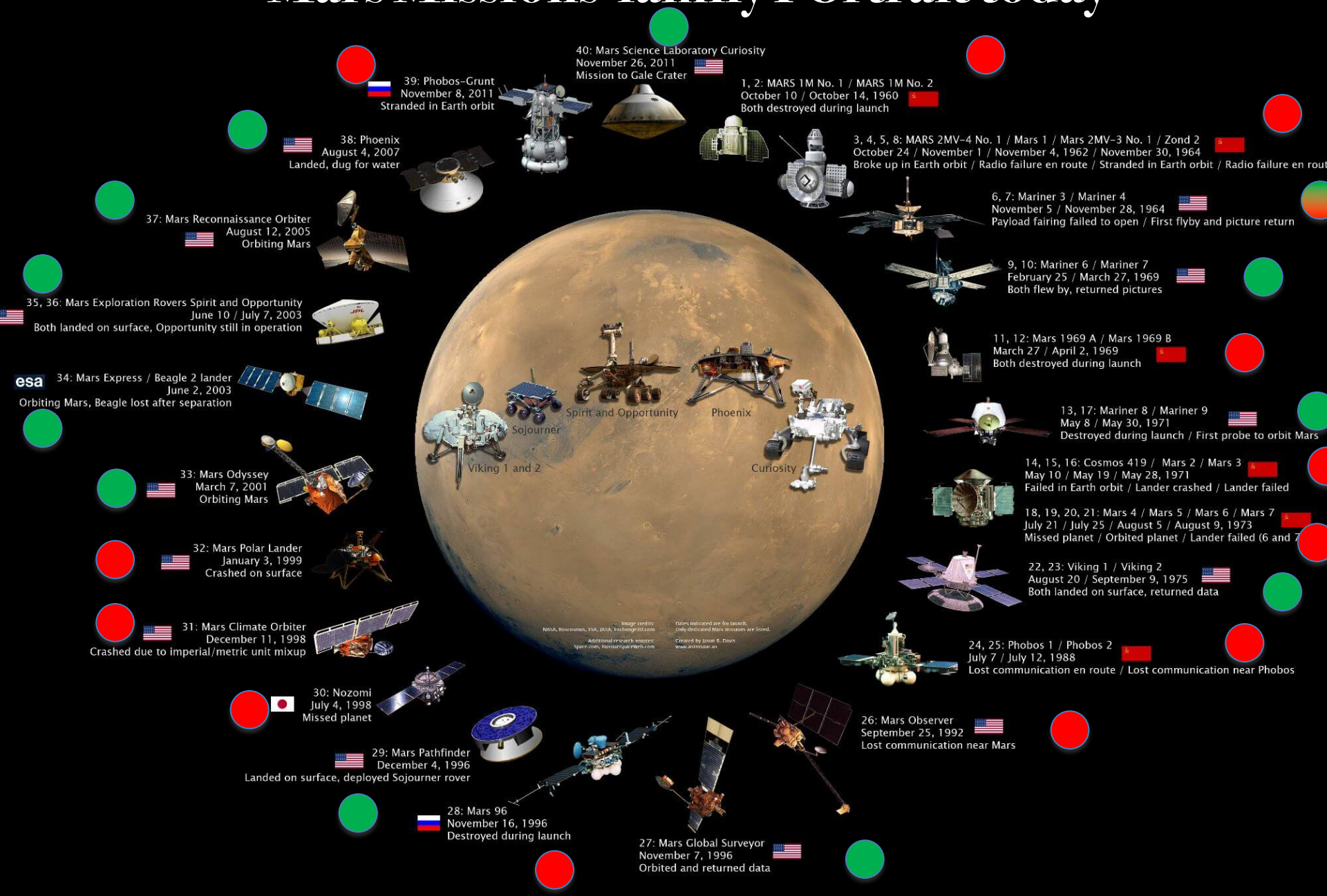
Mars Exploration and the search for the Holy Grail!

