*News from Ongoing and Planned Exploration of Mars

Image: NASA/JPL-Caltech, Malin Space Science Systems.

Morten Bo Madsen, Niels Bohr Institute (NBI), University of Copenhagen (UCPH)

The CERN Accelerator School, Advanced Accelerator Physics, 2019-06-12, Slangerup, Denmark

*Main focus on projects with NBI-UCPH collaboration with NASA

NASA-work at NBI is supported by the CARLSBERG FOUNDATION

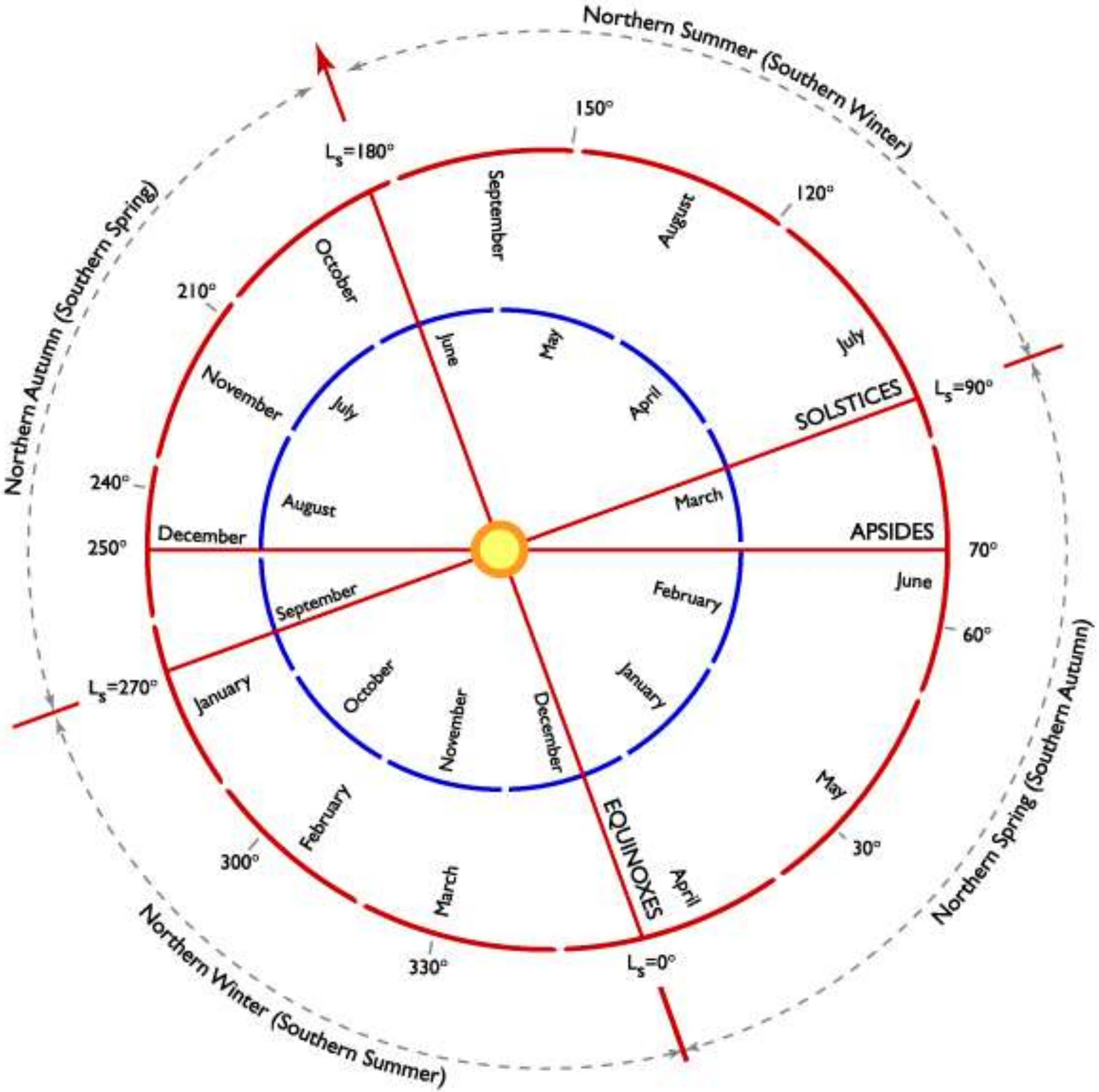
Mars day (Sol):
24 h 39 m

Mars year:
1.88 Earth year
668 Sols

Half major axis:
1.52 AU*

(Present)
Inclination:
25.2°

***1 AU = 149.597.871 km**



Earth compared to Mars

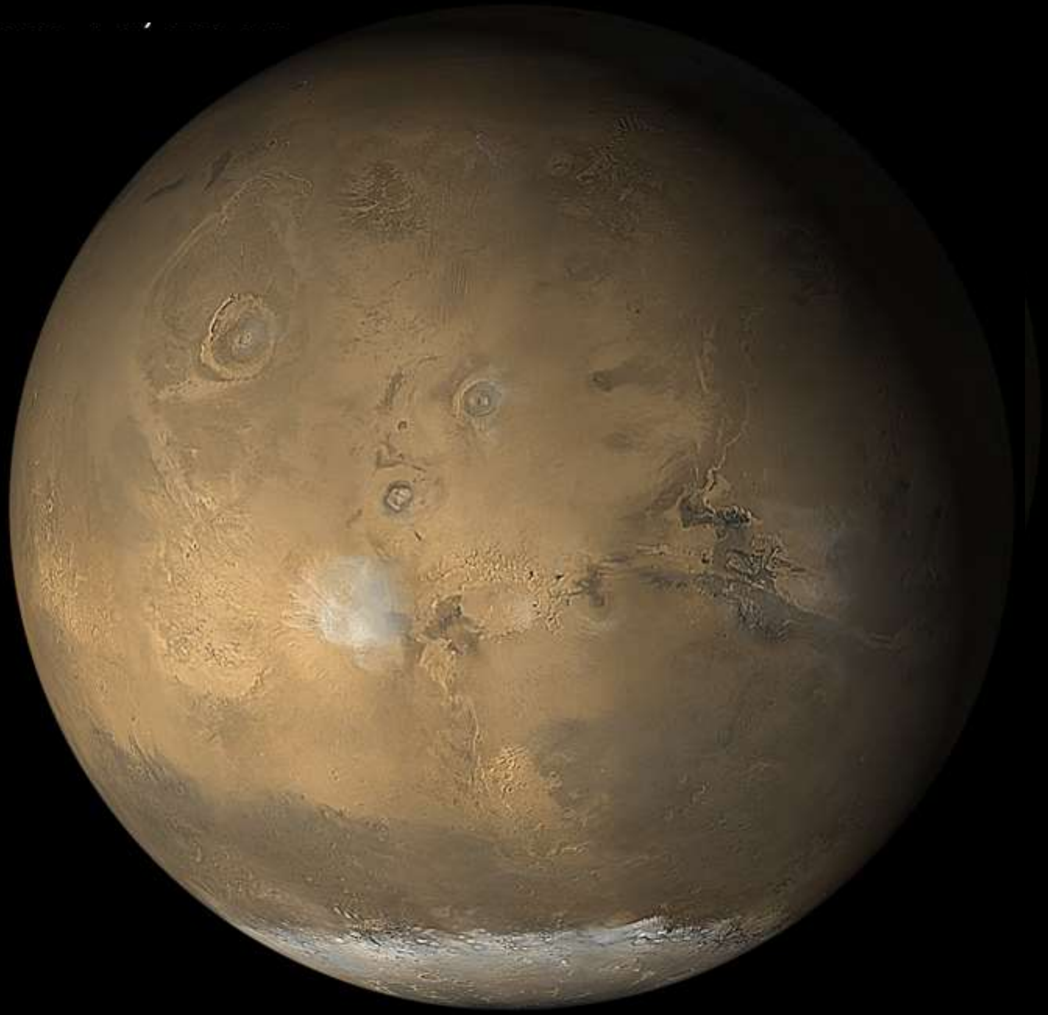
Atmospheric pressure at surface:	101,3 kPa 1013 mBar
Atmospheric composition:	78,1 % N_2 20,95 % O_2 0,93 % Ar 0,041 % CO_2

Atmospheric pressure at surface:	100-600 Pa 1 - 6 mBar
Atmospheric composition:	95,97 % CO_2 1,93 % Ar 1,89 % N_2 0,146 % O_2 0,056 % CO

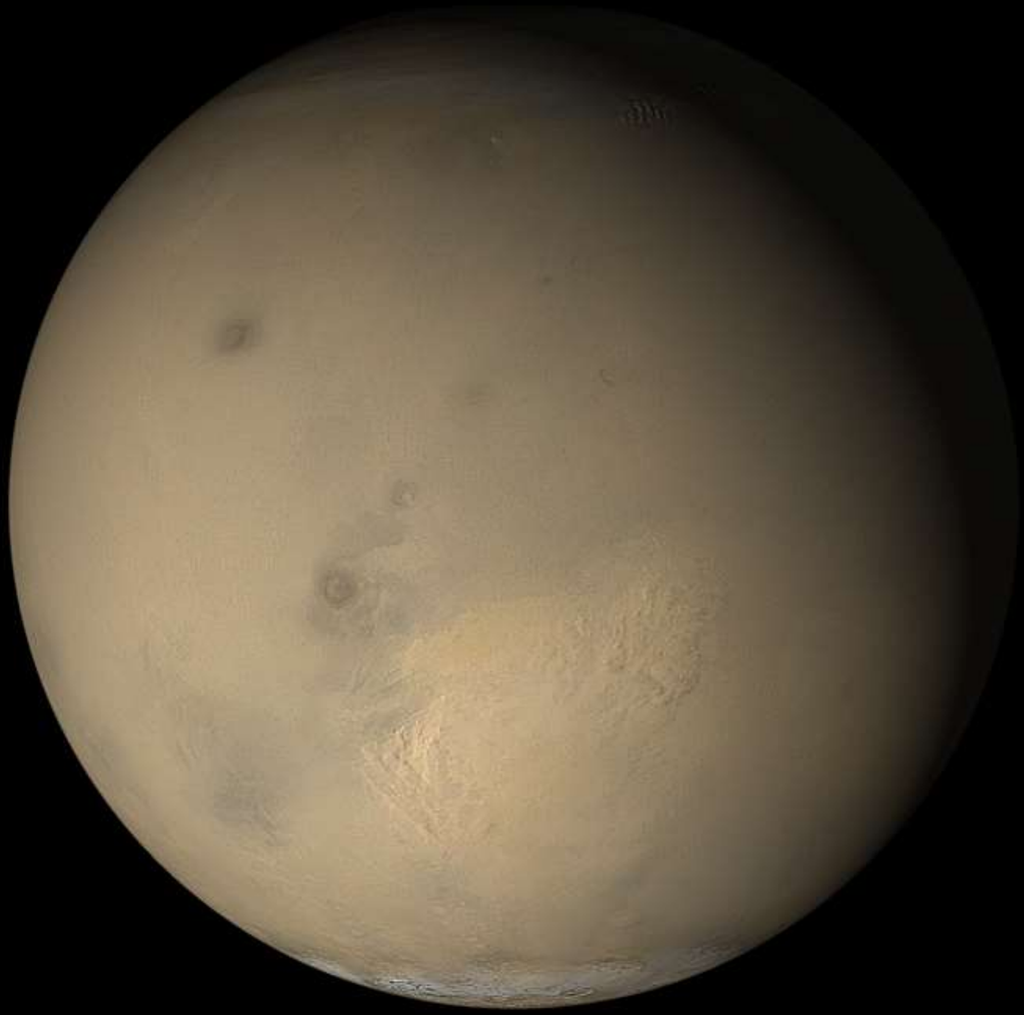
Mars' mass:	0,107 M_E
Radius:	0,532 R_E
Surface area:	0,283 A_E
Gravitational Acceleration (@ surface):	0,377 g_E

