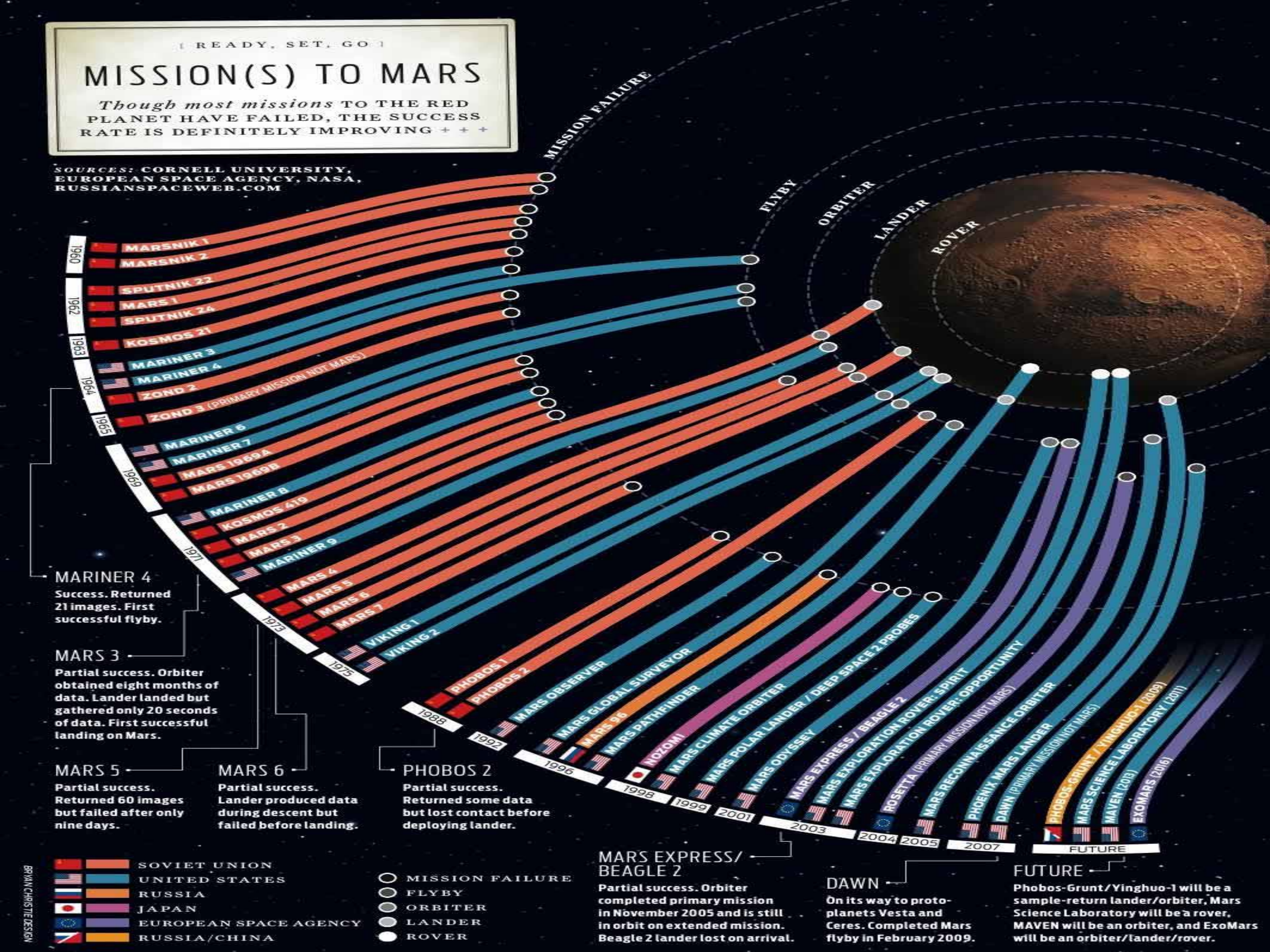
Exploration of Mars by the European Space Agency

Alejandro Cardesín
ESA Science Operations
Mars Express, ExoMars 2016

IAC Winter School, November 2016

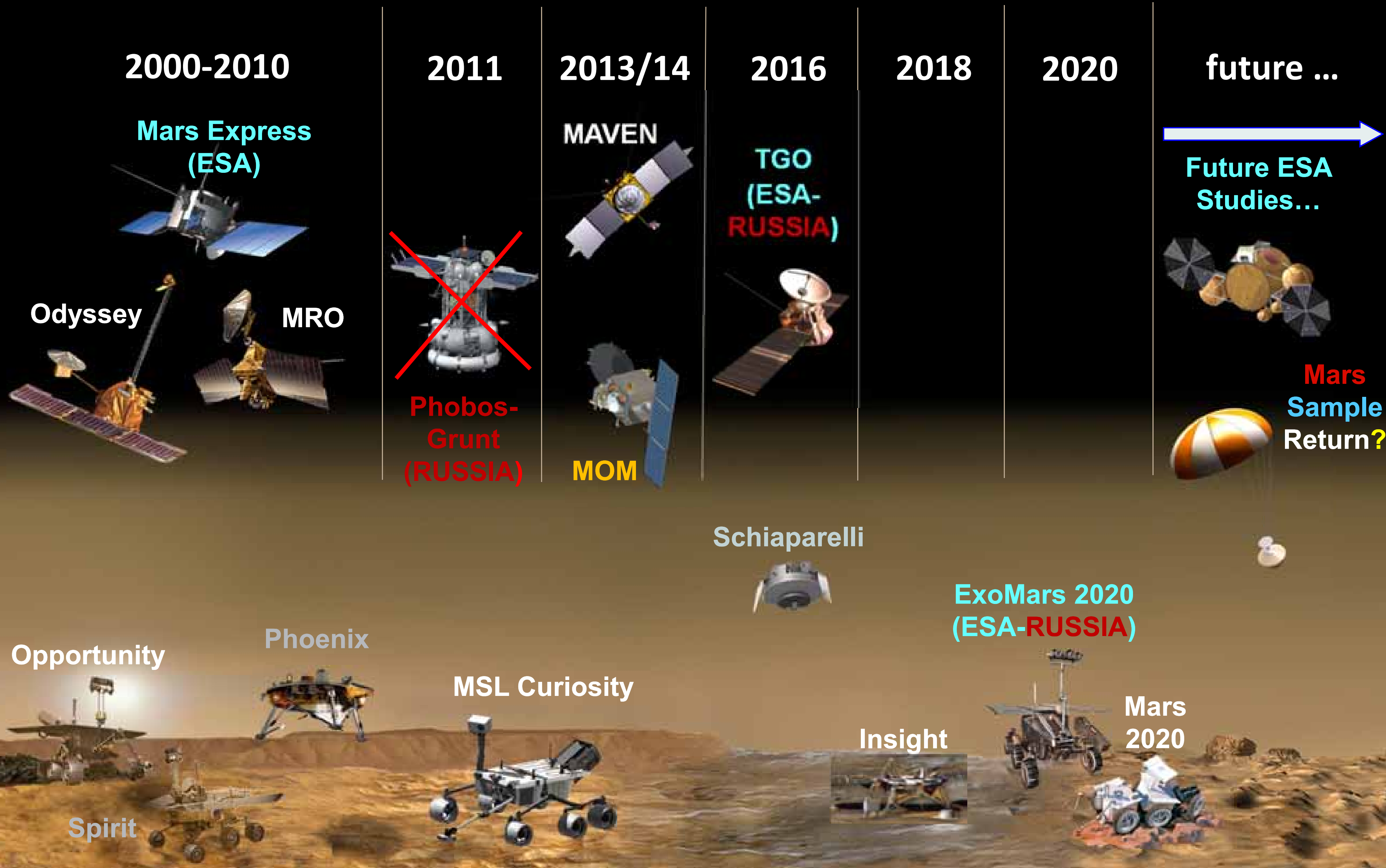
Mars Exploration Missions

European Space Agency



{ READY, SET, GO }
MISSION(S) TO MARS
Though most missions TO THE RED PLANET HAVE FAILED, THE SUCCESS RATE IS DEFINITELY IMPROVING + + +
SOURCES: CORNELL UNIVERSITY, EUROPEAN SPACE AGENCY, NASA, RUSSIANSPACEWEB.COM
MISSION FAILURE
FLYBY
ORBITER
LANDER
ROVER
1960
MARSNIK 1
MARSNIK 2
1962
SPUTNIK 22
MARS 1
SPUTNIK 24
1963
KOSMOS 21
1964
MARINER 3
MARINER 4
ZOND 2
1965
ZOND 3 (PRIMARY MISSION NOT MARS)
1969
MARINER 6
MARINER 7
MARS 1969A
MARS 1969B
1971
MARINER 8
KOSMOS 419
MARS 2
MARS 3
MARINER 9
1973
MARS 4
MARS 5
MARS 6
MARS 7
1975
VIKING 1
VIKING 2
1988
PHOBOS 1
PHOBOS 2
1992
MARS OBSERVER
1996
MARS GLOBAL SURVEYOR
MARS 96
MARS PATHFINDER
1998
NOZOMI
MARS CLIMATE ORBITER
1999
MARS POLAR LANDER / DEEP SPACE 2 PROBES
2001
MARS ODYSSEY
2003
MARS EXPRESS / BEAGLE 2
MARS EXPLORATION ROVER: SPIRIT
MARS EXPLORATION ROVER: OPPORTUNITY
2004
ROSETTA (PRIMARY MISSION NOT MARS)
2005
MARS RECONNAISSANCE ORBITER
2007
PHOENIX MARS LANDER
DAWN (PRIMARY MISSION NOT MARS)
FUTURE
PHOBOS-GRUNT / YINGHUO-1 (2009)
MARS SCIENCE LABORATORY (2011)
MAVEN (2013)
EXOMARS (2016)
MARINER 4
Success. Returned 21 images. First successful flyby.
MARS 3
Partial success. Orbiter obtained eight months of data. Lander landed but gathered only 20 seconds of data. First successful landing on Mars.
MARS 5
Partial success. Returned 60 images but failed after only nine days.
MARS 6
Partial success. Lander produced data during descent but failed before landing.
PHOBOS 2
Partial success. Returned some data but lost contact before deploying lander.
MARS EXPRESS/ BEAGLE 2
Partial success. Orbiter completed primary mission in November 2005 and is still in orbit on extended mission. Beagle 2 lander lost on arrival.
DAWN
On its way to protoplanets Vesta and Ceres. Completed Mars flyby in February 2009.
FUTURE
Phobos-Grunt/Yinghuo-1 will be a sample-return lander/orbiter, Mars Science Laboratory will be a rover, MAVEN will be an orbiter, and ExoMars will be an orbiter/lander/rover.
SOVIET UNION
UNITED STATES
RUSSIA
JAPAN
EUROPEAN SPACE AGENCY
RUSSIA/CHINA
MISSION FAILURE
FLYBY
ORBITER
LANDER
ROVER
BRYAN CHRISTIE DESIGN

Mars Exploration nowadays…



Mars Express 2003-2016 …

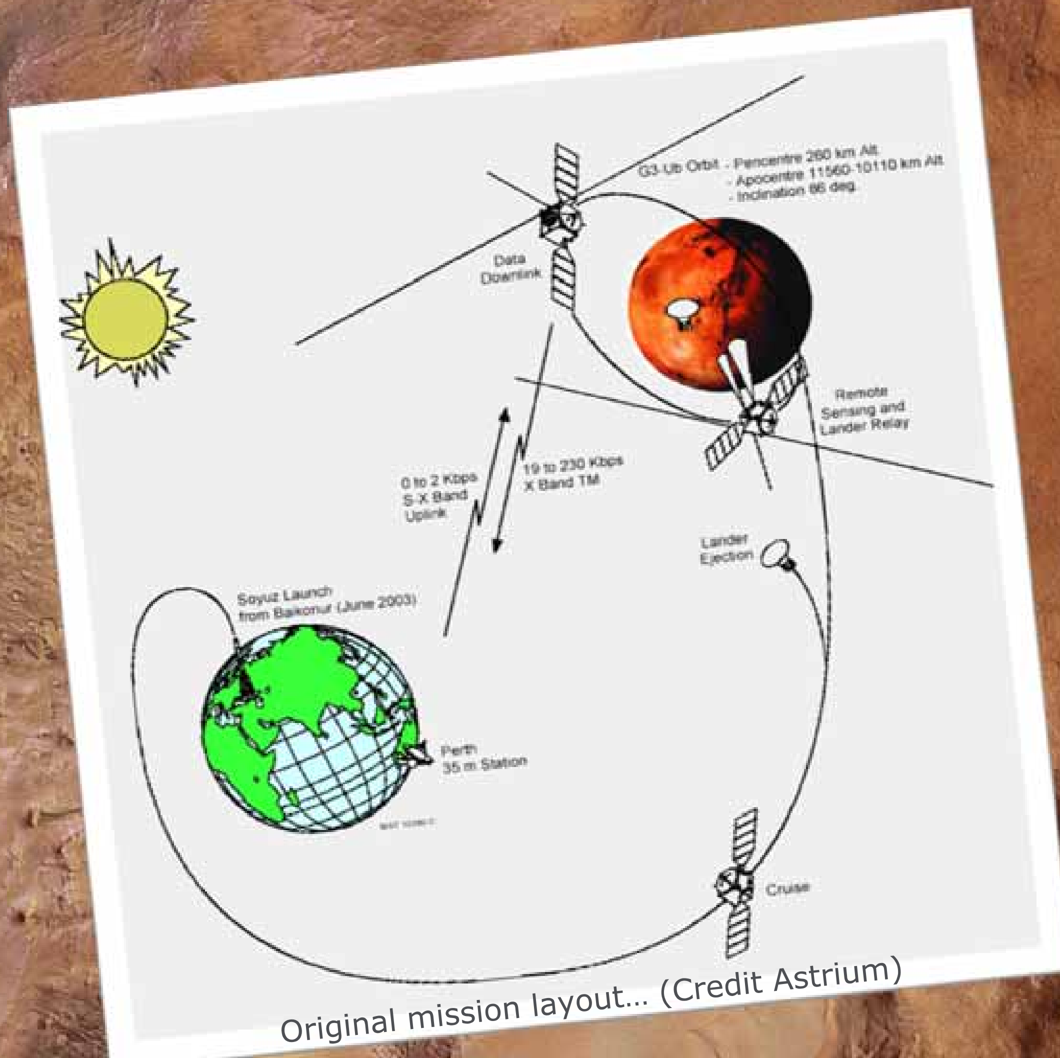
First European Mission to orbit another Planet!

First mission of the “Rosetta family”

Up and running since 2003

First European Mission to orbit another Planet
First European attempt to land on another Planet

Original mission concept

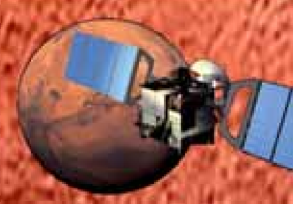


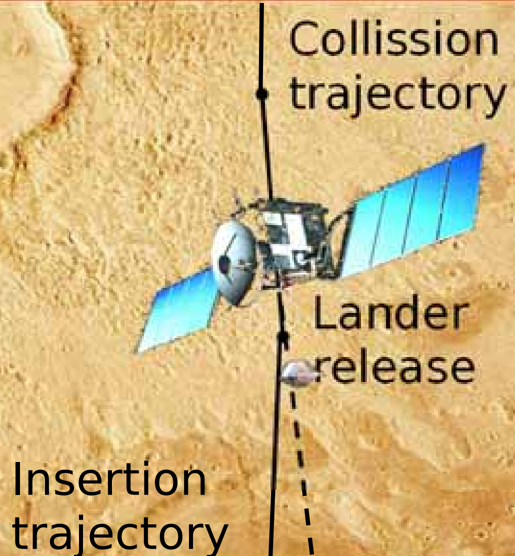
Original mission layout… (Credit Astrium)

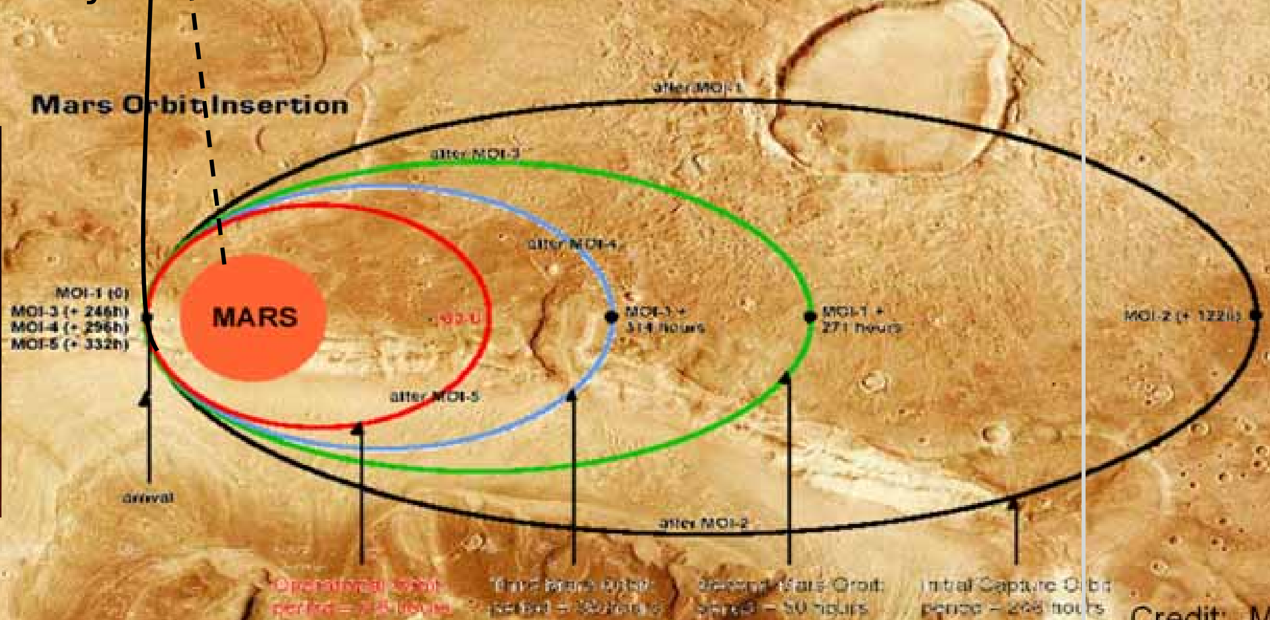
Credit: MEX/HRSC

N → 20 km

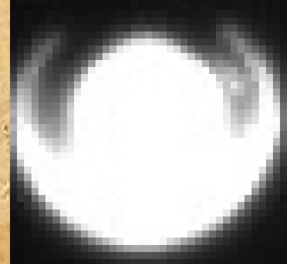
December 2003: Mars Express Lander Release and Orbit Insertion



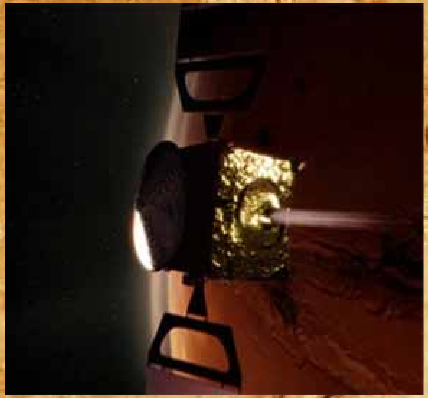




Bye bye Beagle 2!



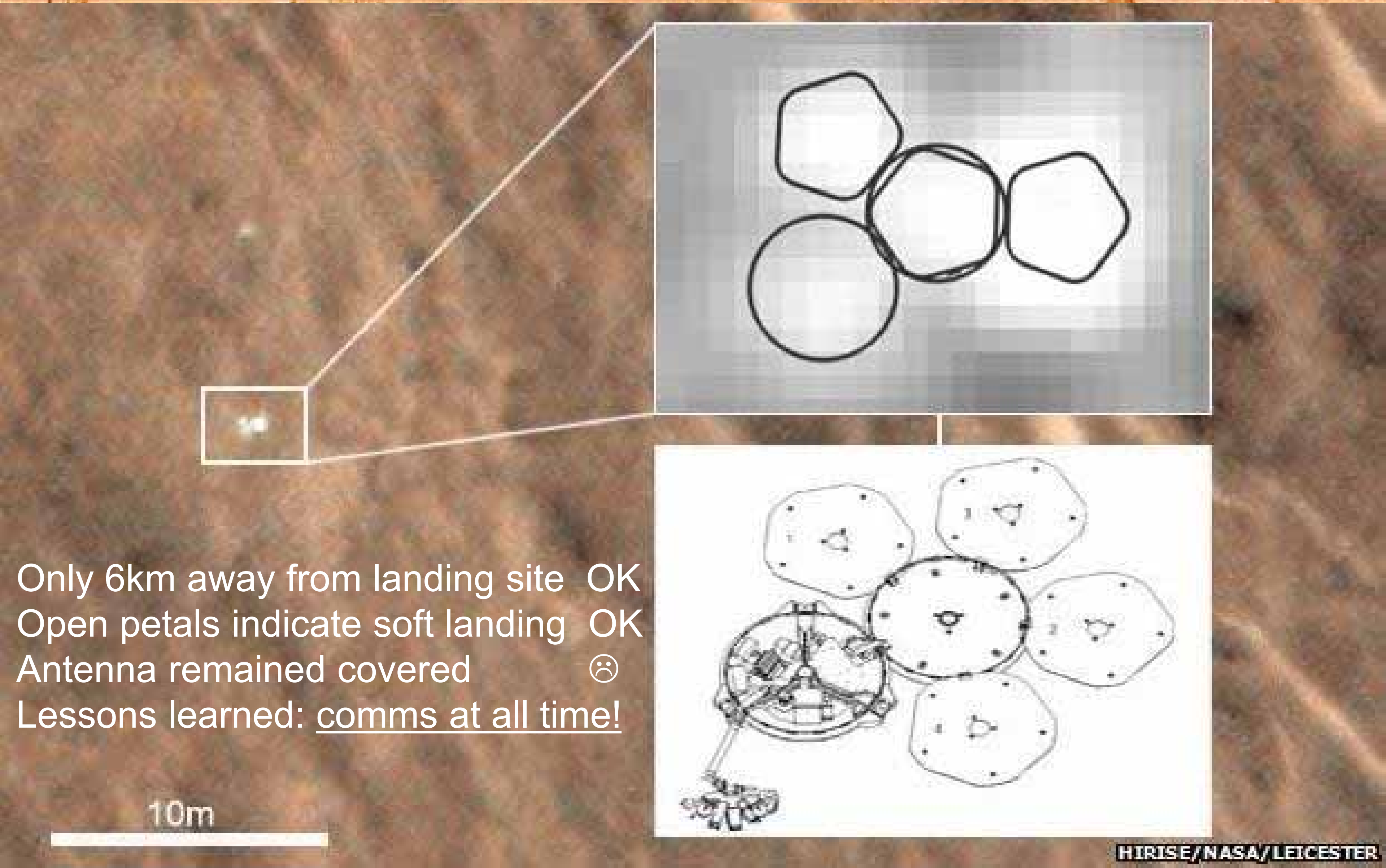
Last picture after release, taken by VMC camera 19/12/2003 8:33



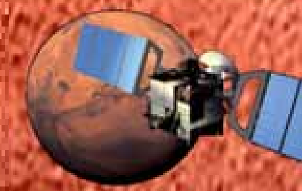
Credit: MEX/HRSC

Beagle 2 was found in January 2015 !

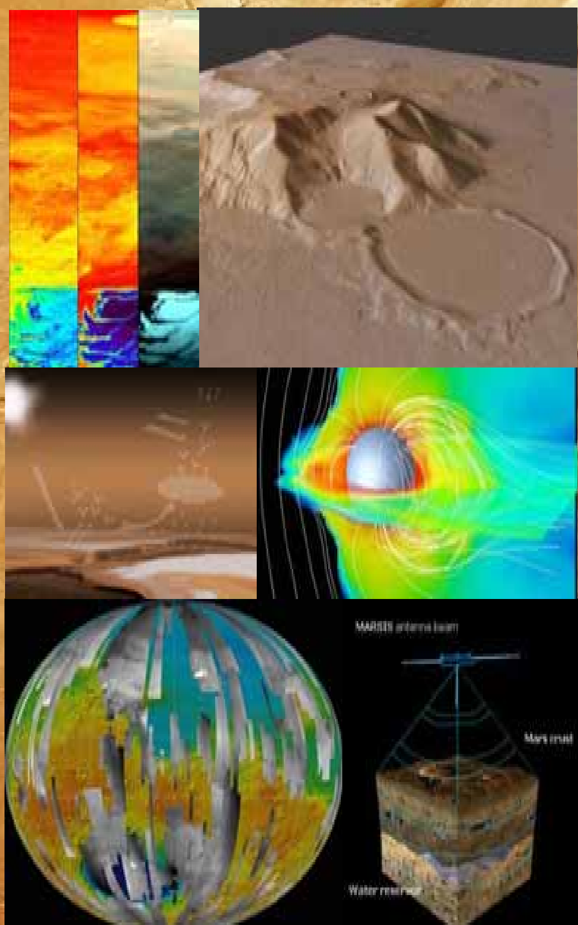
Only 6km away from landing site OK
Open petals indicate soft landing OK
Antenna remained covered ☹
Lessons learned: <u>comms at all time!</u>



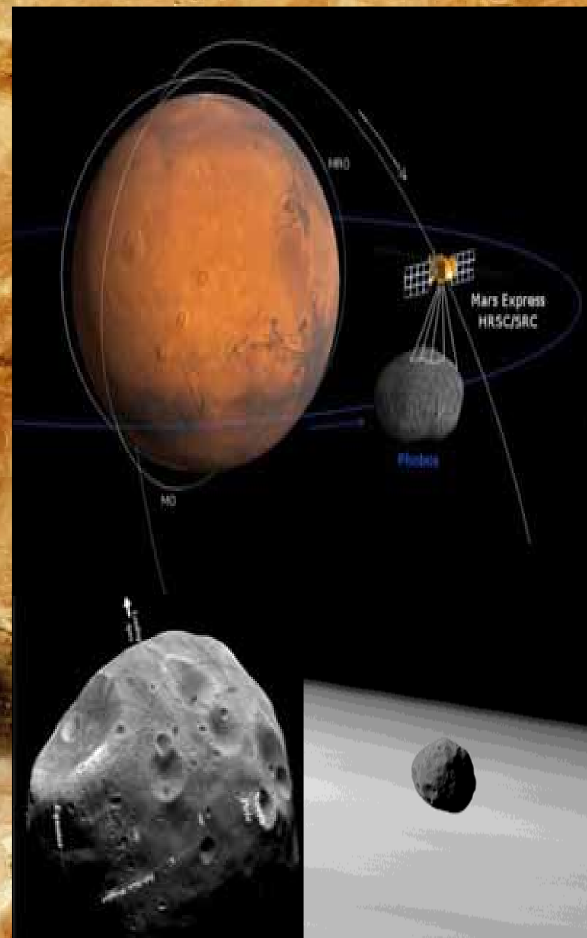
Mars Express: so many missions at once



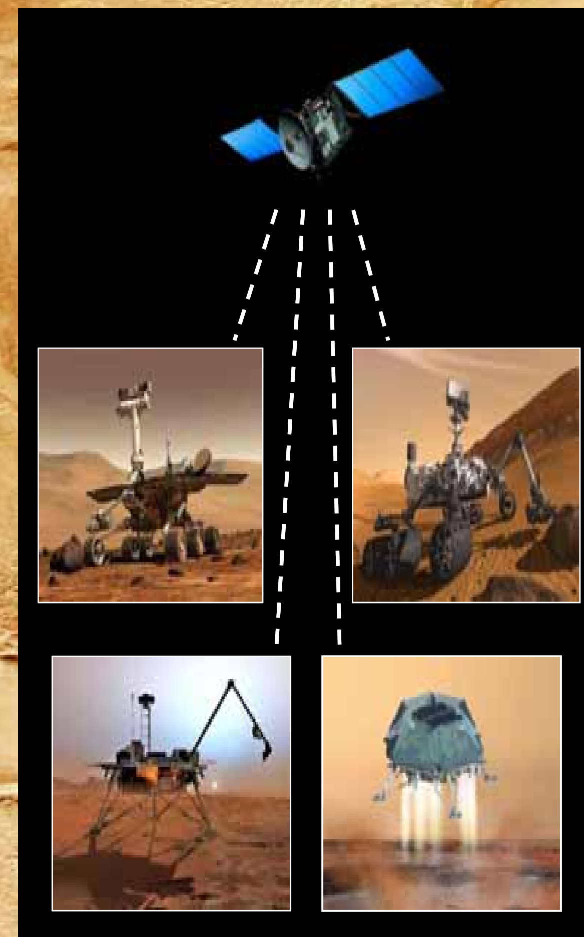
Mars Mission



Phobos Mission

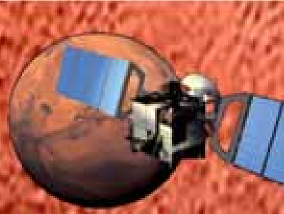


Relay Mission



Credit: MEX/HRSC

Mars Express science investigations



Martian Moons: Phobos & Deimos:
surface, mass, volume, density, …

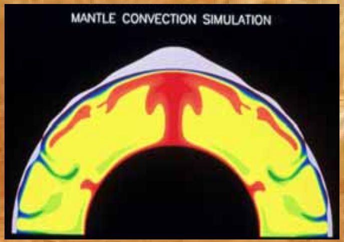
Atmosphere:
composition, dynamics, temperature, climate, clouds, …

