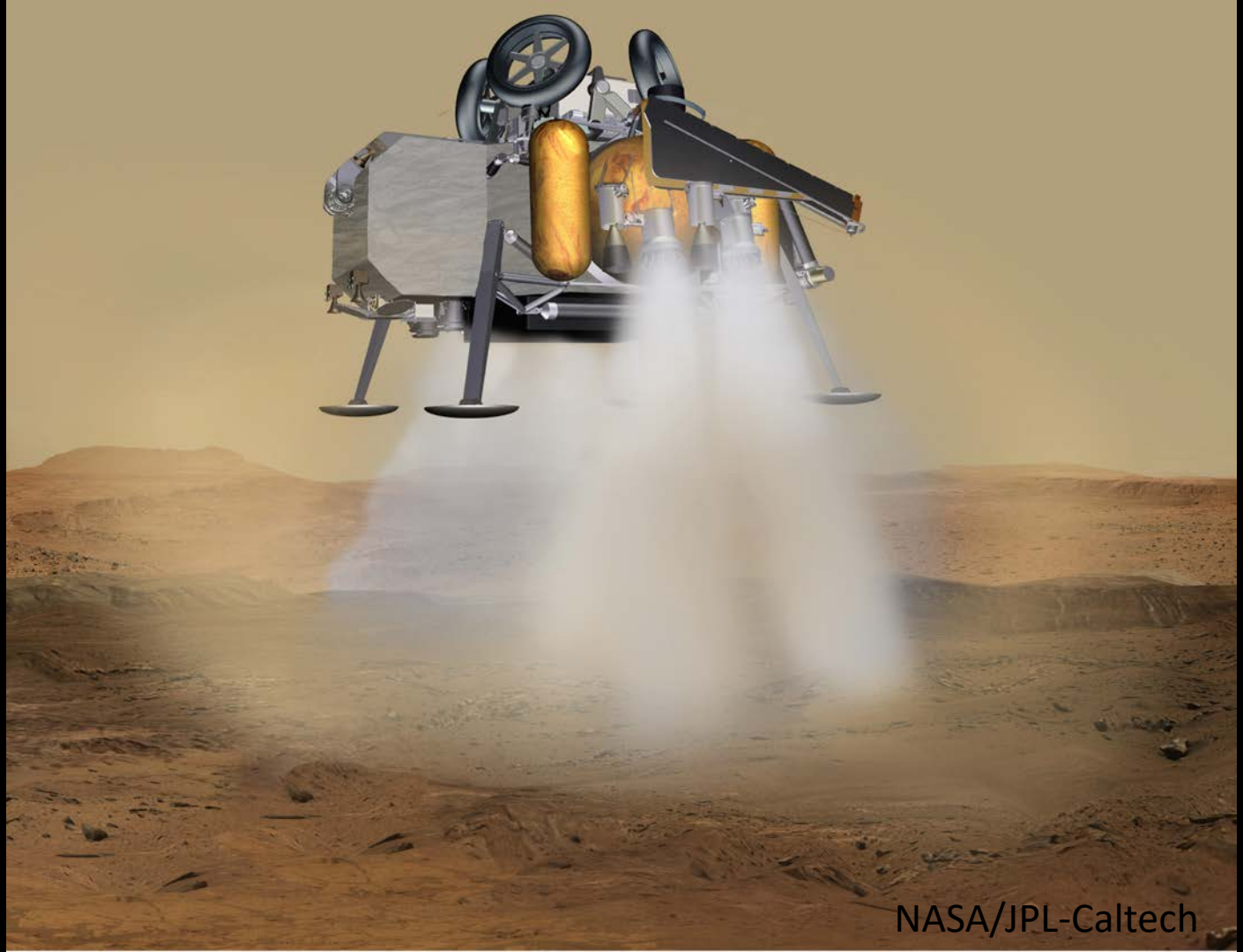
’Montagnac’ (7 Sep) and ‘Montdenier’ (1 Sep) drill holes, taken 7 Sep
NASA/JPL-Caltech


NASA/JPL-Caltech

NASA/JPL-Caltech/University of Arizona/USGS


→ MARS SAMPLE RETURN
esa
Mars 2020 mission
Sample Retrieval Lander mission
Earth Return Orbiter mission
Sample canisters
#ToMarsAndBack
#ExploreFarther