Atmospheric dust

June 10, 2001



July 31, 2001

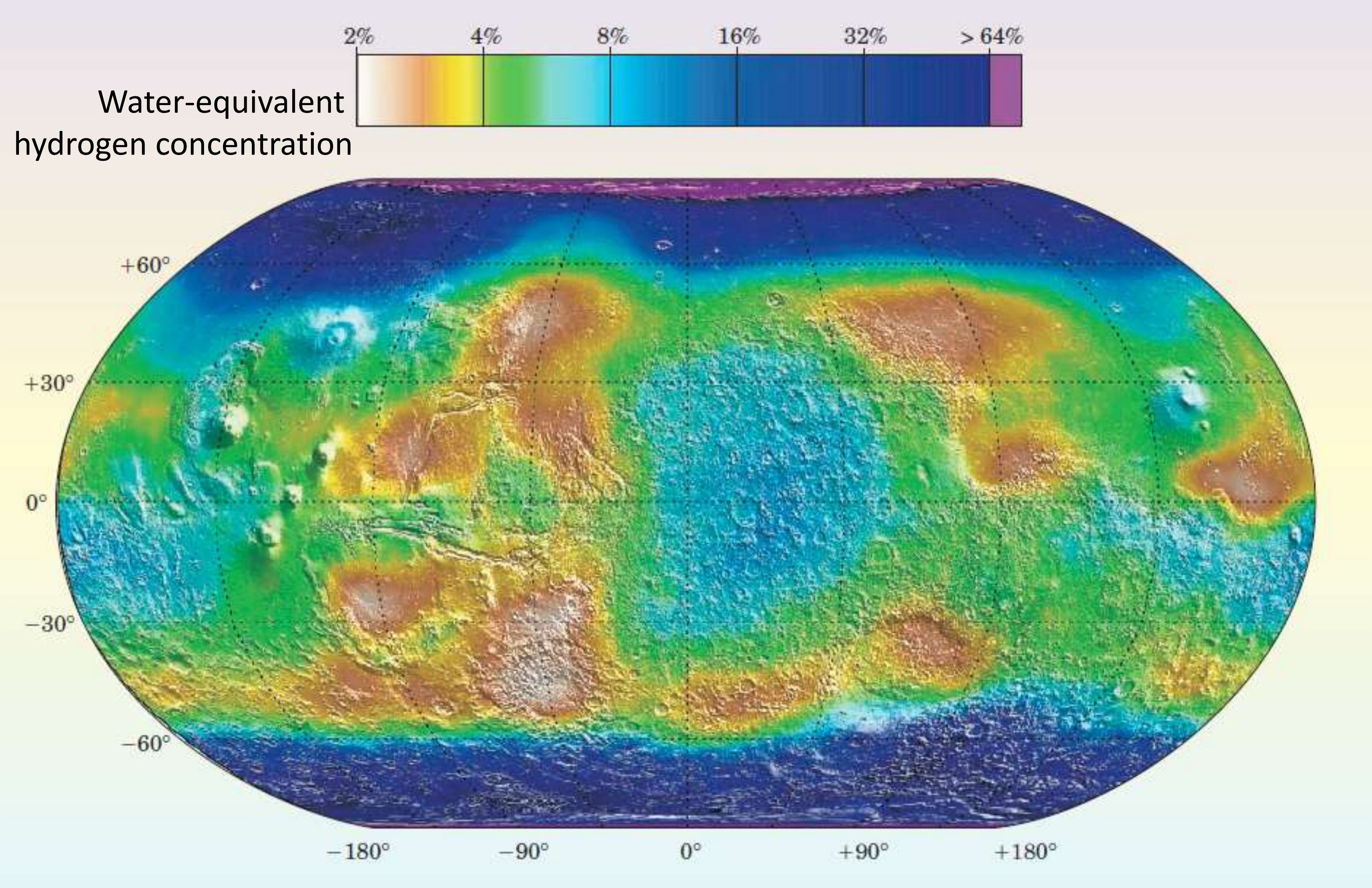


Credits: MSSS, NASA, JPL

HiRISE image

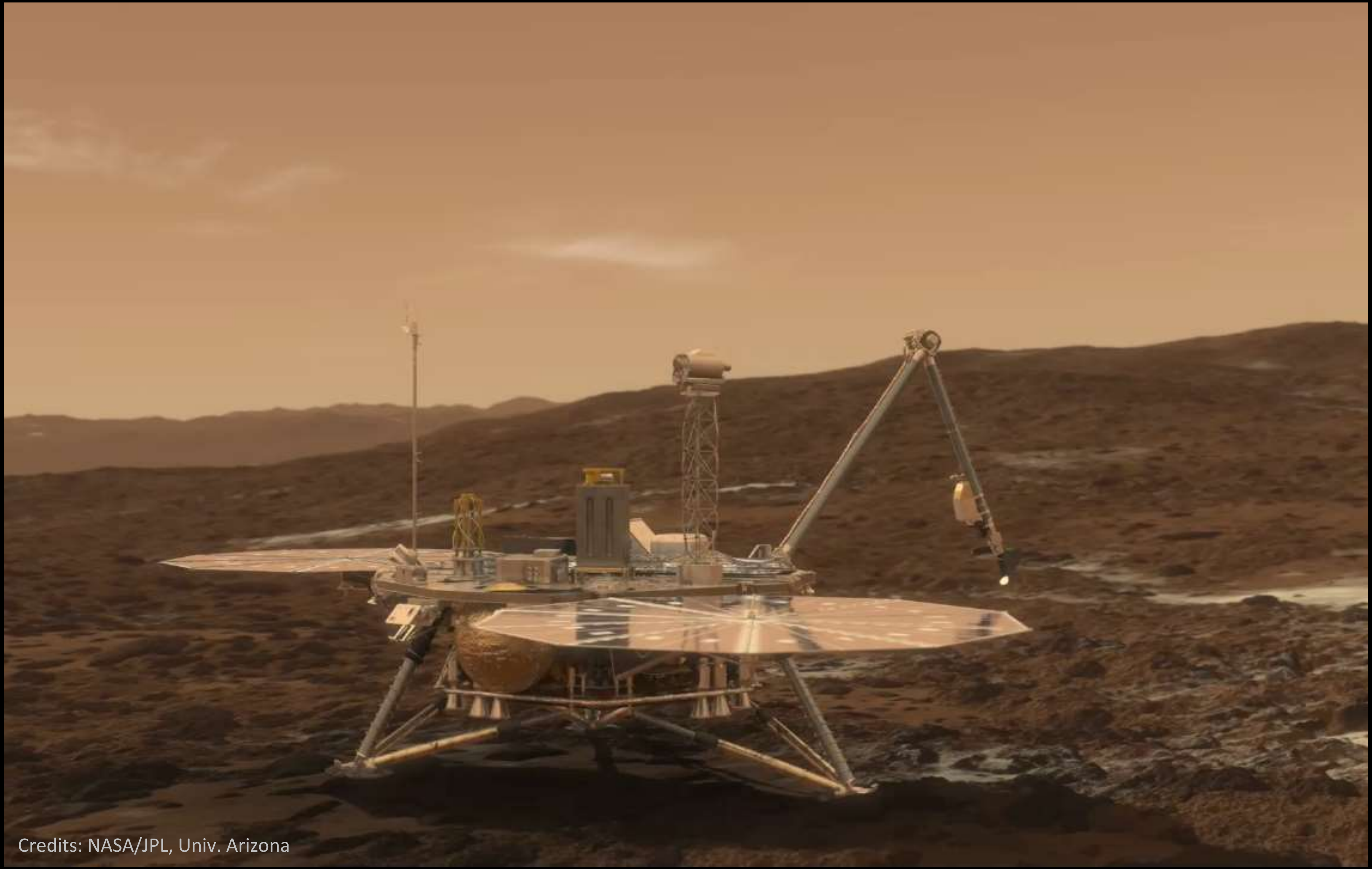
Credits: University of Arizona, NASA, JPL

Mars Odyssey (2001):



[Mitrofanov et al., 2004, Feldman et al., 2004]

NASA’s 2007 Phoenix lander

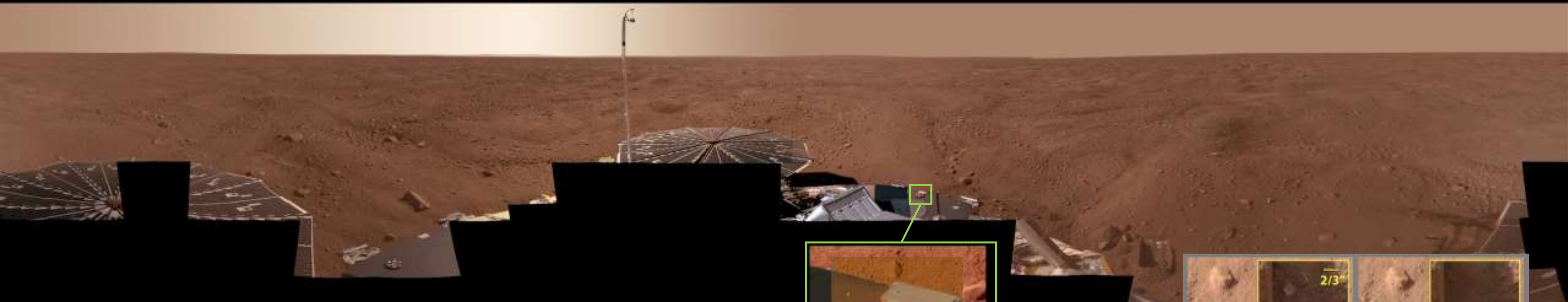


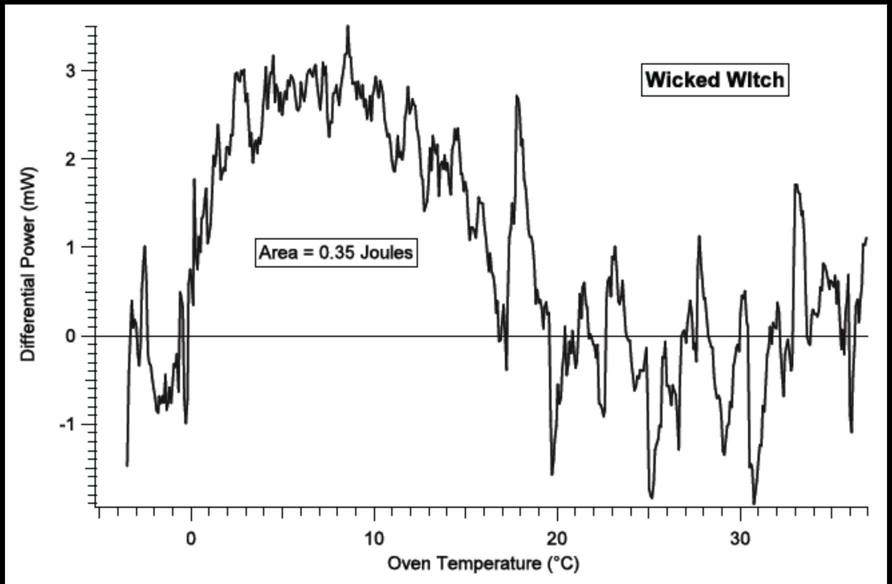
Credits: NASA/JPL, Univ. Arizona

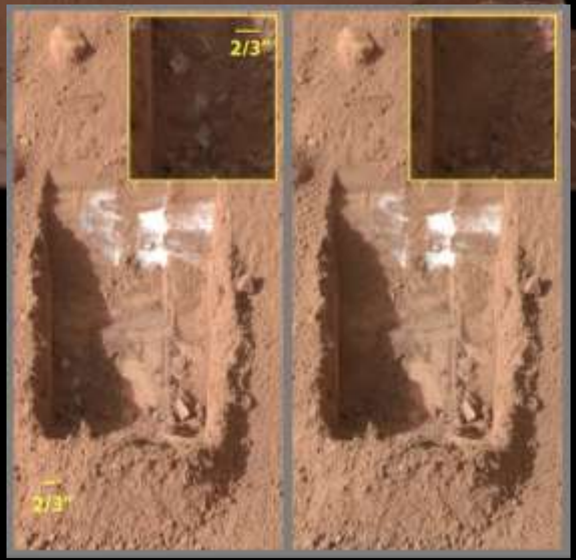
Phoenix – Sol 4/5

Image: University of Arizona, Max Planck Institute for Solar System Research and NASA, JPL.

2008 Phoenix, Vastitas Borialis



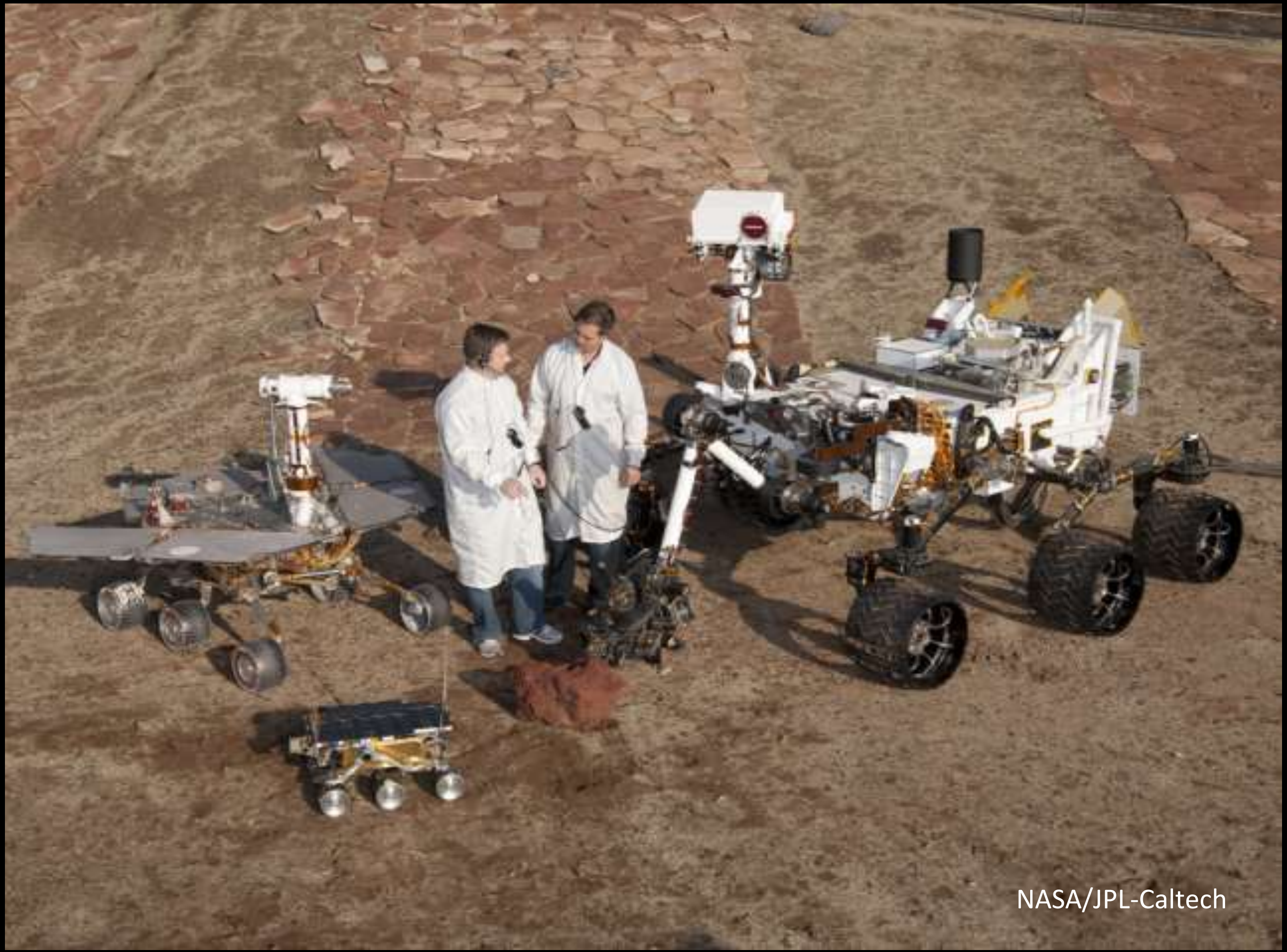




Phoenix proved that there is water(-ice) below the surface where Phoenix landed

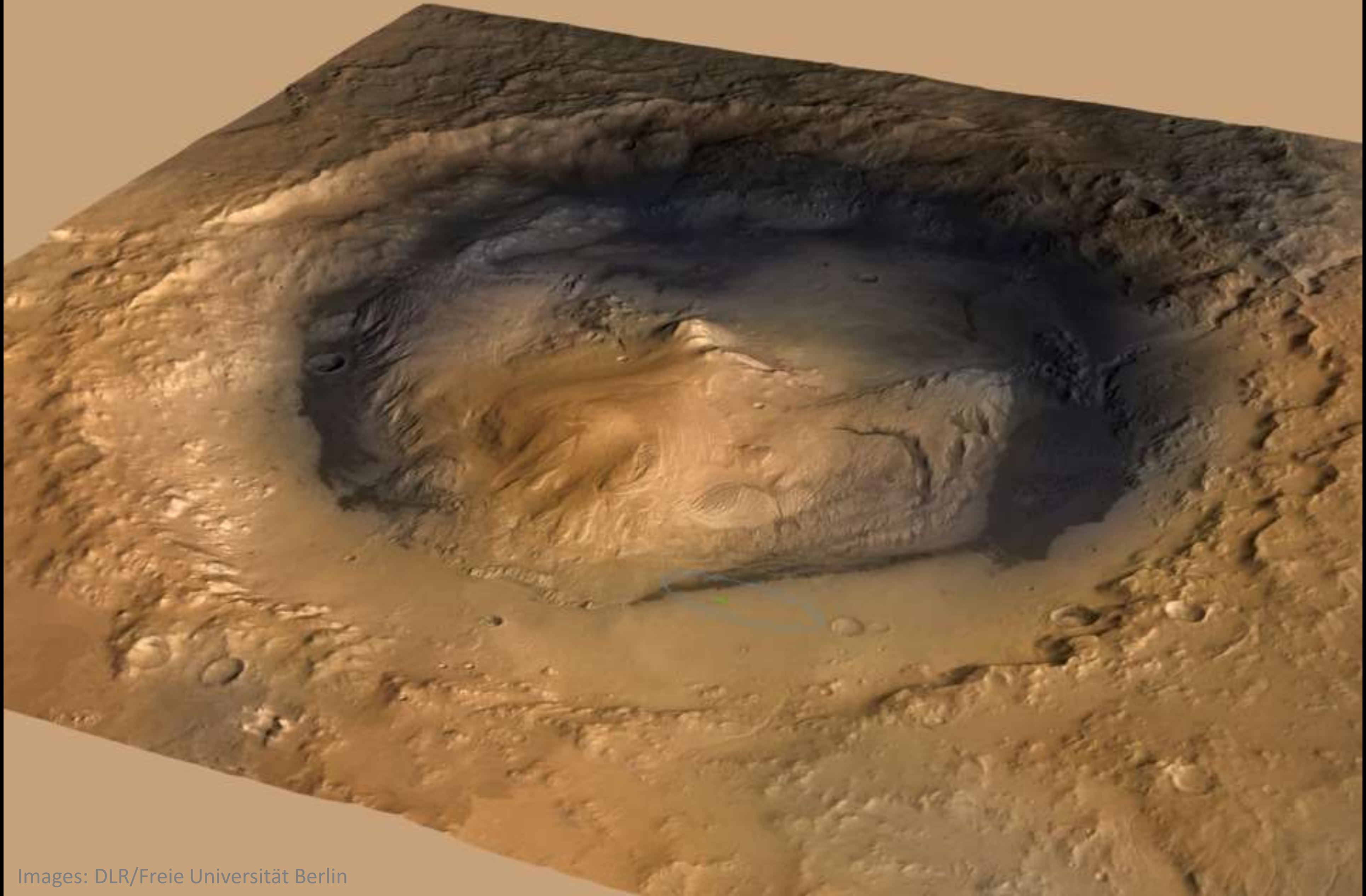
2012 Curiosity

Goal: Evaluate potential of a selected area as a possible habitate for life now or in the past