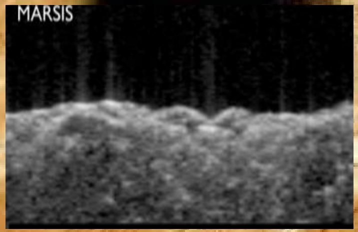
Ionosphere, Magnetosphere, Exosphere,
Interaction with solar wind, auroraes

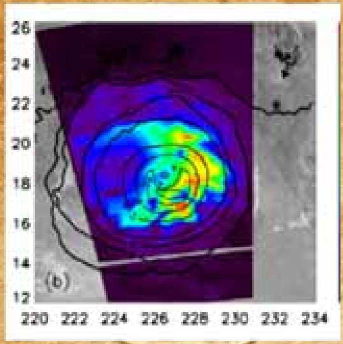
Surface:
geology, composition, mineralogy, …

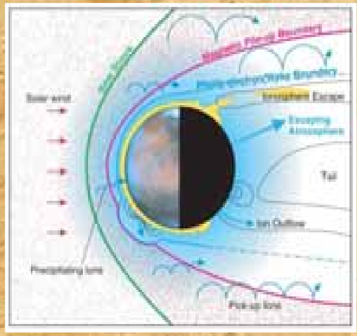
Sub-surface:
physical properties and structures

Interior:
Gravity field



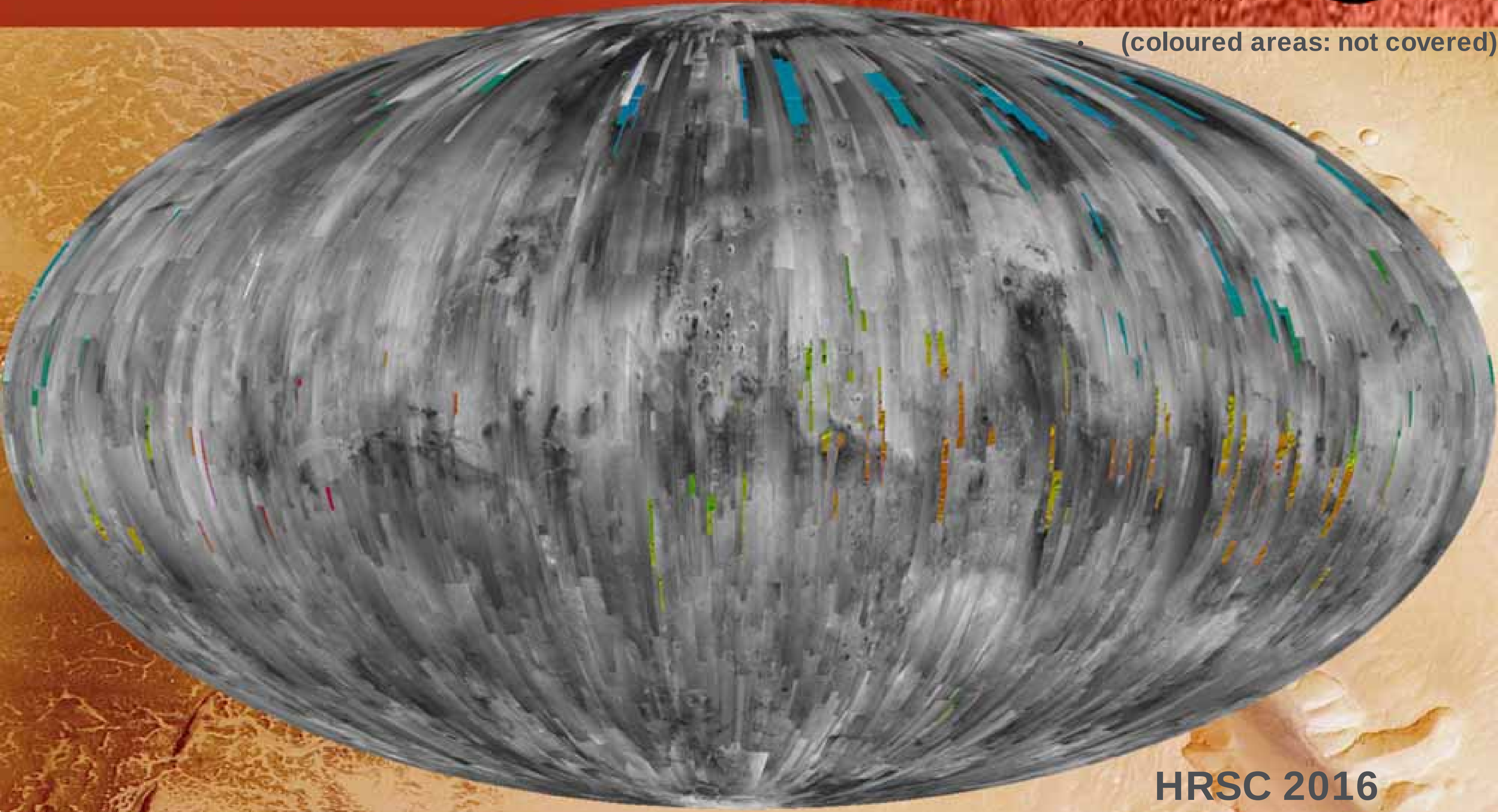






Comprehensive study of the planet and its history

Global coverage



• (coloured areas: not covered)

HRSC 2016

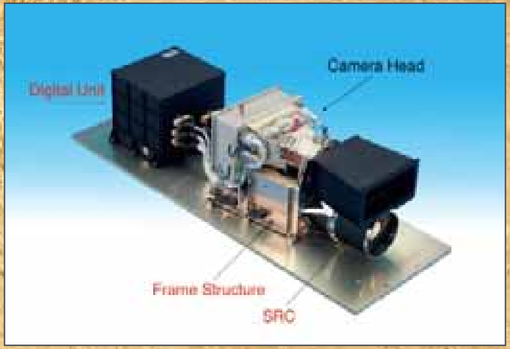
145,000,000 km² total Martian Surface
98% 141,000,000 km² ≤ 100 m/pixel
70% 100,000,000 km² ≤ 20 m/pixel

Credit: MEX/HRSC

Mars Express Payload: 8 Scientific Instruments

ASPERA: Energetic Neutral Atoms Analyser

PI: M. Holstroom, IRF Kiruna (SE)



HRSC: High Resolution Stereo Camera

PI: R. Jaumann, DLR Berlin (DE)

MaRS: Mars Radio Science Experiment

PI: M. Pätzold, RIU Köln (DE)

MARSIS: Sub-Surface Radar

PIs: R. Orosei, Univ. Rome (IT)
J. Plaut, JPL (US)

OMEGA: Visible and Infrared Mineralogical Mapping Spectrometer

PI: J. P. Bibring, IAS Orsay (FR)

PFS: Planetary Fourier Spectrometer

PI: M. Giuranna, INAF Rome (IT)

SPICAM: UV and IR Spectrometer

PI: F. Montmessin, Latmos Paris (FR)

VMC Camera

A.Sanchez Lavega, UPV/EHU (ES)

M. Almeida, DADP (CH)

ESOC, ESAC, ESTEC

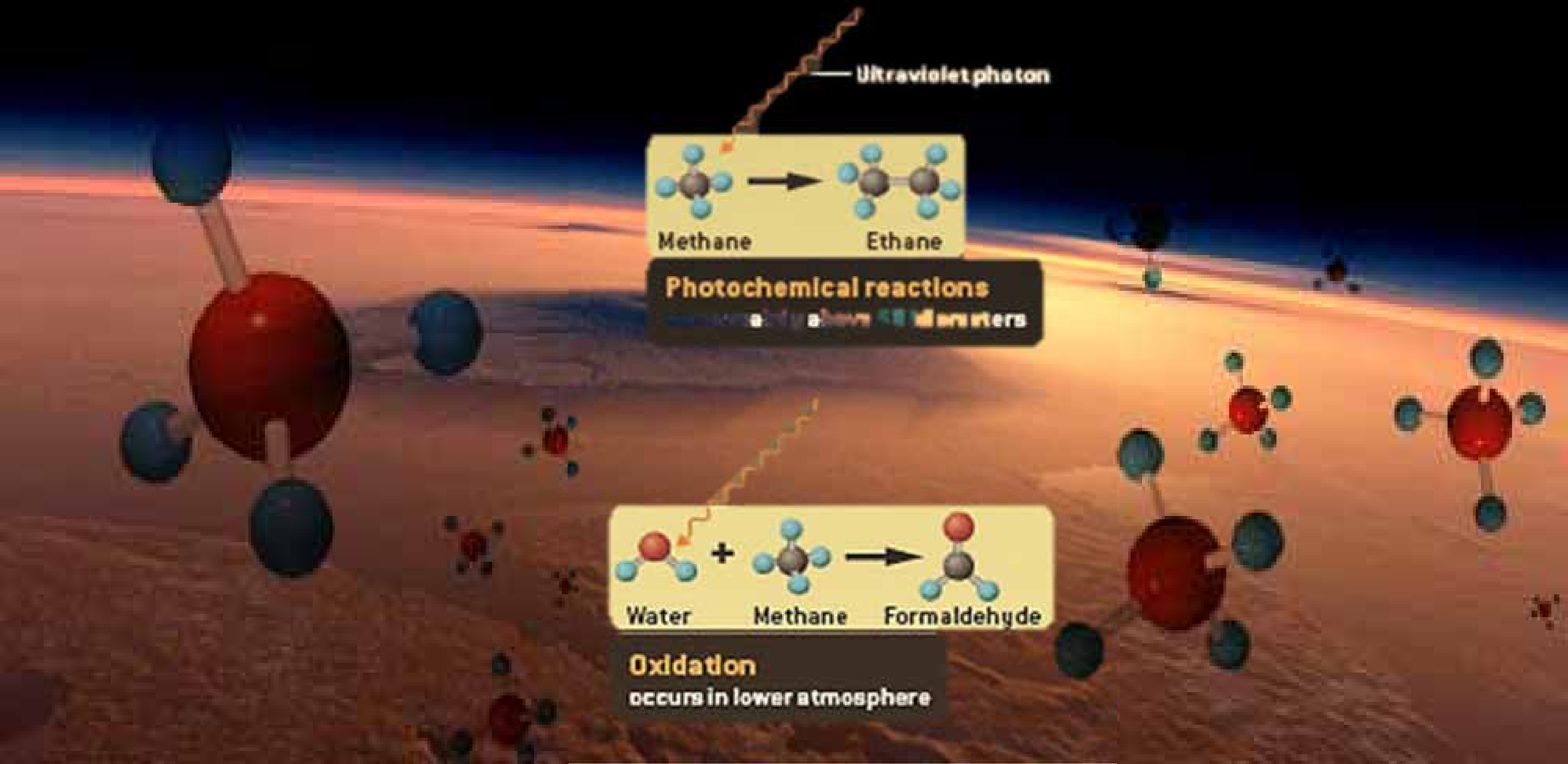
Credit: MEX/HRSC

Mars Express Science Highlights Summary Video (~2min) https://youtu.be/hyWC_zPTLsI

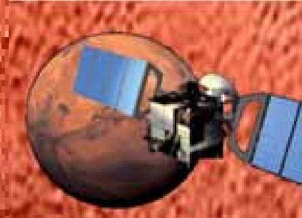
Life on Mars: Mars Express to ExoMars Video (~4min) https://youtu.be/o52UR3CTJMQ

Methane (CH_4) on Mars shouldn't be there

Methane molecules are destroyed by UV radiation within 100~300 years



Methane (CH_4) on Mars
Detection by Mars Express

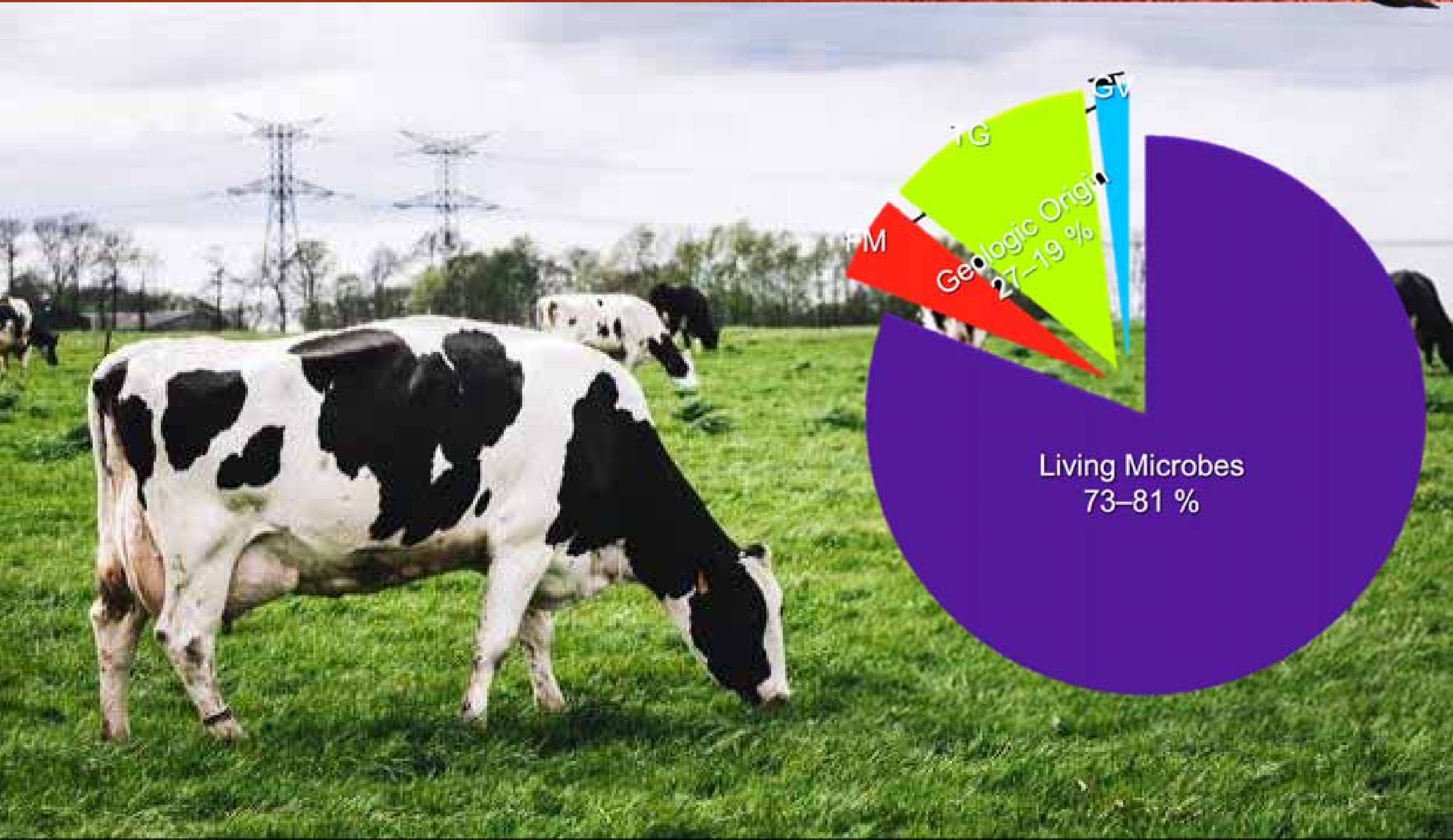


In 2004: three different groups reported observation of methane in Martian atmosphere:

- _Formisano et al_. (Science 2004) 0~35ppbv
- *Krasnopolsky et al*.(Icarus 2004) ~10ppbv
- *Mumma et al*.(DPS meeting 2004) ~250ppbv

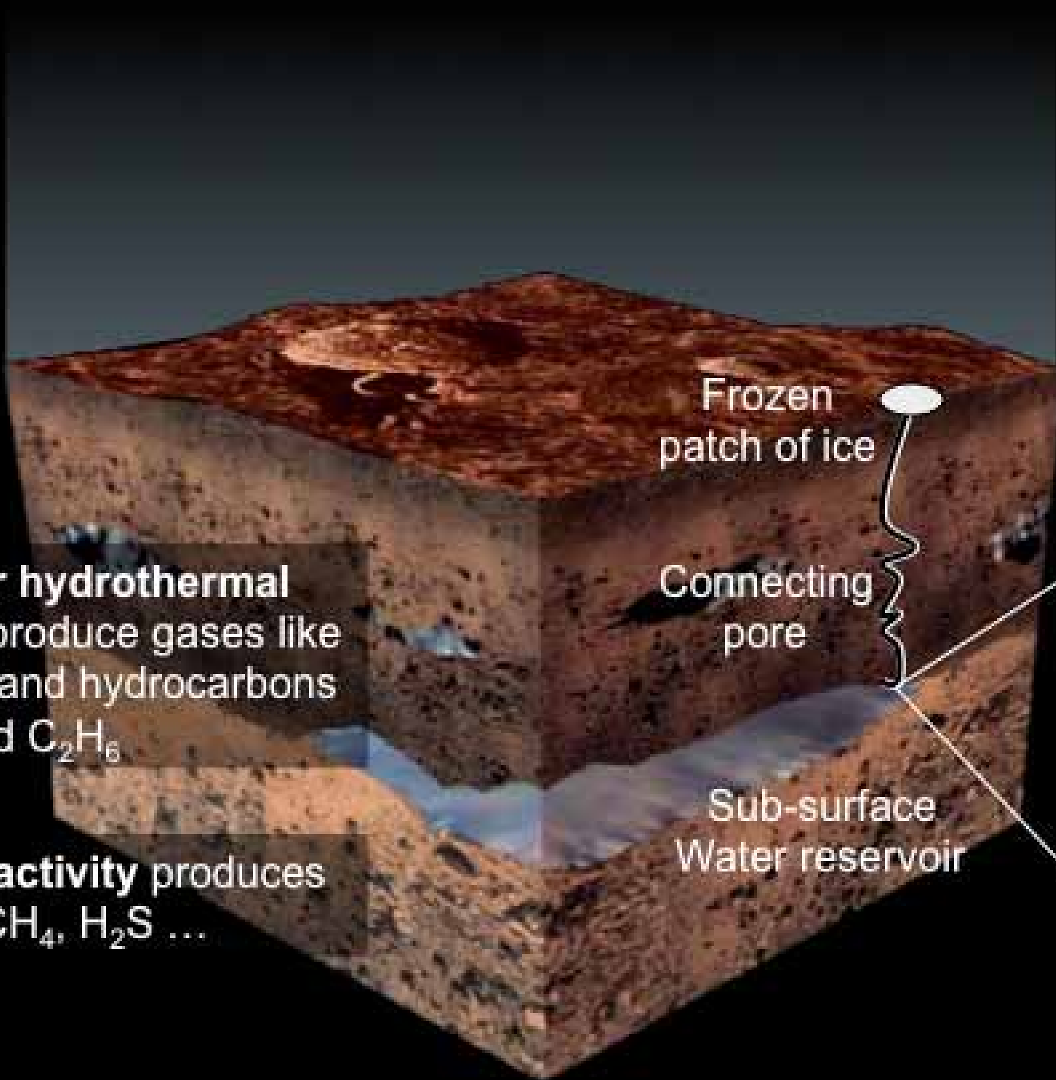
Methane existence has great geological/biological implications

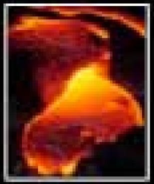
Where is Methane on Earth coming from?



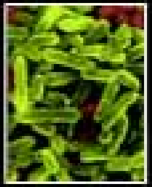
Methane may mean either life or geology : both with liquid water !

Subsurface Methane Sources



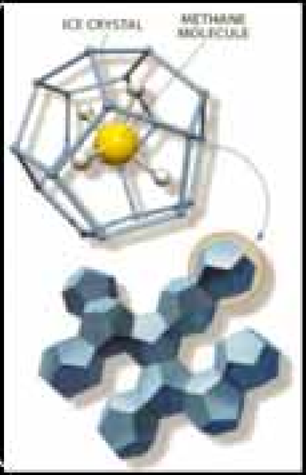


Volcanic or hydrothermal processes produce gases like SO_2,CO_2,.. and hydrocarbons like CH_4 and C_2H_6



Biological activity produces gases like CH_4, H_2S …

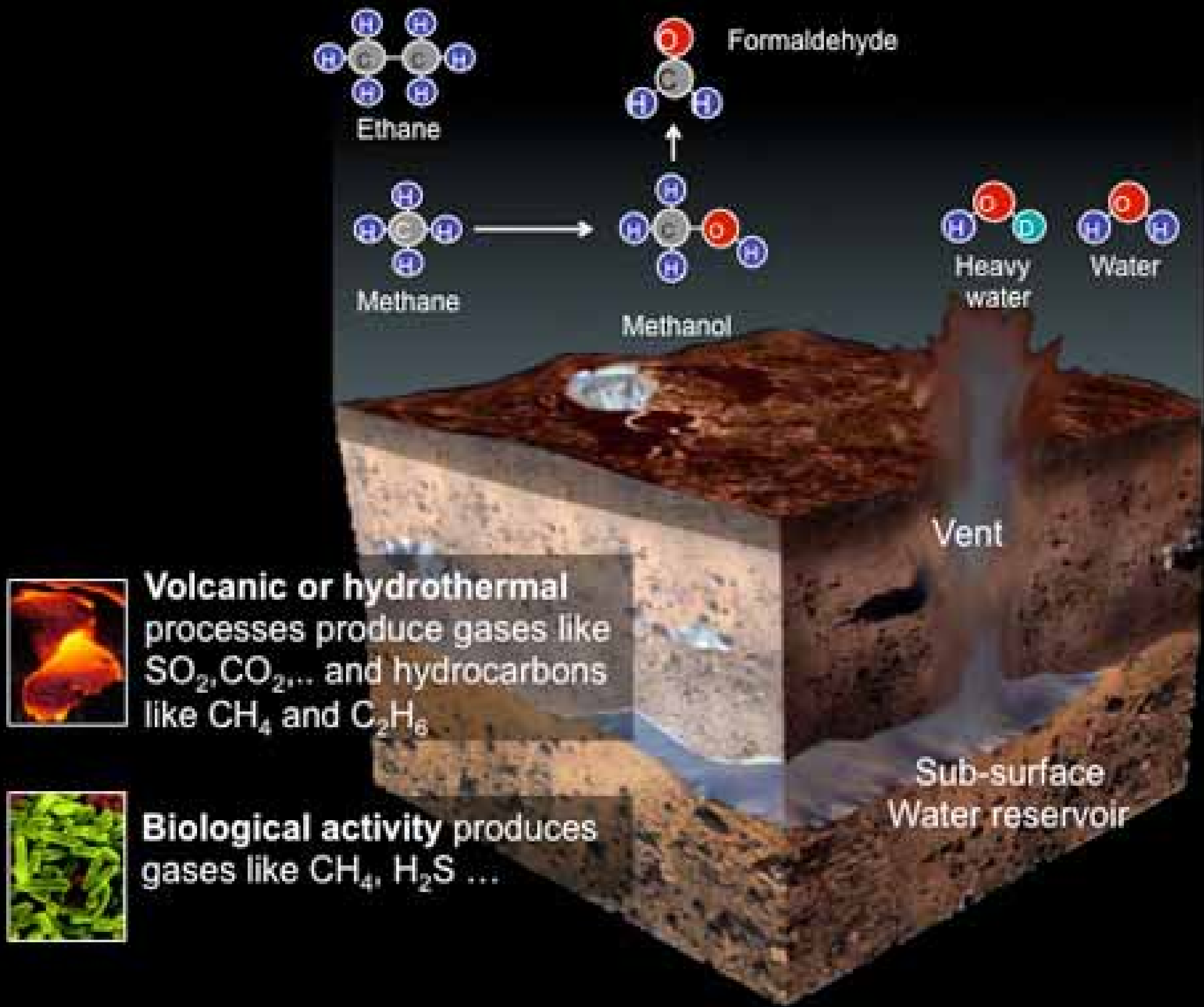
Methane could be stored in the form of clathrates



Villanueva et al, 2009

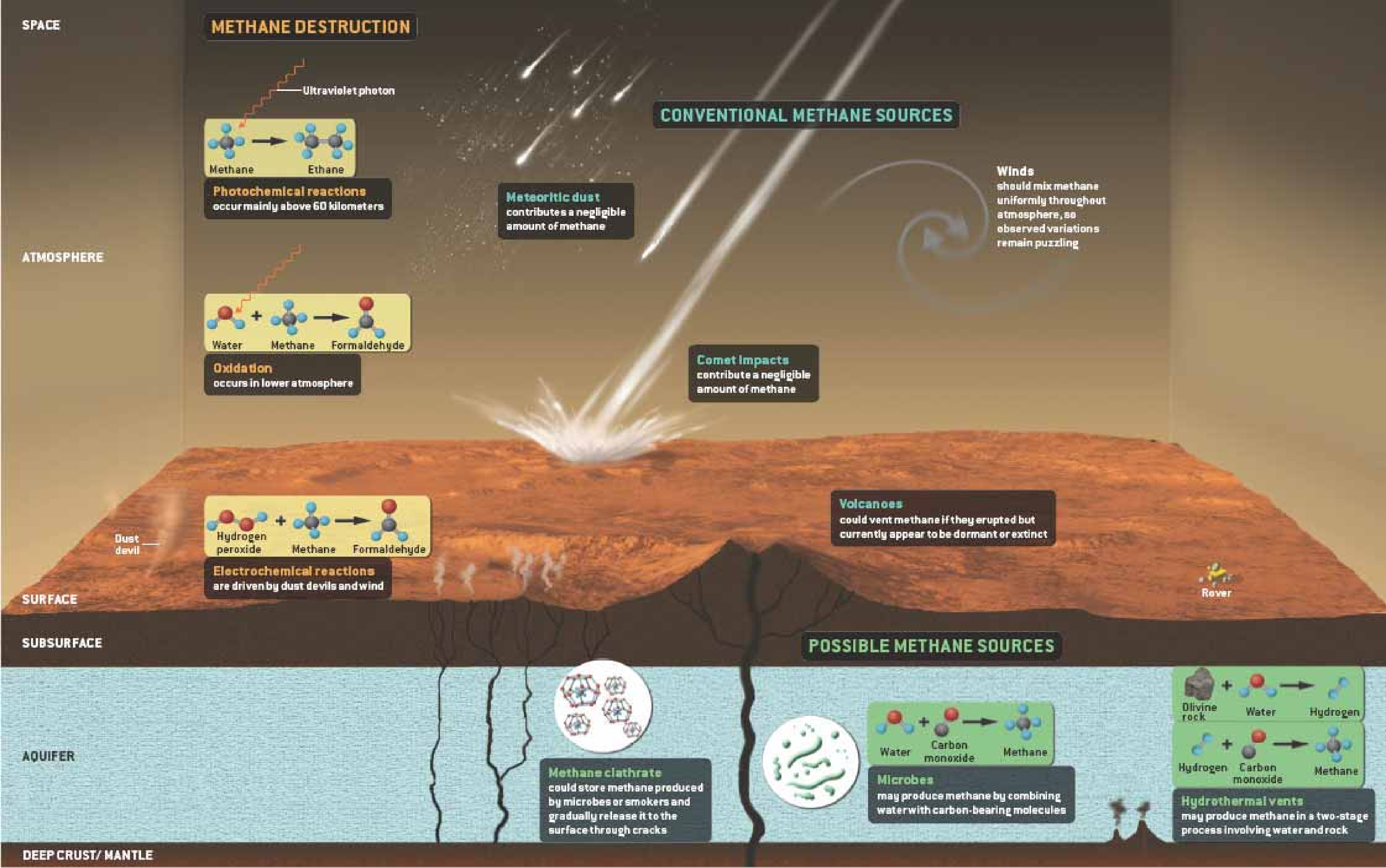
Methane and Water on Mars

Methane Workshop, Frascati Italy, Villanueva et al. 2009



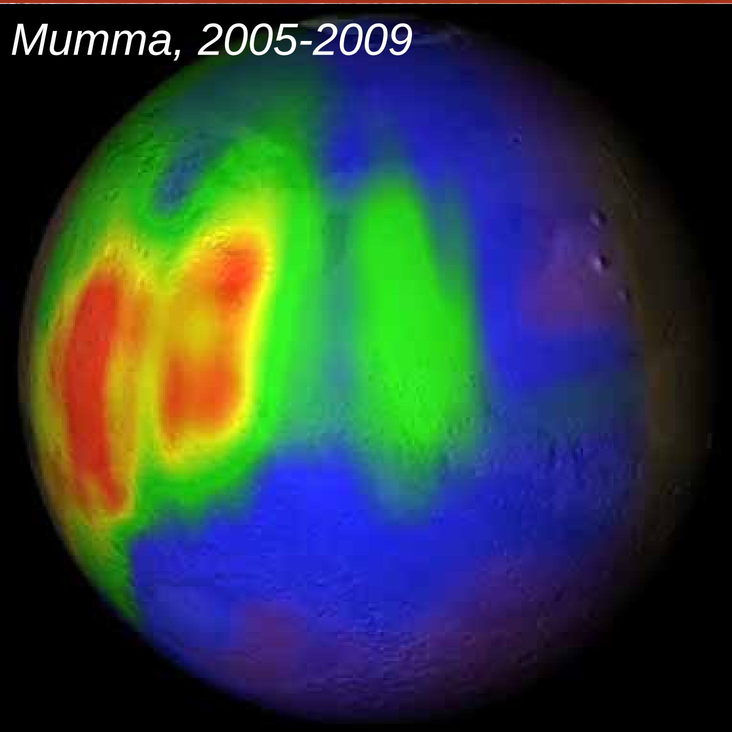
METHANE ON MARS

By all rights, Mars should have zero methane. The gas is quickly cleansed from the air by chemical reactions driven by sunlight or weather patterns, and known geologic and astronomical processes cannot replenish it fast enough. Thus, the methane hints at unseen activity, such as black smokers or methane-creating microbes swimming in underground bodies of water.