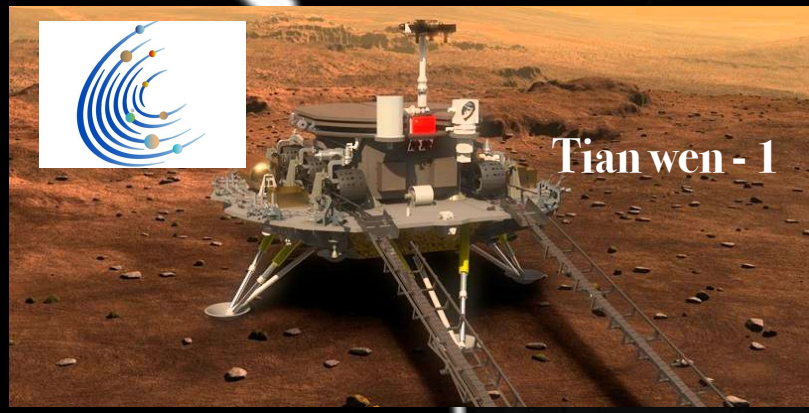
Enrico Flamini

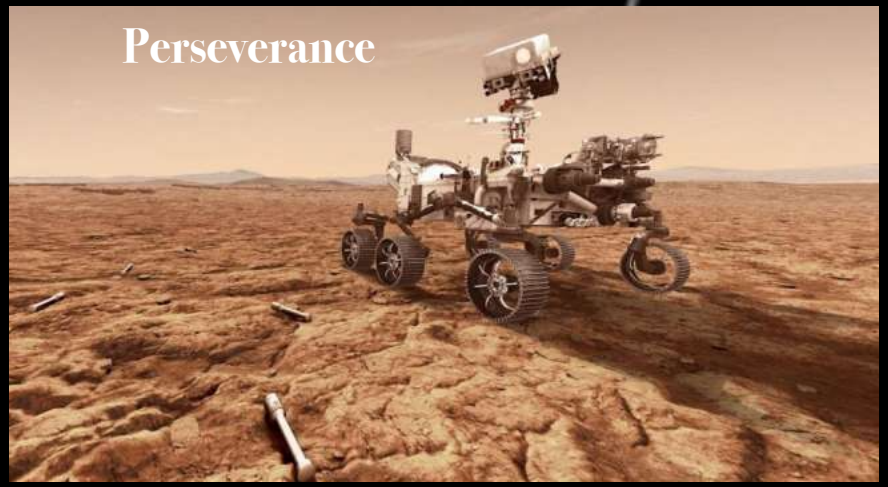
IRSPS- Università D'Annunzio

Mars Missions family Portrait today



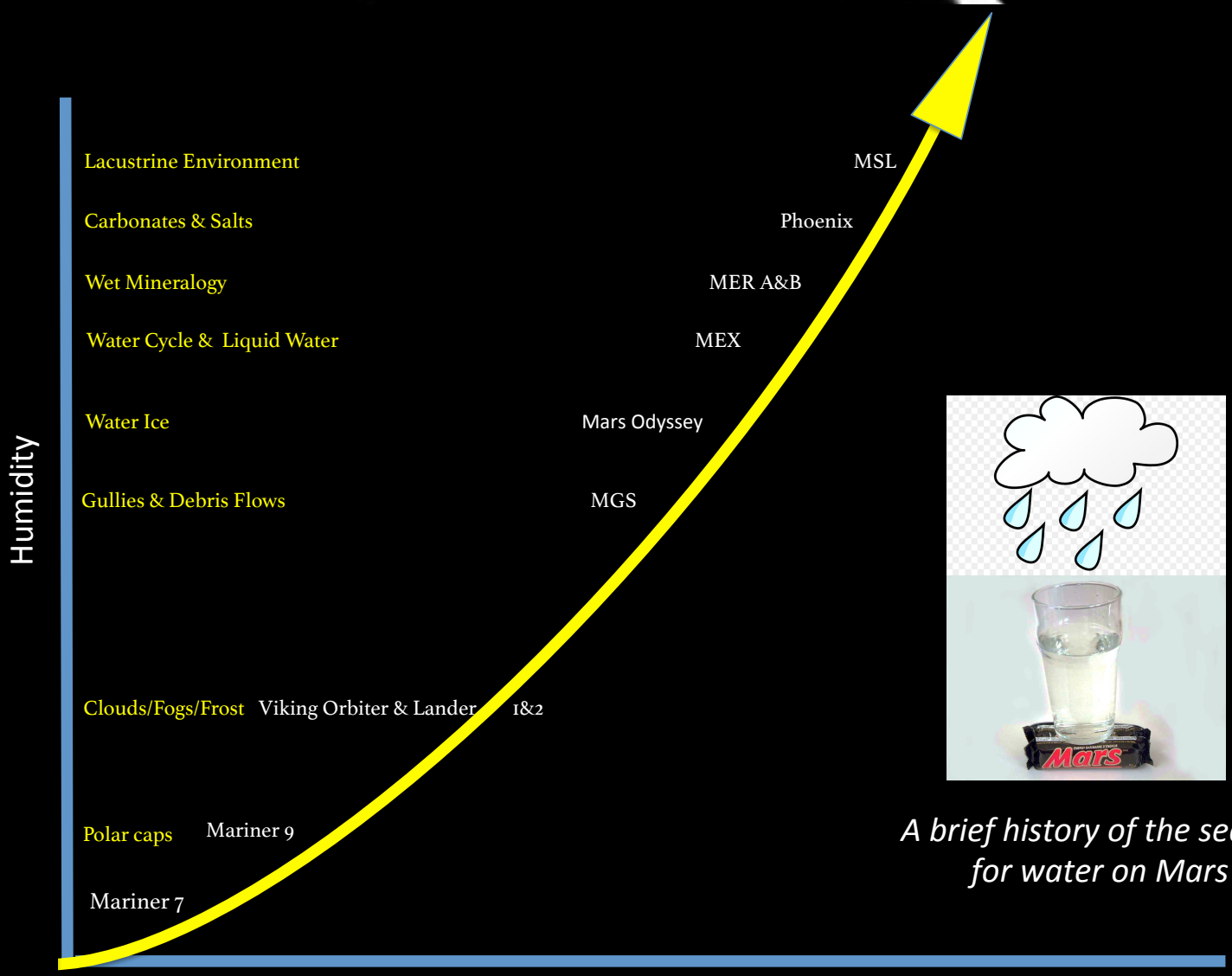
The New members of the Family





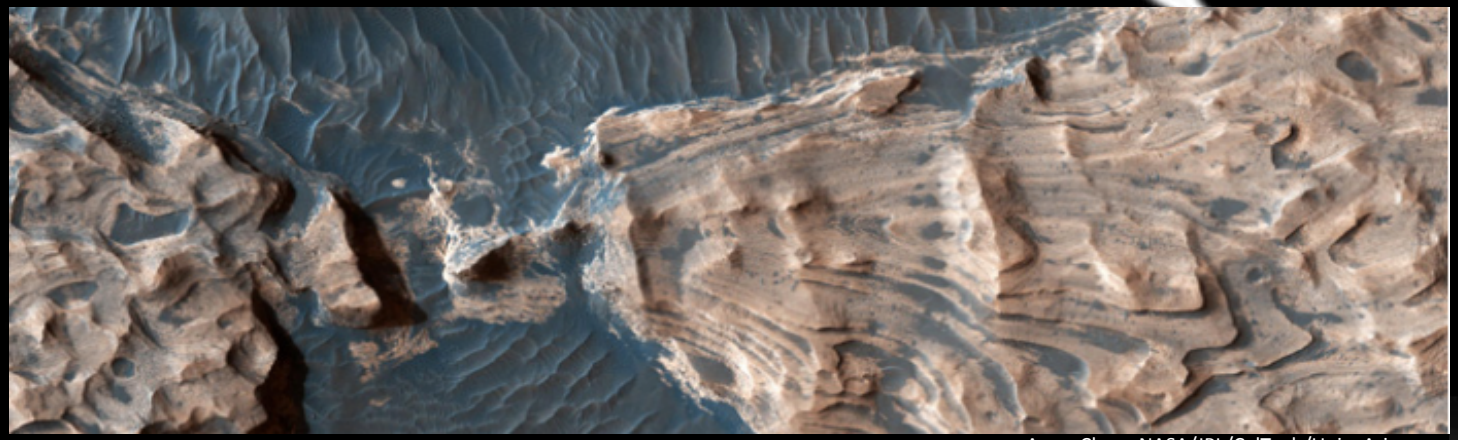
Mars: Why?

Mars Missions and Findings



A brief history of the search for water on Mars