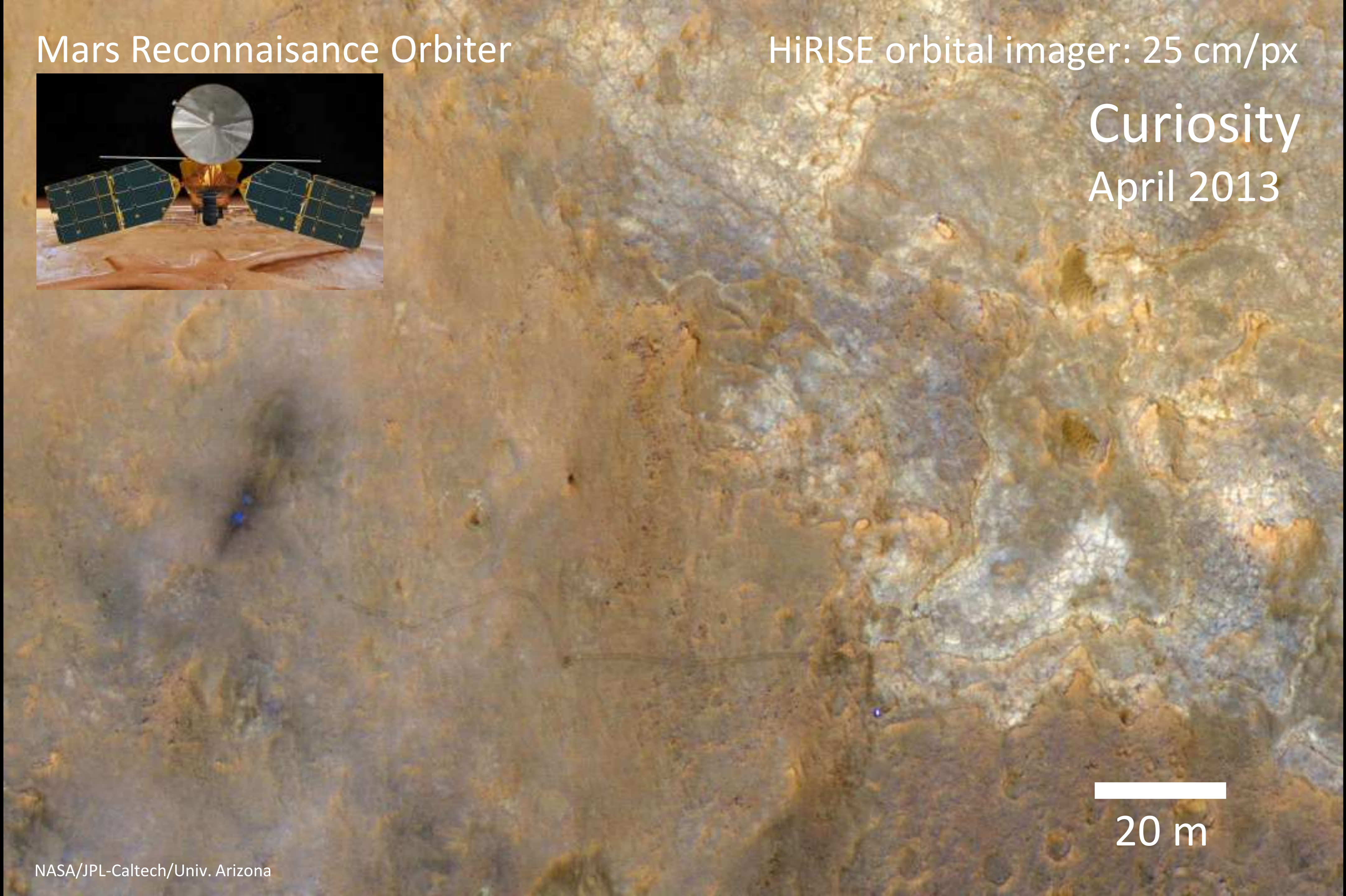


Credit: NASA/JPL

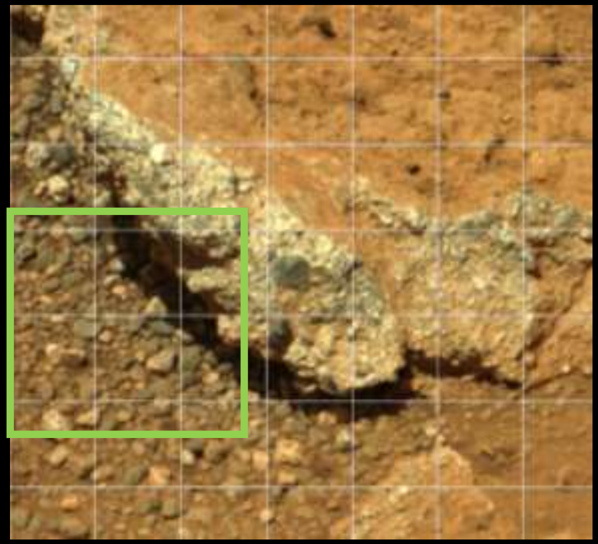
Gale crater and Mount Sharp

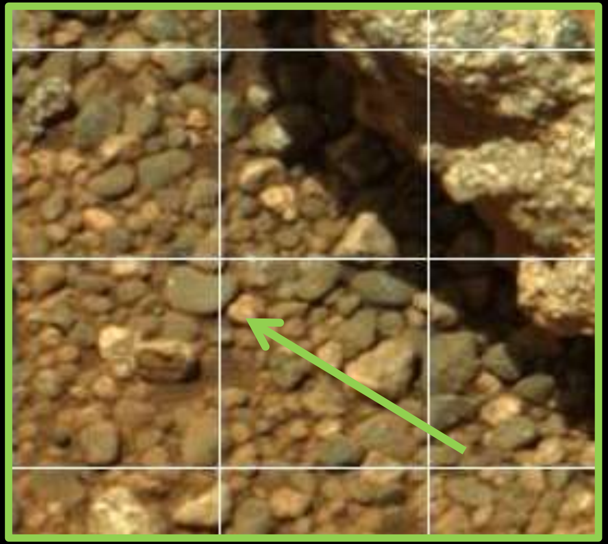


Images: DLR/Freie Universität Berlin


Mars Reconnaisance Orbiter
HiRISE orbital imager: 25 cm/px
Curiosity
April 2013
20 m
NASA/JPL-Caltech/Univ. Arizona

2012 Curiosity, Gale Crater

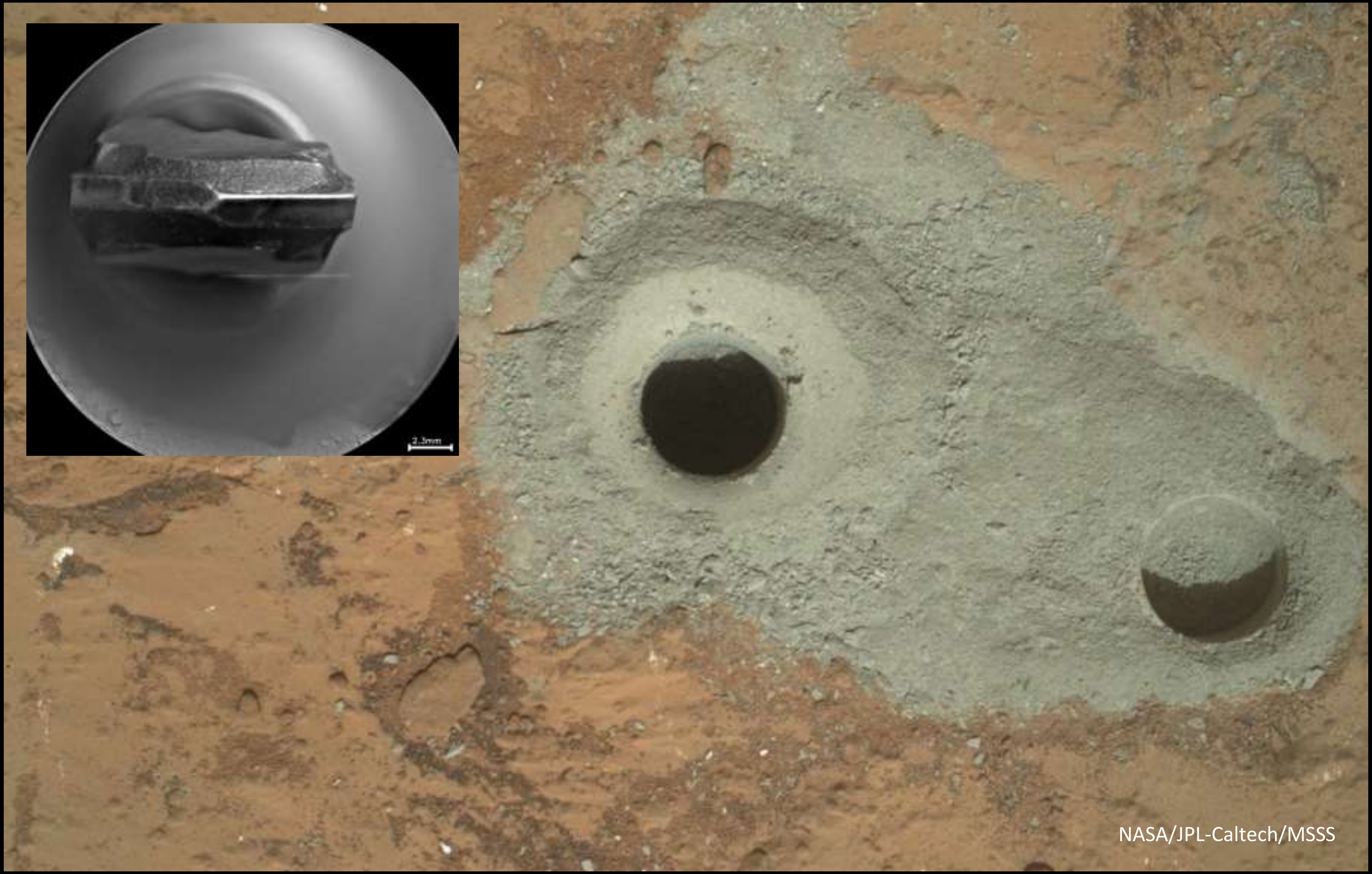




Curiosity "selfie" recorded on sol 177 by MAHLI

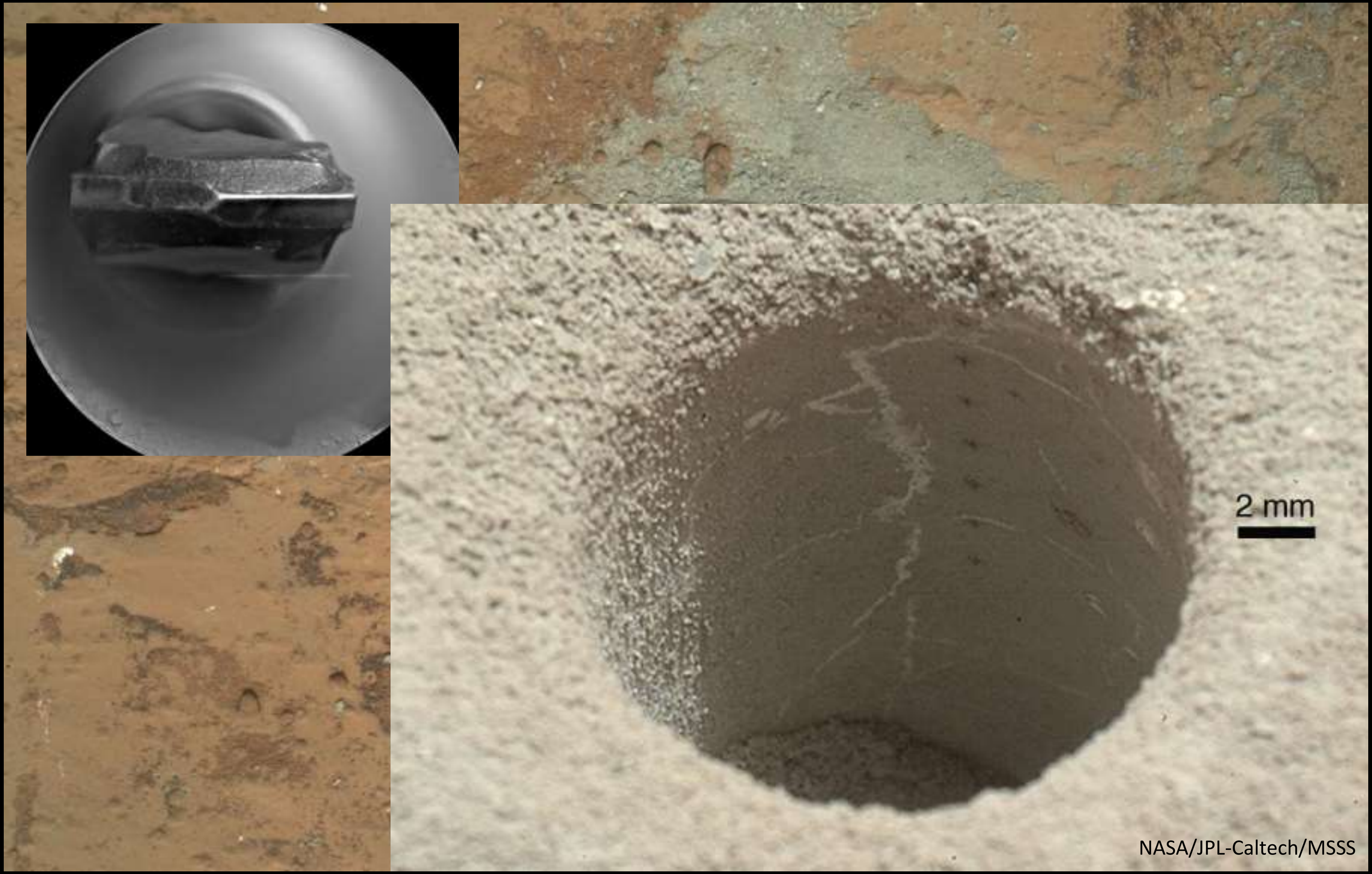
Images: NASA/JPL-Caltech/MSSS

Images: NASA/JPL-Caltech/MSSS



16 mm diameter drill holes (64 and 16 mm deep)