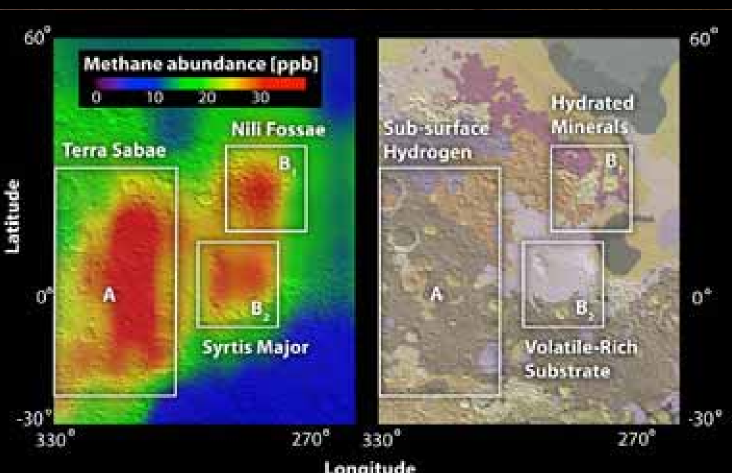


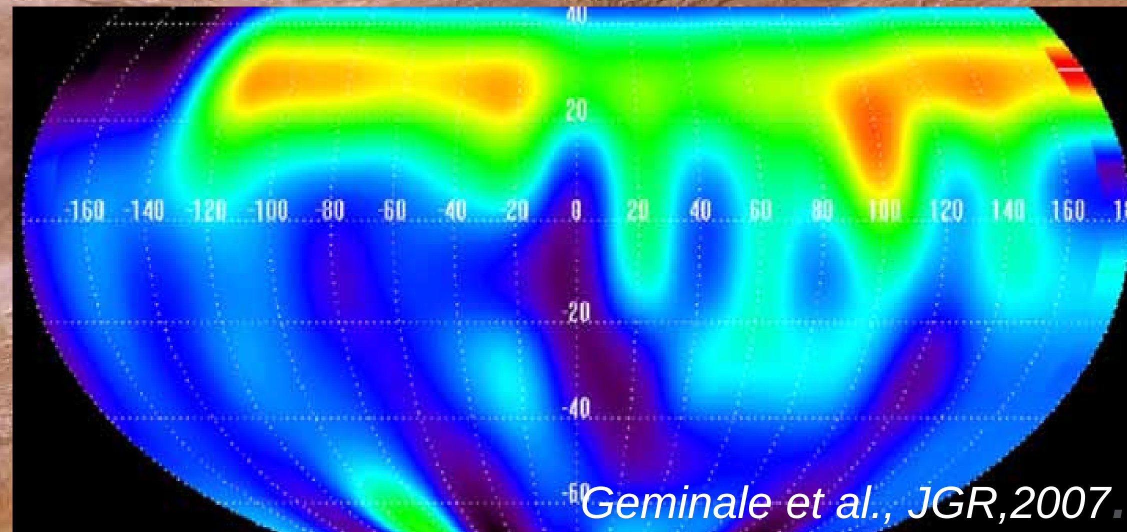
Methane detection over time

further measurements, but still controversial

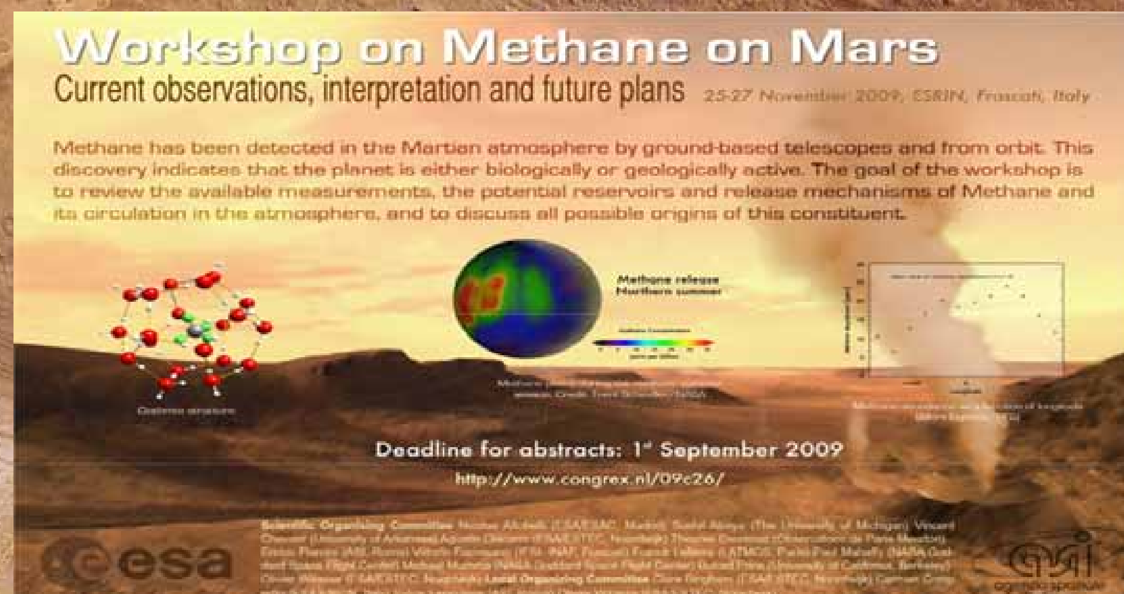


Mumma, 2005-2009





Geminale et al., JGR,2007.



Workshop on Methane on Mars

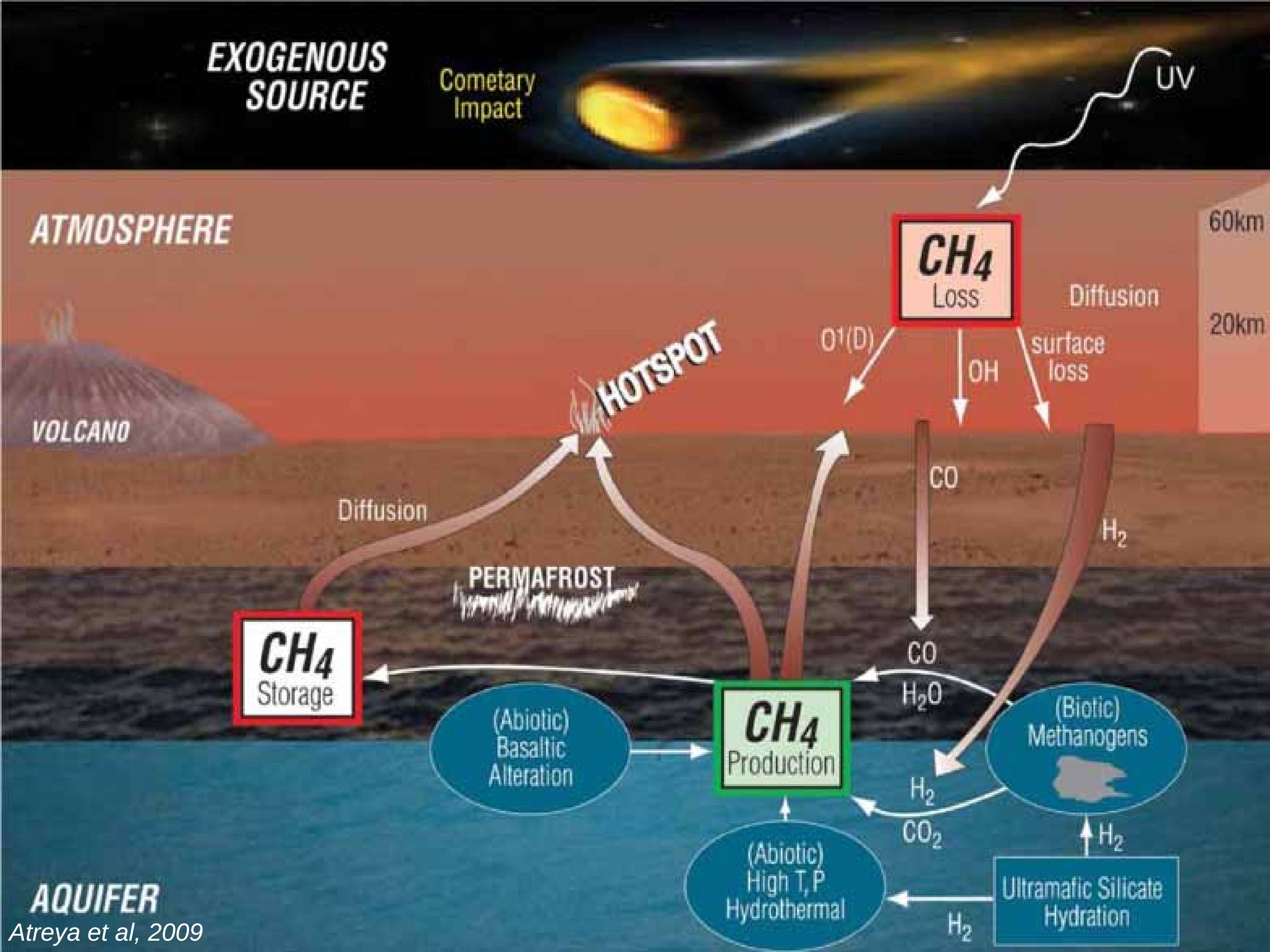
Current observations, interpretation and future plans 25-27 November 2009, ESRIN, Frascati, Italy

Methane has been detected in the Martian atmosphere by ground-based telescopes and from orbit. This discovery indicates that the planet is either biologically or geologically active. The goal of the workshop is to review the available measurements, the potential reservoirs and release mechanisms of Methane and its circulation in the atmosphere, and to discuss all possible origins of this constituent.

Deadline for abstracts: 1st September 2009

http://www.congrex.nl/09c26/

esa



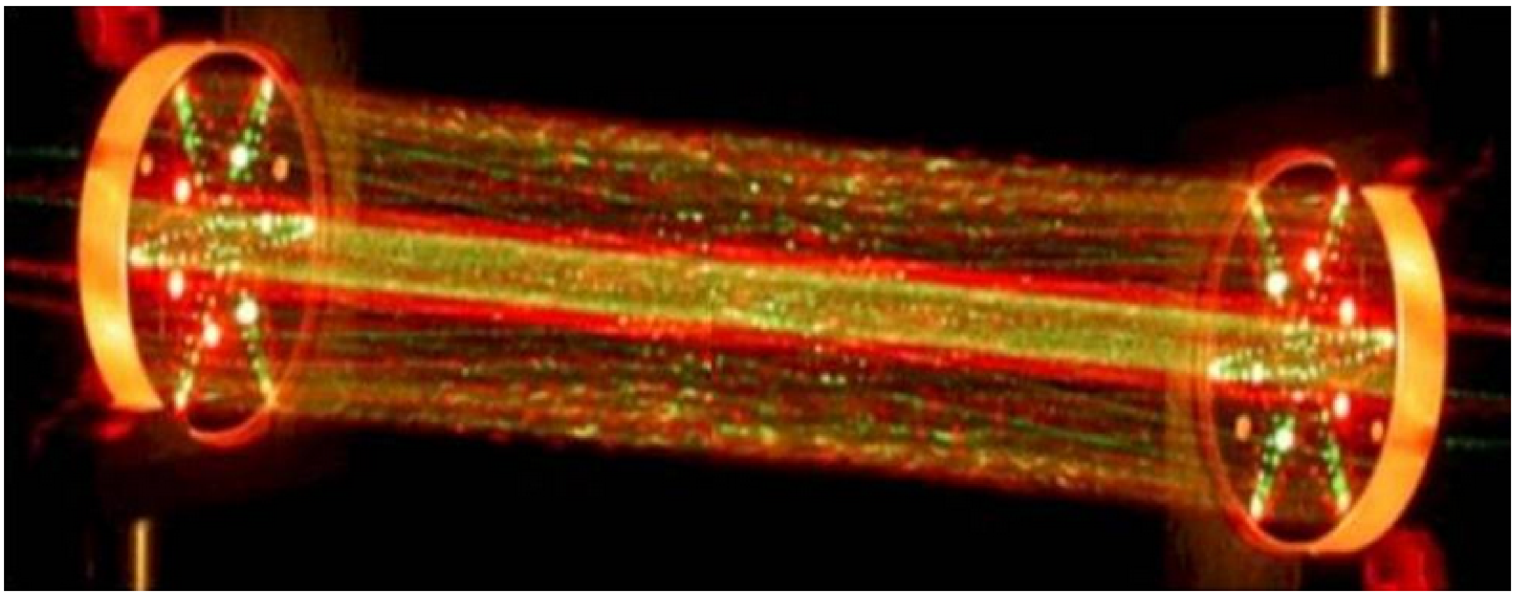
Atreya et al, 2009

MSL Curiosity 2013: no Methane???

Mars Curiosity

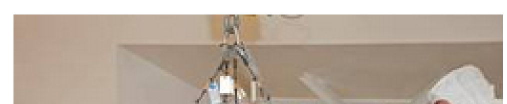
Sept. 19, 2013

NASA Curiosity Rover Detects No Methane on Mars



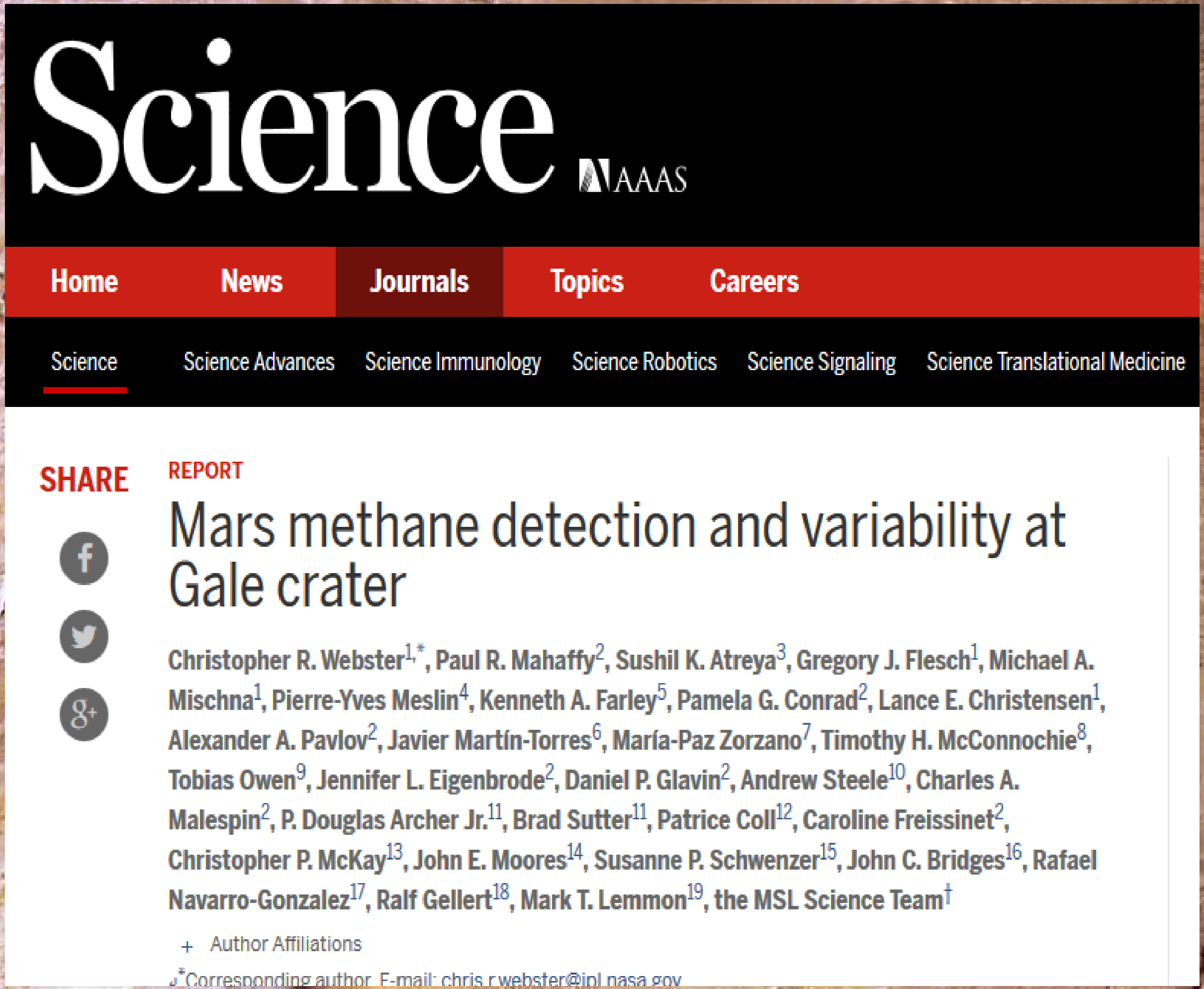
This picture shows a lab demonstration of the measurement chamber inside the Tunable Laser Spectrometer, an instrument that is part of the Sample Analysis at Mars investigation on NASA's Curiosity rover.
Credits: NASA/JPL-Caltech

PASADENA, Calif. -- Data from NASA's Curiosity rover has revealed the Martian environment lacks methane. This is a surprise to researchers because previous data reported by U.S. and international scientists indicated positive detections.



Credit: MEX/HRSC

MSL Curiosity 2014: actually… Methane is there! (but it comes and goes?)



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REPORT

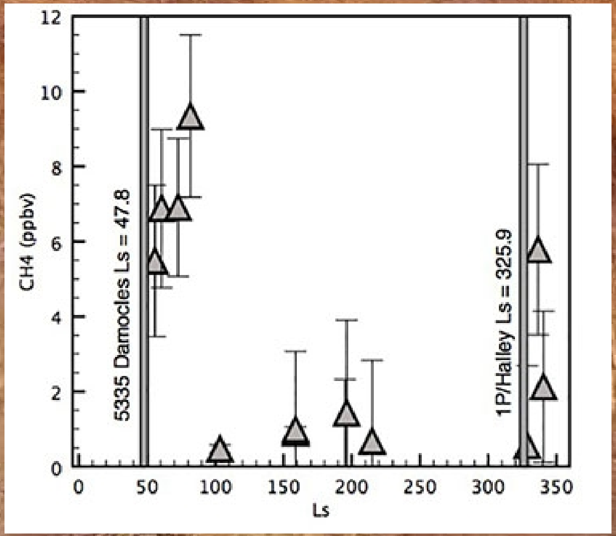
Mars methane detection and variability at Gale crater

Christopher R. Webster[1,*], Paul R. Mahaffy[2], Sushil K. Atreya[3], Gregory J. Flesch[1], Michael A. Mischna[1], Pierre-Yves Meslin[4], Kenneth A. Farley[5], Pamela G. Conrad[2], Lance E. Christensen[1], Alexander A. Pavlov[2], Javier Martín-Torres[6], María-Paz Zorzano[7], Timothy H. McConnochie[8], Tobias Owen[9], Jennifer L. Eigenbrode[2], Daniel P. Glavin[2], Andrew Steele[10], Charles A. Malespin[2], P. Douglas Archer Jr.[11], Brad Sutter[11], Patrice Coll[12], Caroline Freissinet[2], Christopher P. McKay[13], John E. Moores[14], Susanne P. Schwenzer[15], John C. Bridges[16], Rafael Navarro-Gonzalez[17], Ralf Gellert[18], Mark T. Lemmon[19], the MSL Science Team[†]

+ Author Affiliations

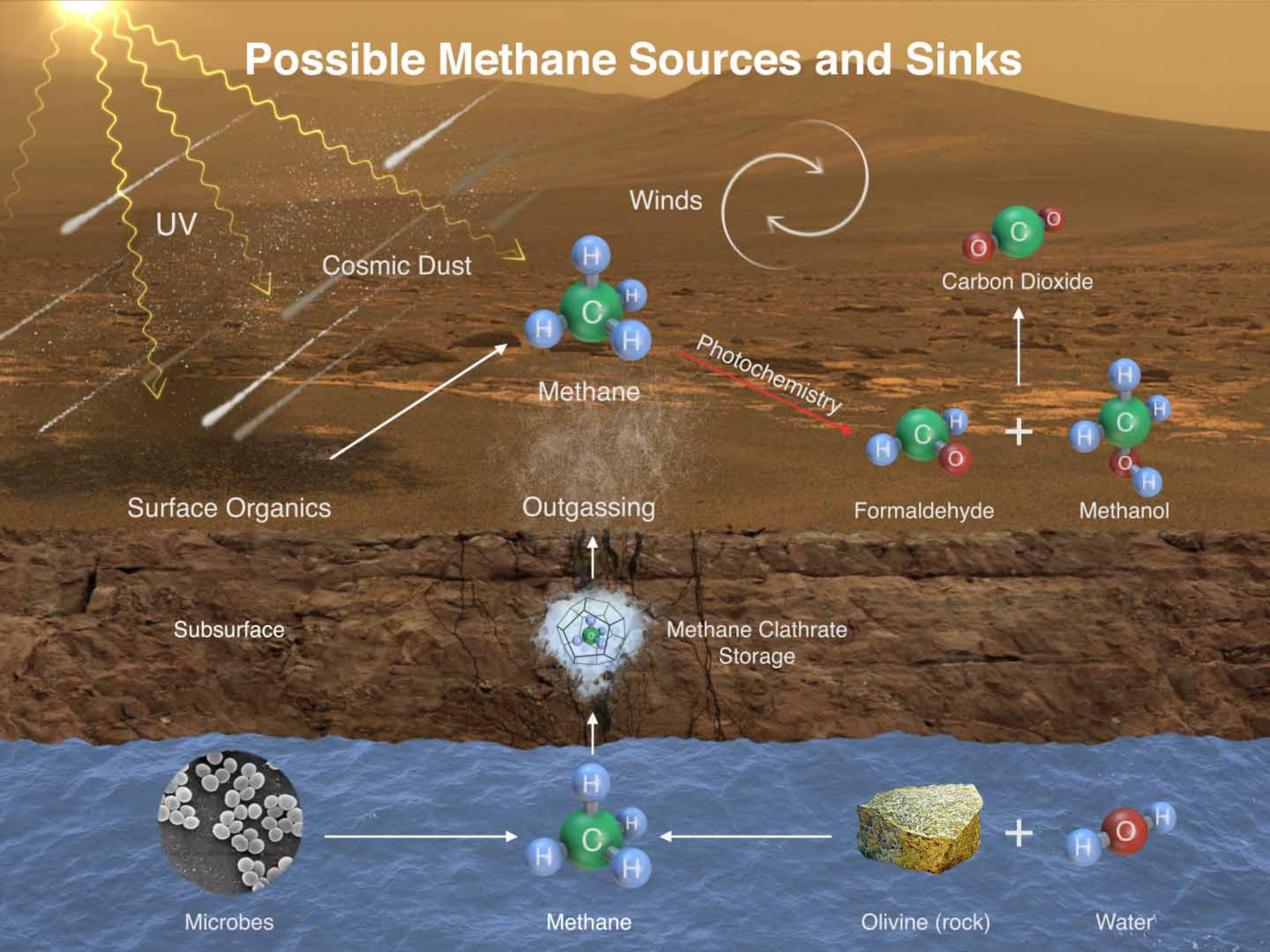
*Corresponding author. E-mail: chris.r.webster@jpl.nasa.gov

Methane appears and disappears within months

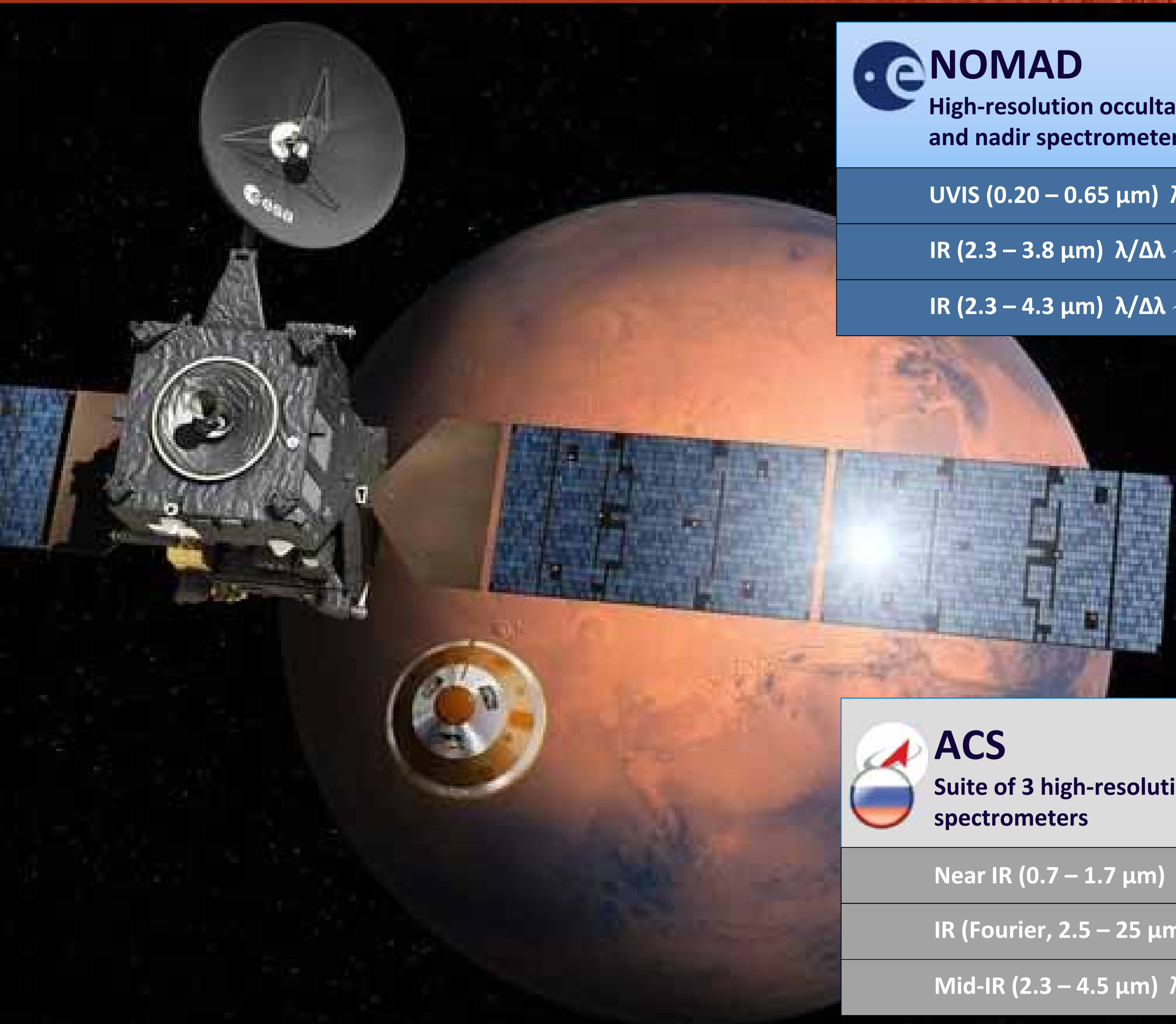


Now we need sources and sinks!