NASA/JPL-Caltech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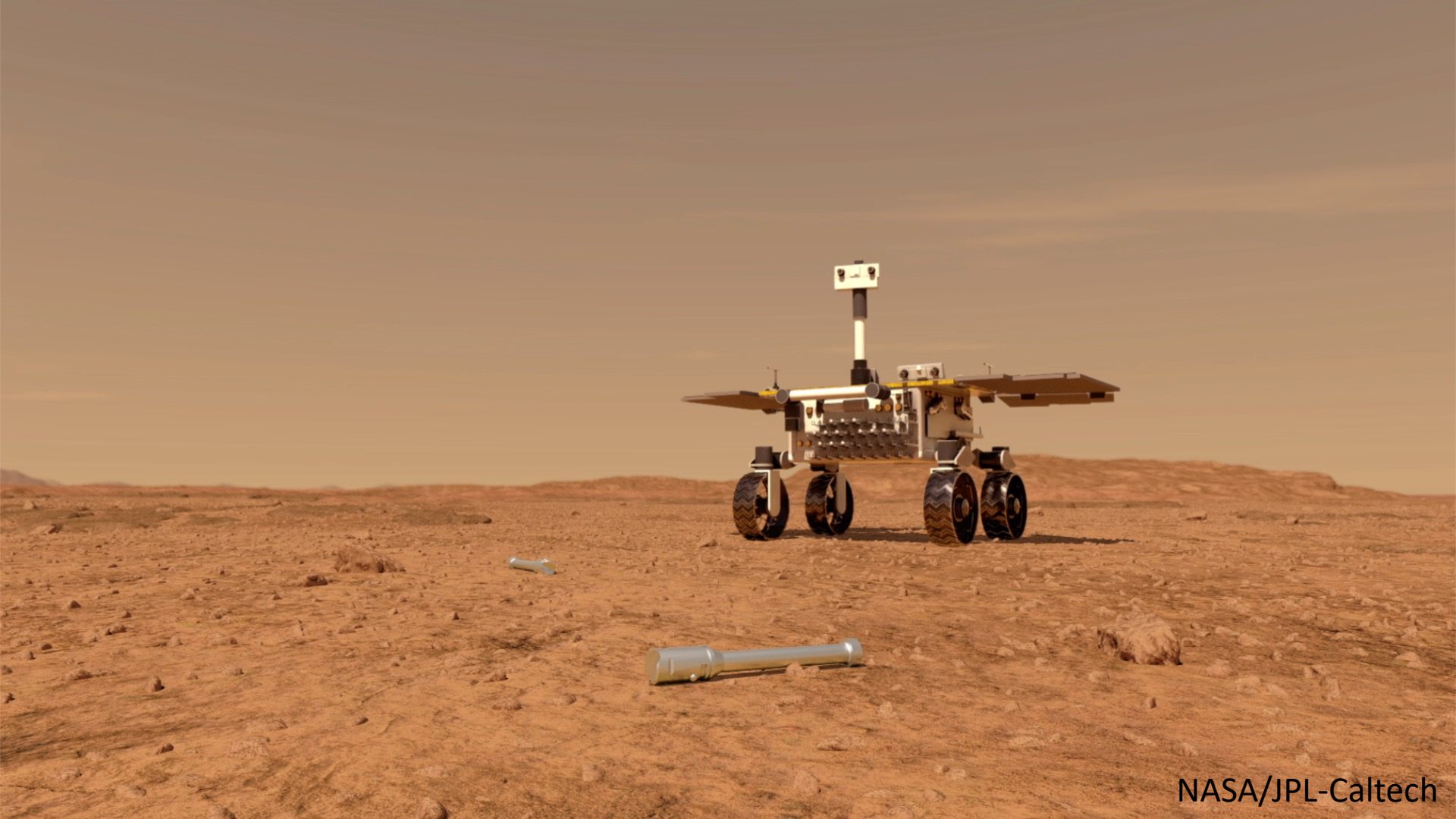