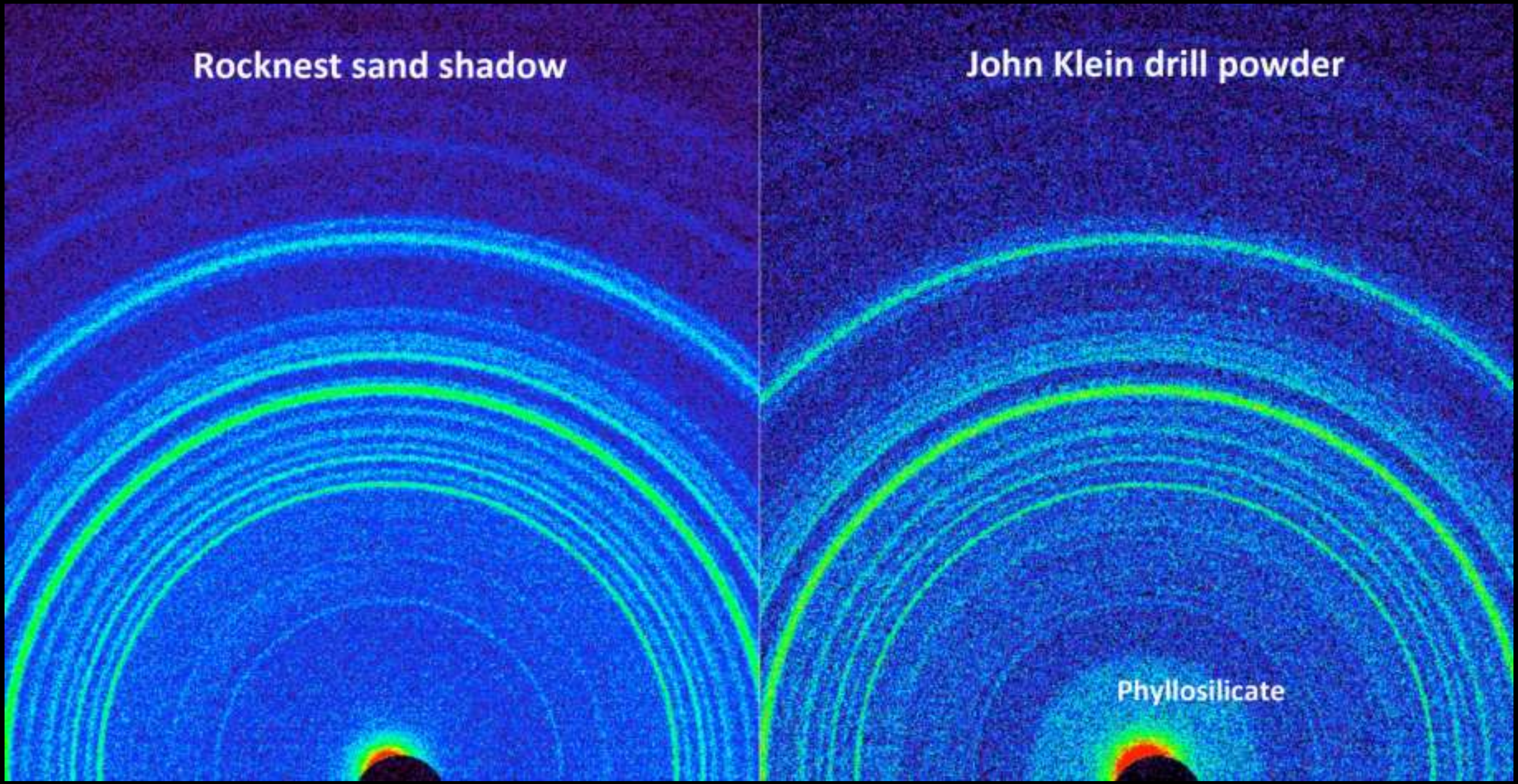
Images: NASA/JPL-Caltech/MSSS



16 mm diameter drill hole (ChemCam shot marks in wall)

Images: NASA/JPL-Caltech/MSSS/Univ. de Nantes

CheMin-results



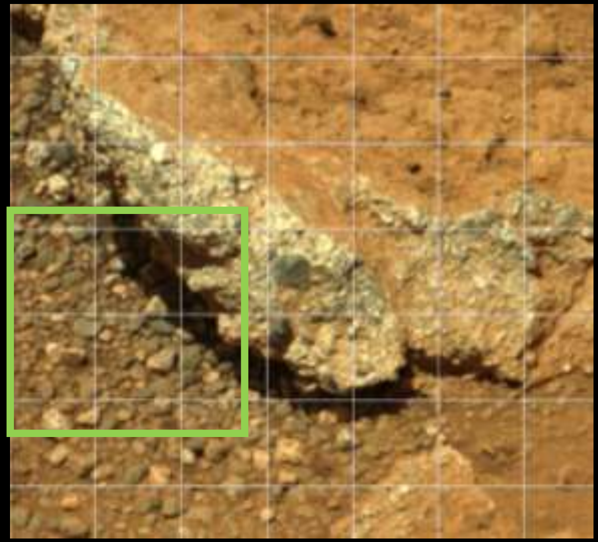
Phyllosilicates formed under neutral pH conditions.

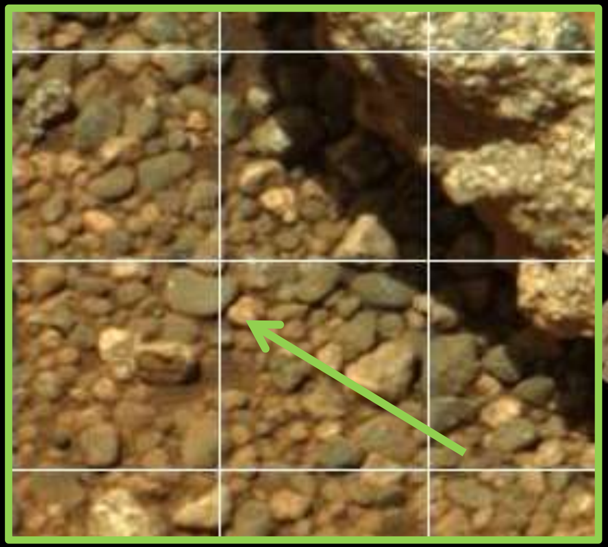
Image: NASA-AMES/JPL-Caltech

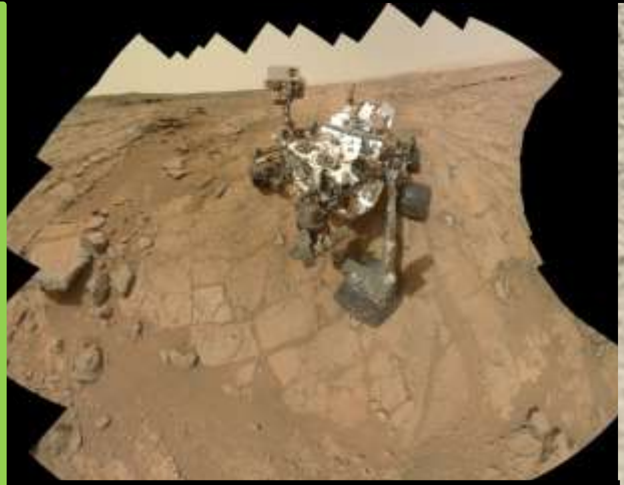
NASA's MSL Curiosity Rover, Gale Crater

Pebbles rounded by streaming water: Rivers once flowed here …
Old lake sediments of neutral pH and chlorobenzene
Intermittent lakes throughout early history of Gale crater

Mars once DID have an environment conducive for Life!







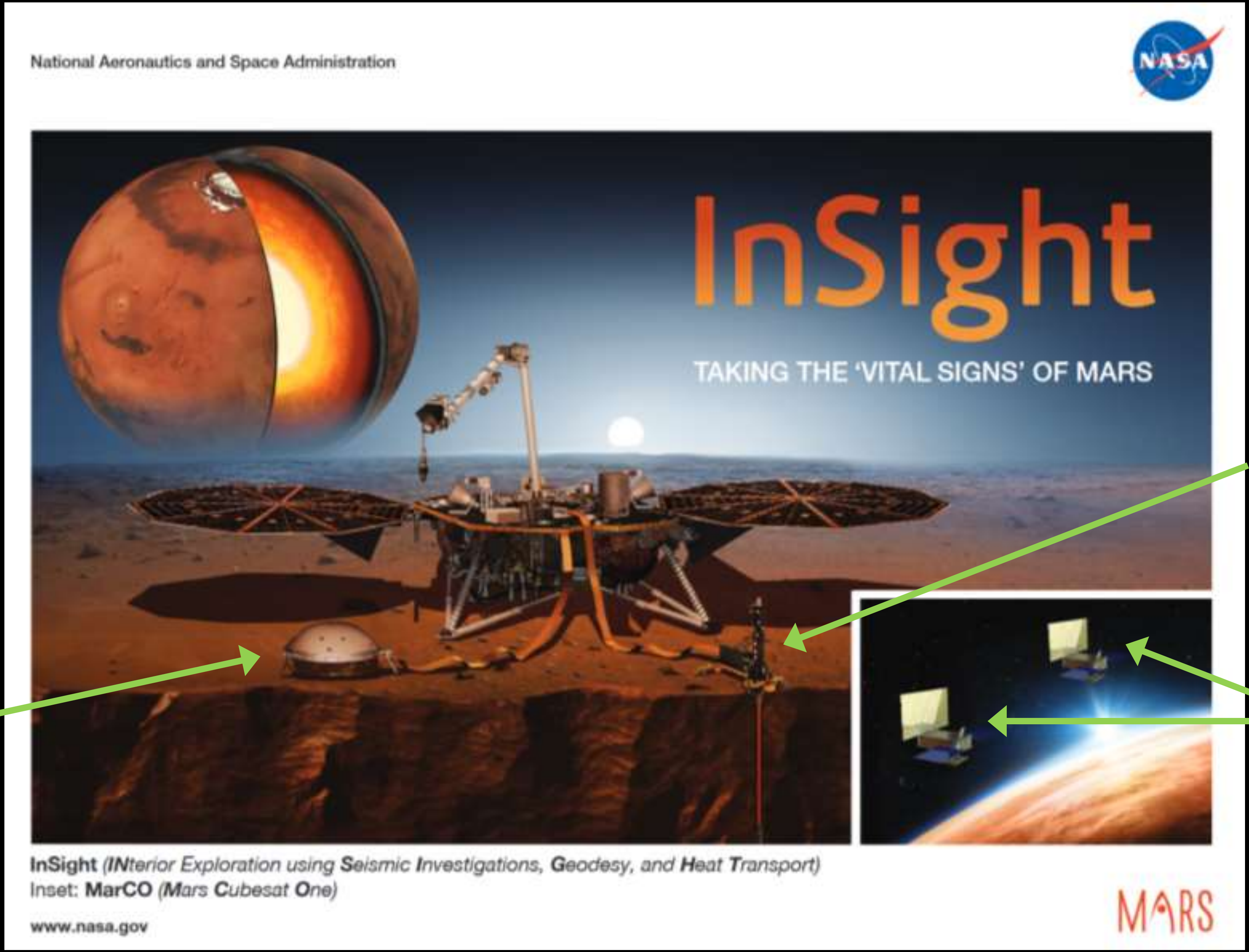
This work was supported by DFF and TICRA.

Images: NASA/JPL-Caltech, Malin Space Science Systems.

Astronomical observations using Mastcam

Phobos passing Deimos (left) – and passing by the Sun (right)