Credit: MEX/HRSC


Possible Methane Sources and Sinks
UV
Cosmic Dust
Winds
Methane
Carbon Dioxide
Photochemistry
Formaldehyde
Methanol
Surface Organics
Outgassing
Subsurface
Methane Clathrate Storage
Microbes
Methane
Olivine (rock)
Water

ExoMars TGO science instruments may give us the answer soon…

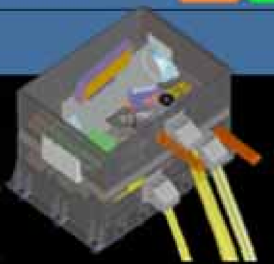


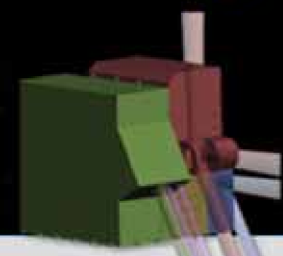
NOMAD

High-resolution occultation and nadir spectrometers

Atmospheric composition (CH_4, O_3, trace species, isotopes) dust, clouds, P&T profiles

UVIS (0.20 – 0.65 µm) λ/Δλ ~250	SO Lim Nad
IR (2.3 – 3.8 µm) λ/Δλ ~10,000	SO Lim Nad
IR (2.3 – 4.3 µm) λ/Δλ ~20,000	SO





ACS

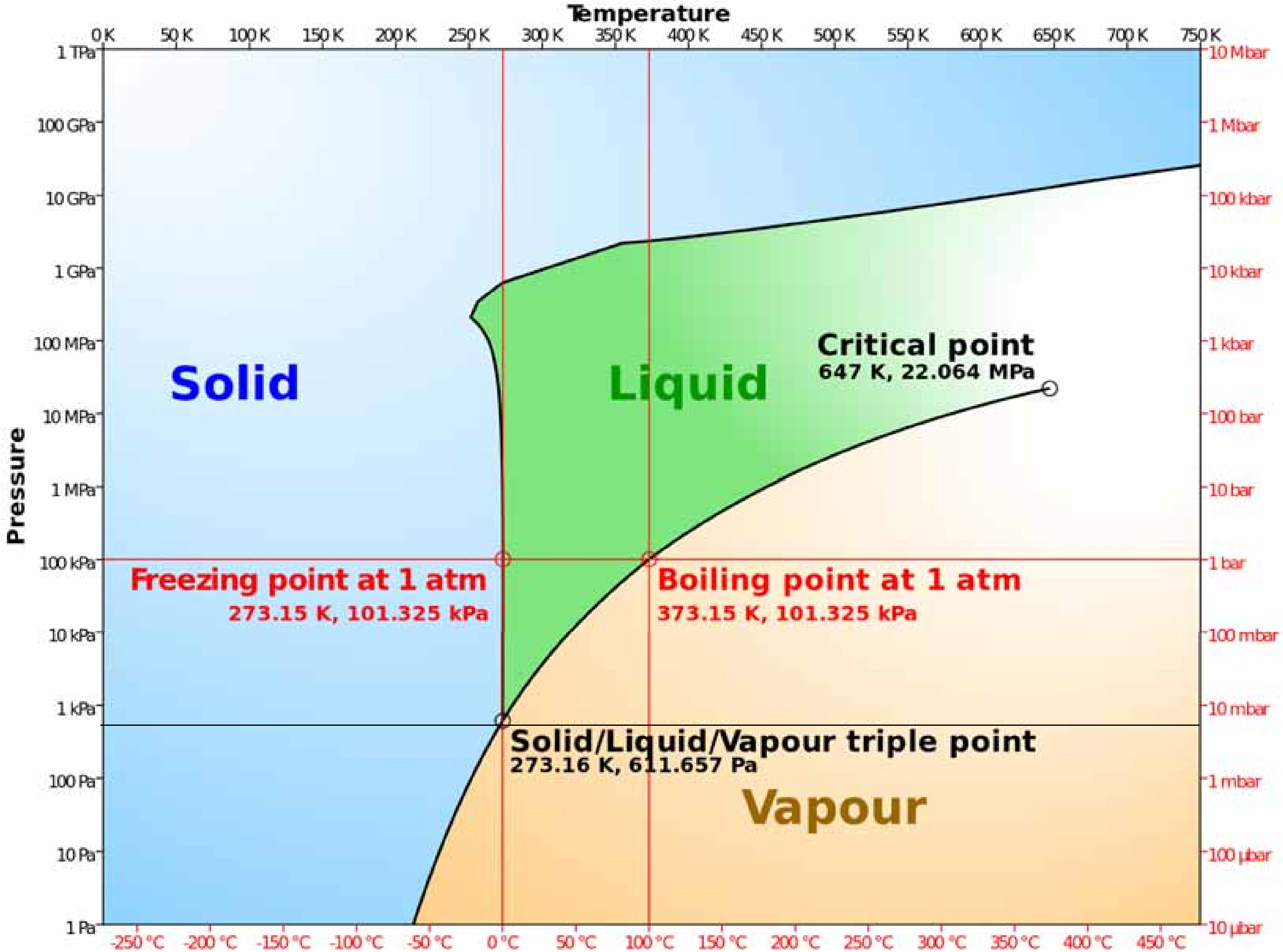
Suite of 3 high-resolution spectrometers

Atmospheric chemistry, aerosols, surface T, structure

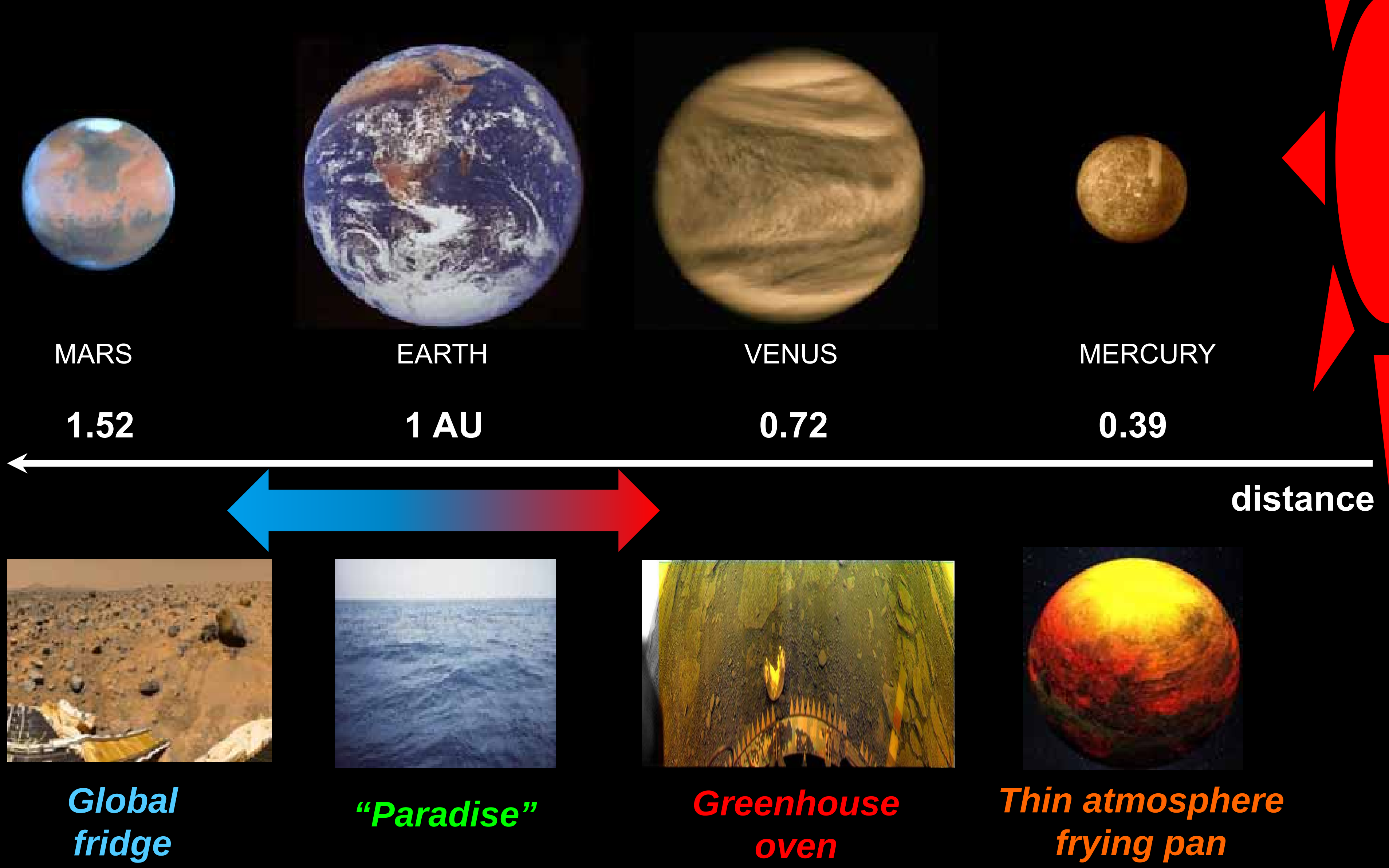
Near IR (0.7 – 1.7 µm) λ/Δλ ~20,000	SO Lim Nad
IR (Fourier, 2.5 – 25 µm) λ/Δλ ~4,000 (SO)/500 (N)	SO Nad
Mid-IR (2.3 – 4.5 µm) λ/Δλ ~50,000	SO

Mars History of liquid water…
(and life???)

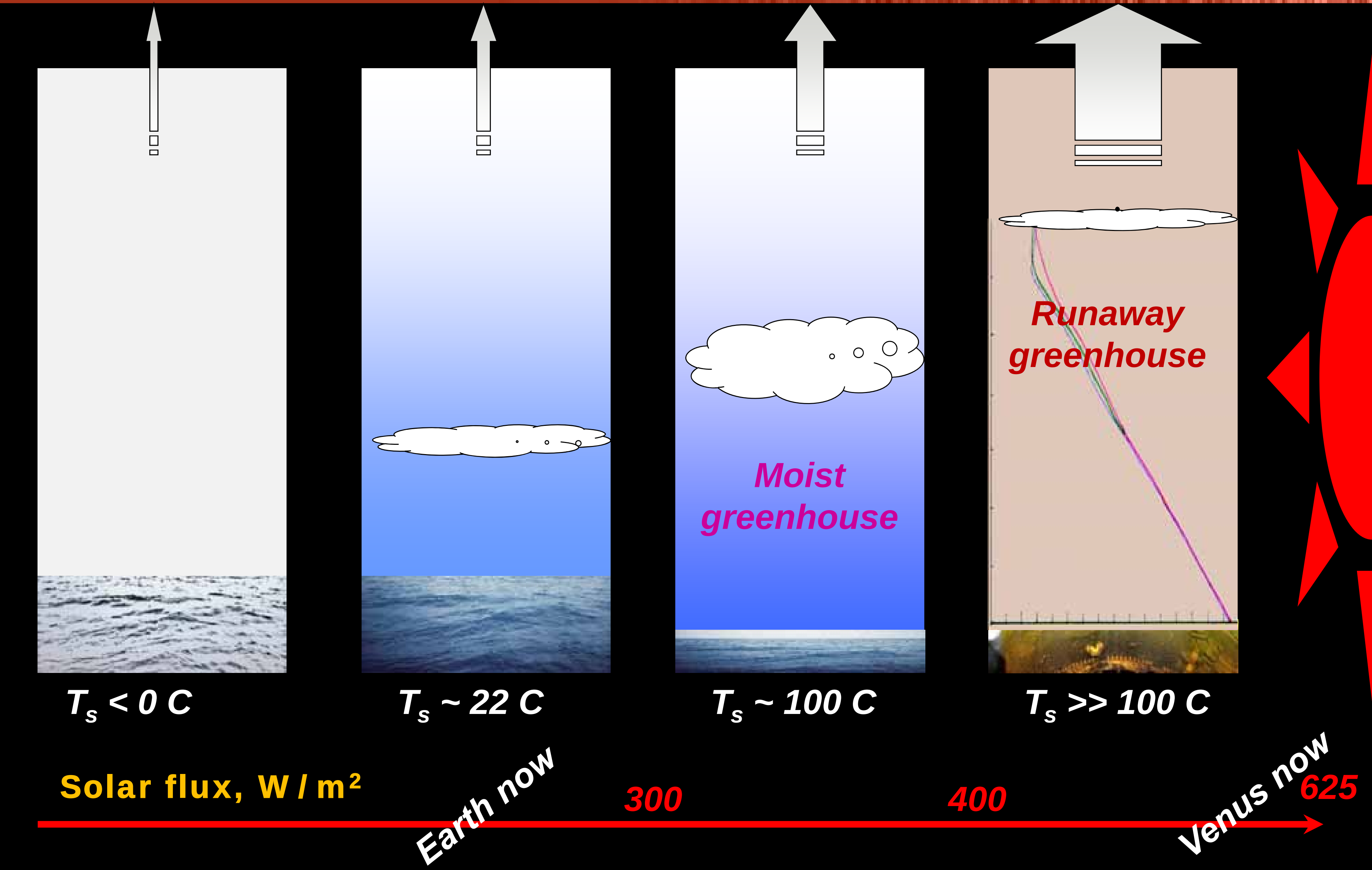
Water Phase: Temperature & Pressure



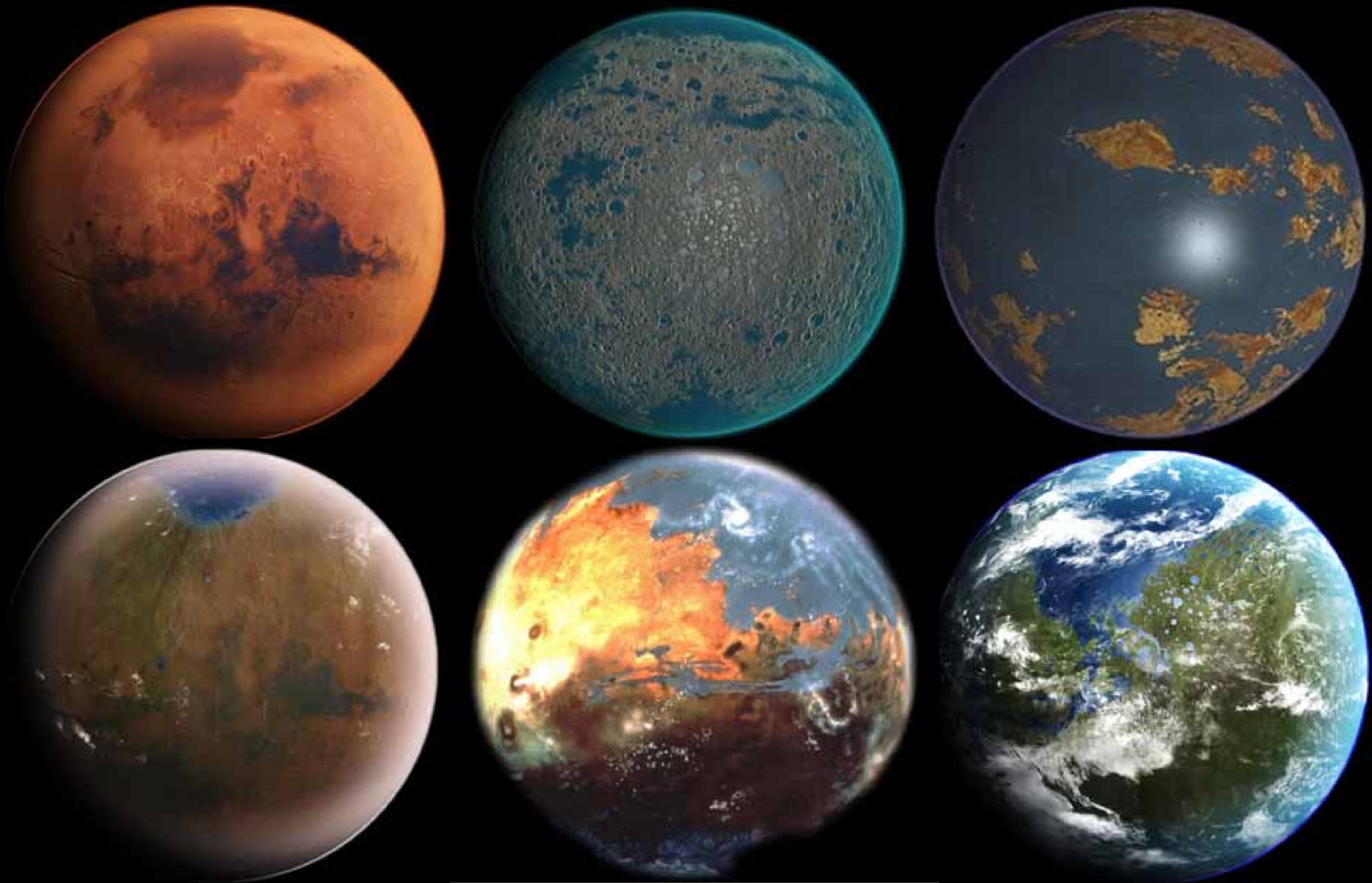
Habitability zone in the Solar System



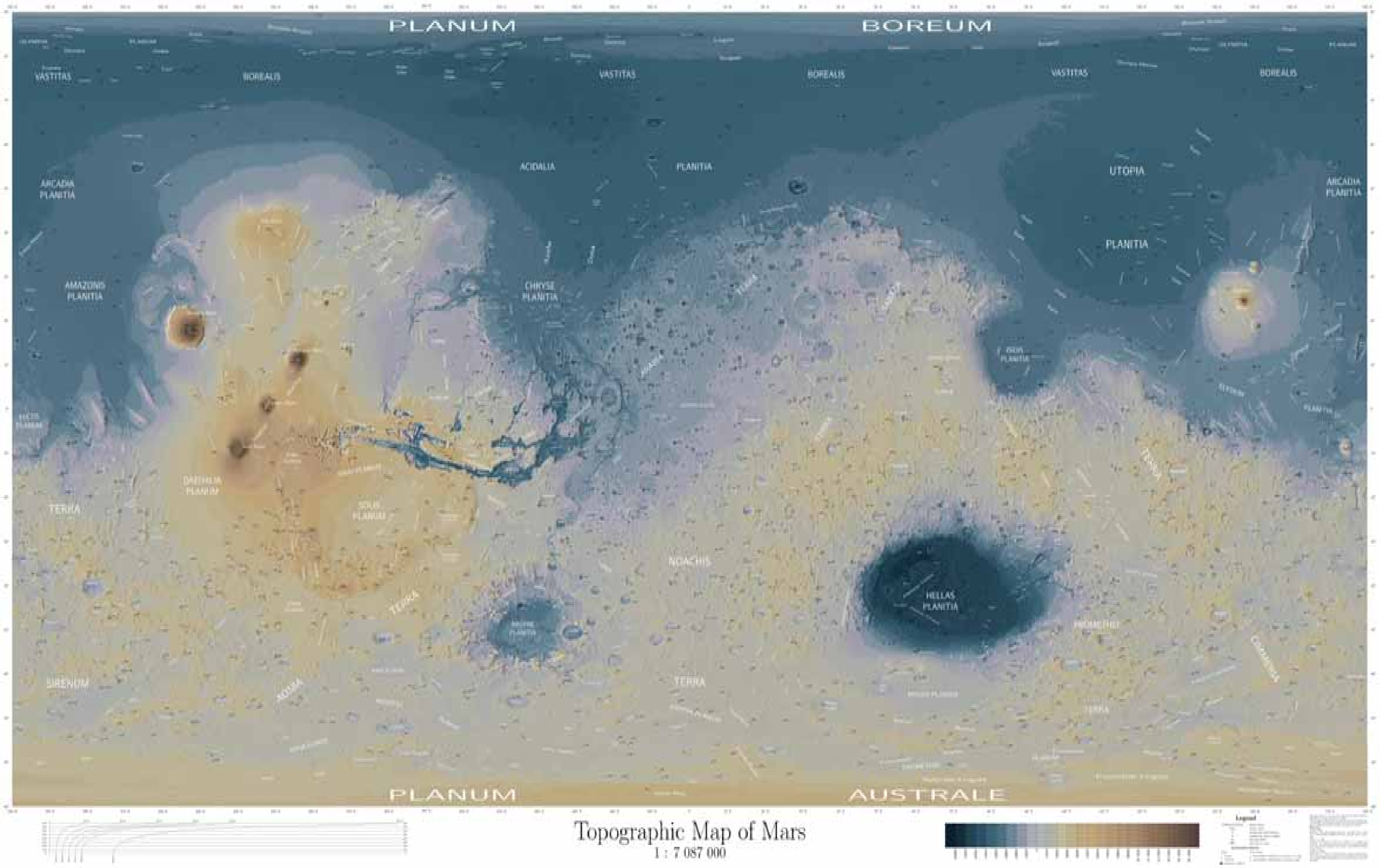
Water balance on an Earth-like planet
(Greenhouse effect and atmospheric escape)



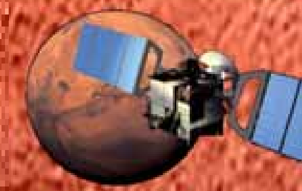
Possible evolution of Mars???

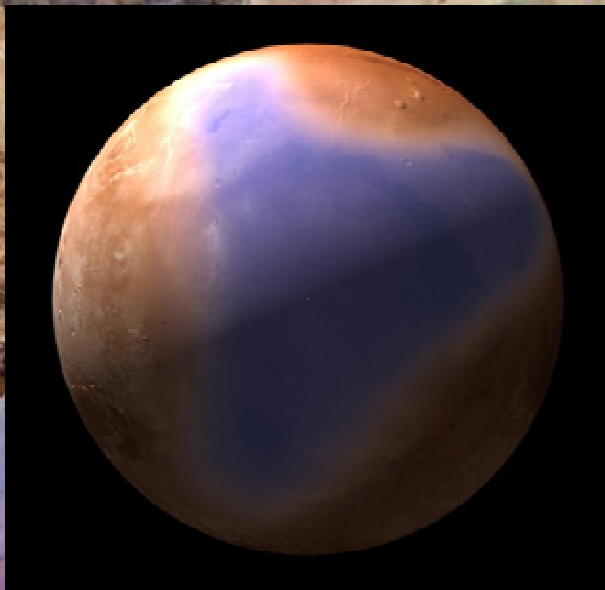


Mars today: surface elevation map

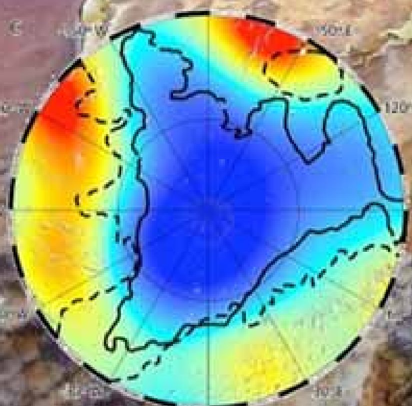


History based on other Physical Properties: dielectric constant measurement by MARSIS

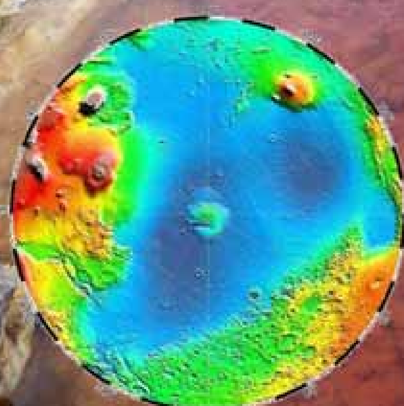




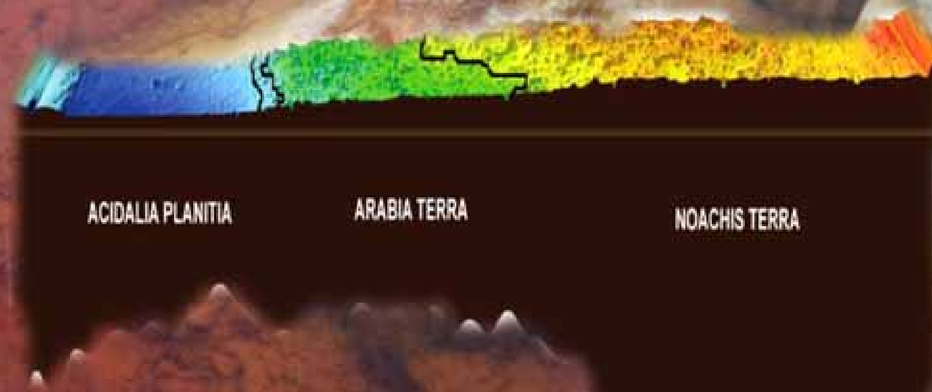
- Dense volcanic rocks have high dielectric constants (basalt ~10)
- Low density porous sediments are lower (sedimentary <10)
- Pure water ice also has low dielectric constant (ice ~3)
- Maps of low dielectric constant are consistent with topography and with **paleo-ocean shoreline** around Mars' northern plains
- **Episodic fluvial evolution** of the northern plains resulting in massive ice deposits with layers of sediment and volcanic materials maybe before the underlying ice had sublimed away.



J. Mouginot et al. 2012



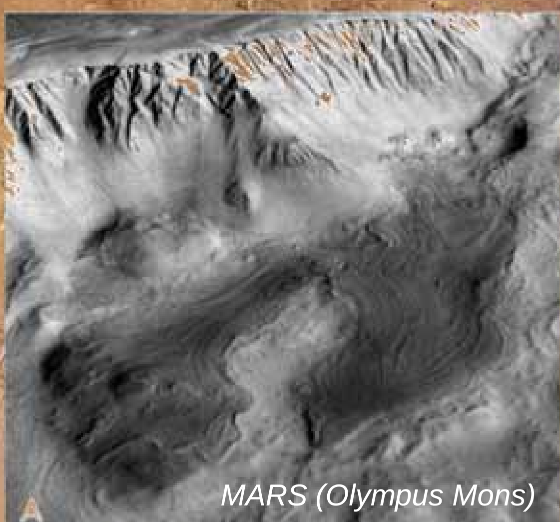
Topography



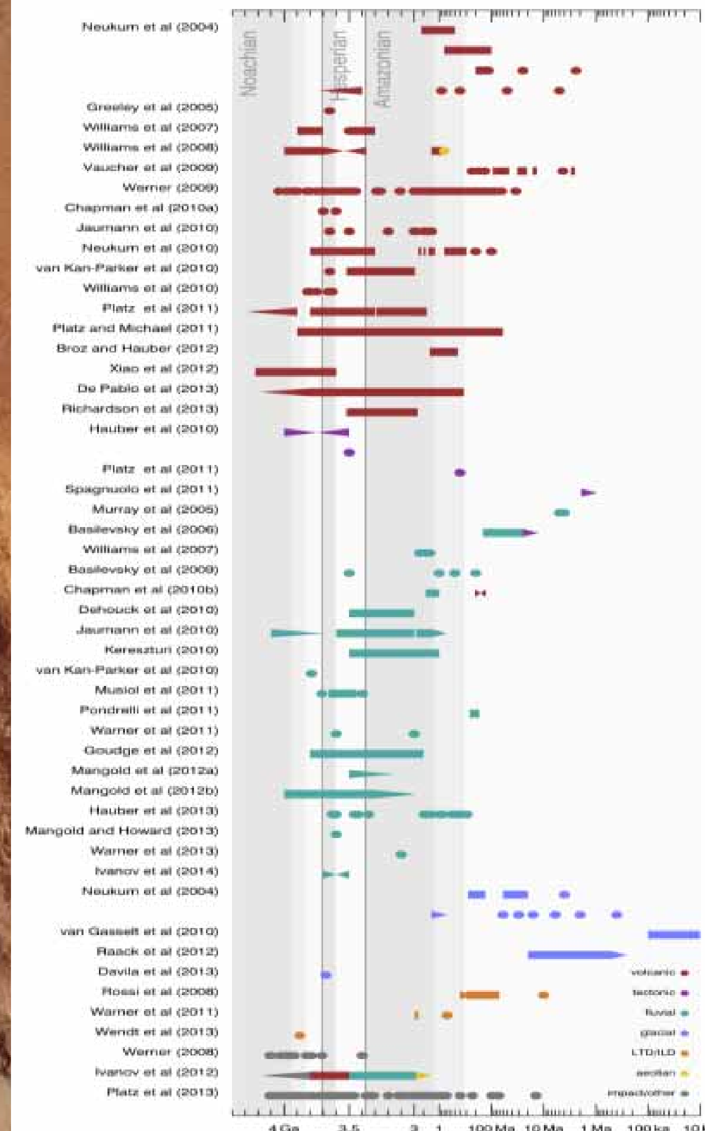
History based on Geologic Analysis: Glacial and Fluvial features by HRSC

Oldest fluvial features >100My ago
In line with oldest volcanic features

Glacial structures are more recent (<1My)

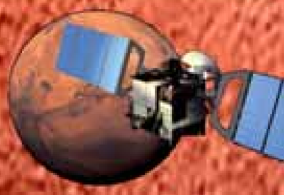


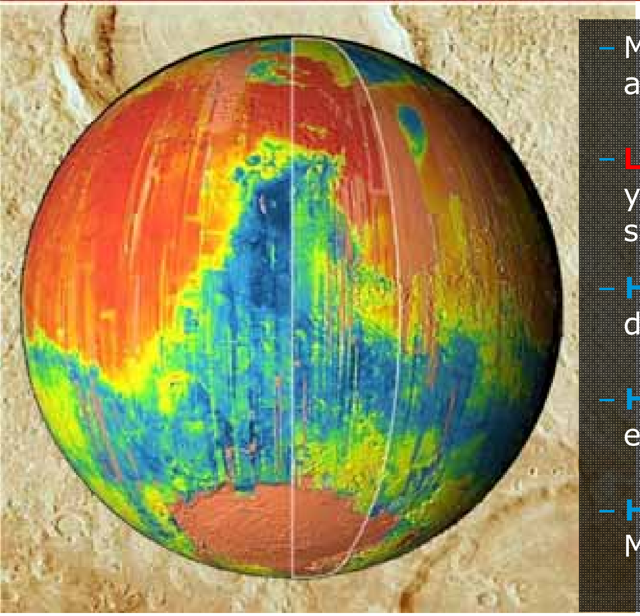
Credit: MEX/HRSC



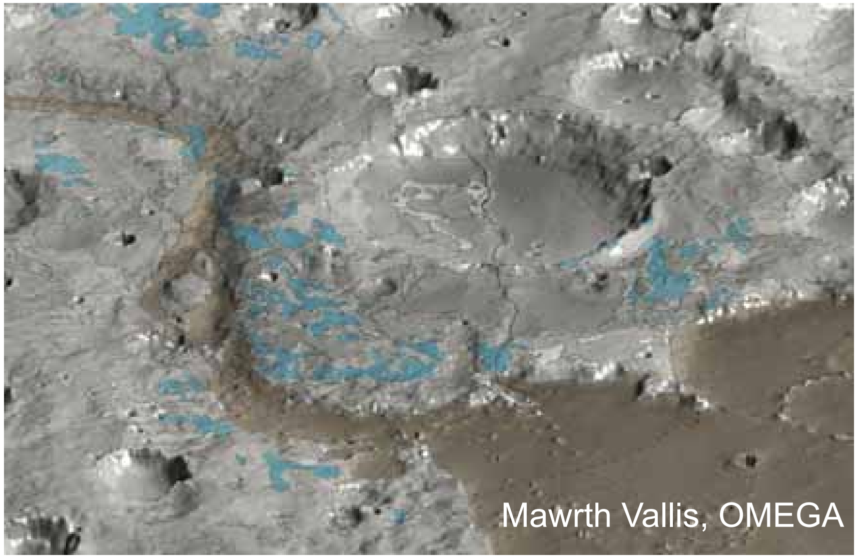
R. Jaumann et al., PSS 2015

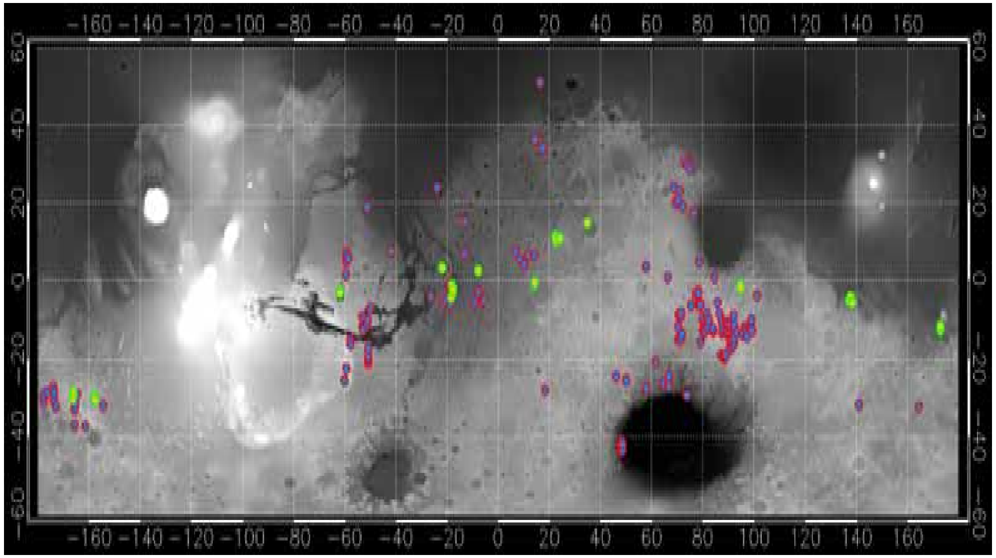
History based on chemical analysis: hydrated minerals detected by OMEGA