Planet Boundary Conditions



Aram Chaos NASA/JPL/CalTech/Univ. Arizona

Setting the boundary conditions:

- Obliquity Variations
- Inner Structure and Heat Flow
- Permafrost Behavior and Effects
- Morphological and Mineralogical Evidences

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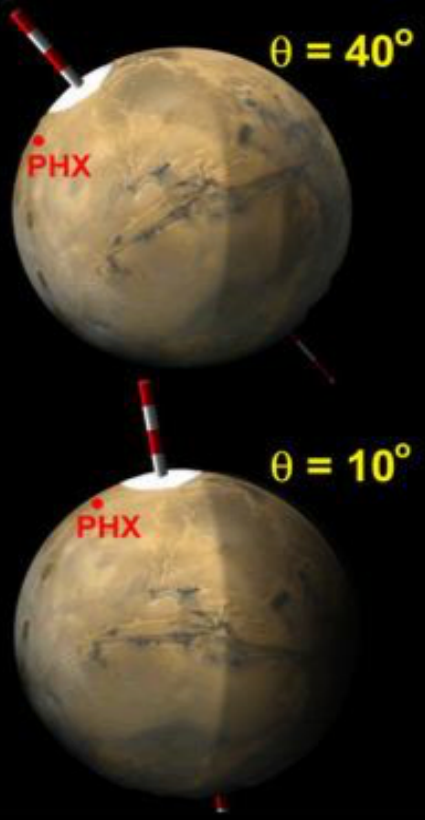
Obliquity Variations