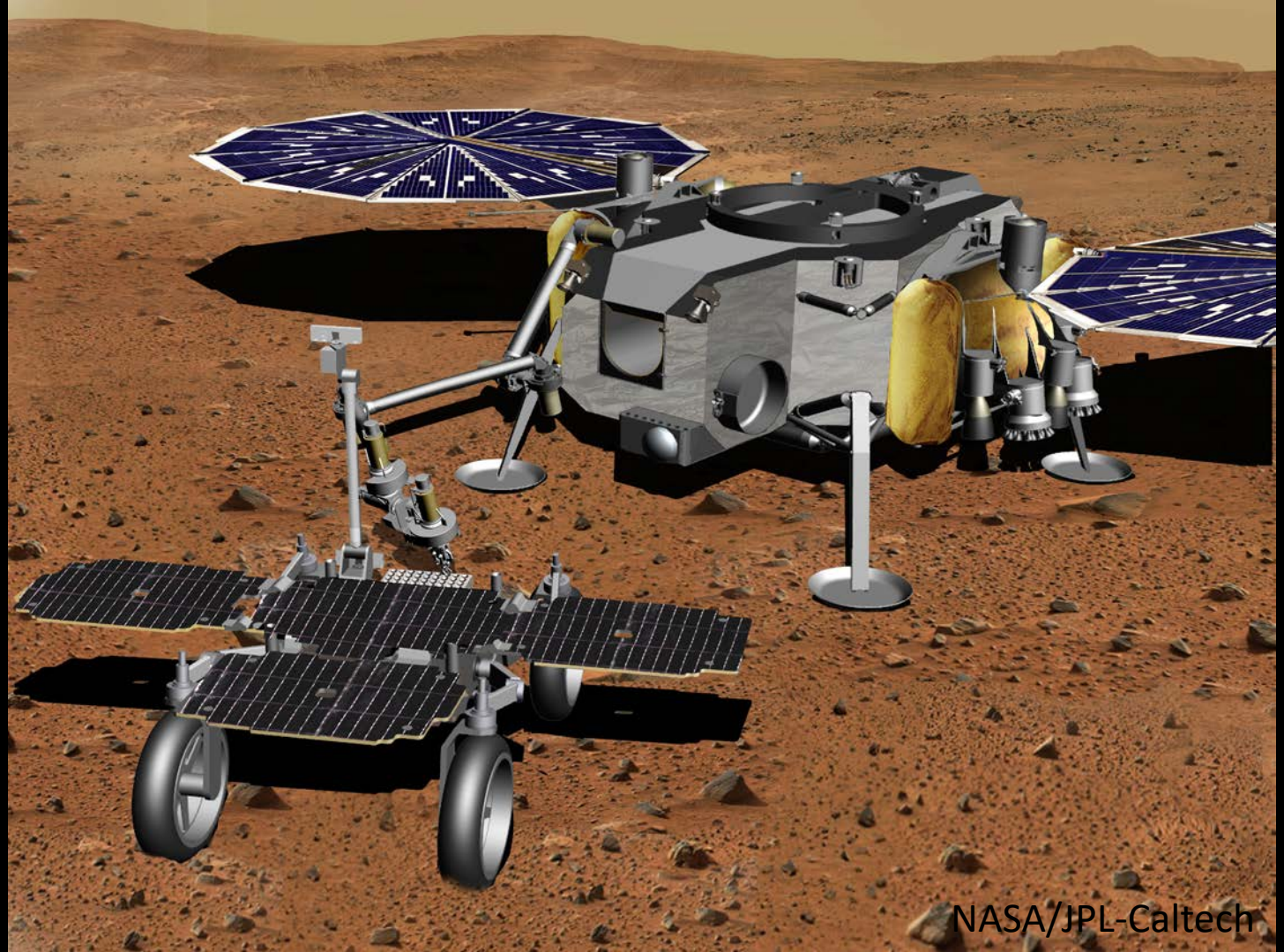
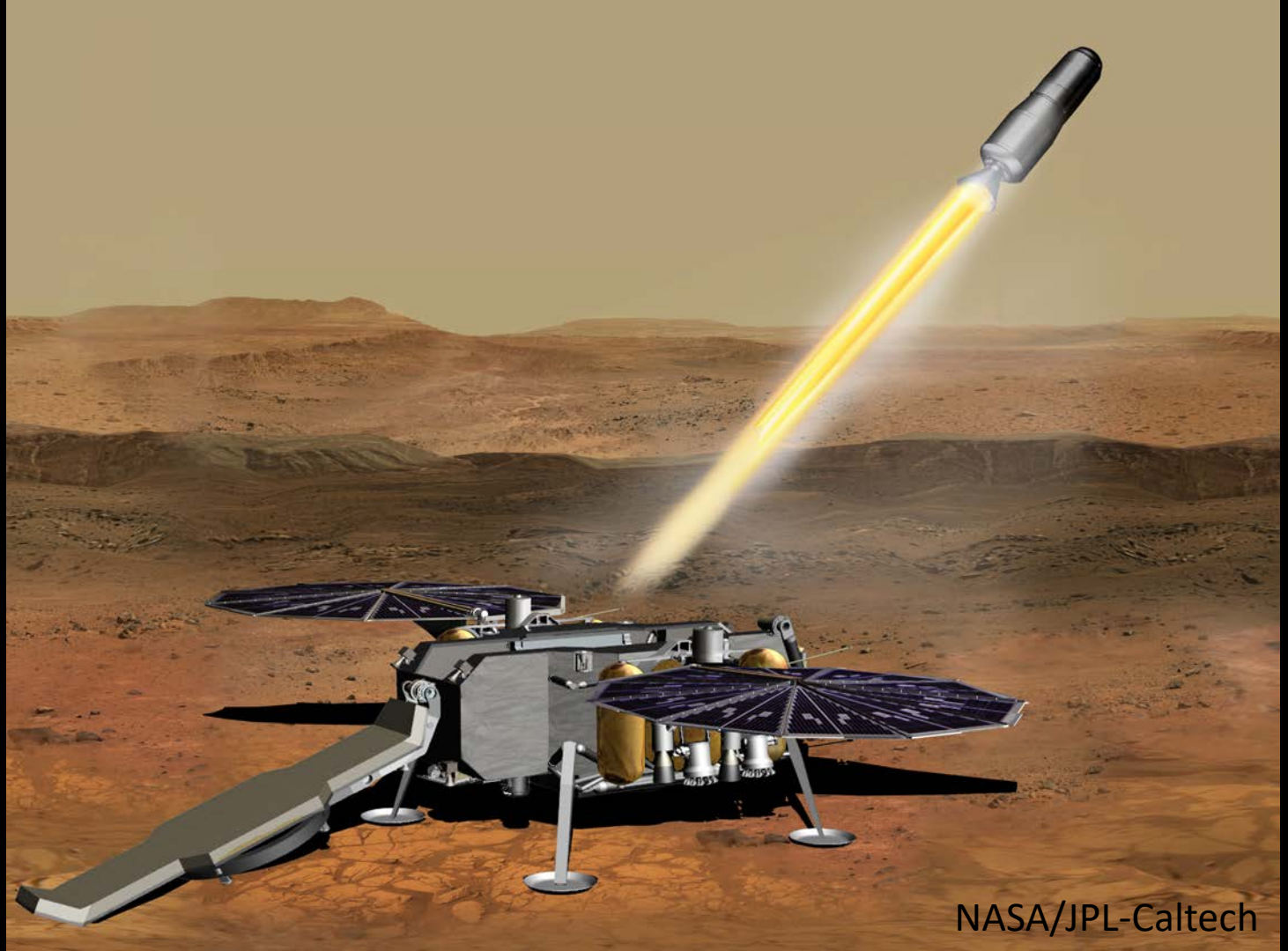