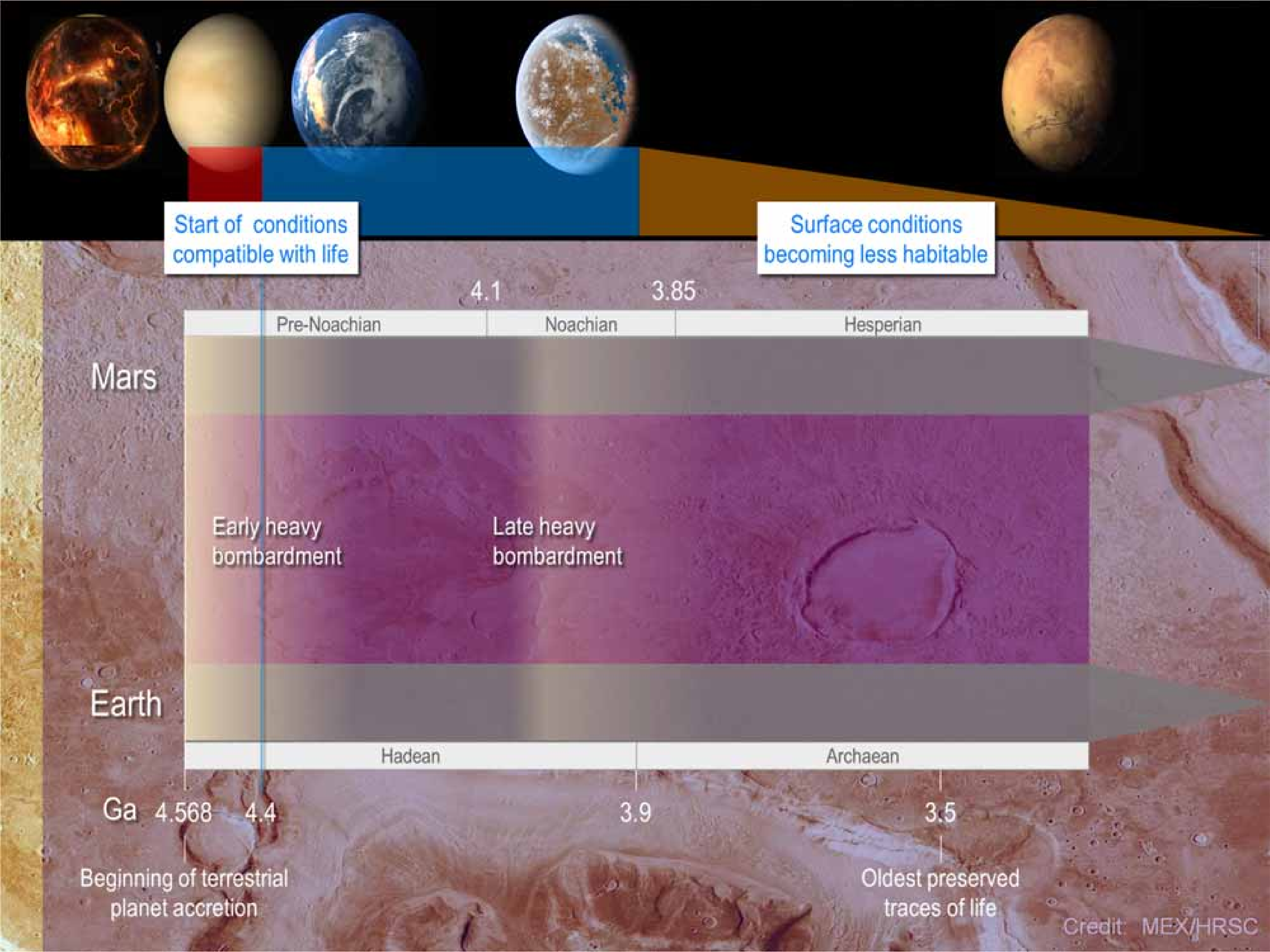




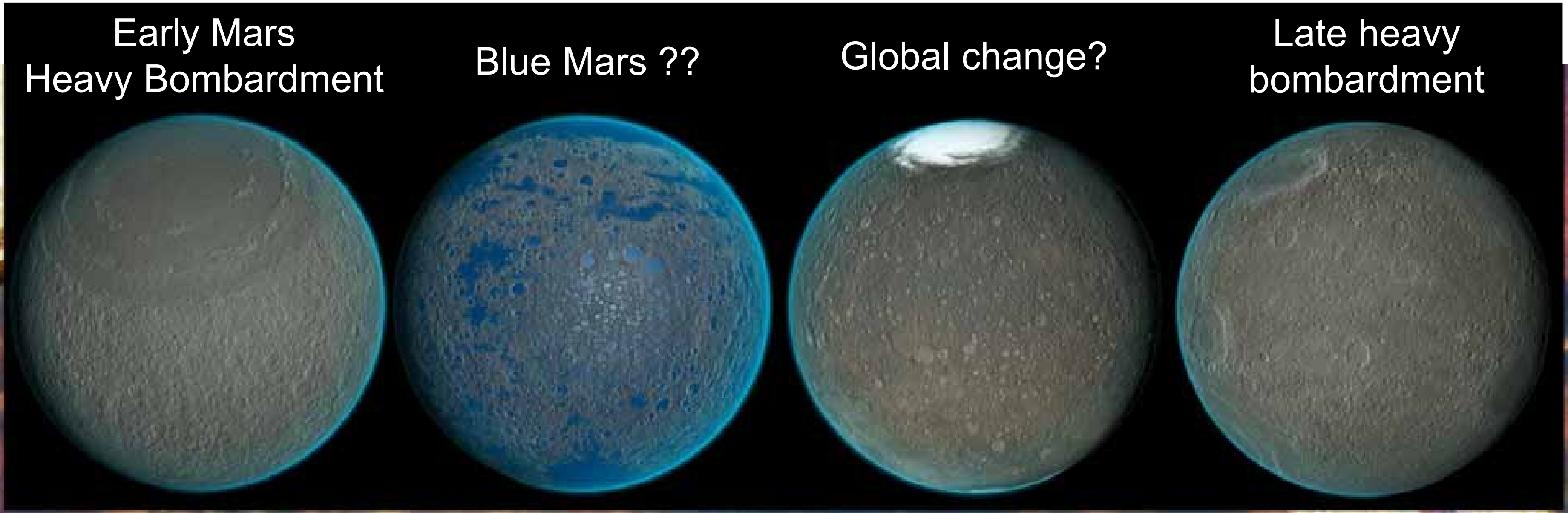
- Mars surface mainly **ferric oxyde red dust in northern young areas** and **Mafic minerals in older terrains** (olivine and pyroxene)
- **Liquid water is not responsible for Mars red color:** red dust (ferric oxydes) in younger Northern Lowlands do not show presence of water in its mineral structure;. (*oxidized without water/dehydrated, so no water?*)
- **Hydrated minerals found, but not in obvious "wet" places**, river floors or deposits from outflow channels. (*wet events too sudden to alter minerals?*)
- **Hydrated Phyllosilicates (clays) are in very ancient locations**, Noachian era, buried rocks that only exposed by erosion. (*Wet ancient Mars?*)
- **Hydrated Sulfates require very acid water**, detected in Meridiani, Valles Marineris, and northern dark dunes.



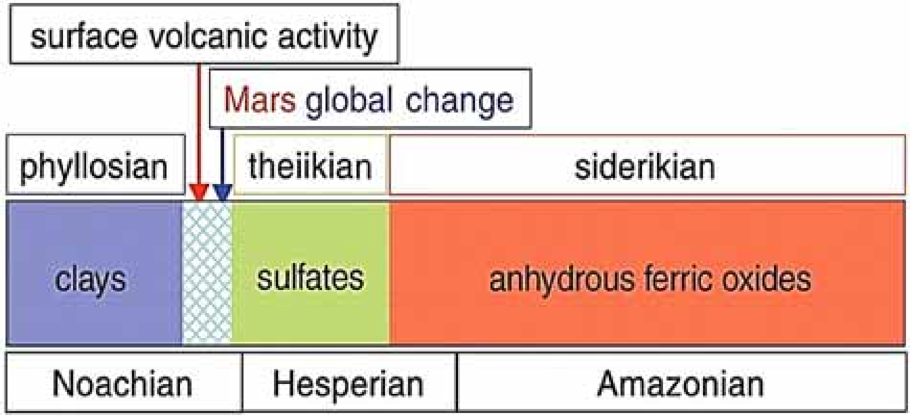



Start of conditions compatible with life
Surface conditions becoming less habitable
4.1
3.85
Pre-Noachian
Noachian
Hesperian
Mars
Early heavy bombardment
Late heavy bombardment
Earth
Hadean
Archaean
Ga
4.568
4.4
3.9
3.5
Beginning of terrestrial planet accretion
Oldest preserved traces of life
Credit: MEX/HRSC

Martian History revisited based on hydrated mineral detection

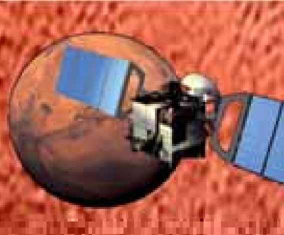


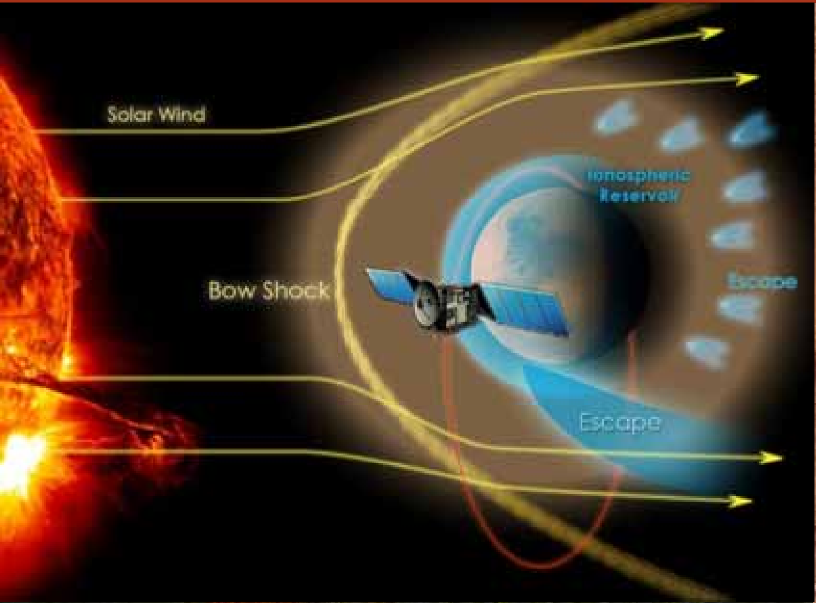
- **Phyllosian era**: Phyllosilicates found in oldest terrains formed by aqueous alteration very early in the planet's history;
- **Theiikian era**: Sulfates formed later in acidic environment.
- **Siderikian era**: since 3.5 Gyears, dominated by the formation of anhydrous ferric oxides in a slow superficial weathering, without liquid water playing a major role across the planet.

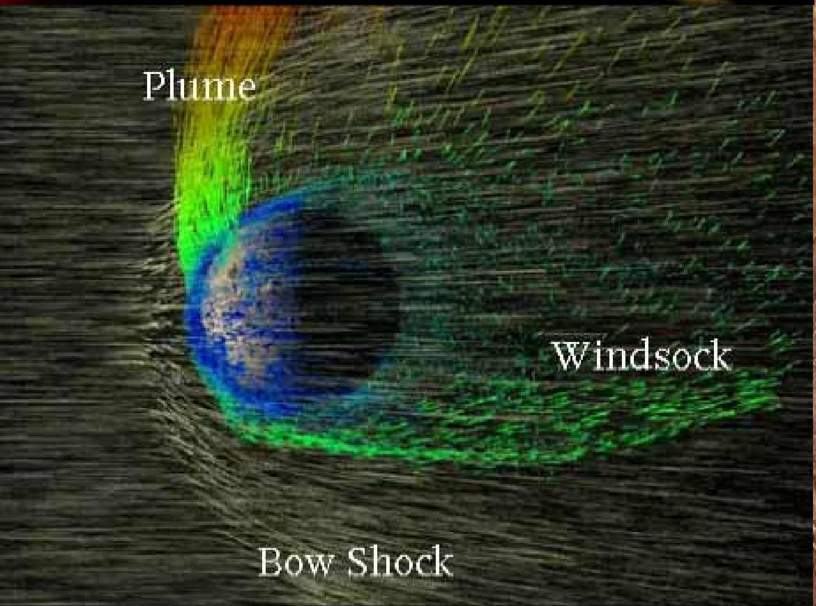


Revisited history of Mars, based on the detection of hydrated minerals (Bibring et al., 2006), in Mawrth Vallis (top left)

Atmospheric and Water Escape







Where did the water and the atmosphere go?

Mars Express ASPERA analysis of ion composition & escape.

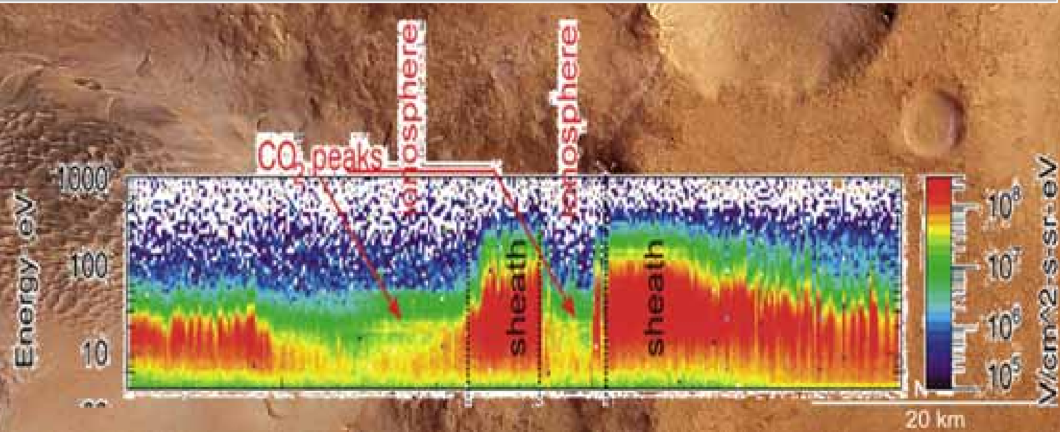
Escape dominated by hydrogen & oxygen ions (WATER!)

~1 ton per day → **~1m of Global Ocean** loss in 3~4Gyear

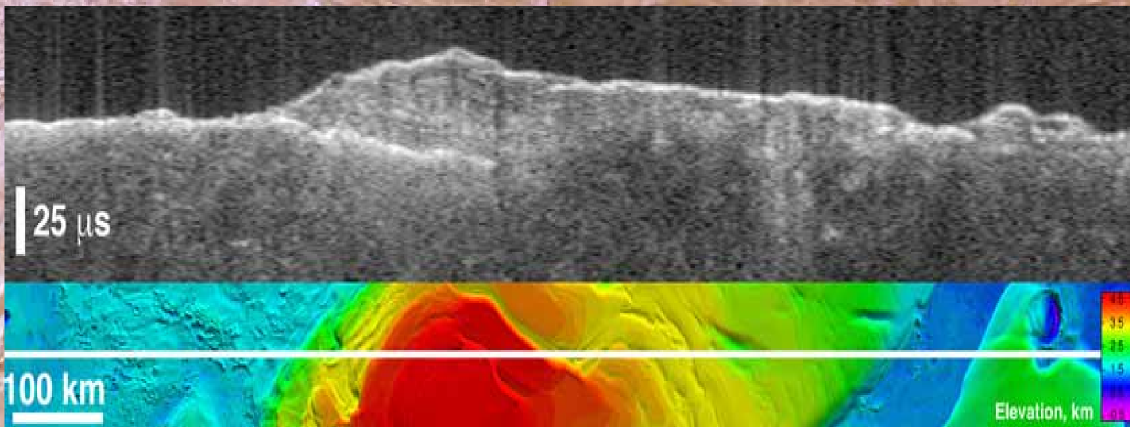
Ion escape is not enough to remove the martian atmosphere. Some other mechanism is required: loss of neutral atoms?

Water may be stored below planet's surface or polar caps

Also escape rate of carbon dioxide (CO2) is extremely slow, insufficient to for most planet's assumed atmospheric loss.



Polar Ice Subsurface structures by MARSIS

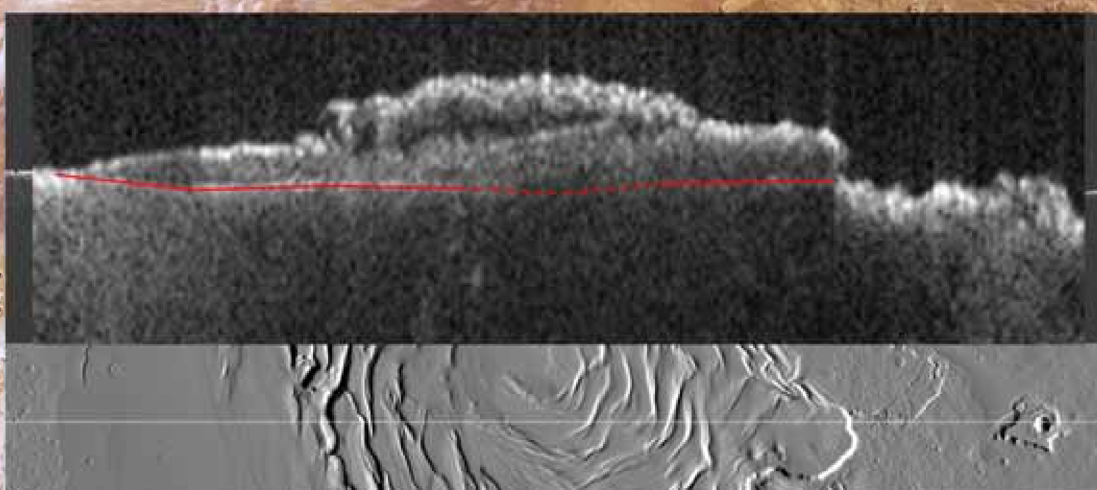


MARSIS analysis of Water ice in polar caps down to a few kms

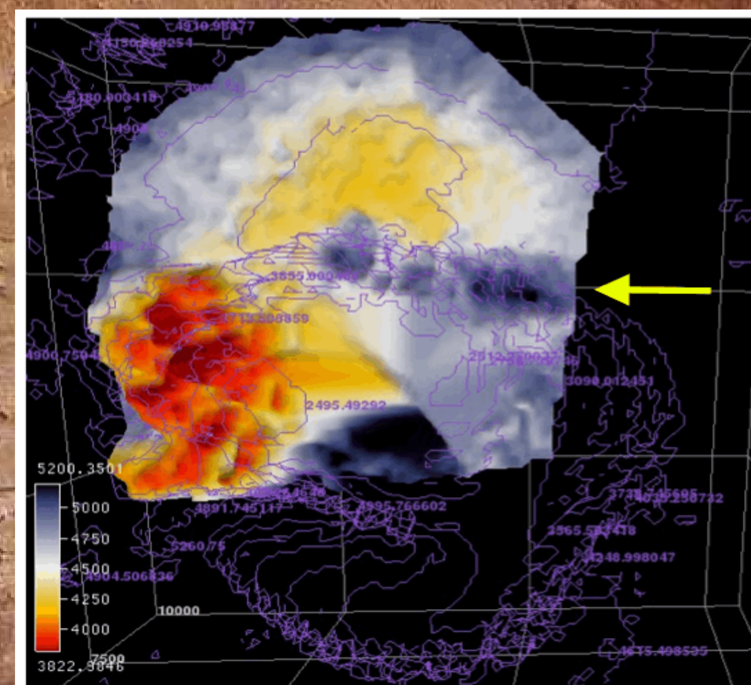
Equivalent to global ocean of 10~50m

More ice can be trapped deeper, also more distributed along the whole planet subsurface

3D reconstruction of ice polar caps



Credit: MEX/HRSC

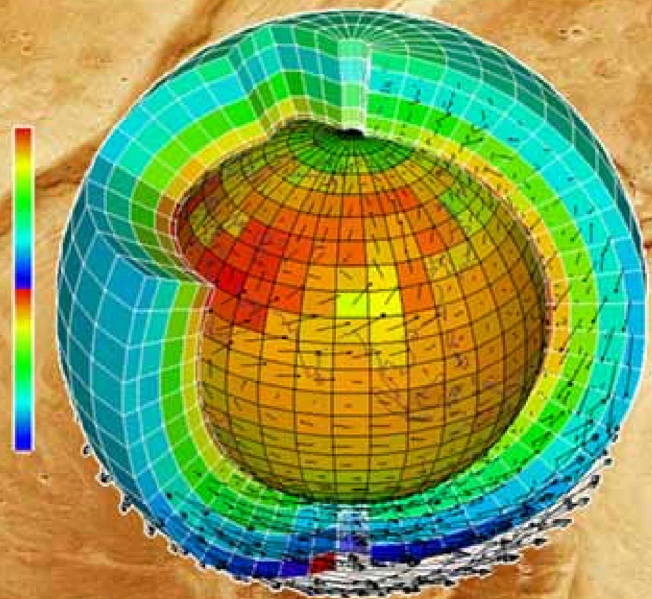


Frigeri et al.

Global Monitoring of Climate variability

Global Climate Model

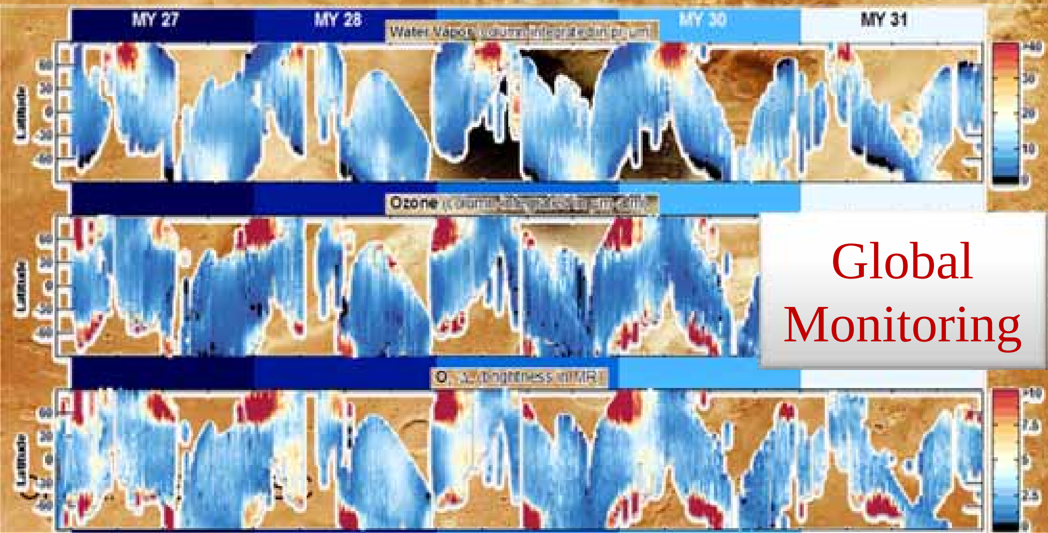
F. Forget et al.