Scientific experiments on board NASA's InSight lander

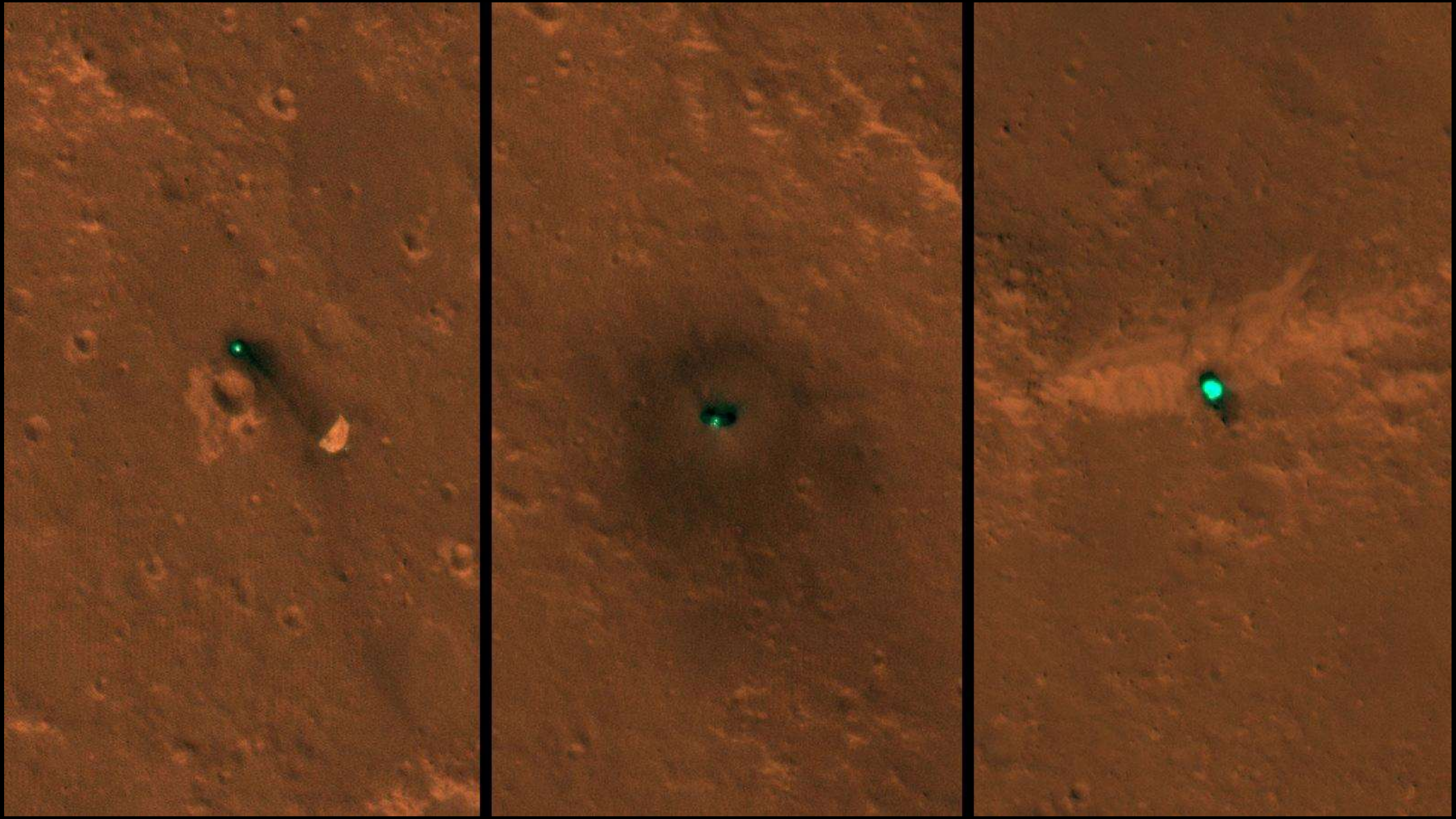


HP^3, heat-measuring probe

SEIS, Two seismometers

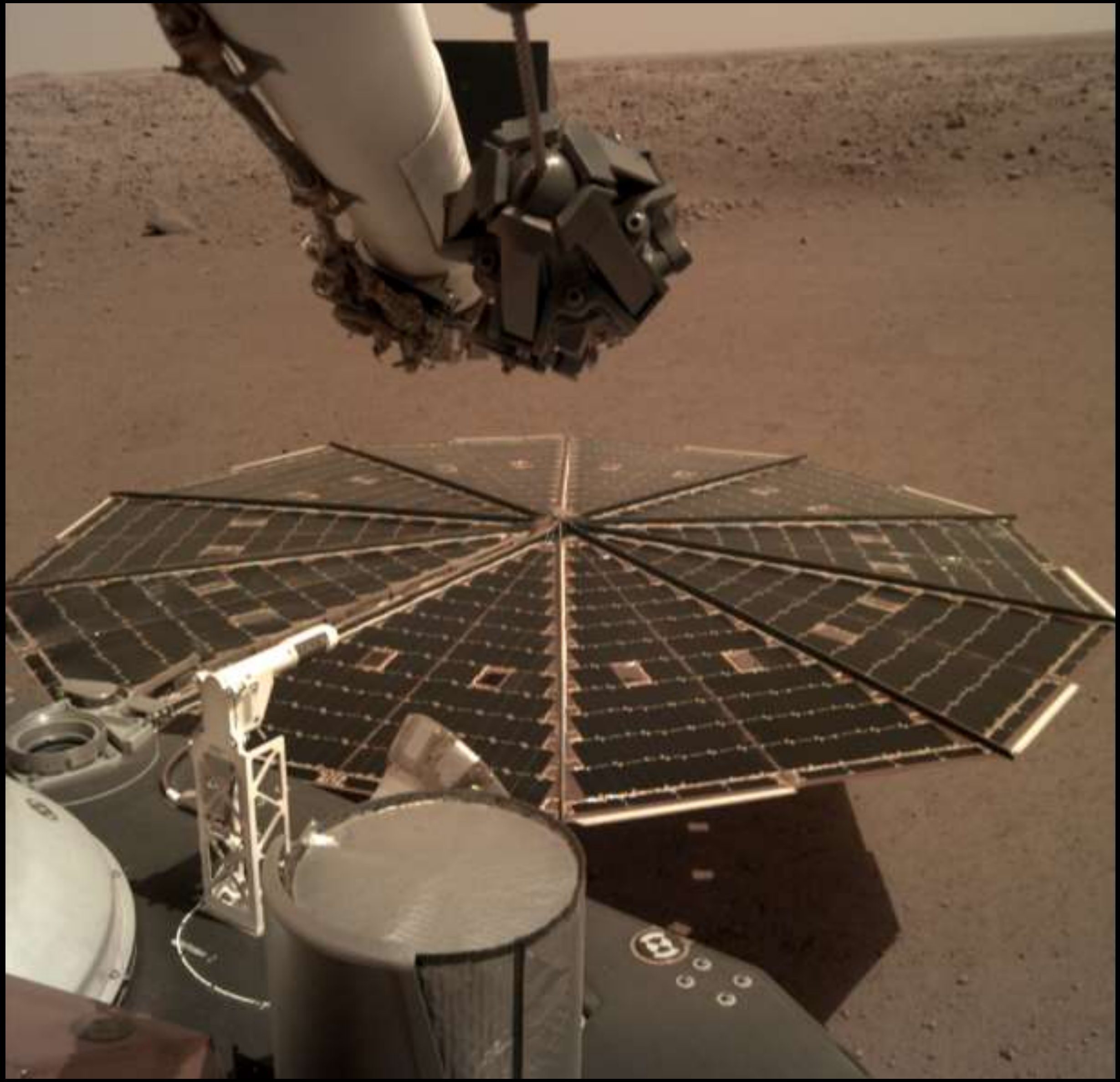
[MARCO, Two micro sattelites]

Source: NASA / JPL



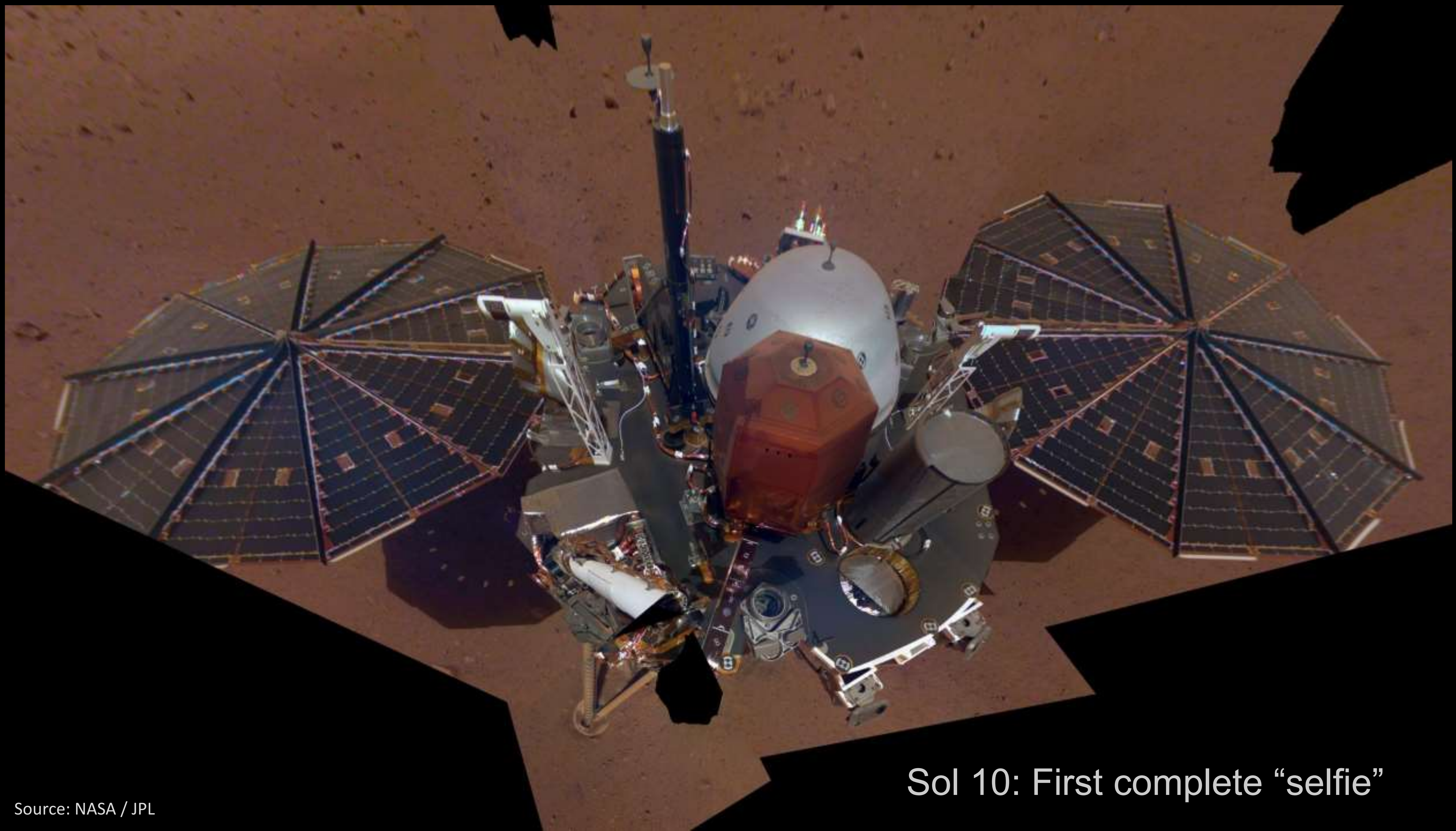
HiRISE-images of InSights landing site on Chryse Planitia, Mars

Source: NASA/JPL; Arizona State University



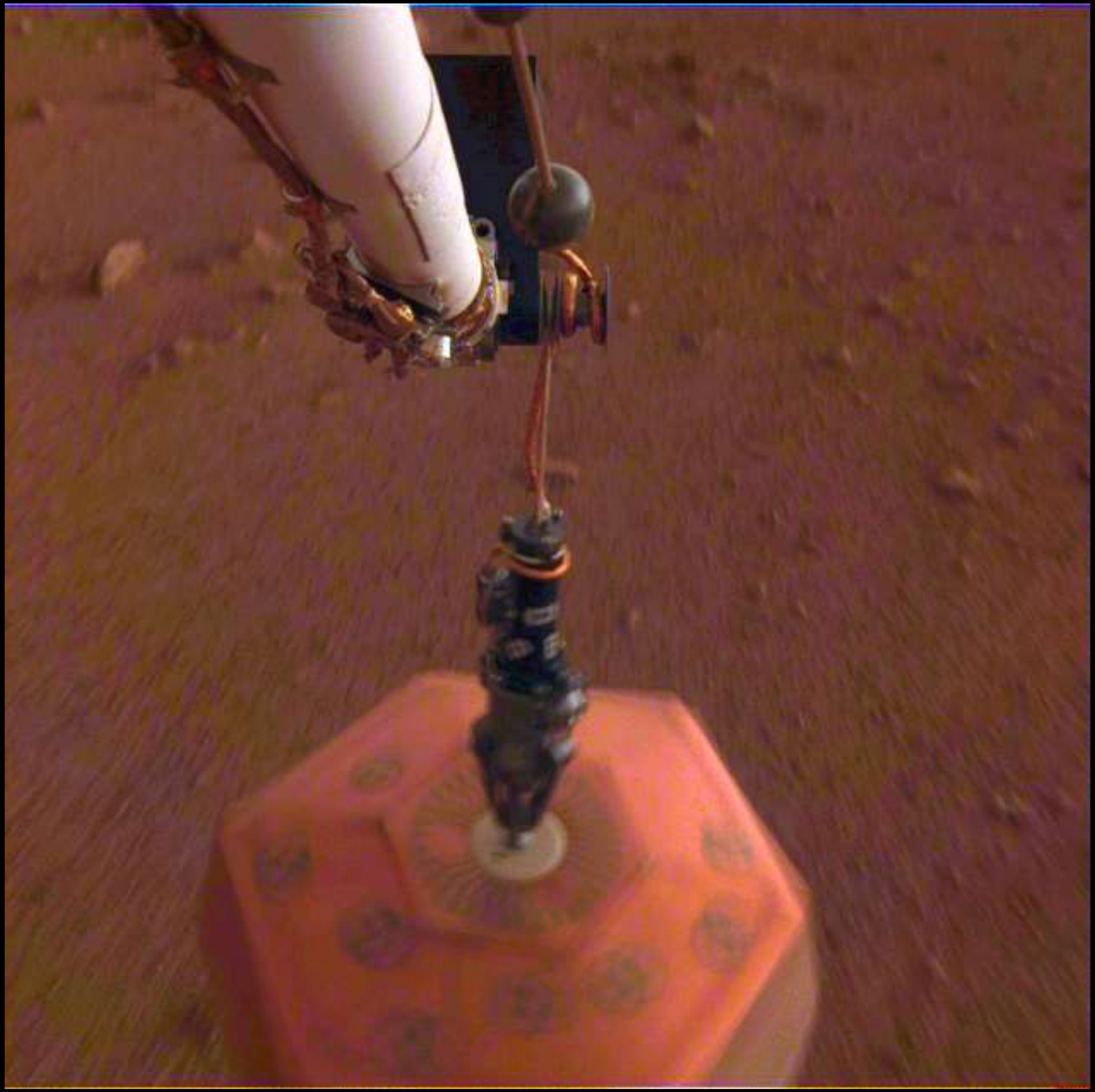
First task (automatic): Deployment of solar panels

Source: NASA / JPL



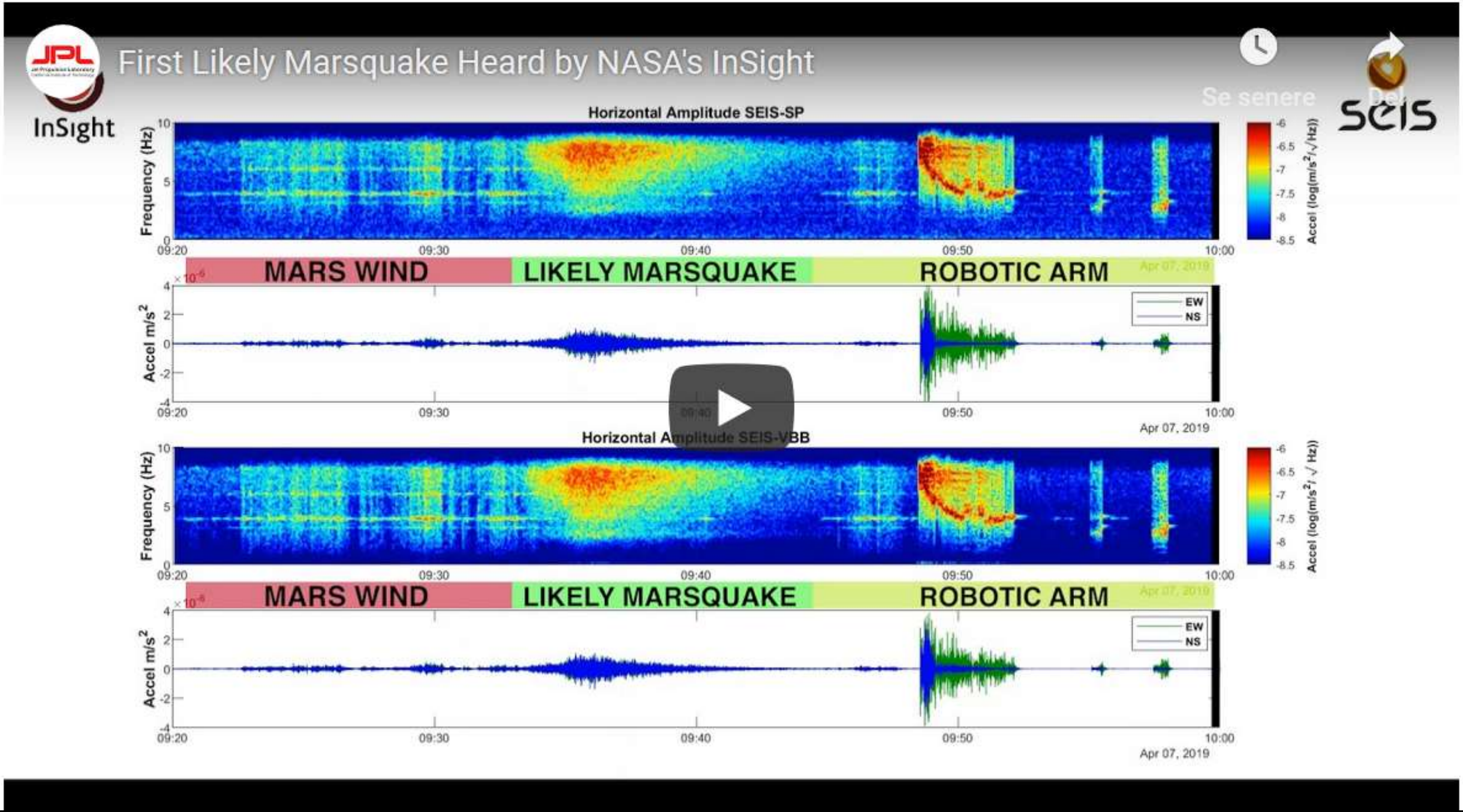
Sol 10: First complete “selfie”