NASA/JPL-Caltech


NASA/JPL-Caltech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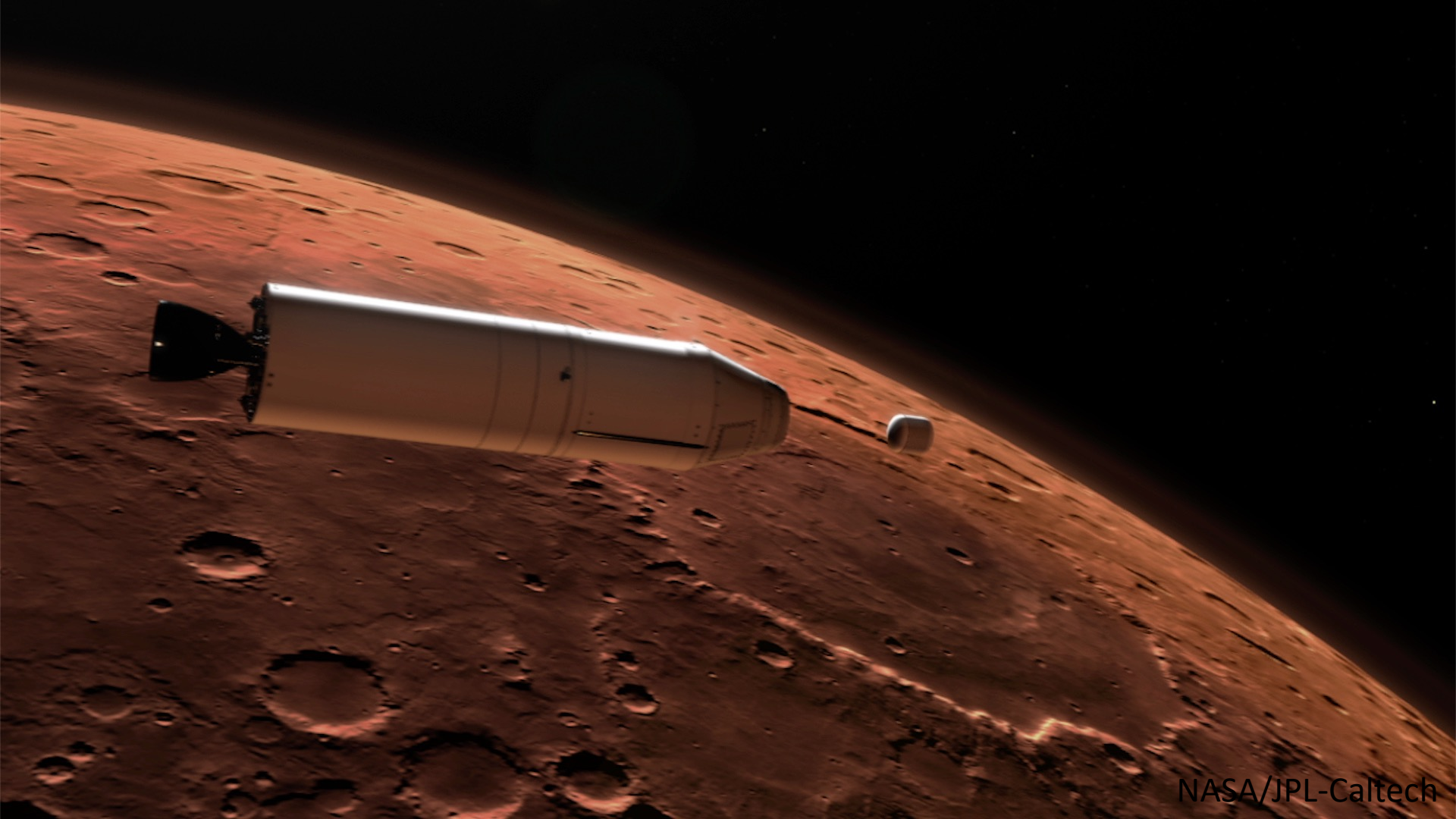
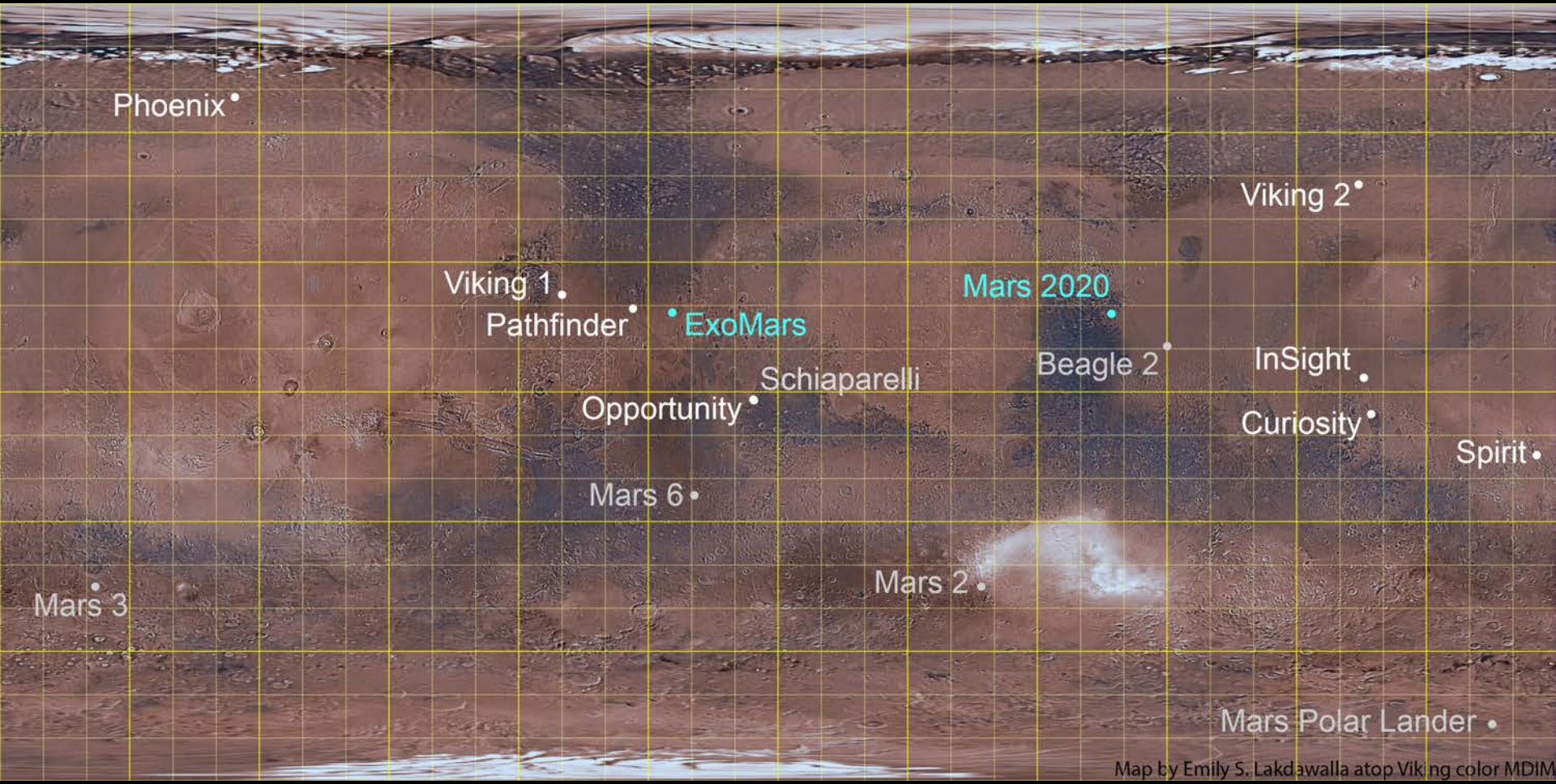