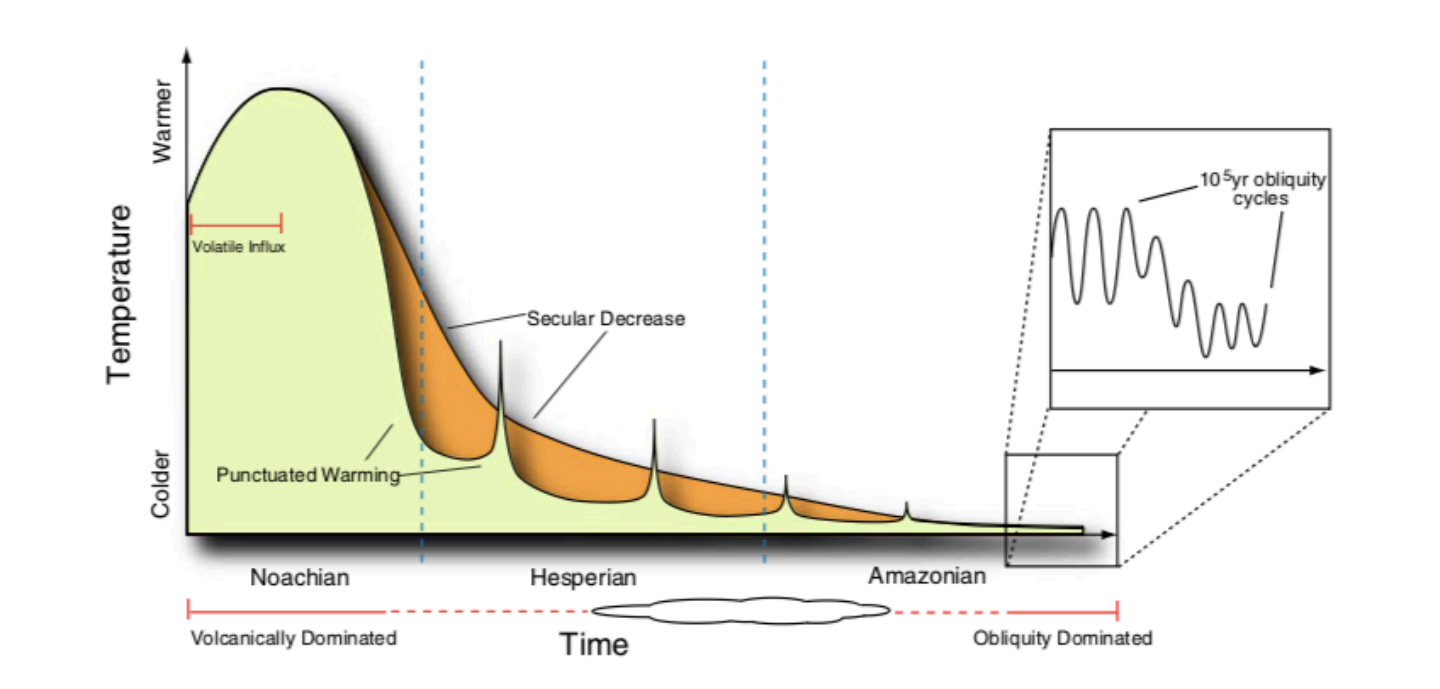
High Sun
Warm Summer
High Humidity

High Obliquity

Low Sun
Cool Summer
Low Humidity

Low Obliquity

Obliquity Variations

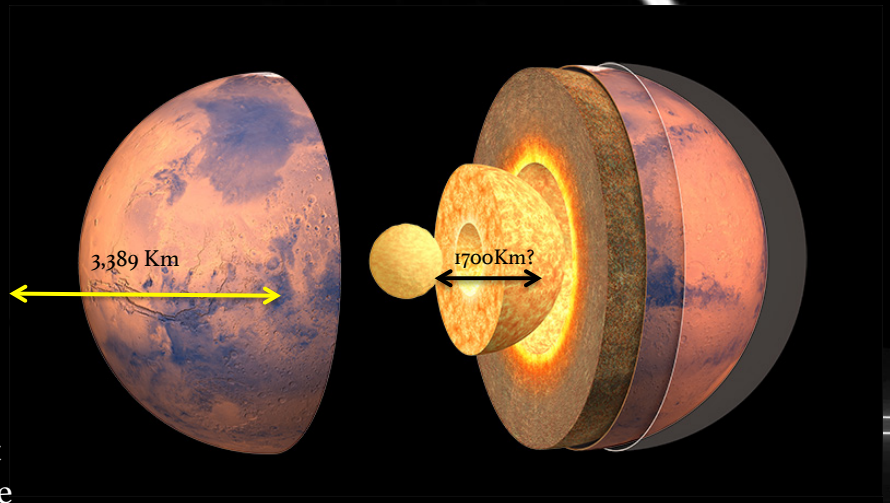


MISCHNA ET AL.: OBLIQUITY/TRACE GAS GREENHOUSES ON MARS, JGR 2013

Martian obliquity has a periodic cycle of ~124,000 years and oscillates regularly, with swings of as much as 30–40 per cycle. Numerical integrations have calculated Martian obliquity back as far as 20 Myr [Laskar et al., 2004] and have provided probability functions of Martian obliquity (which is chaotic on longer timescales) throughout its history.

Inner Structure

Mars Geophysics



Waiting for InSight results…we only know mass, diameter and moment of inertia.

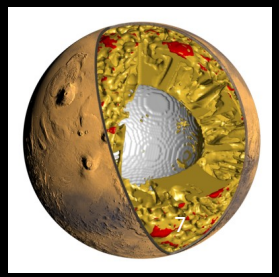
Satellites orbit perturbations point towards a layered internal structure

The Martian crust is thought to be between 30 and 100 Km thick depending on the hemisphere, with a mean thickness of 65 Km, a value that is closer to that of the Earth's continental crust.

Theoretical simulations show that the Martian mantle should still be subject to convective motions, the planet having a sufficient amount of heat to fuel such motions. However, unlike the Earth, this convection has perhaps not been able to correctly homogenize the mantle's material

Is the hemispherical dichotomy an indication of ancient plate tectonics?