Glacial Forms

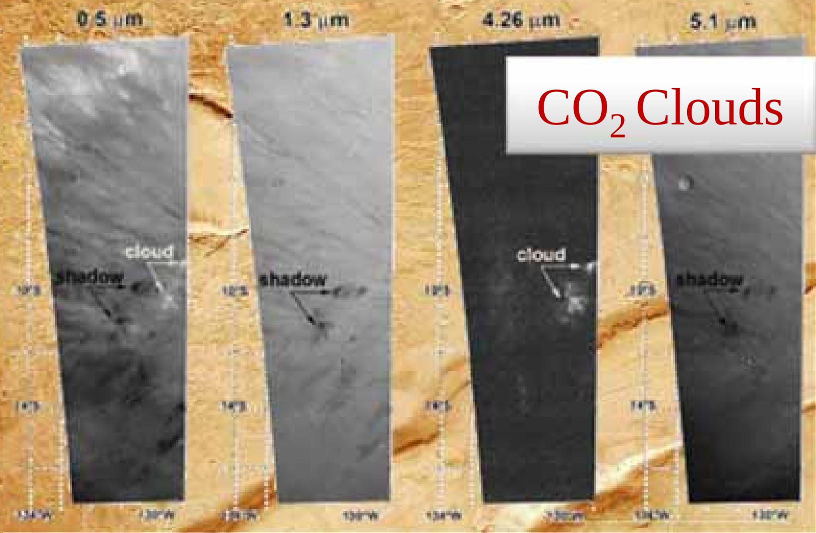
HRSC

Montmessin et al., Icarus, 2015



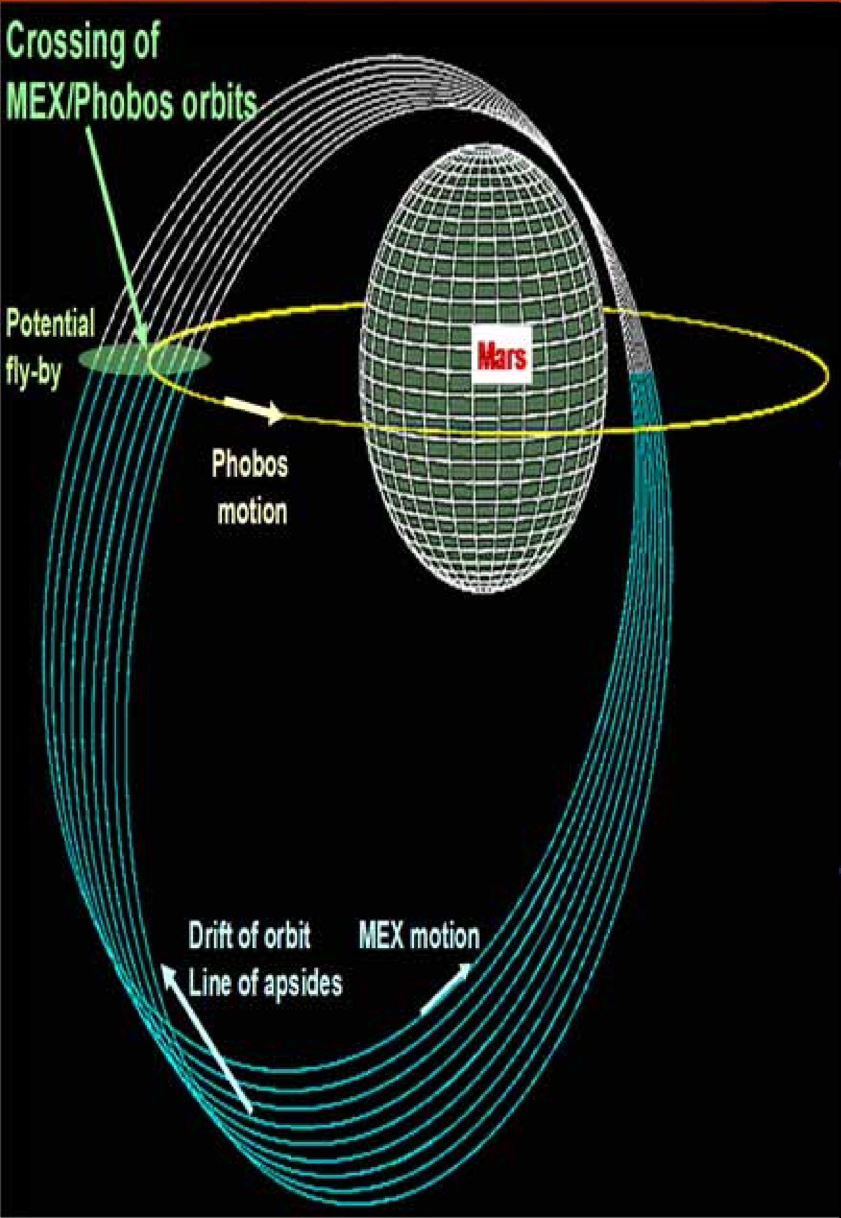
Global Monitoring

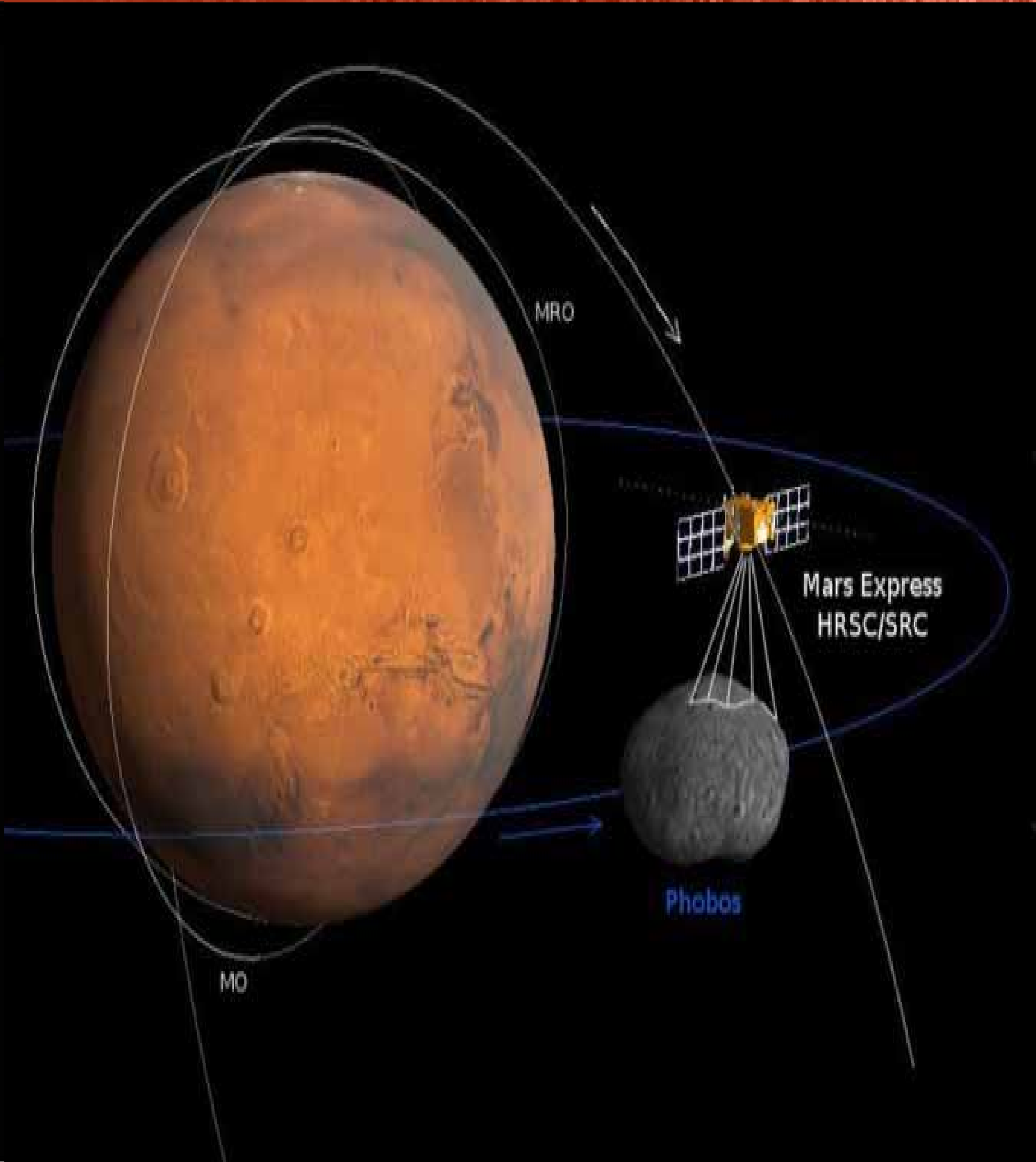
OMEGA



CO_2 Clouds

Characterisation of Phobos and Deimos



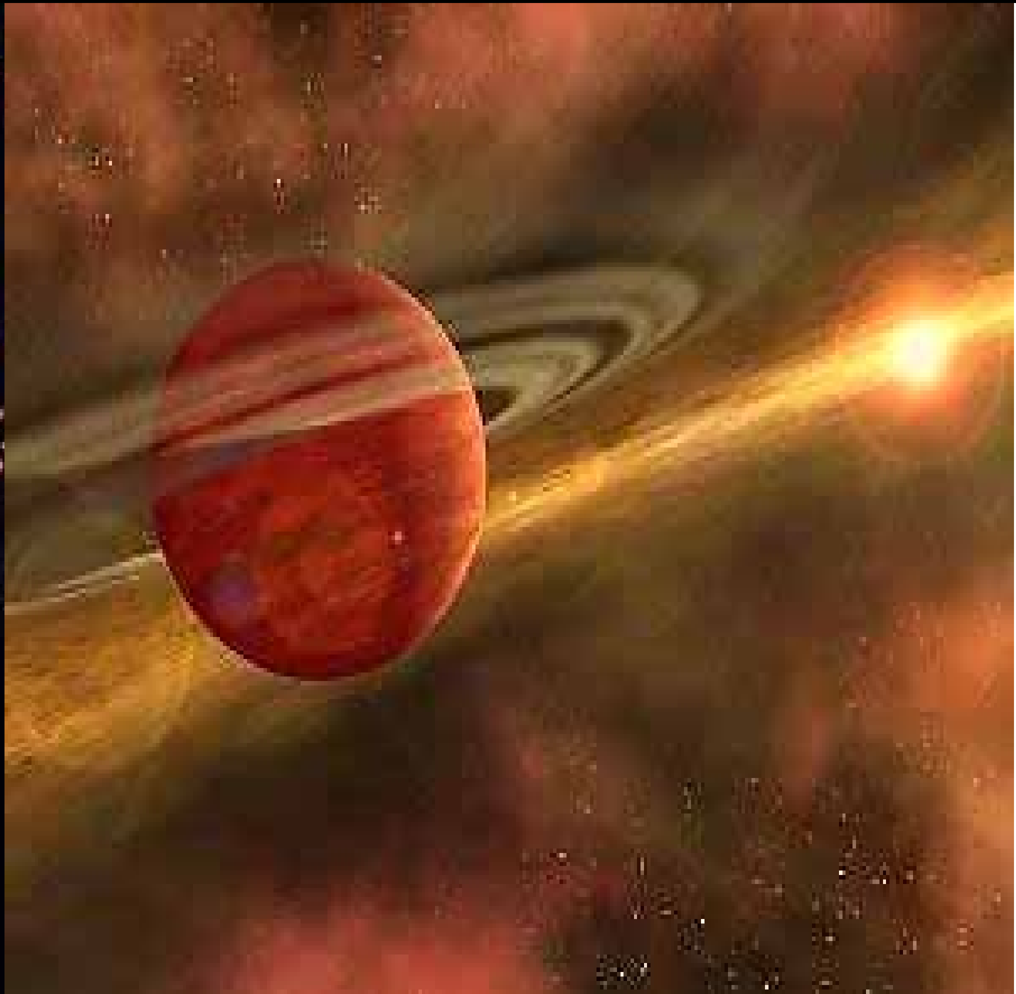



N
5 km


S

Origin of Phobos and Deimos

captured asteroid? surviving planetesimals?
remnant of a giant impact of a large object on Mars?



Present and Future European Missions to Mars

esa

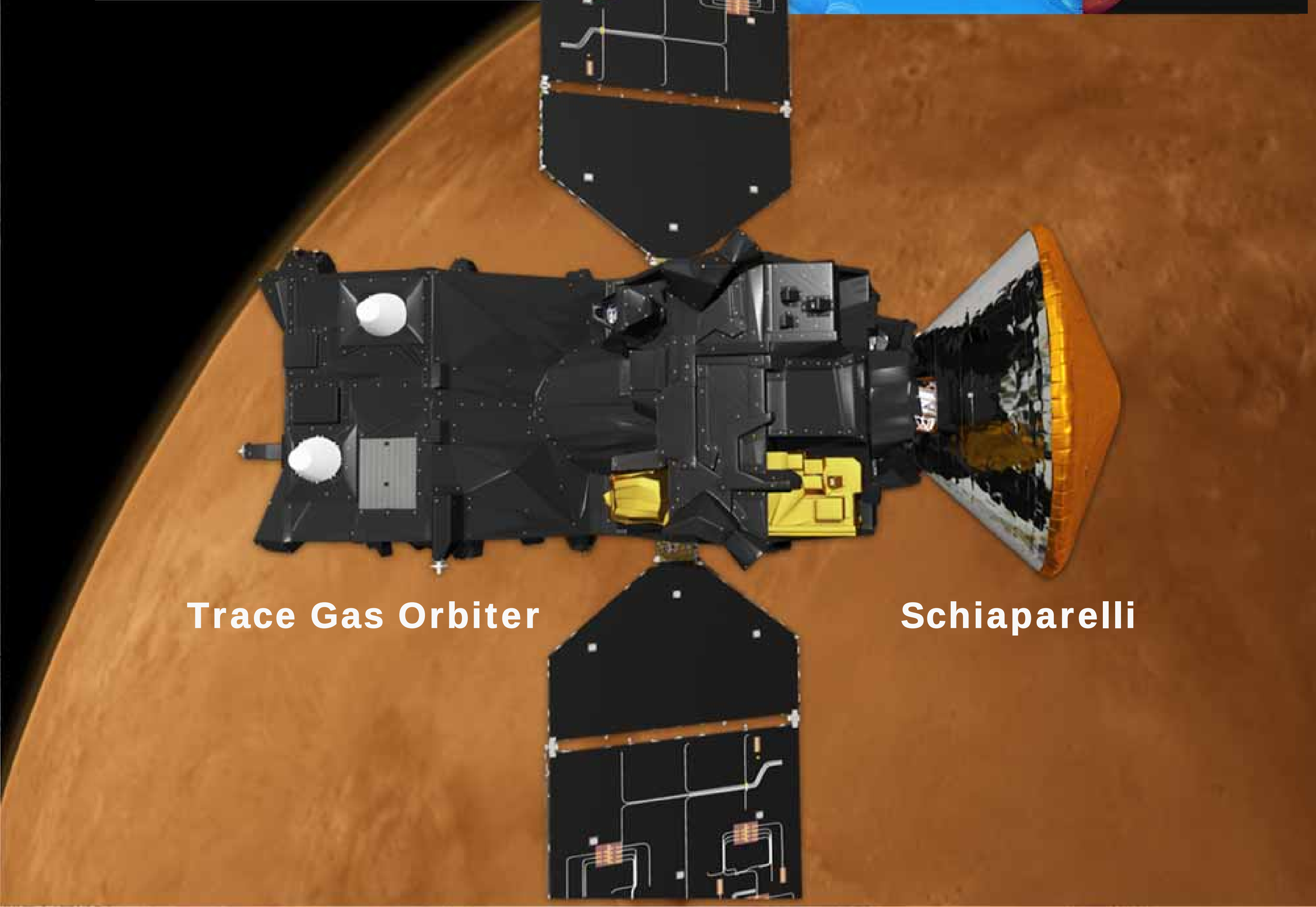
РОСКОСМОС

2 missions: orbiter in 2016, surface rover in 2020

- Cooperation between ESA and Roscosmos
- Includes contribution from NASA.

Credit: MEX/HRSC

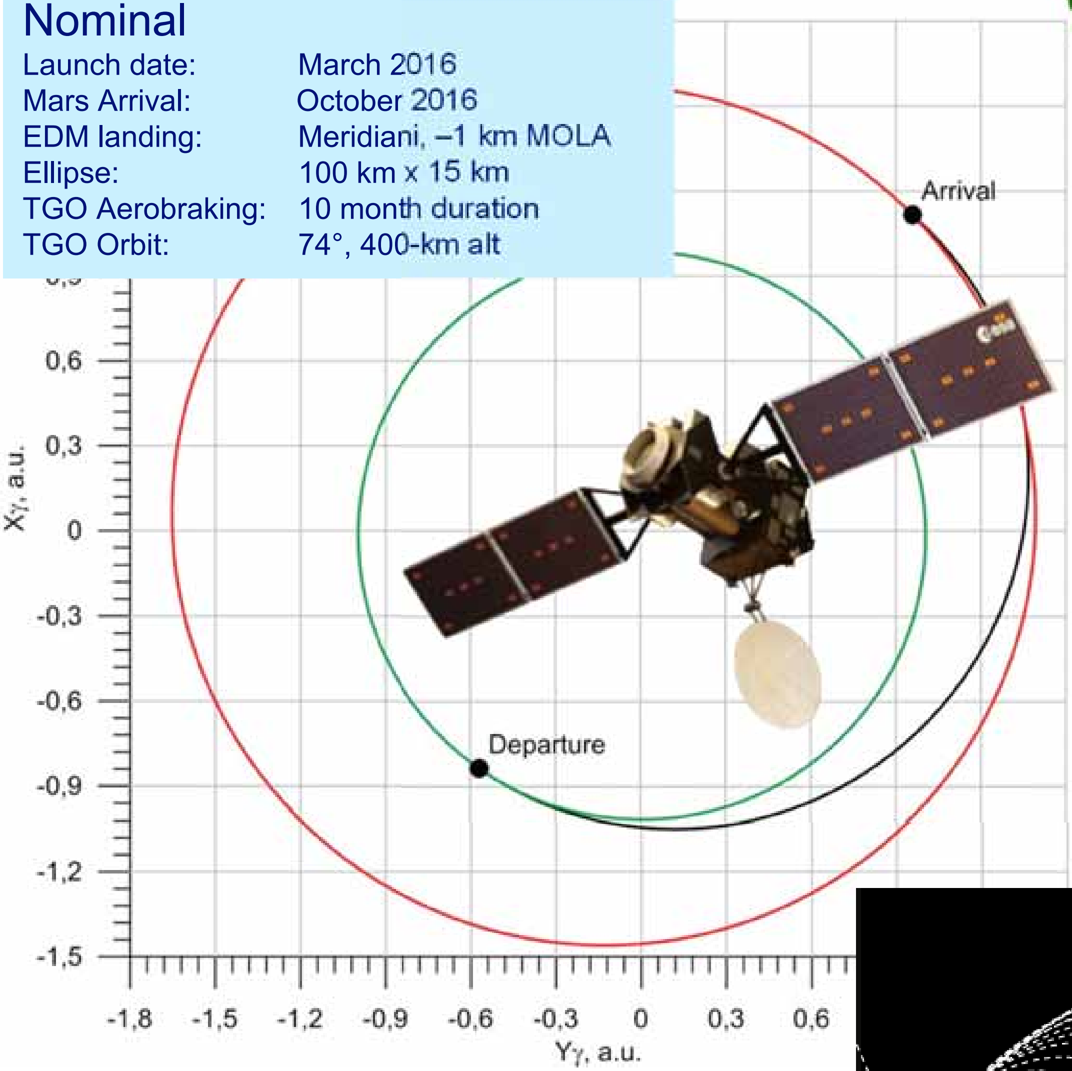
ExoMars 2016

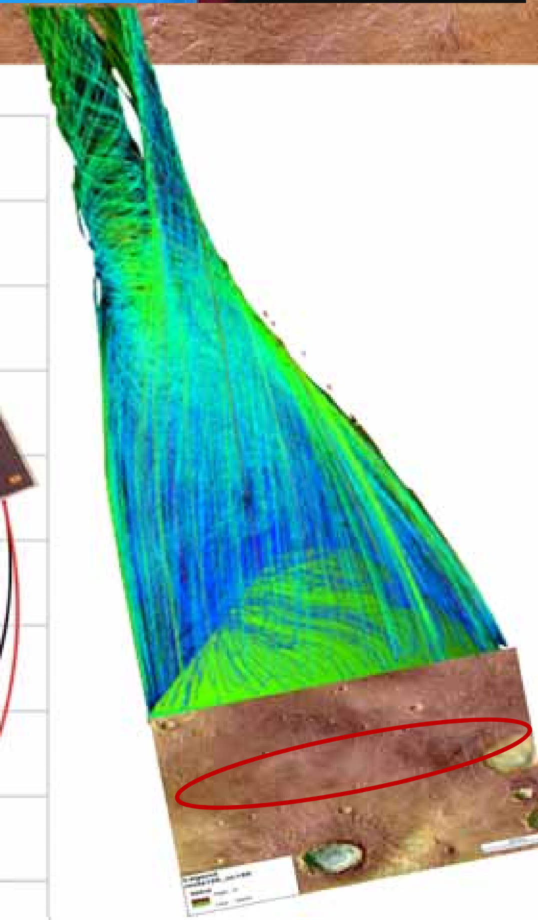


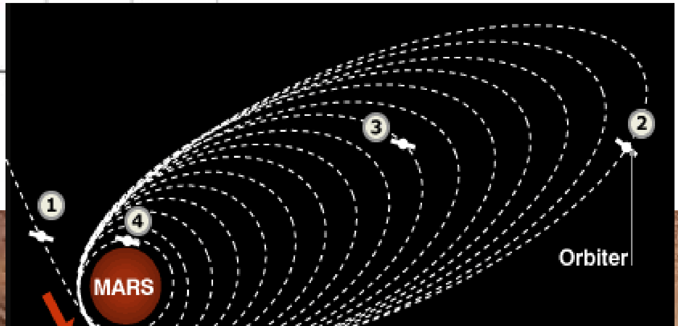
Mission Profile

Nominal

Launch date:	March 2016
Mars Arrival:	October 2016
EDM landing:	Meridiani, –1 km MOLA
Ellipse:	100 km x 15 km
TGO Aerobraking:	10 month duration
TGO Orbit:	74°, 400-km alt







Credit:
MEX/HRSC

ExoMars 2016: Objectives

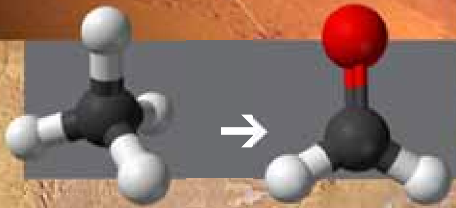
TECHNOLOGY OBJETIVES

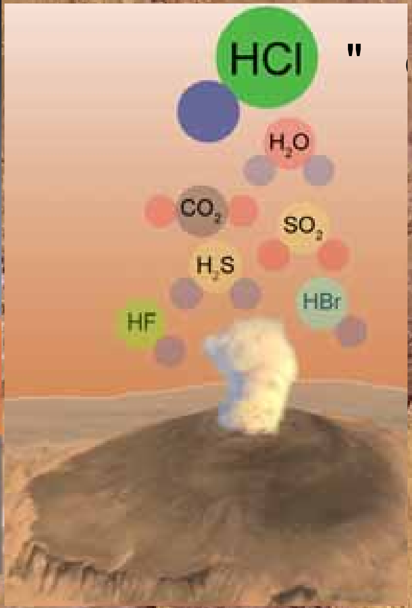
- Entry, Descent and Landing with science instrumentation
- Relay Communications until 2022

2016

SCIENCE OBJECTIVES

- Study of martian atmosphere: minor gases and sources
- Detailed surface analysys.





Credit: MEX/HRSC

Video: Arrival at Mars 19 Oct 2016

Schiaparelli: Demonstration Module

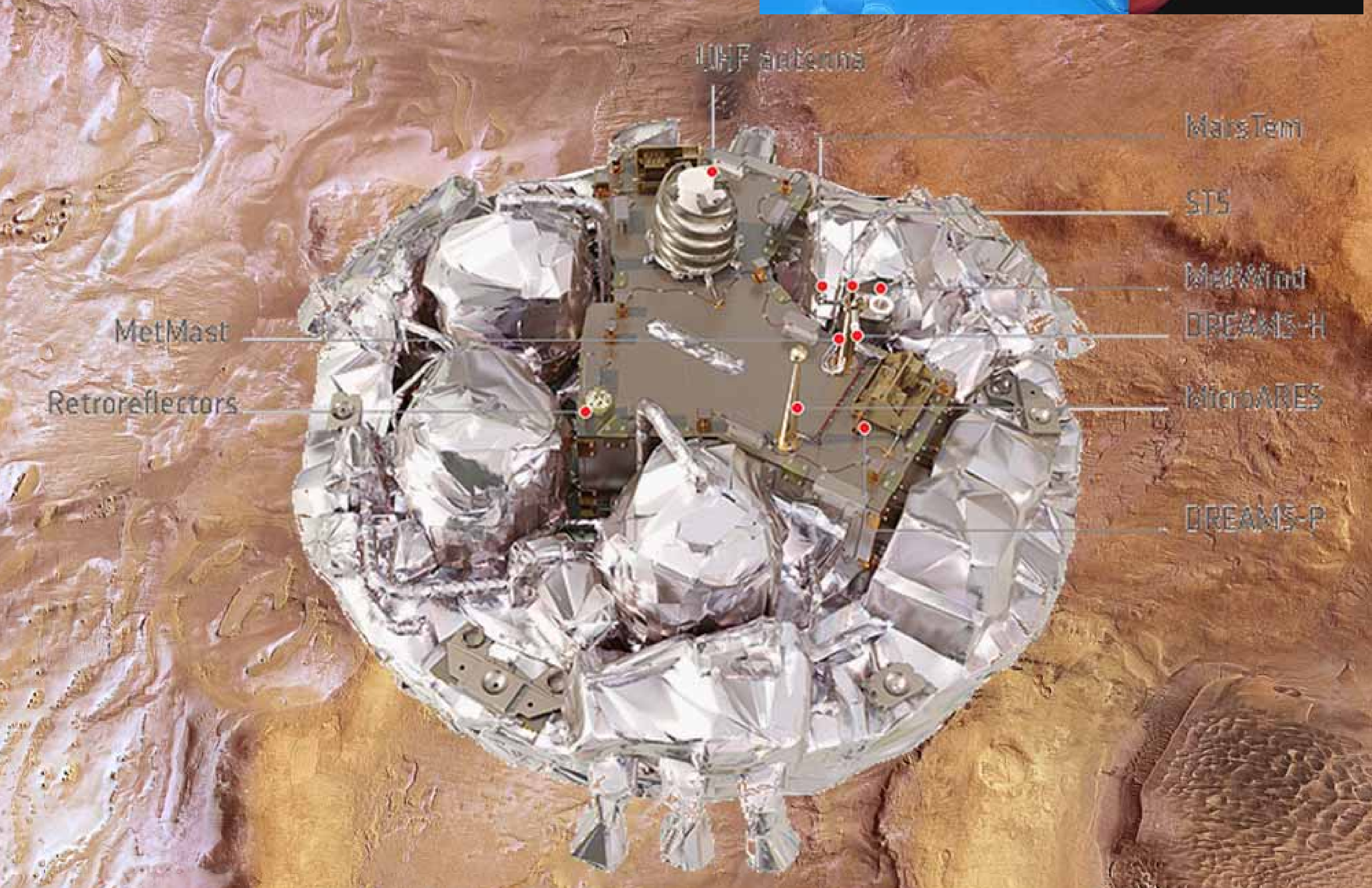
Schiaparelli

- Demonstration of technology for Entry, Descent and Landing on Mars
- Platform for environmental measurements during descent and on surface

PAYLOAD

- Integrated mass: 5 kg;
- Surface lifetime: 2–3 sols;
- Measurements:
  - Descent atmospheric science;
  - Pressure, Temperature, wind speed and direction;
  - Optical depth;
  - Atmospheric charging;
  - Descent camera.