NASA/JPL-Caltech

Diamond – Harwell campus


Phoenix
Viking 2
Viking 1
Pathfinder
ExoMars
Mars 2020
Beagle 2
InSight
Schiaparelli
Opportunity
Curiosity
Spirit
Mars 6
Mars 2
Mars 3
Mars Polar Lander
Map by Emily S. Lakdawalla atop Viking color MDIM

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

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

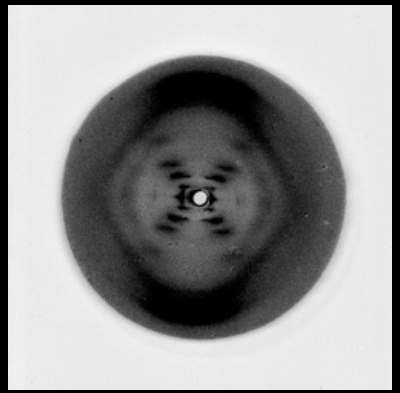
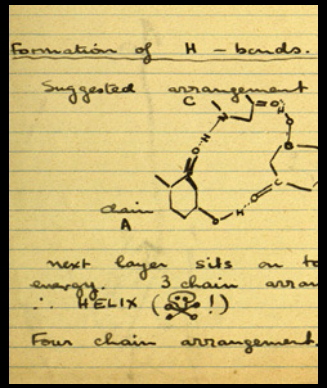
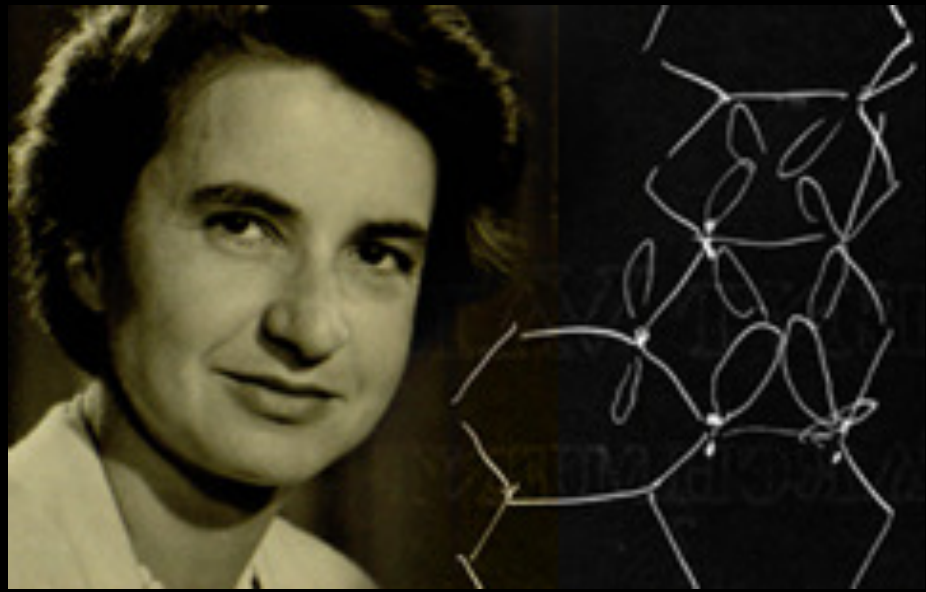