Ana Plesa/DLR



Heat Flow

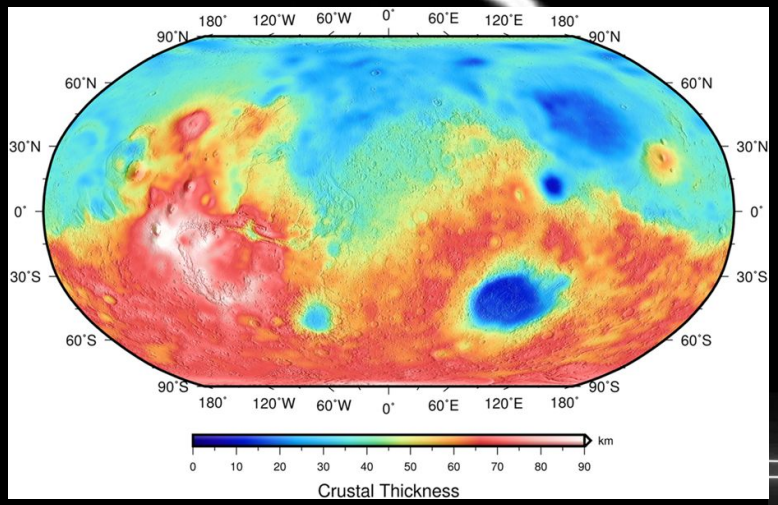
Mars has a Heat Flow (heat flows varying between 14 and 25 mW m^{-2}, with an average value of 19 mW m^{-2} that increases in intensity where the crust is thicker (sum of the heat generated in the crust and the heat flow from the mantle)

The bulk Urey ratio U_r describes the contribution of internal heat production to planetary-scale energy balance.

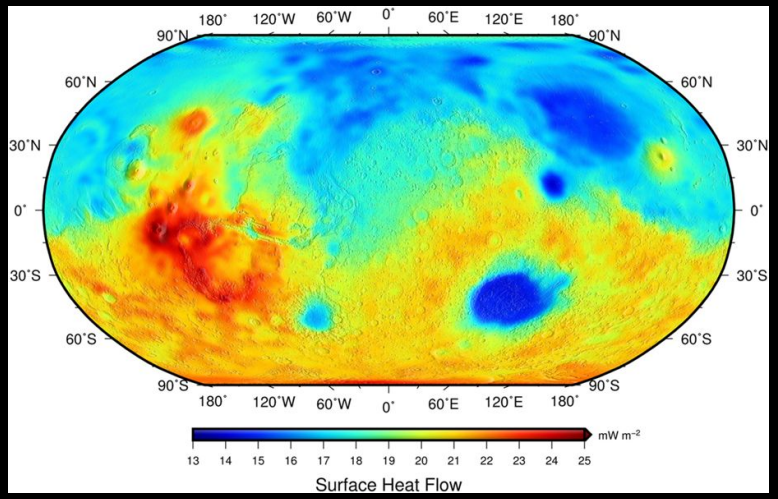
U_r is the ratio between total internal heat production and total heat loss through the surface

On Earth U_r is 0.35

On Mars is (presumably) 0.70-0.75



Parro et al Nature Scientific Reports, 2017



Permafrost

Permafrost: why is it important?

Permafrost is a major characteristic of the Mars surface

On the basis of IR observations permafrost ice extends down to 13° latitude in the Southern Hemisphere but is restricted to latitudes higher than 32° in the north (Vincedon, Forget & Mustard *J. Geophys. Res., 115,2010).*

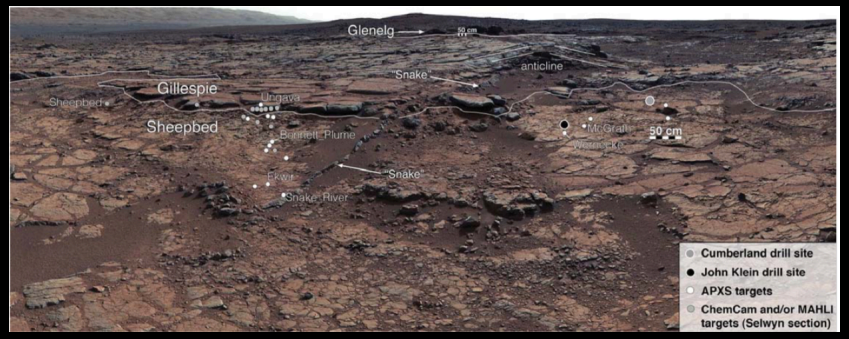
Coradini & Flamini solved the equation of the heat propagation under Martian conditions and demonstrated the existence of a secul *1979).* layer' of about 100-m depth (*J. Geophys. Re., 19*

30 years later Mitrofanov et al (Geophysical Research Letters, vol. 34, 2007) confirmed the existence of an equilibrium top layer (ETL), in the North hemisphere, and a non-equilibrium DTL in the South Emisphere (due to presence of dust)

Both ETL and DTL act as “insulator” screening deep layer from heat/cold waves propagation