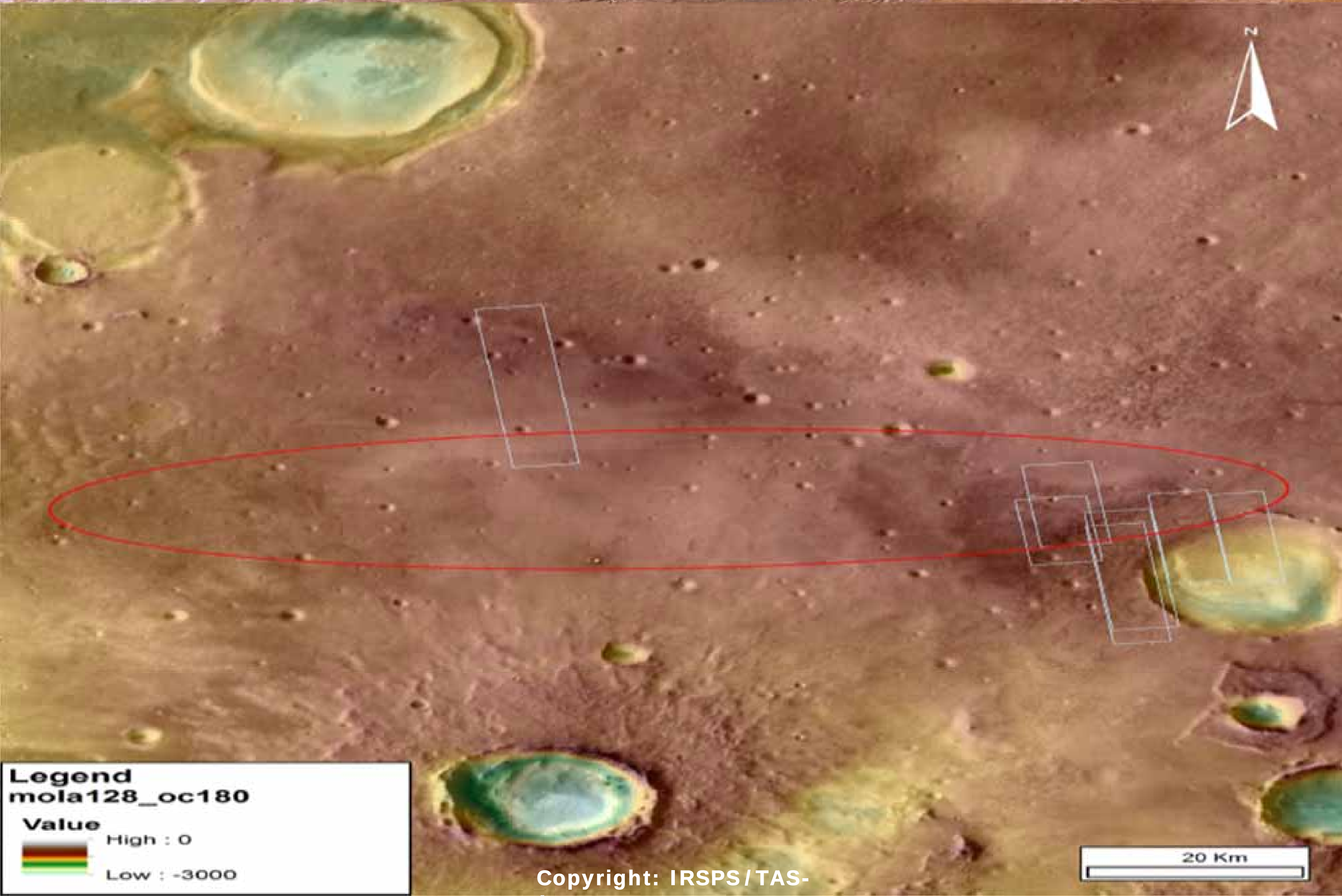
EDM: Schiaparelli



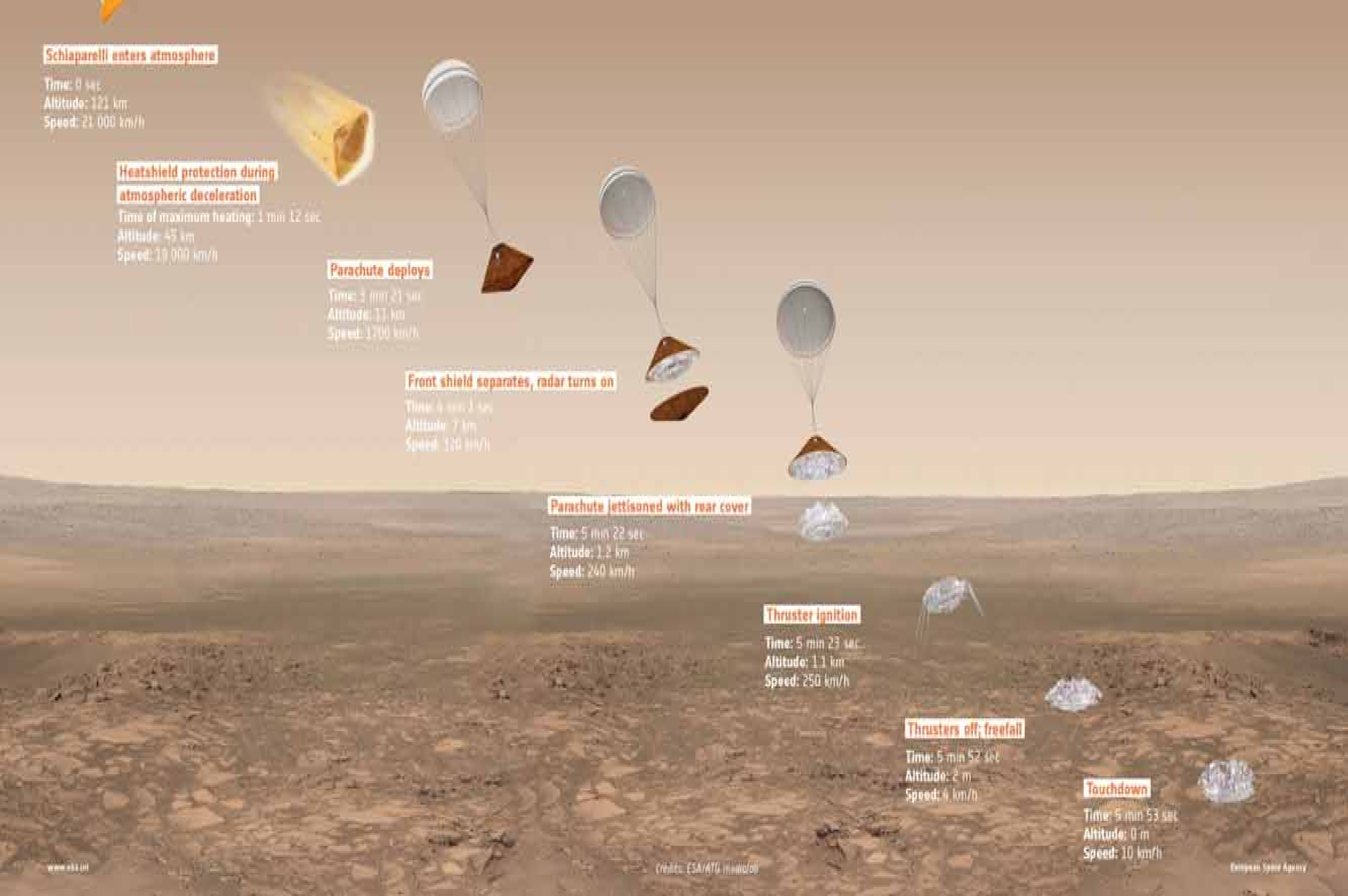
Credit:
MEX/HRSC


Parachute

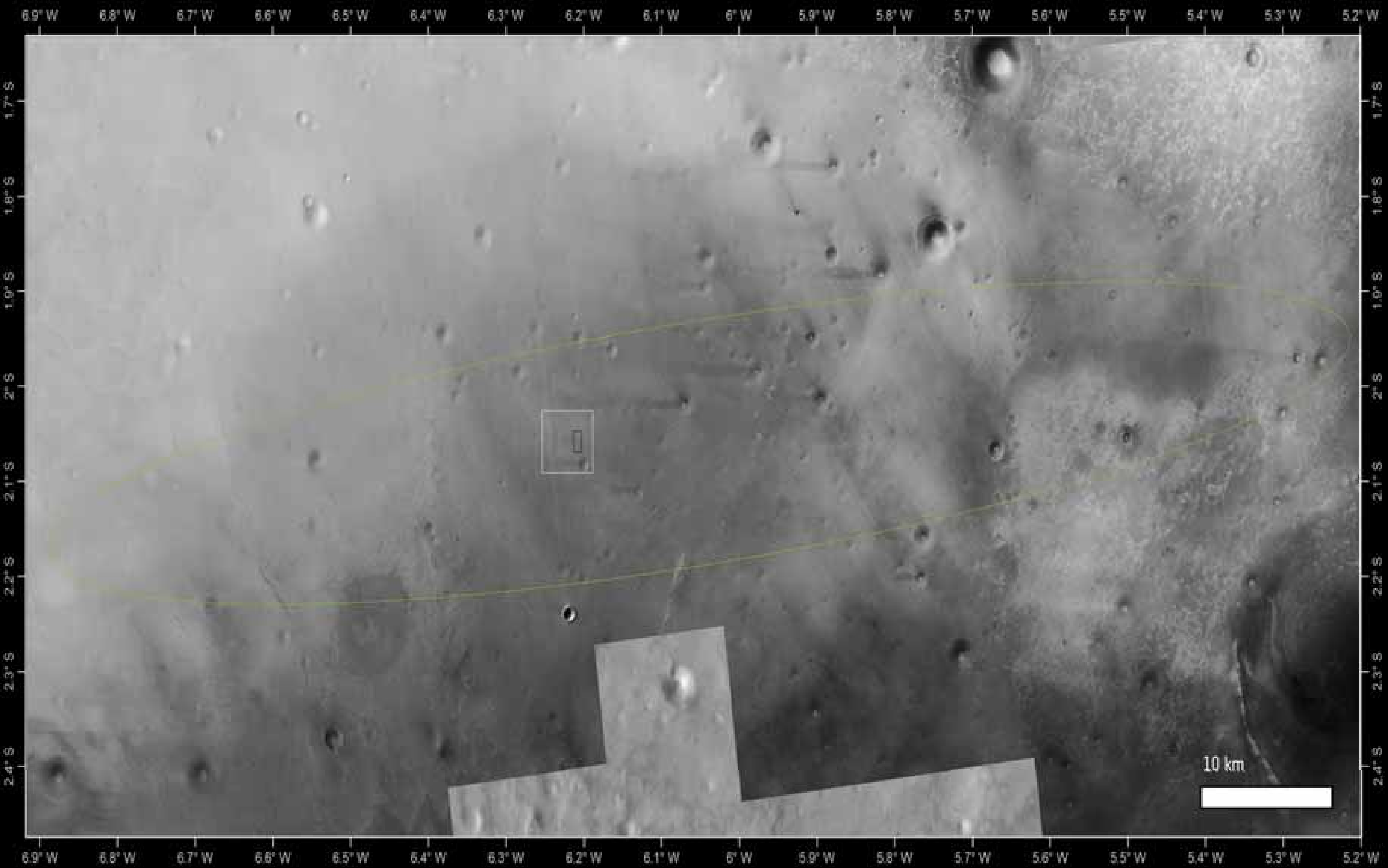
Landing Ellipse on Meridiani



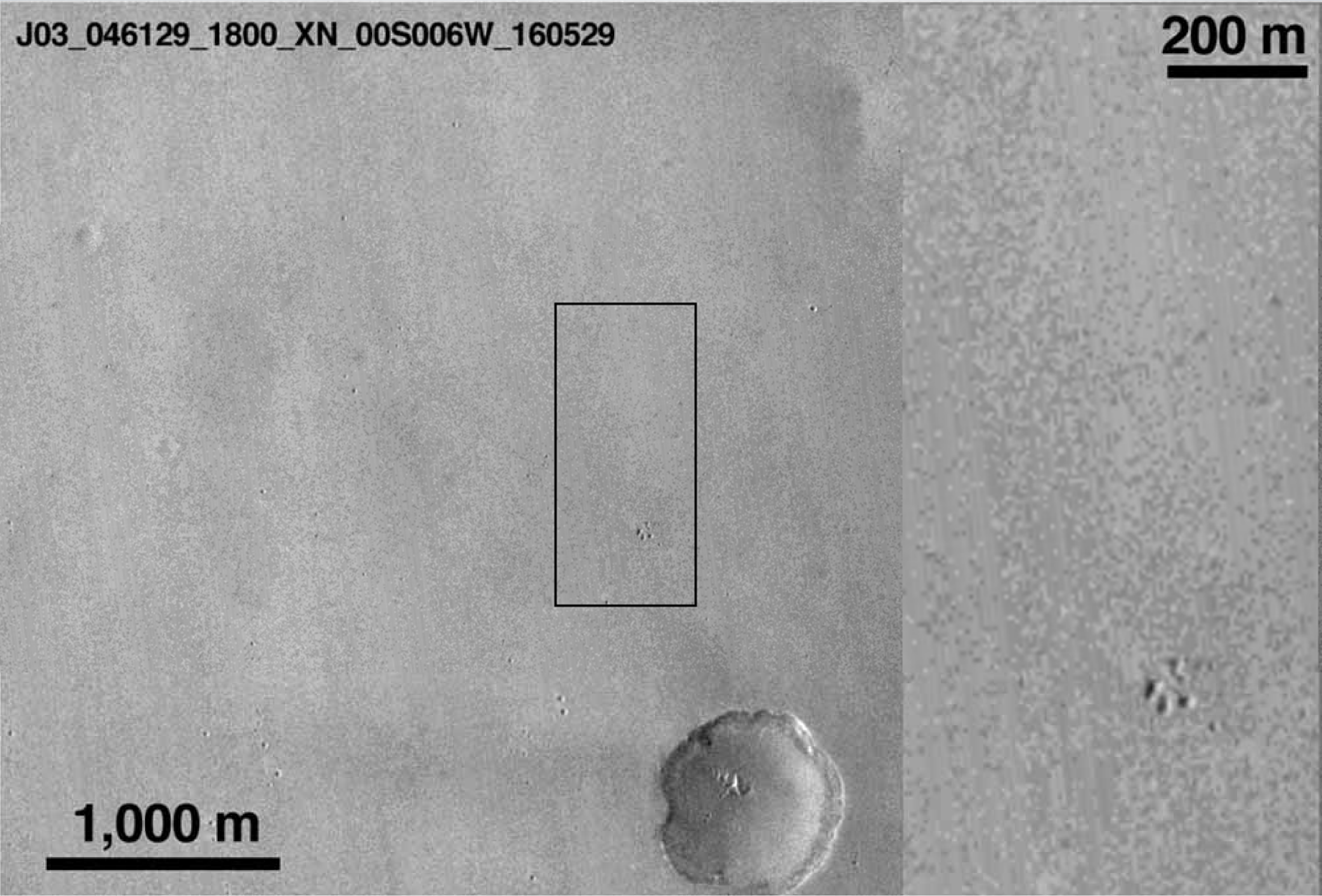
Schiaparelli Entry Descent and Landing
19 Oct 2016 16:43-16:49 CEST



MRO Low Resolution Camera



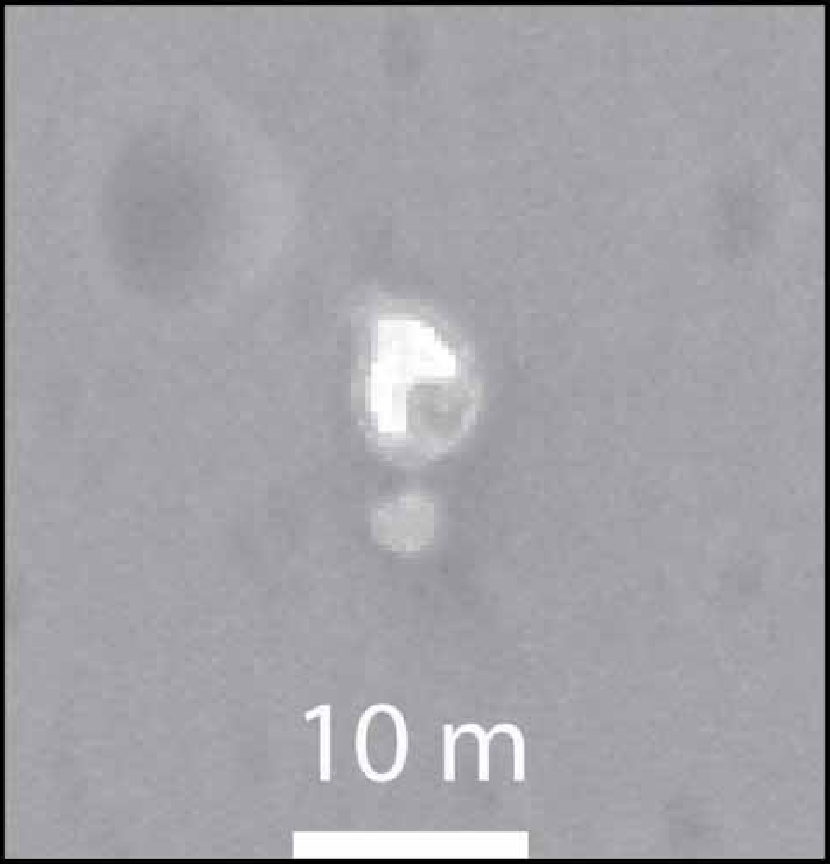
MRO Low Resolution Camera



MRO High Resolution Camera

MRO High Resolution Color Image Lander

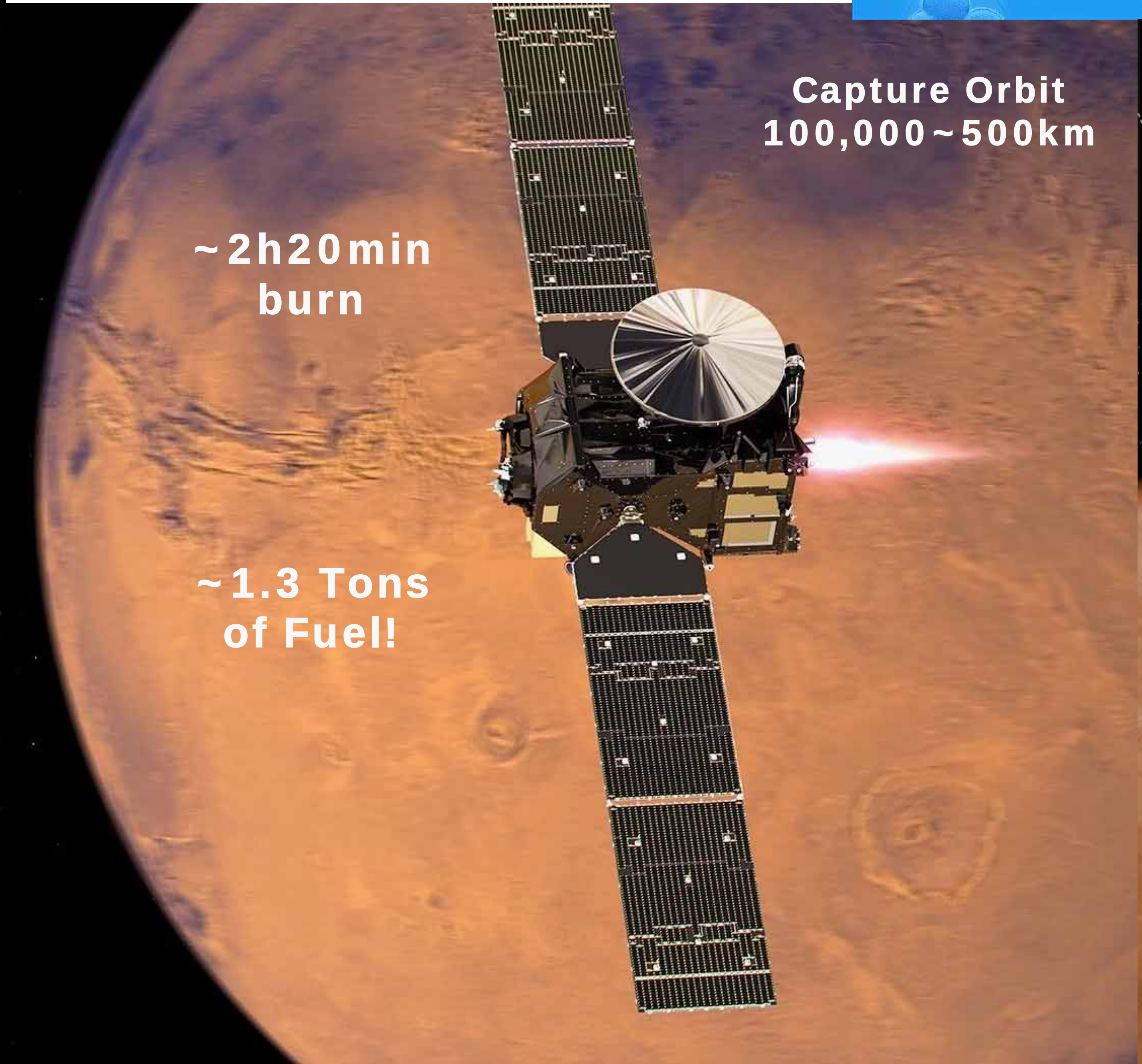
MRO High Resolution Color Image Parachute



25 Oct

1 Nov

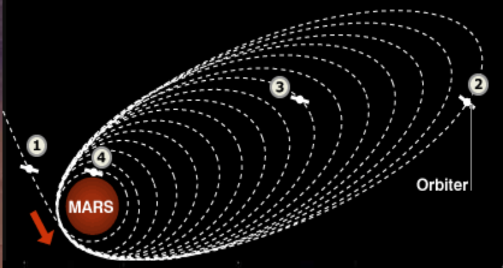
TGO Orbit Insertion: 19 Oct 2016



Capture Orbit
100,000~500km

~2h20min
burn

~1.3 Tons
of Fuel!



Orbit Circularization
down to ~400km

Aerobraking
~9 months in 2017

Trace Gas Orbiter

NOMAD

High-resolution occultation and nadir spectrometers

Atmospheric composition (CH_4, O_3, trace species, isotopes) dust, clouds, P&T profiles

UVIS (0.20 – 0.65 µm) λ/Δλ ~250	SO Lim Nad
IR (2.3 – 3.8 µm) λ/Δλ ~10,000	SO Lim Nad
IR (2.3 – 4.3 µm) λ/Δλ ~20,000	SO

CaSSIS

High-resolution, stereo camera

Mapping of sources
Landing site selection

ACS

Suite of 3 high-resolution spectrometers

Atmospheric chemistry, aerosols, surface T, structure

Near IR (0.7 – 1.7 µm) λ/Δλ ~20,000	SO Lim Nad
IR (Fourier, 2.5 – 25 µm) λ/Δλ ~4,000 (SO)/500 (N)	SO Nad
Mid-IR (2.3 – 4.5 µm) λ/Δλ ~50,000	SO

FREND

Collimated neutron detector

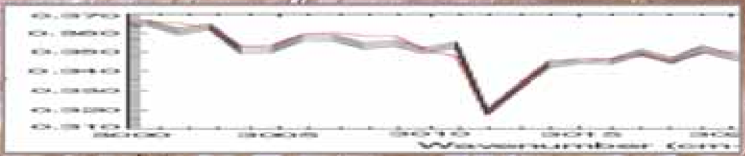
Mapping of subsurface water and hydrated minerals

Credit: MEX/HRSC

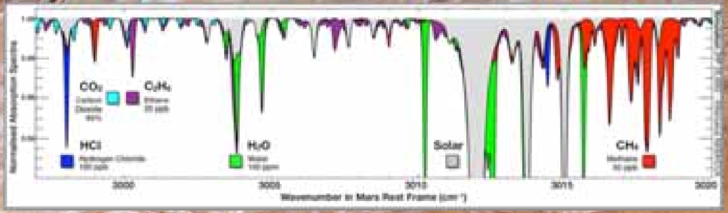
Atmosphere Spectroscopy Analysis

EXOMARS

PFS on MEX



NOMAD and ACS on TGO



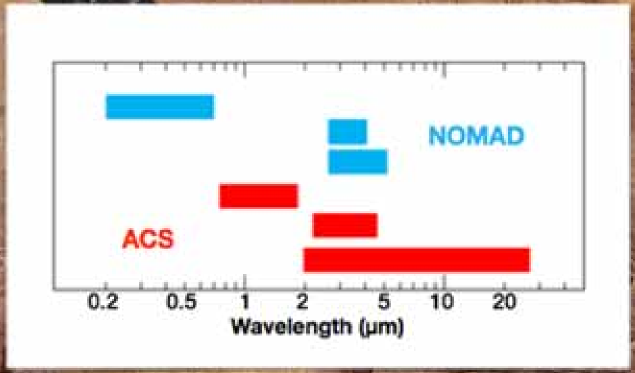
- Methane detection can be confirmed by many absorption bands.
- TGO methane sensitivity is 100 ppt (~1000 times better than Mars Express).
- The ability to also measure other hydrocarbons will help establish its origin.

Infrared:

CO_2 (and $^{13}CO_2$, ^{17}OCO, ^{18}OCO, $C^{18}O_2$), CO (and ^{13}CO, $C^{18}O$), H_2O (and HDO), NO_2, N_2O, CH_4 (and $^{13}CH_4$, CH_3D), C_2H_2, C_2H_4, C_2H_6, H_2CO, HCN, OCS, HCl, HO_2, H_2S, aerosols/ice

Ultraviolet:

O_3 and SO_2



ACS & NOMAD

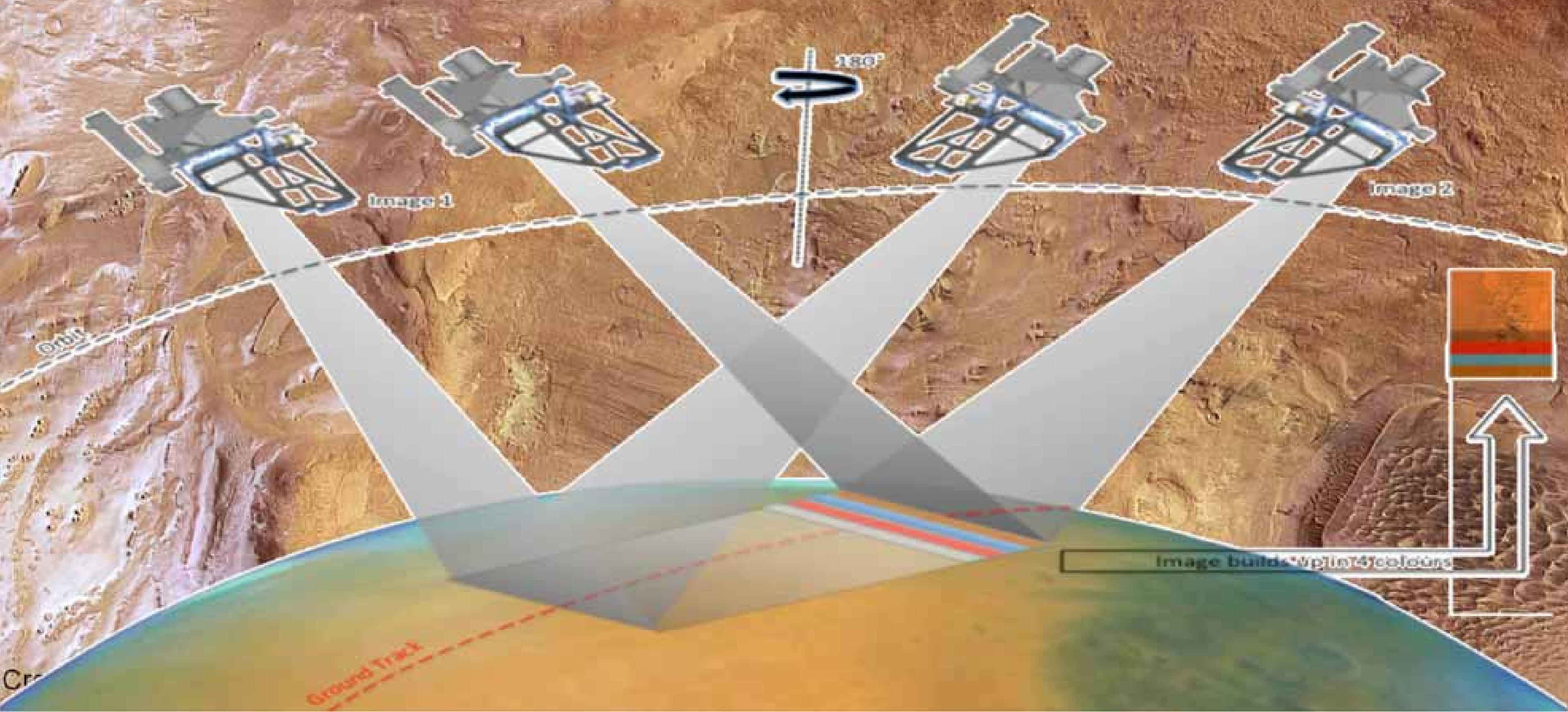
Credit: MEX/HRSC

High Resolution Stereo Imaging

CaSSIS
High-resolution, stereo camera

Mapping of sources
Landing site selection

- Stereo and colour camera (4 filters)
- Resolution ≤ 5 m/pixel
- Imaging swath is 9-km wide

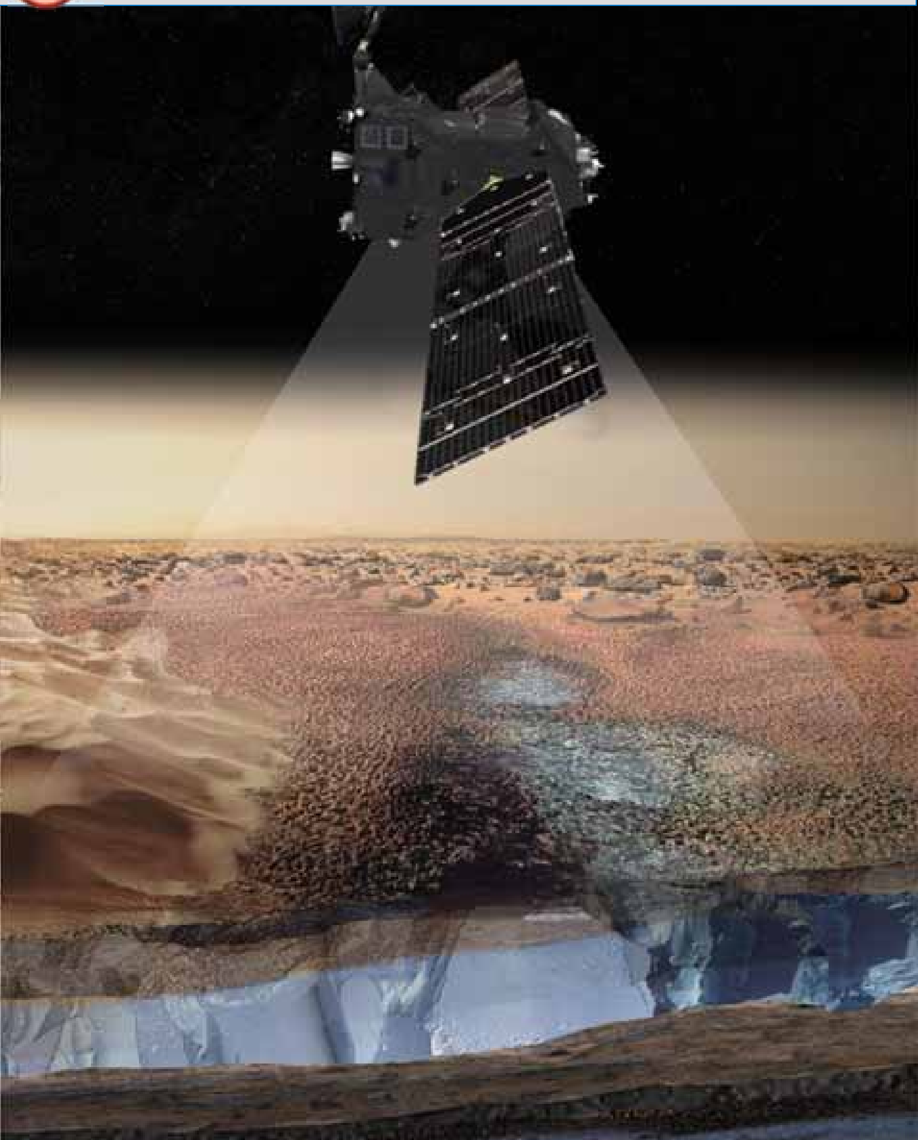


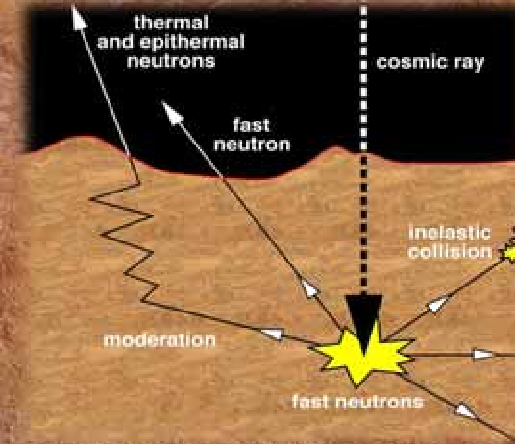
Detection of Sub-surface Water

FREND

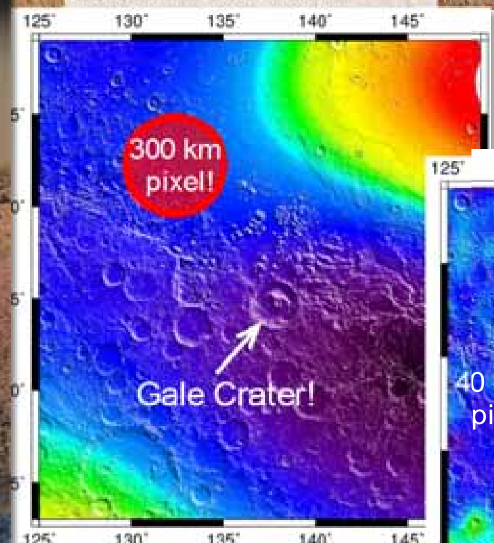
Collimated neutron detector

Mapping of subsurface water and hydrated minerals

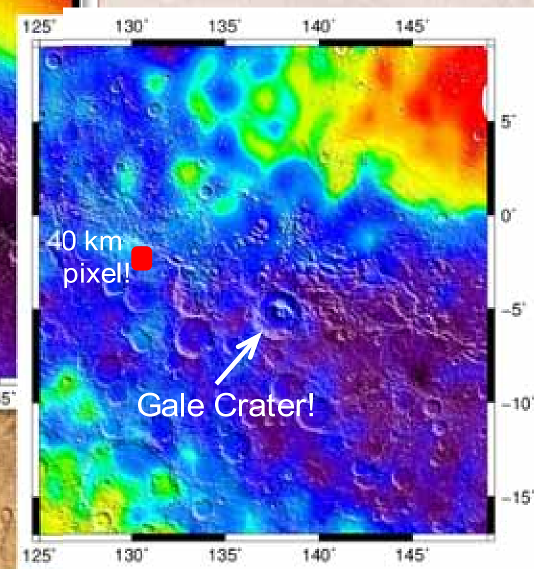




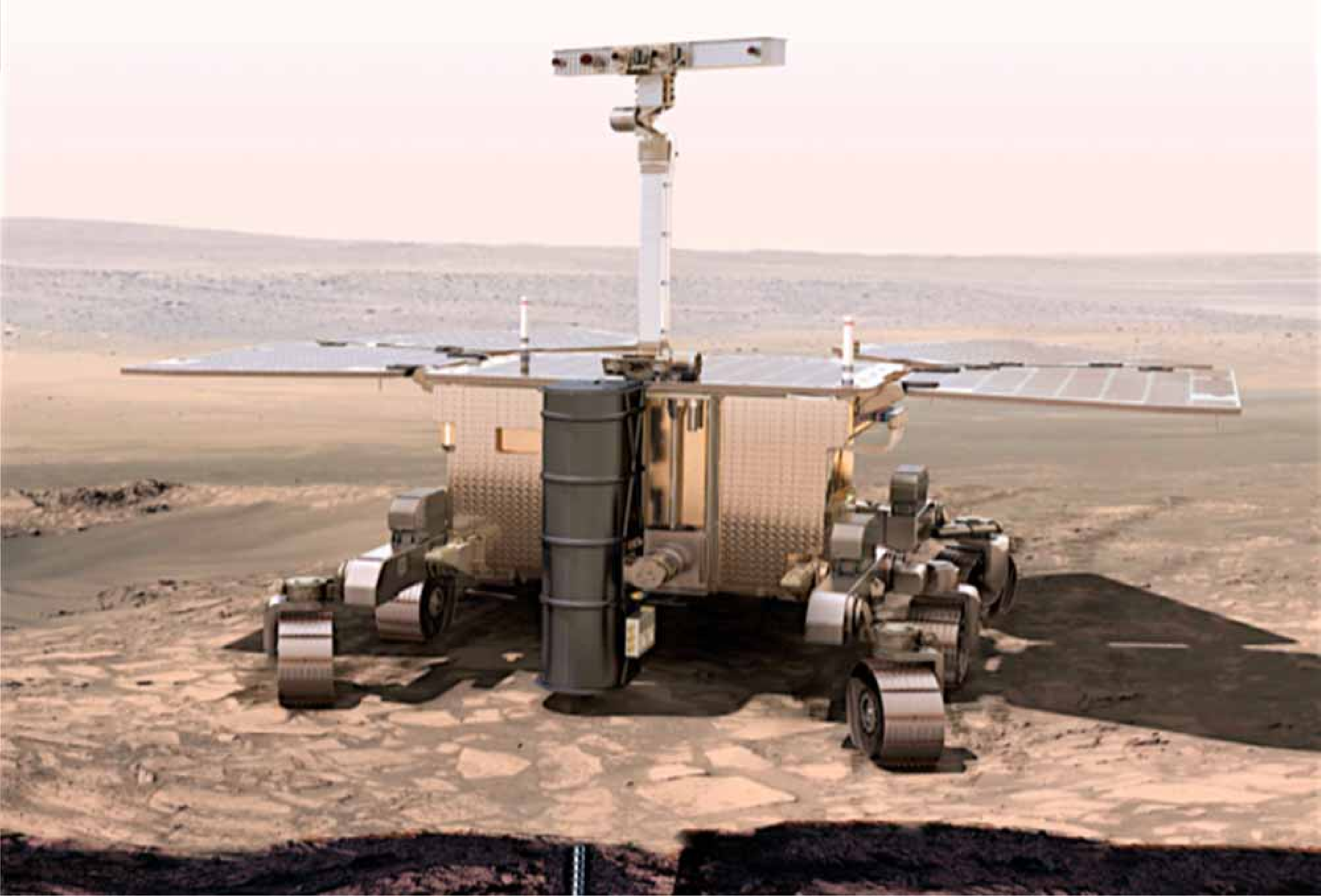
HEND/Odyssey data, !
300-km resolution!