Source: NASA / JPL



Deployment of seismometers on Chryse Planitia

Source: NASA / JPL

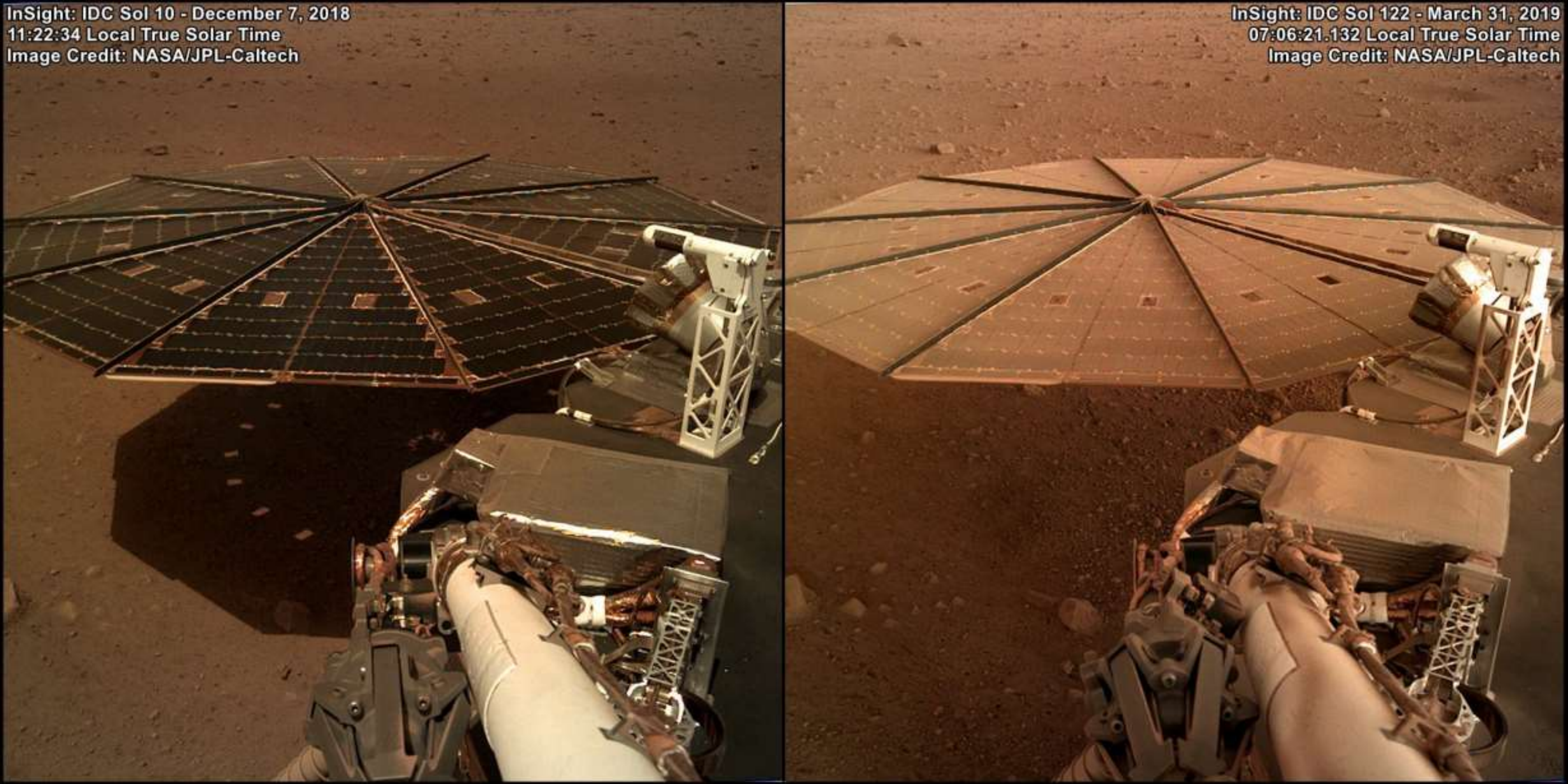


Detection of first Mars-quake, 2019-04-23

Source: NASA / JPL

First images of a cloudy sky

Source: NASA / JPL

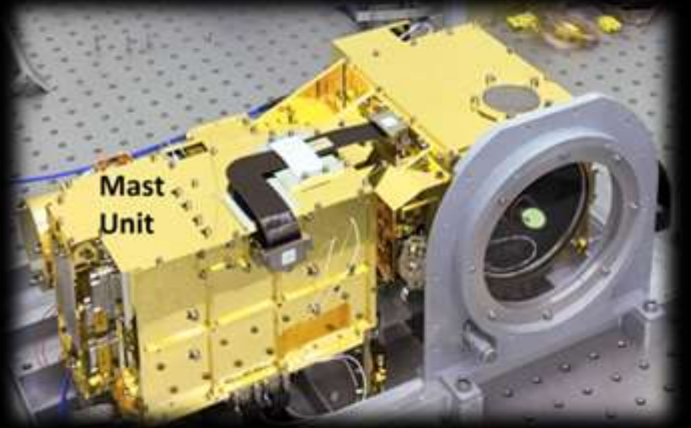


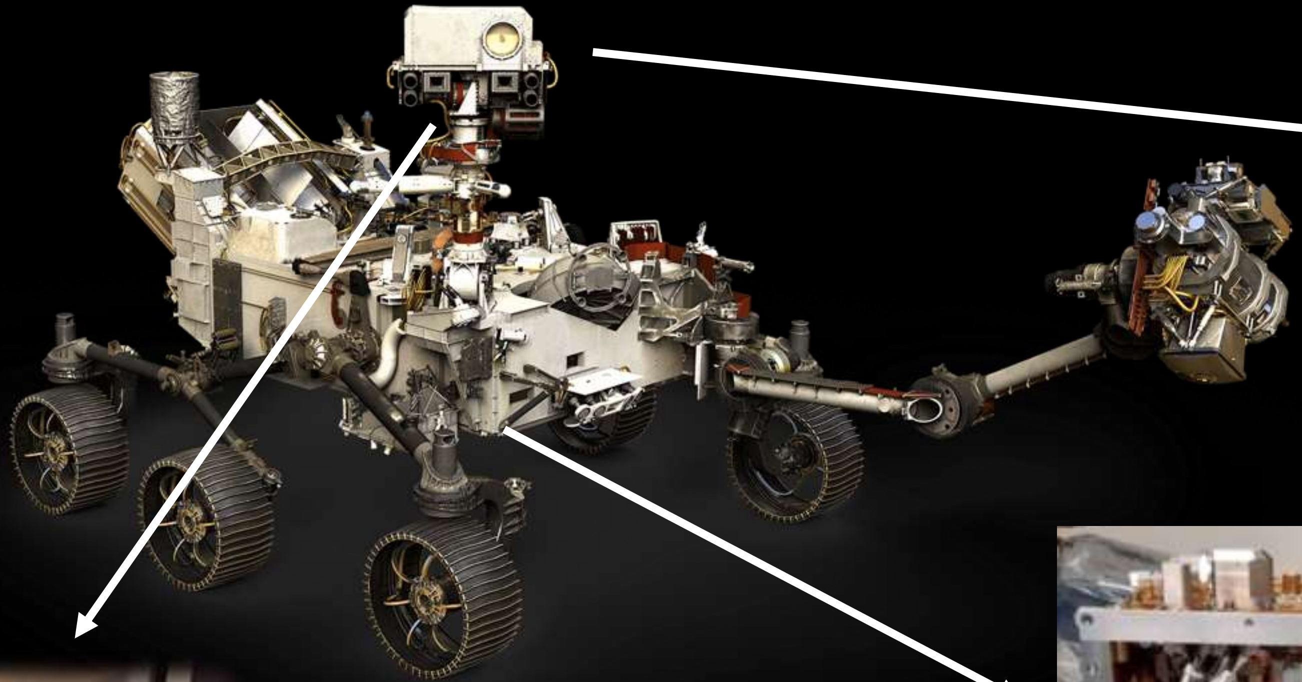
Accumulation of dust through 122 sols

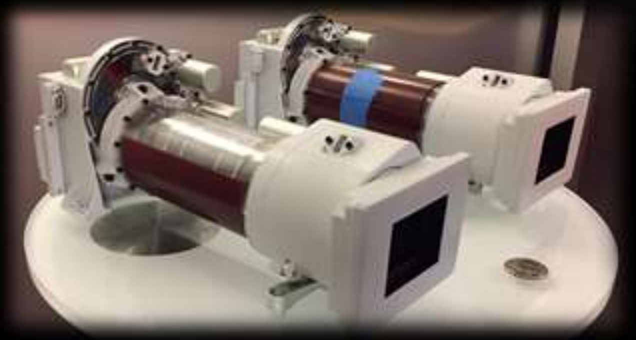
Source: NASA / JPL

University of Copenhagen has a formal association with three experiments on NASA’s Mars 2020 Rover:

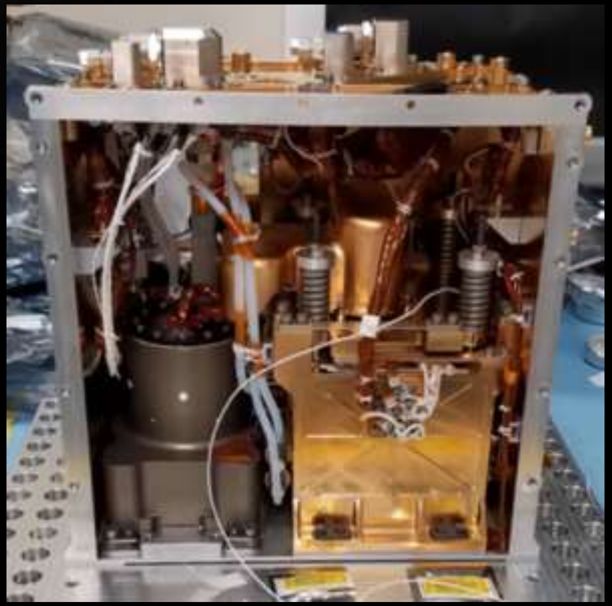
SuperCam with LIBS, ”remote microscopy”, VNIR- and Raman-spectroscopy







Mastcam-Z
with VNIR multispectral images

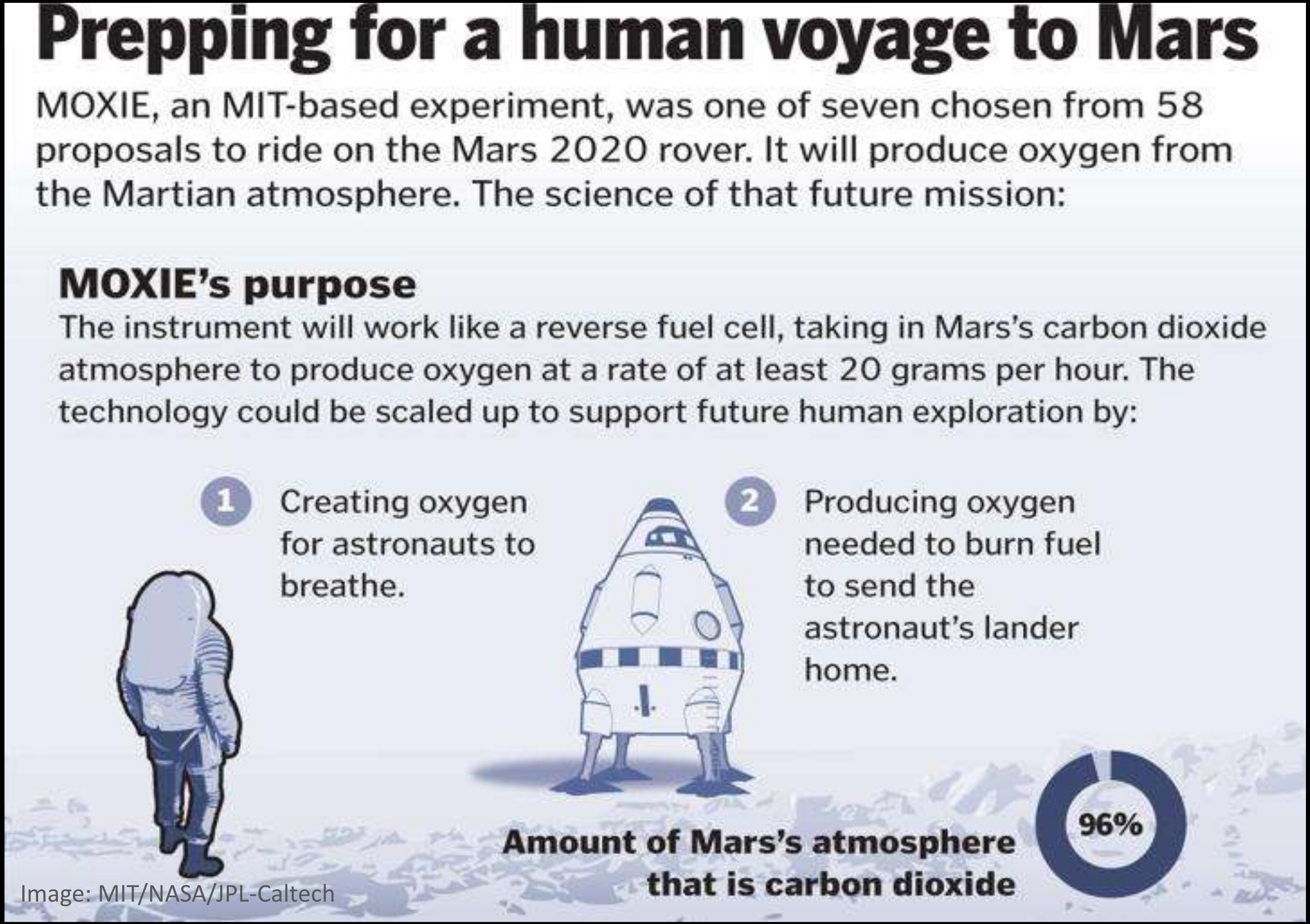


MOXIE:
Oxygen production
on Mars
by solid state
electrolysis of CO_2

Source: NASA / JPL

MOXIE will produce oxygen directly from the Mars atmosphere

MOXIE:
Contributions from USA, United Kingdom, and Denmark.
In Denmark: Chris Graves, DTU Energy and MBM, NBI, UCPH.