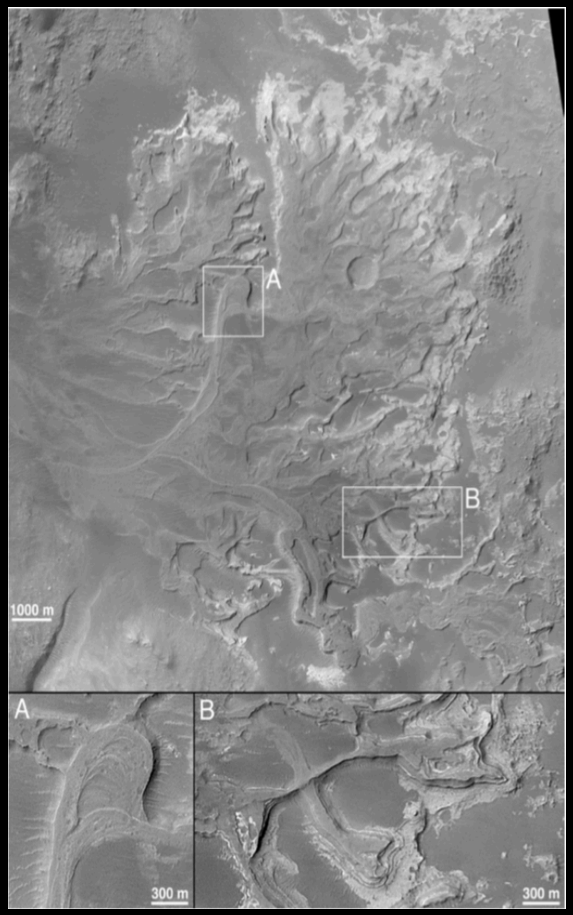
Ground Evidences

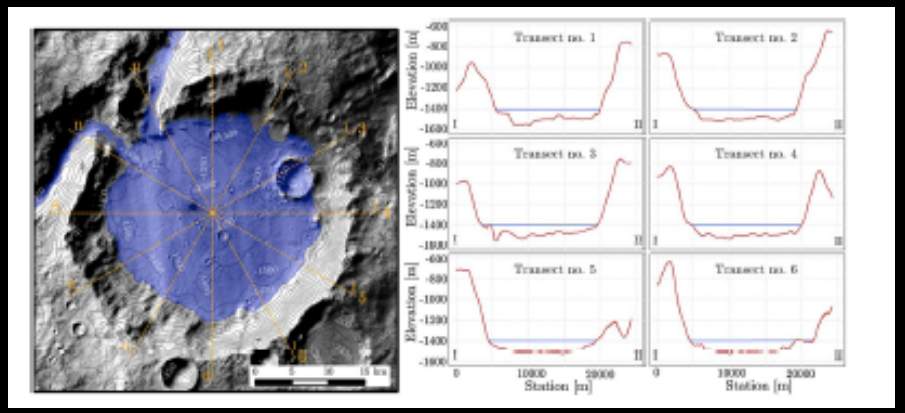
Mineralogy of an ancient lacustrine succession from the Murray formation, Gale crater, Mars: Rampe et al., Earth & Planet. Sci. Letters 471, 2017.



A Habitable Fluvio-Lacustrine Environment at Yellowknife Bay, Gale Crater, Mars Grotzinger et al. SCIENCE, 343, 2014