Simulation of FREND/TGO data based on HEND/Odyssey, !
40-km resolution!



ExoMars 2020



ExoMars 2020 Objectives

2020

SCIENCE OBJECTIVES

- Search for signs of present and past life on Mars
- Research for water in subsurface and environment

TECHNOLOGY OBJECTIVES

- Movility on Msurface (up to a few kilometers);
- Direct access to martian subsurface (2m depth drill);
- Sample acquisition and analysis from surface and subsurface

SCIENCE OBJECTIVES

- Characterisation of Surface environment.

TECHNOLOGY OBJECTIVES

- Descent and landing platform
- Communications with European and Russian stations

Credit: MEX/HRSC

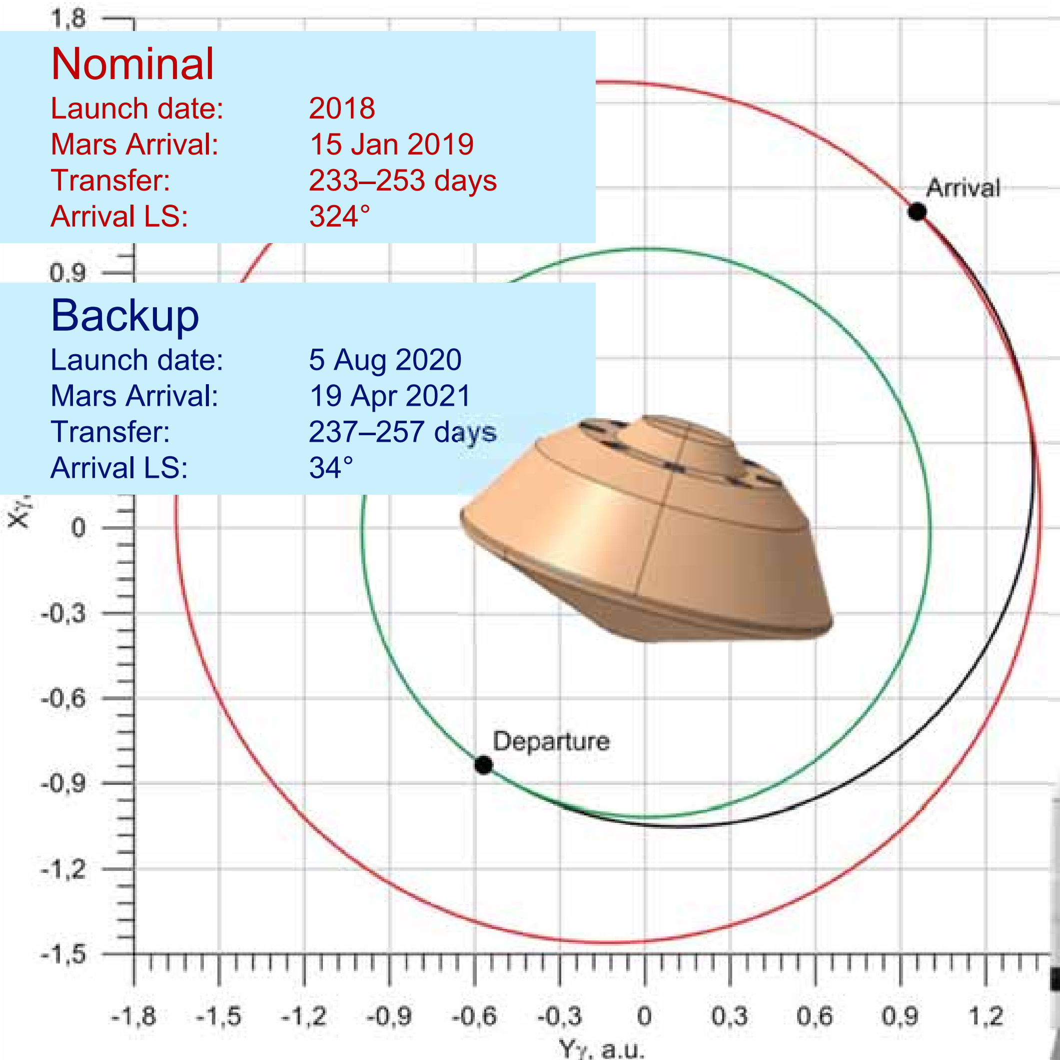
Launch

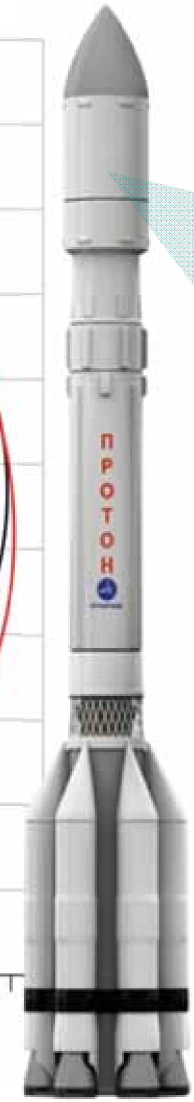
Nominal

Launch date: 2018
Mars Arrival: 15 Jan 2019
Transfer: 233–253 days
Arrival LS: 324°

Backup

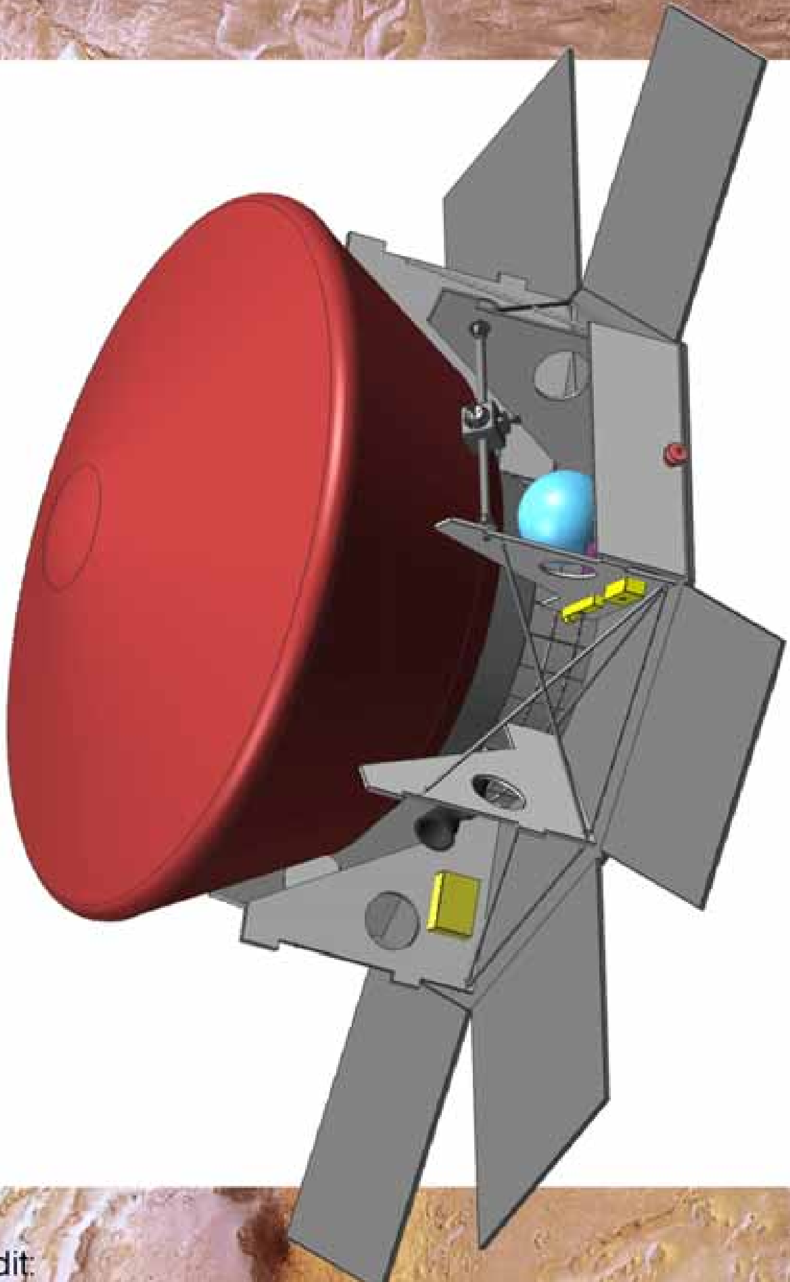
Launch date: 5 Aug 2020
Mars Arrival: 19 Apr 2021
Transfer: 237–257 days
Arrival LS: 34°

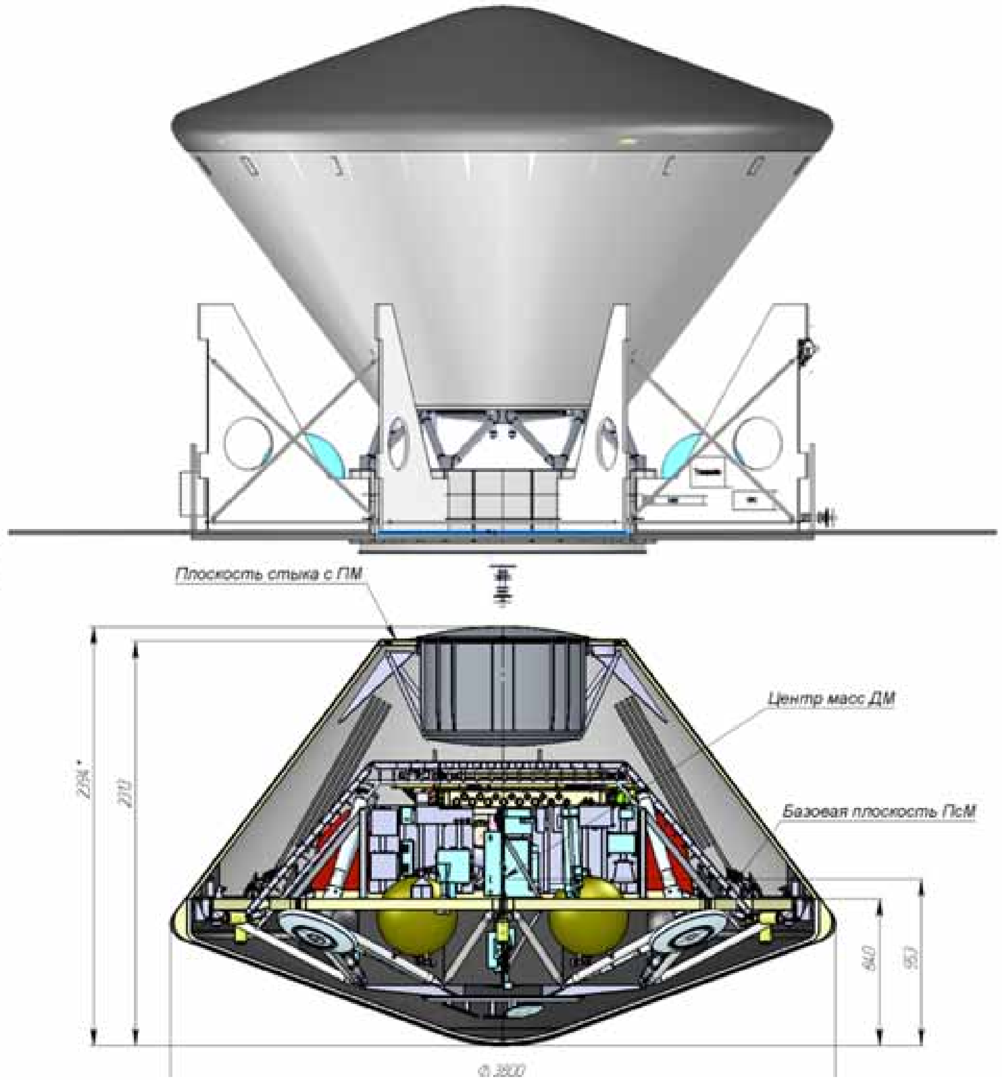




Credit: MEX/HRSC

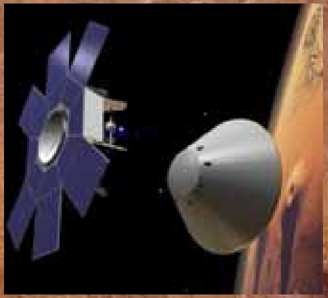
Carrier and Descent module

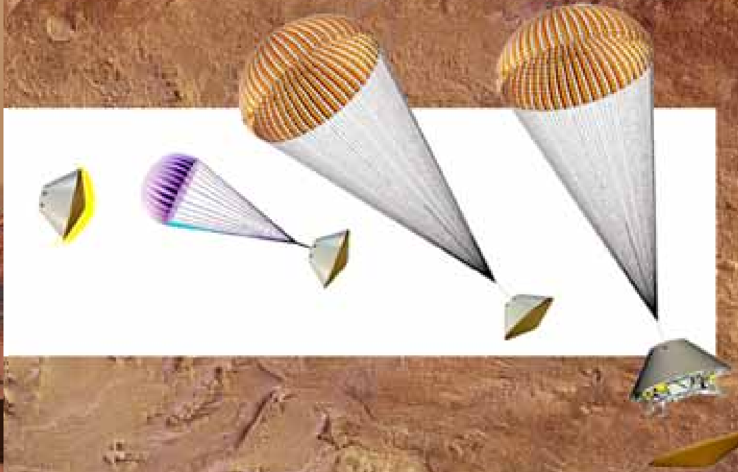




Credit: MEX/HRSC

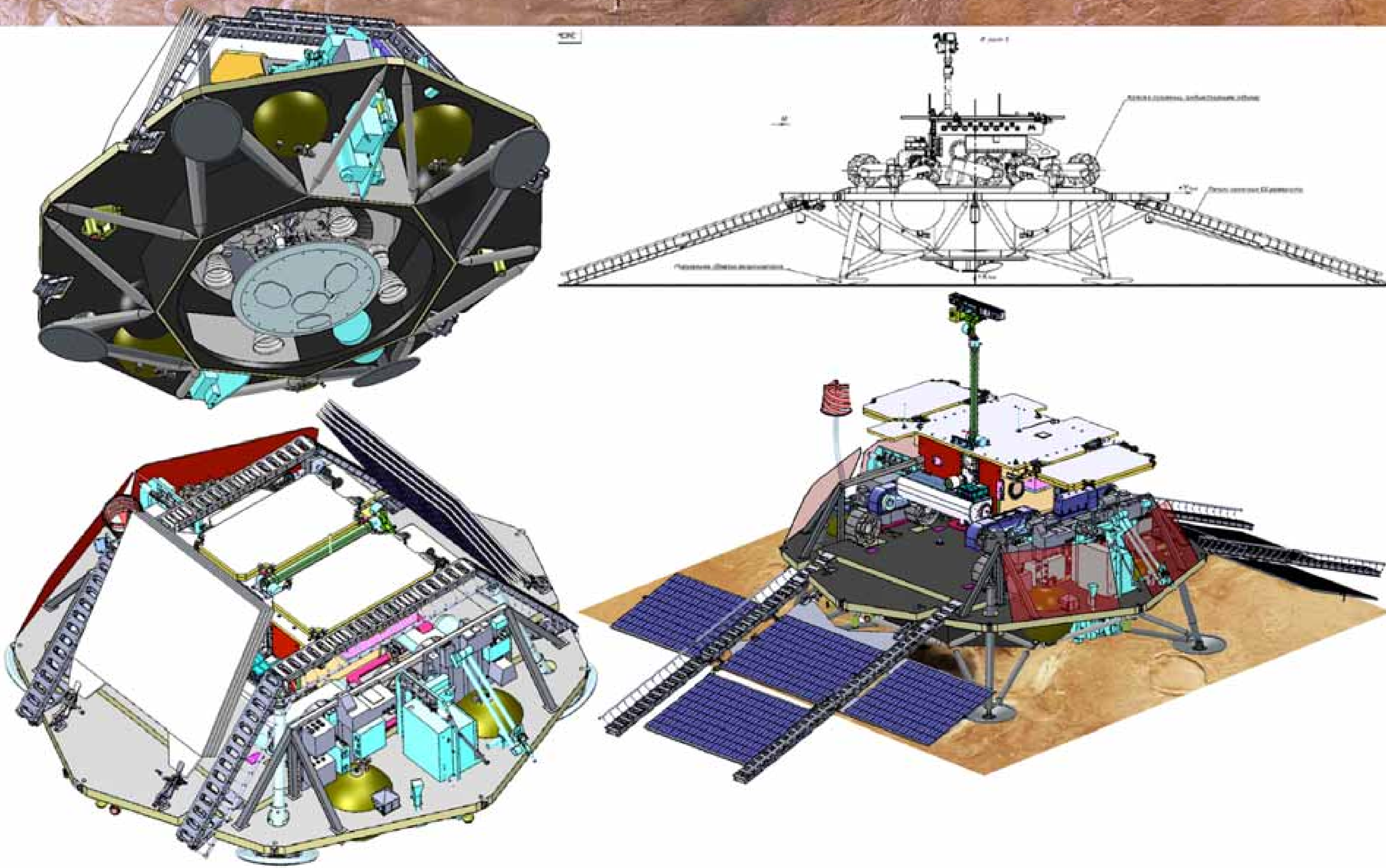
Entry, Descent and Landing





Credit:
MEX/HRSC

Surface Platform

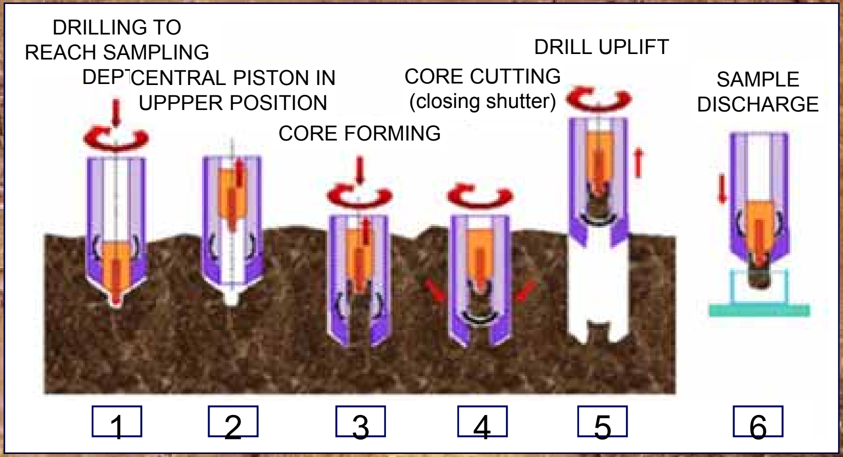


Credit: MEX/HRSC

Pasteur Exploration Module

Credit:
ESA/Medialab

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



Pasteur Science 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

λ = 1.15 – 3.3 µm, 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 ∞

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

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

Credit: MEX/HRSC

Surface Mission

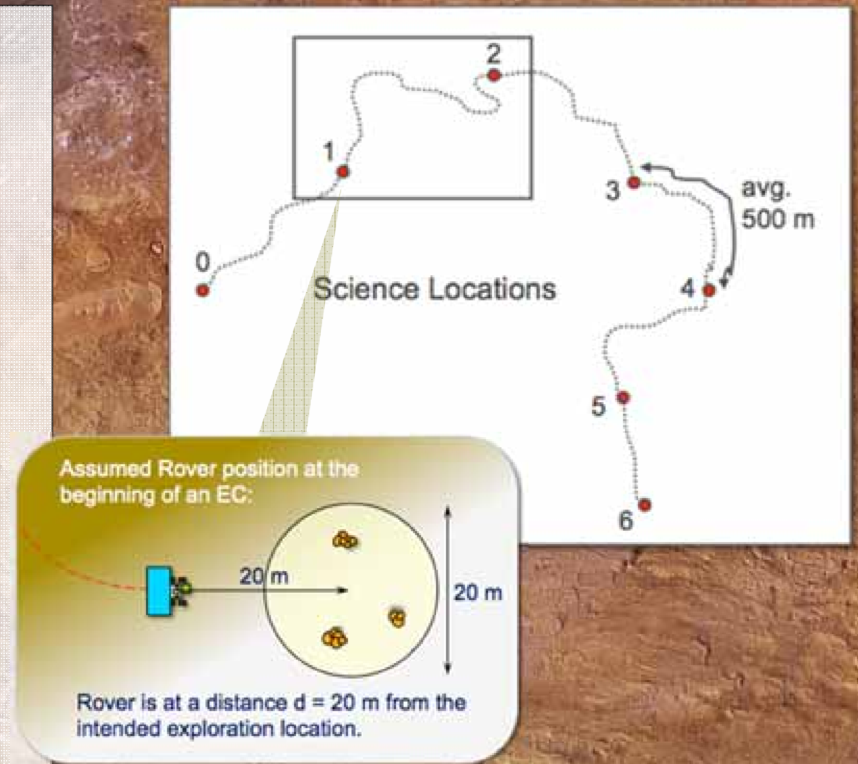
The rover reference surface mission includes:

a) EXIT LANDING AREA:
Scientifically it serves the purpose to get away from any rocket organic contamination before opening the analytical laboratory to the Martian environment.

b) BLANK ANALYSIS RUNS:
To demonstrate that the rover's sample pathway is free from organic contamination.

c) 6 EXPERIMENT CYCLES:
Combined surface and subsurface exploration, resulting in 6 surface and 6 subsurface samples.

d) 2 VERTICAL SURVEYS:
At one location, collect and analyse samples at depths of 0, 50, 100, 150, and 200-cm. Results in 10 additional subsurface samples.

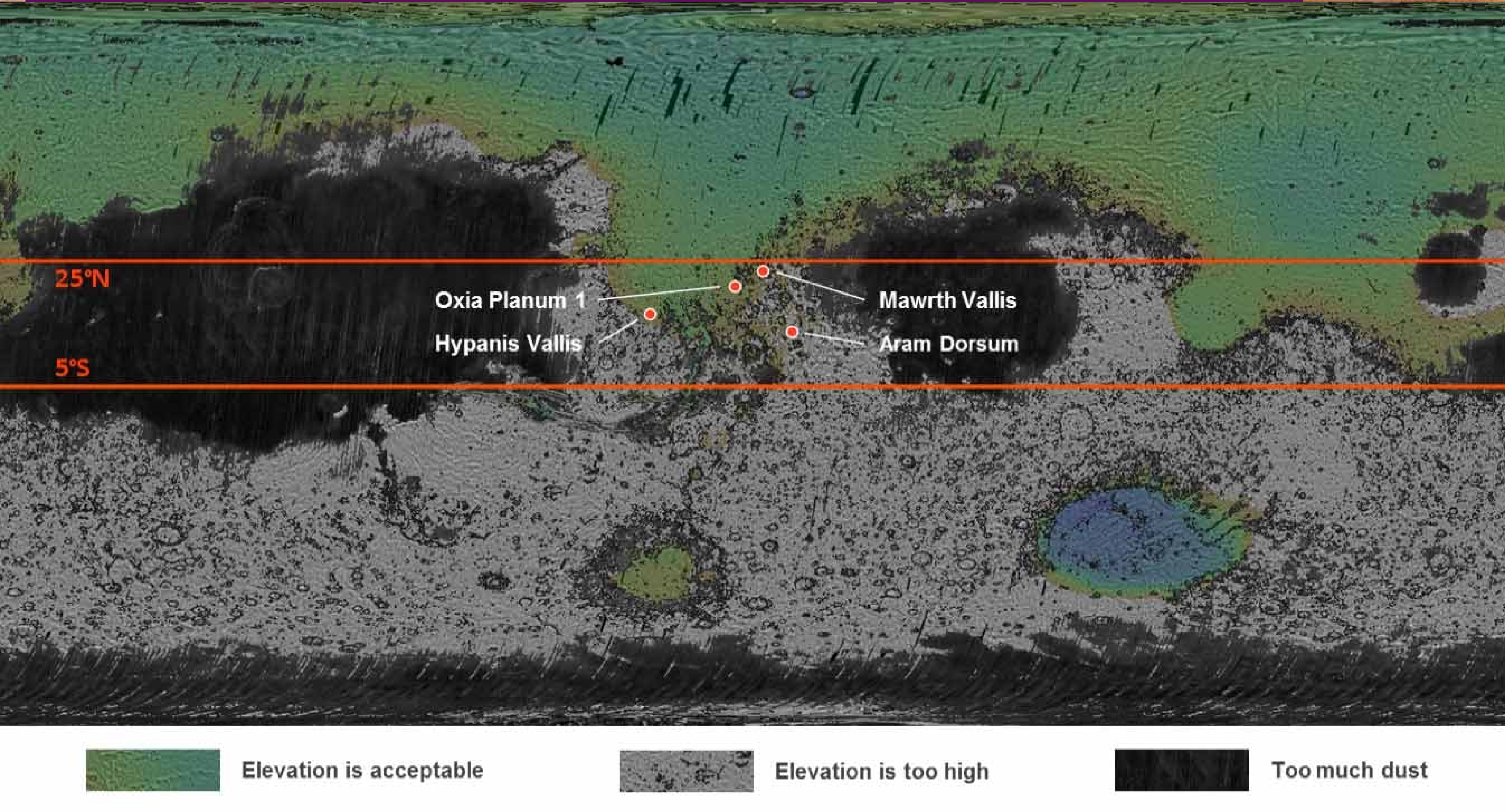


Credit: MEX/HRSC

Landing Site

Landing site selection process is critical to cover mission objectives:

- Must be old (≥ 3.6 Gaños), and have a humid “past” environment.
- Must have great capacity for conservation of bio-markers.
- Must fulfill requirements for descent trajectory and landing risks.



Conclusions

2016: ExoMars Trace Gas Orbiter

- Improve our understanding of Mars and atmospheric processes of exo-biological relevance
- Example of international cooperation.
- Technology demonstration for future exploration.

2018: ExoMars Rover and Surface Platform

- Mission with great exo-biological importance.
- First attempt to combine mobility and sub-surface sounding.
- Rover with state-of-the-art scientific instrumentation.
- Pasteur Module will study for the first time:
  - Organic molecules and bio-markers for present and past life;
  - Vertical characterisation of geochemistry and water.
- Surface platform will measure environmental properties.

One more step in the roadmap for exploration towards the **Mars Sample Return** challenge

Credit: MEX/HRSC

ExoMars 2016&2020 Video

https://youtu.be/-JhCUVxjFfA

THANKS!