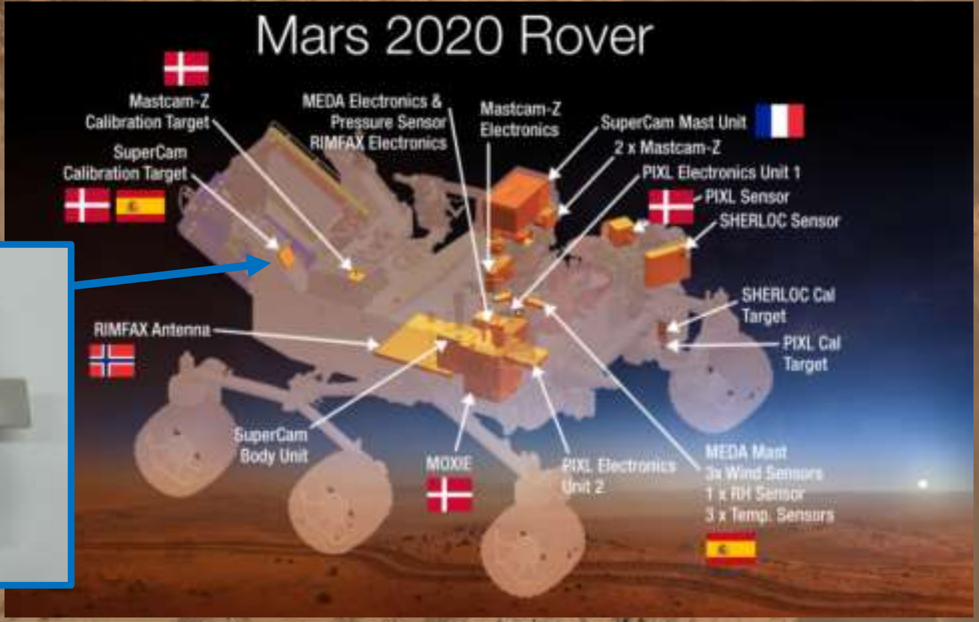


NASA's Mars 2020 Rover based on Curiosity will collect and cache samples from Mars …

We are thrilled to participate

When returned these samples will be scrutinized during decades to follow! :

SuperCam calibration target



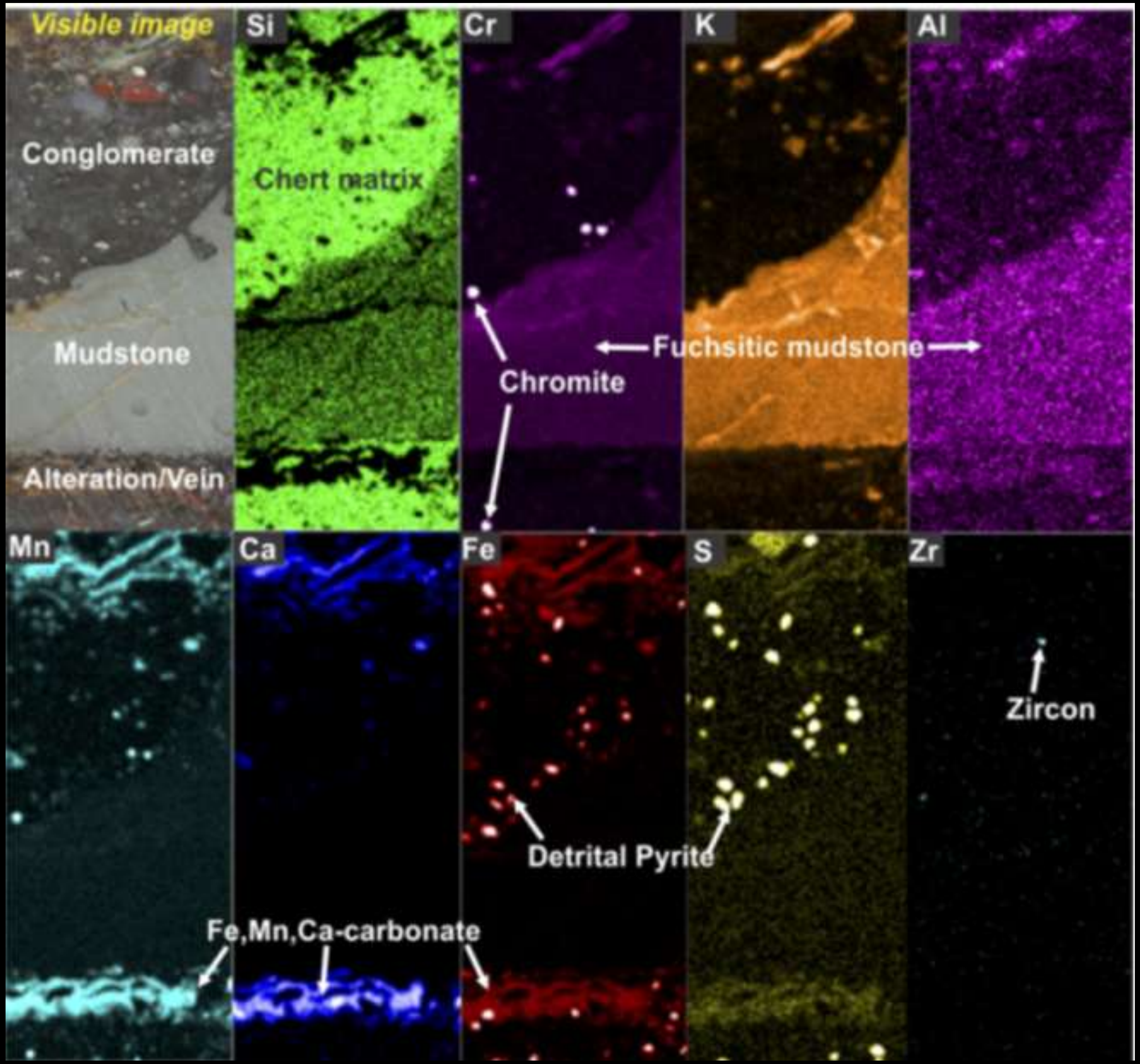
This work is supported by the CARLSBERG FOUNDATION

PIXL – Planetary Instrument for X-ray Lithochemistry – mikro-XRF

PIXL:

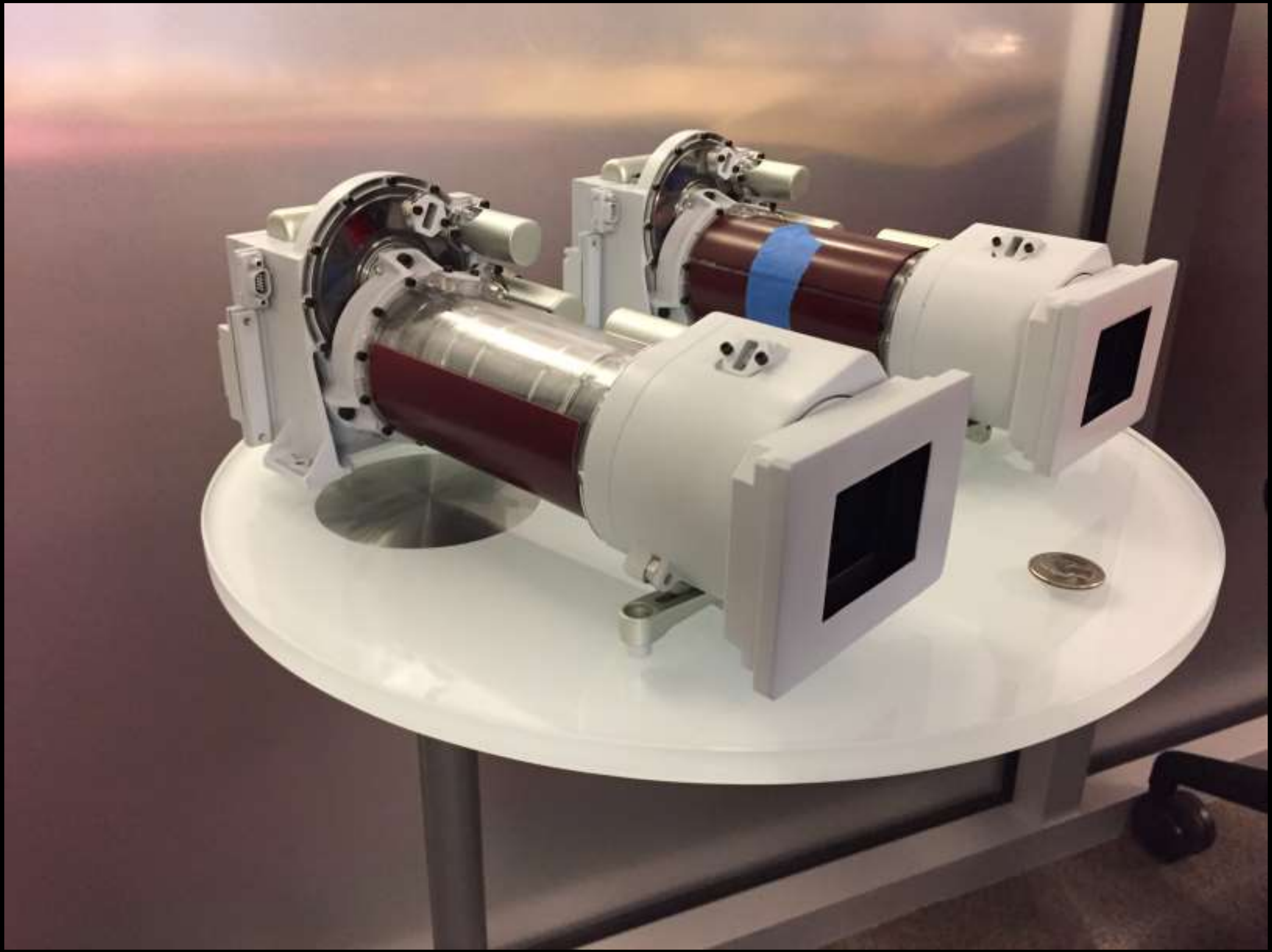
Contributions from USA, and Denmark.

In Denmark: John Leif Jørgensen, DTU Space.



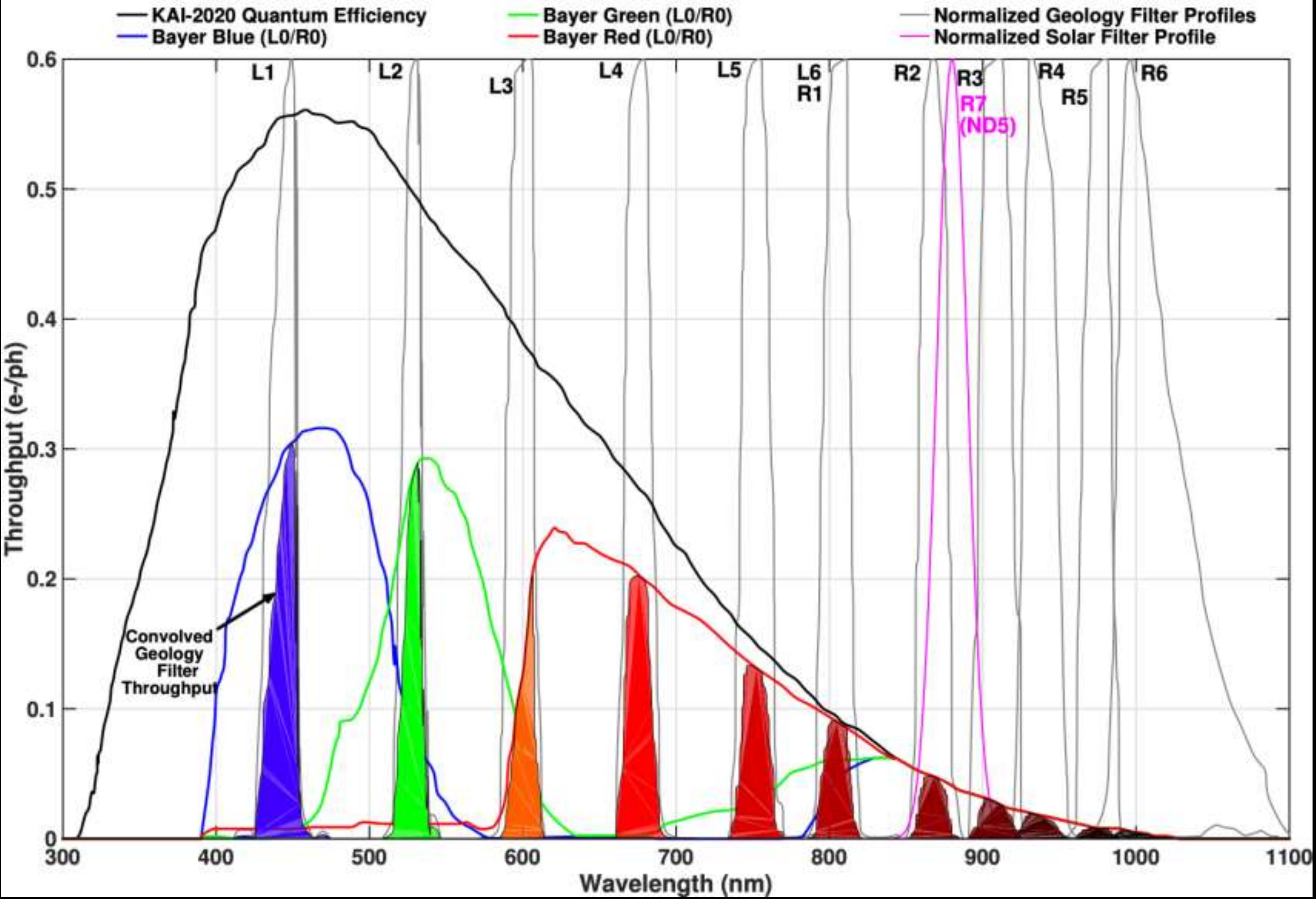
Source: NASA / JPL

Mastcam-Z stereo camera with multispectral sensitivity



Source: NASA/JPL; Arizona State University

Mastcam-Z stereo camera with multispectral sensitivity



Source: NASA/JPL; Arizona State University

Flight units of radiometric calibration targets for Mastcam-Z were received at JPL on 2019-05-20