Evidences from Orbit



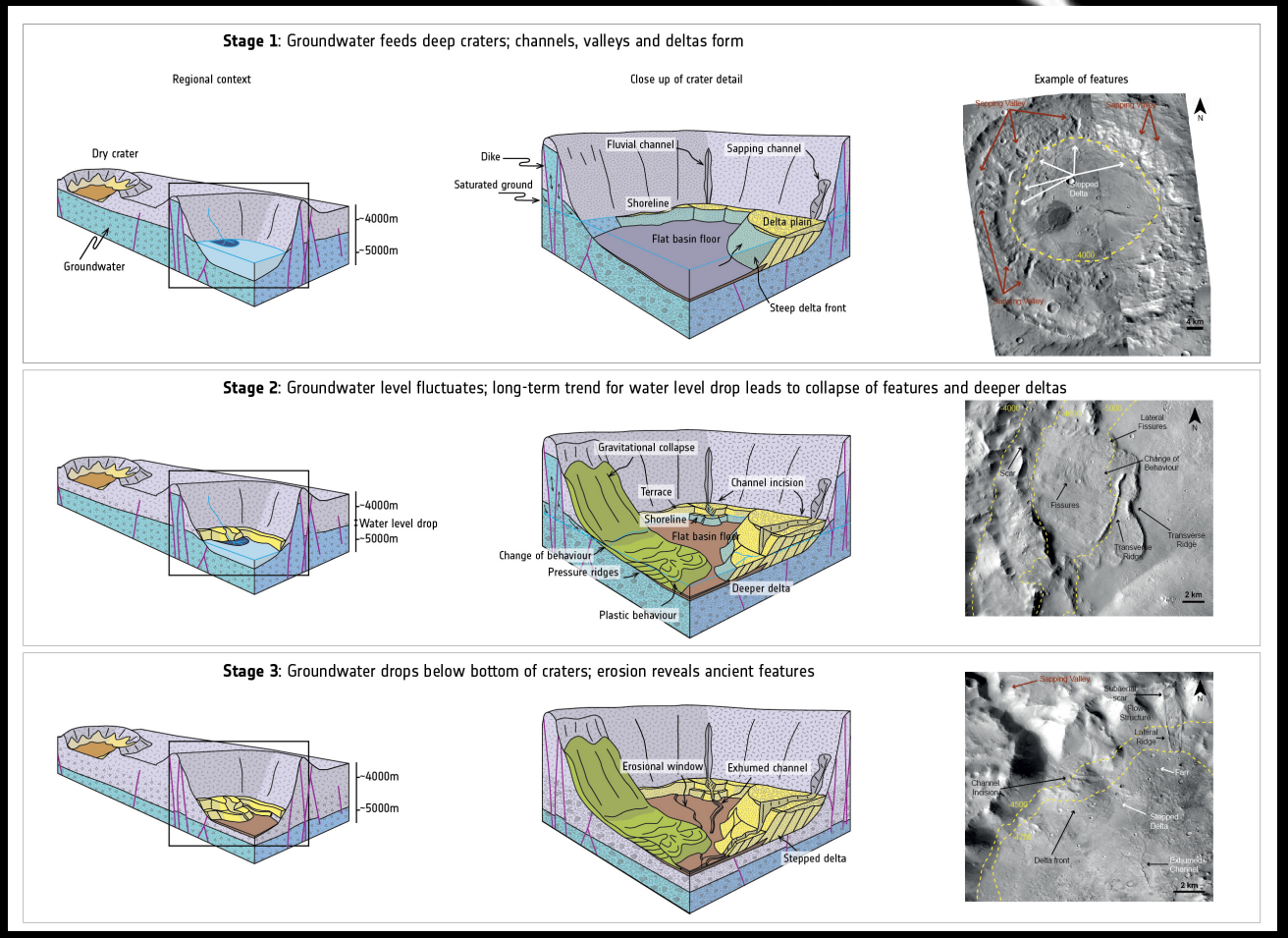


Hydraulic modeling of the tributary and the outlet of a Martian paleolake located in the Memnonia Quadrangle (Baratti et al., J. Geophys. Res. Planets, 120, 2015)

Evolution and depositional environments of the Eberswalde fan delta, Mars (M Pondrelli, et al. - Icarus, 2008)

Evidence for Persistent Flow andAqueous Sedimentation on Early Mars (Malin and Edgett, SCIENCE 302, 2003)

Groundwater planet-wide system



Geological evidence of planet-wide groundwater system on Mars: Salese et al., JGR 2018

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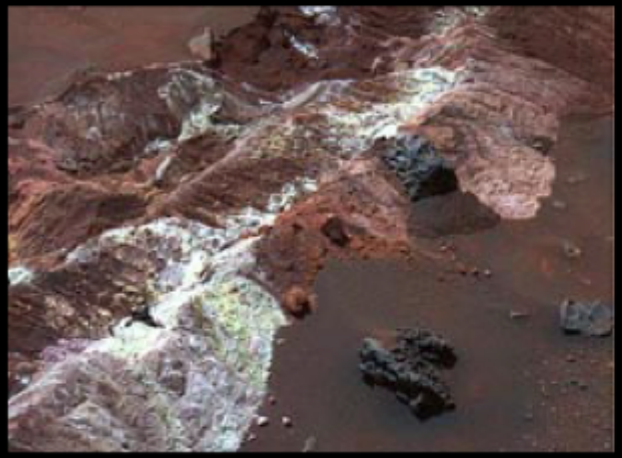
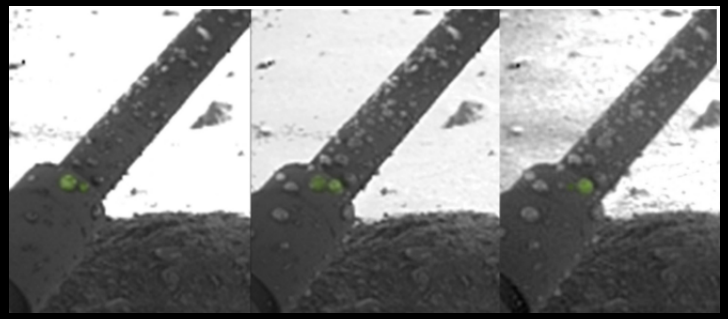
Surface Evidences