Photo 51



Working notes on DNA



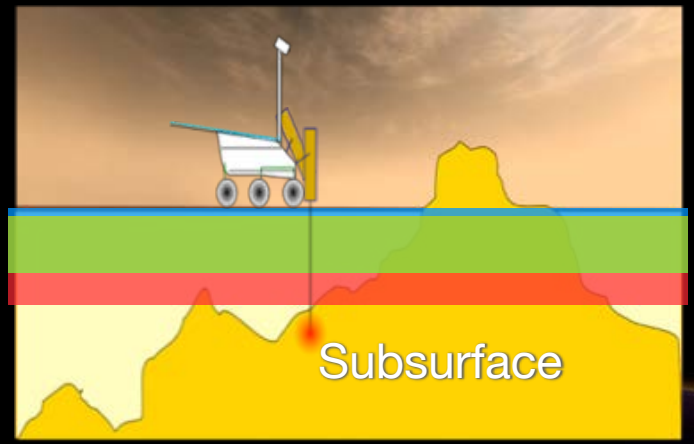
Wellcome library

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

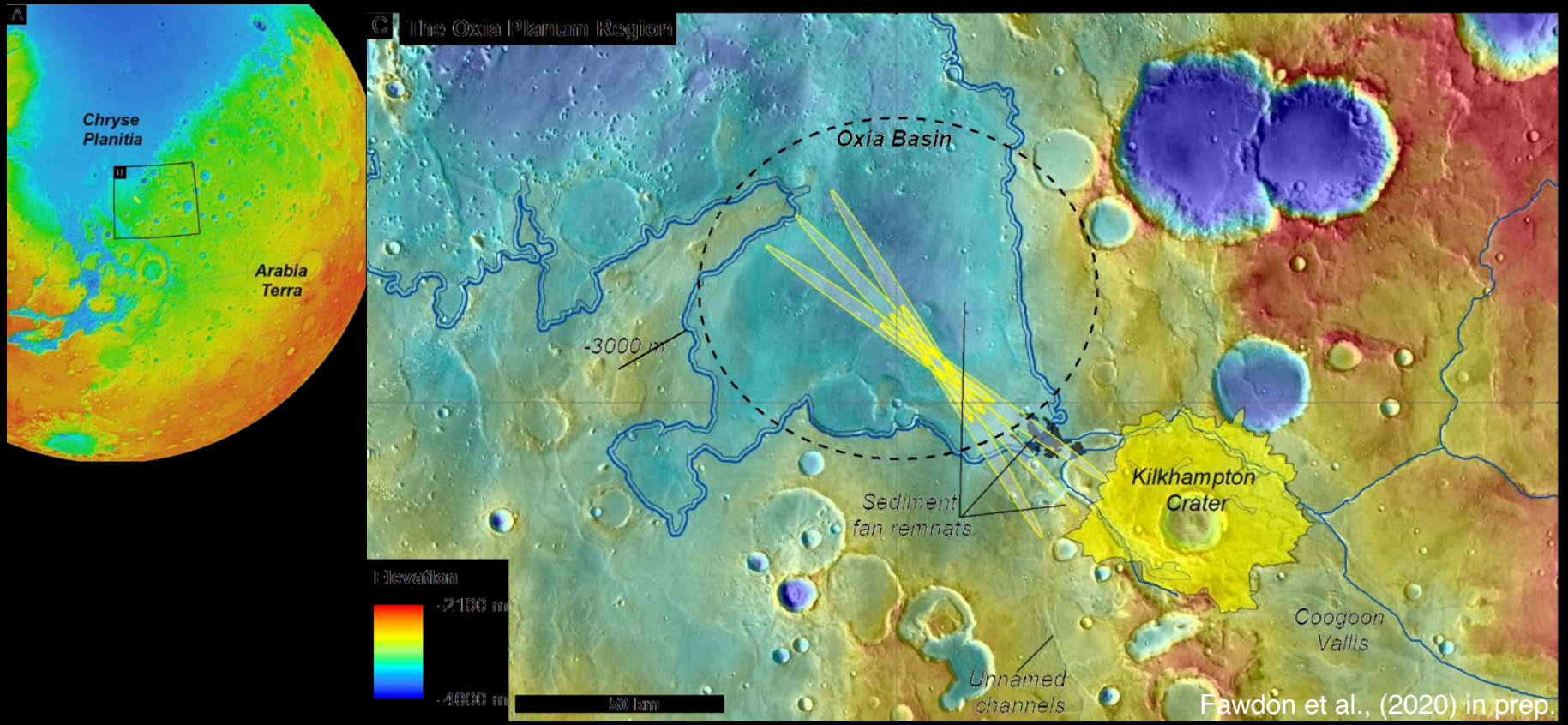
UV radiation	~ 1 mm
Oxidants	~ 1 m
Ionising radiation	~ 1.5 m

ExoMars exobiology strategy:

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

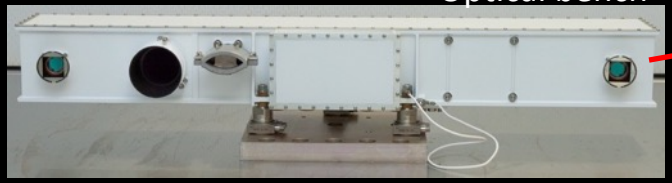
Rosalind Franklin landing site - Oxia Planum

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



PanCam on the rover

Optical bench

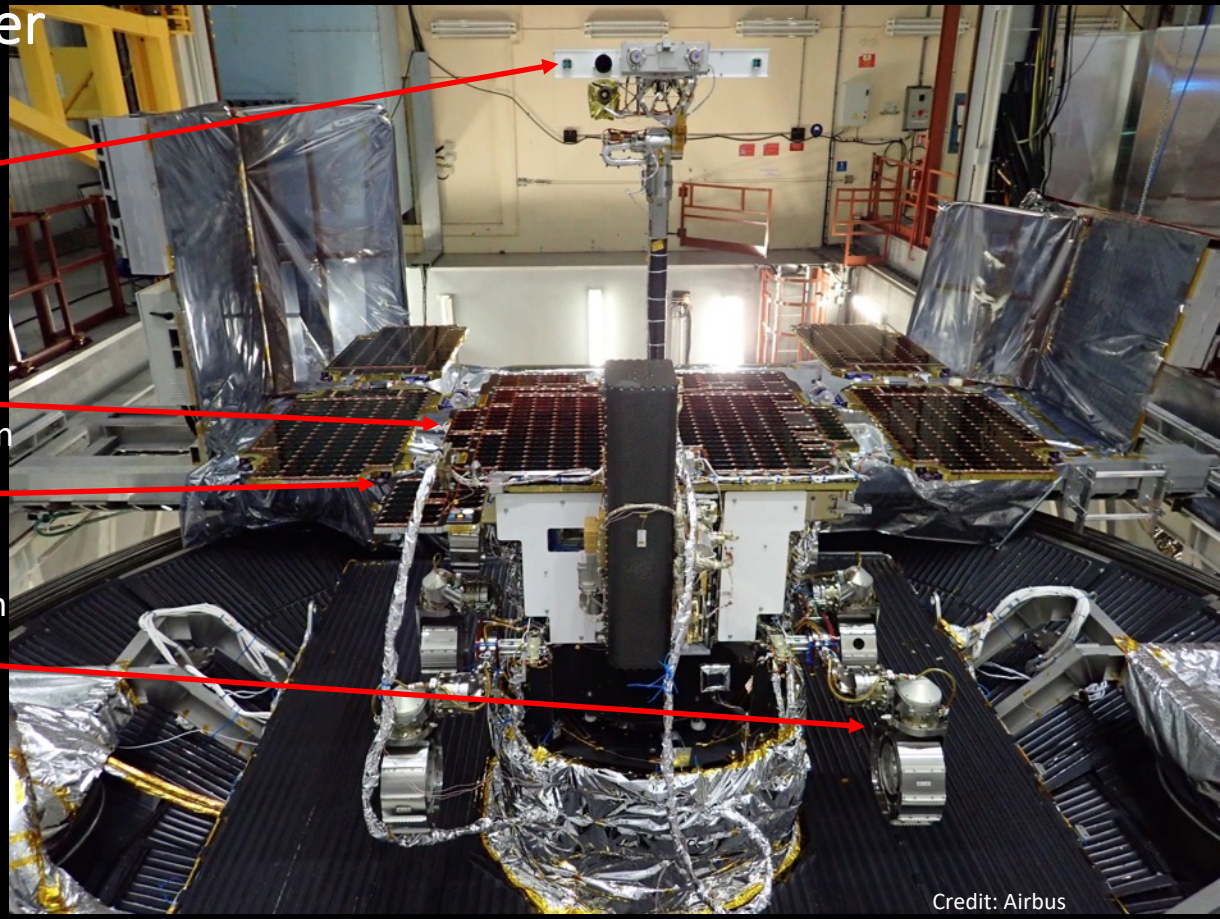


Credit: M. de la Nougerede, UCL/MSSL

Fiducial markers

Calibration target

Rover inspection mirror



Credit: Airbus

PANCAM

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PanCam's filters

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

Summary

Golden age of Mars exploration

Hope, Tianwen-1 & Zhurong, Perseverance & Ingenuity arrived in 2021

2 samples (~6 cm) cached already for Mars Sample Return (2026-31)

Next year, Rosalind Franklin (ExoMars 2022) will provide an important new dimension on Mars: drill 2m under surface

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