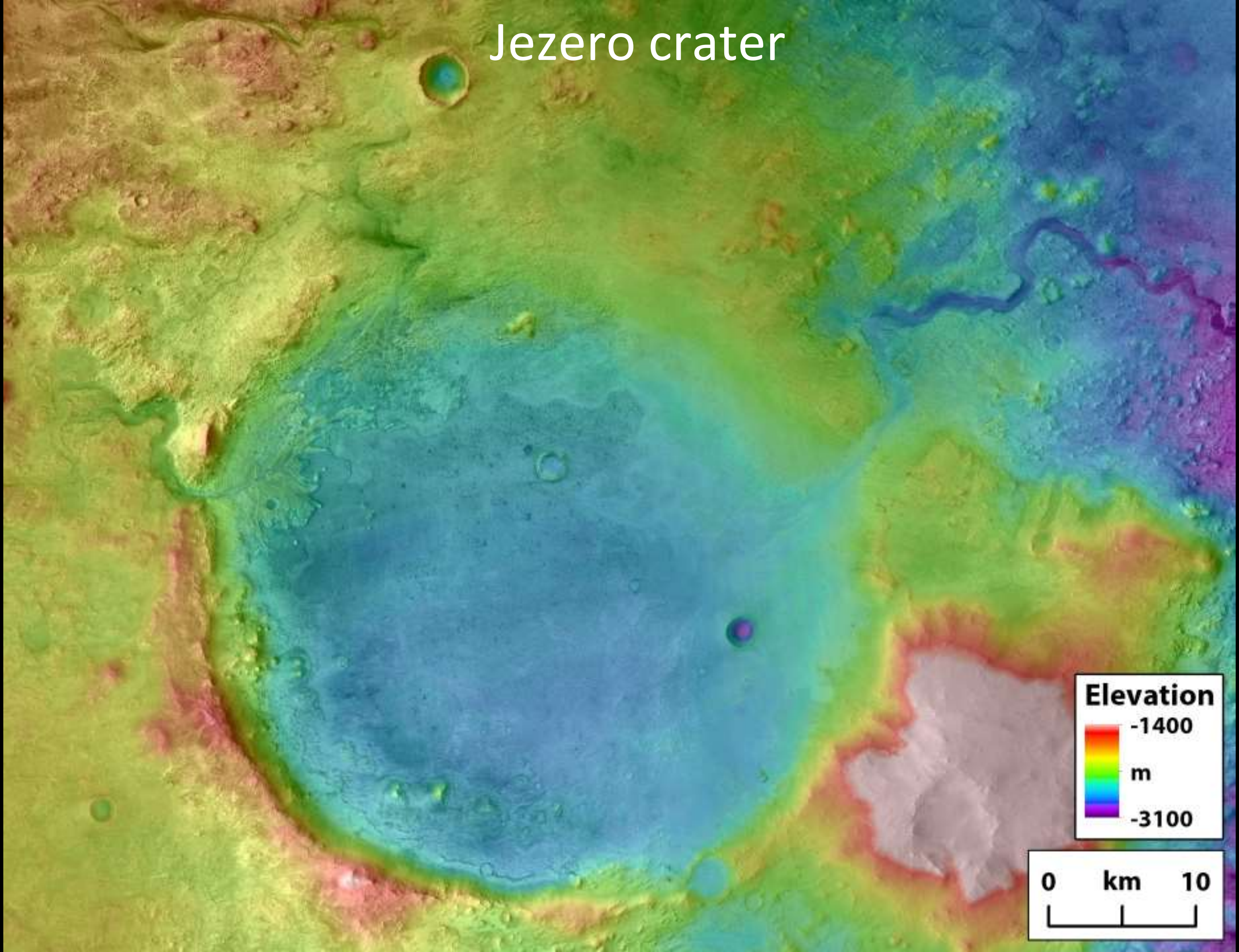
MASTCAM
Z
MARS 2020 ROVER

Source: NBI/UCPH; NASA/JPL; Arizona State University

Rocknest & Rocknest small dune (Curiosity)

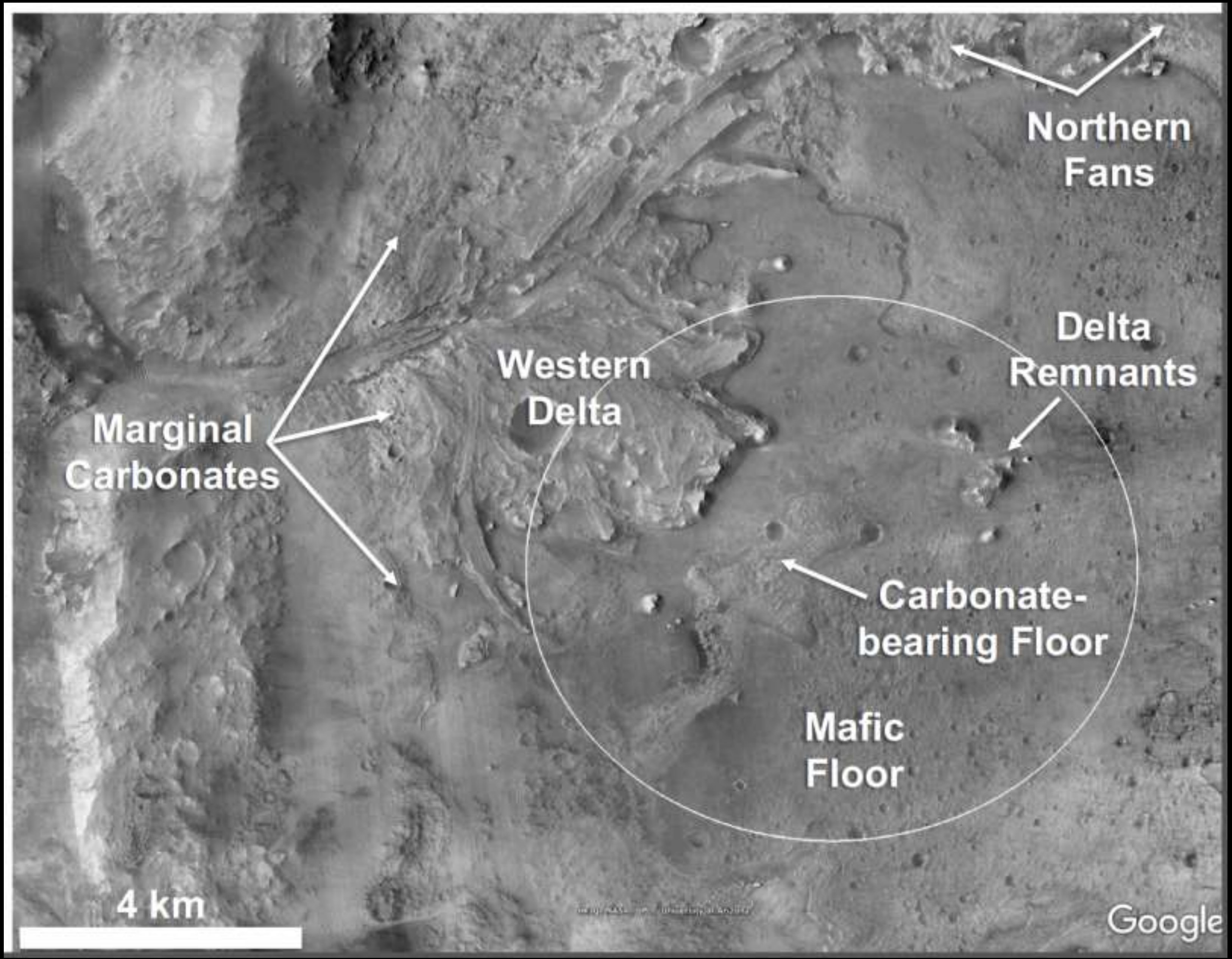
Source: NASA/JPL; Malin Space Science Systems

Jezero crater



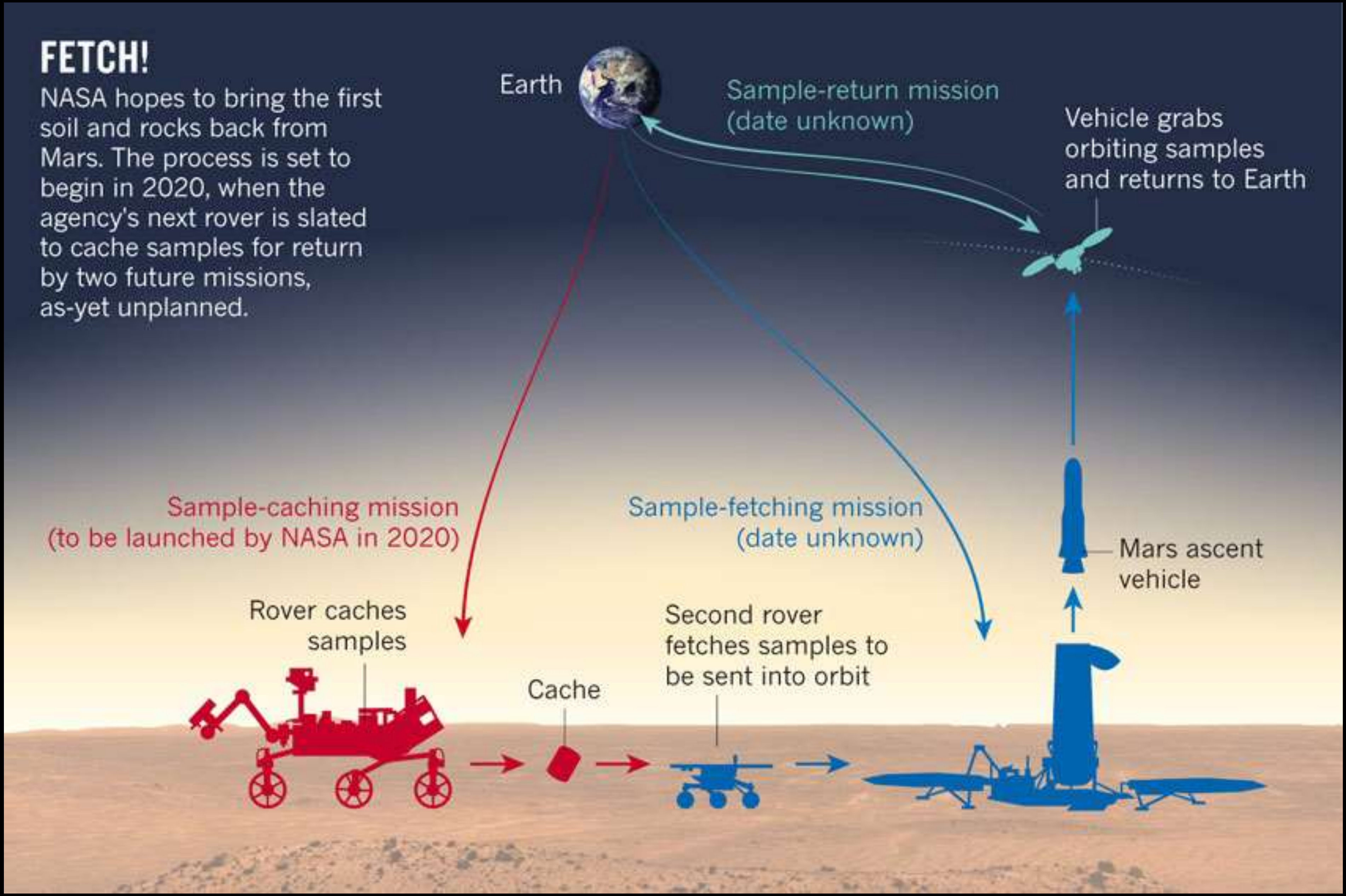
Source: NASA/JPL

Jezero: Planning of the mission



Source: NASA/JPL

Fetching the cached samples



Source: NASA/JPL

2018-04-26 a ”Statement of Intent” was signed – about NASA and ESA together – fetching the collected samples!

Joint Statement of Intent between the National Aeronautics and Space Administration and the European Space Agency on Mars Sample Return

April 26, 2018

Pursuant to the highest objectives established by the international scientific community for planetary science, the National Aeronautics and Space Administration (NASA), and the European Space Agency (ESA), expressed a mutual interest in pursuing cooperation on Mars sample return activities through the signature of a 2008 Agreement addressing potential cooperation on future space exploration sample return activities that extends through December 31, 2020;

Recognizing that NASA and ESA continue sharing the common objective of together preparing and launching a set of complementary missions by the end of the next decade that would return samples from Mars to Earth for scientific research;

Recognizing that both agencies are implementing missions and conducting preparatory activities which will contribute to the realisation of a Martian sample return mission, including the NASA Mars 2020 mission that will cache samples for return to Earth and the ESA-Roscosmos Trace Gas Orbiter and ExoMars missions that will expand ESA's operational experience at Mars;

Recognizing that the 2016 ESA Council meeting at the Ministerial level mandated that ESA prepare for the next ESA Mars mission, considering European participation in an international Mars Sample Return (MSR) mission as a key objective;

Recognizing NASA and ESA's mutual objective to collaborate on a joint MSR endeavor potentially based on a reference architecture under consideration whereby NASA would lead a MSR campaign as the systems architect and lead an MSR Lander (SRL) mission, and ESA would lead a MSR Orbiter mission and provide the Sample Fetch Rover and the Sample Transfer Arm to the SRL mission and NASA would provide the Sample Capture, Handling, and Containment system and the Earth Entry Vehicle to the MSR Orbiter; this endeavor may be in concert with other international or commercial partners;

NASA and ESA intend to develop a joint MSR plan and to complete the studies needed to reach the level of technical and programmatic maturity required to pursue an effective MSR partnership, specifically defining the respective roles and responsibilities sufficient to lead to an international agreement between the two agencies in time to be submitted for approval to their respective authorities at the end of 2019.

Thomas Zurbuchen **Associate Administrator** **for Science** **NASA**	**David Parker** **Director** **Human and Robotic Exploration** **Programmes** **ESA**

Contact-information and links:
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Most recent update: 2019-01-12

http://mars.nasa.gov/mars2020/ Everything available on NASA's 2020 Mars rover

https://mars.nasa.gov/insight/ Om NASA's InSight-mission (opsendelse 5. maj 2018)

https://mars.nasa.gov/insight/multimedia/raw-images Rå (”friske”) billeder

http://mars.jpl.nasa.gov/msl/news/whatsnew/ Curiosity news
http://mars.jpl.nasa.gov/msl/multimedia/raw/?s= Raw (”fresh”) images
http://mars.jpl.nasa.gov/mars3d/ (not only MSL) Mars 3D-images
phoenix.lpl.arizona.edu NASA's Phoenix Mars Lander
marsrovers.jpl.nasa.gov Mars Exploration Rovers (Spirit and Opportunity)

Other useful links:
www.nasa.gov/mars General link for NASA's Mars-missions
www.nbi.ku.dk/mars Mars-group at the NBI
www.marslab.dk Mars Simulation Laboratory, Aarhus University

http://exploration.esa.int/mars/48088-mission-overview/ ExoMars 2020 Rover & Surface Platform
http://exploration.esa.int/mars/ ESA's Robotic Exploration of Mars
http://www.esa.int/SPECIALS/Mars_Express/index.html ESA's Mars mission Mars Express

http://rosetta.esa.int/ ESA's Comet rendezvous & landing mission Rosetta

https://en.wikipedia.org/wiki/Third-party_evidence_for_Apollo_Moon_landings
www.copenhagensuborbitals.com A private Danish space project