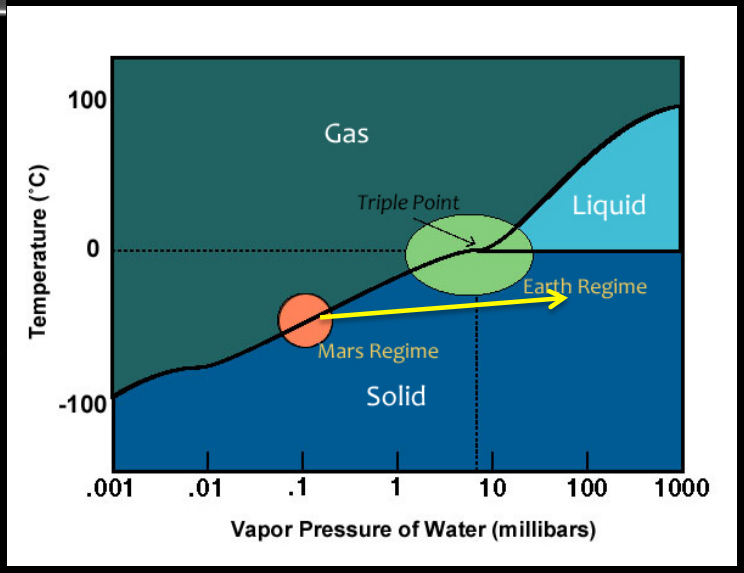
Mars Location This false-color image taken by Mars Rover Spirit's panoramic camera (Pancam) shows salt deposits on the basin floor of Gusev Crater. These salts may record the past presence of water on Mars, as they are most easily mobilized and concentrated in a liquid solution. (Image credit: NASA/JPL/Cornell)

Earth Analog This image shows evaporite deposits near springs in the region of Cuatrocienegas, Mexico. Evaporites are sediments that form from the evaporation of saline water. (Image credit: John W. Holt, Institute for Geophysics, University of Texas)

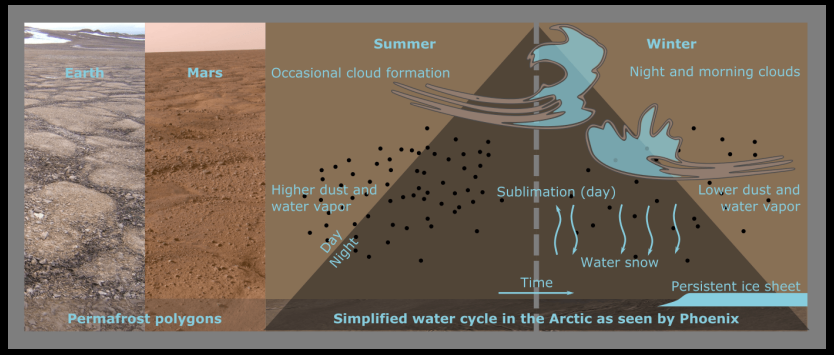
the Water Cycle on Mars



Existed → Still exists



this site would have a night-time relative humidity that's sufficient for perchlorate salts to latch on to water molecules. As the temperature warms during the day, the salts would give up the water to the atmosphere again, creating a water cycle.



It is reasonable to assume that a good percentage of water percolated underground mixing with surficial and underground salts

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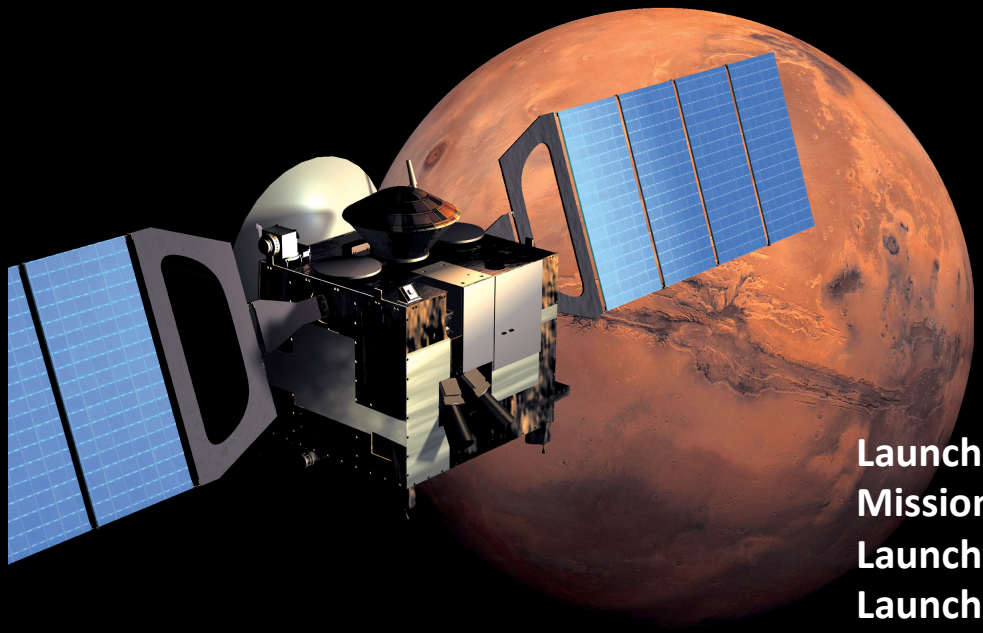
Mars Express (MEX for his friends), the Martian water diviner



Launch date: 02-Jun-2003 17:45 UT
Mission end: 31 December 2022
Launch vehicle: Soyuz-Fregat
Launch mass: 1223 kg
Mission phase: Operational
Orbit: Orbital Inclination: 86.9°
Pericentre: 330 km
Apocentre: 10 530 km
Period: 7 h 00 m

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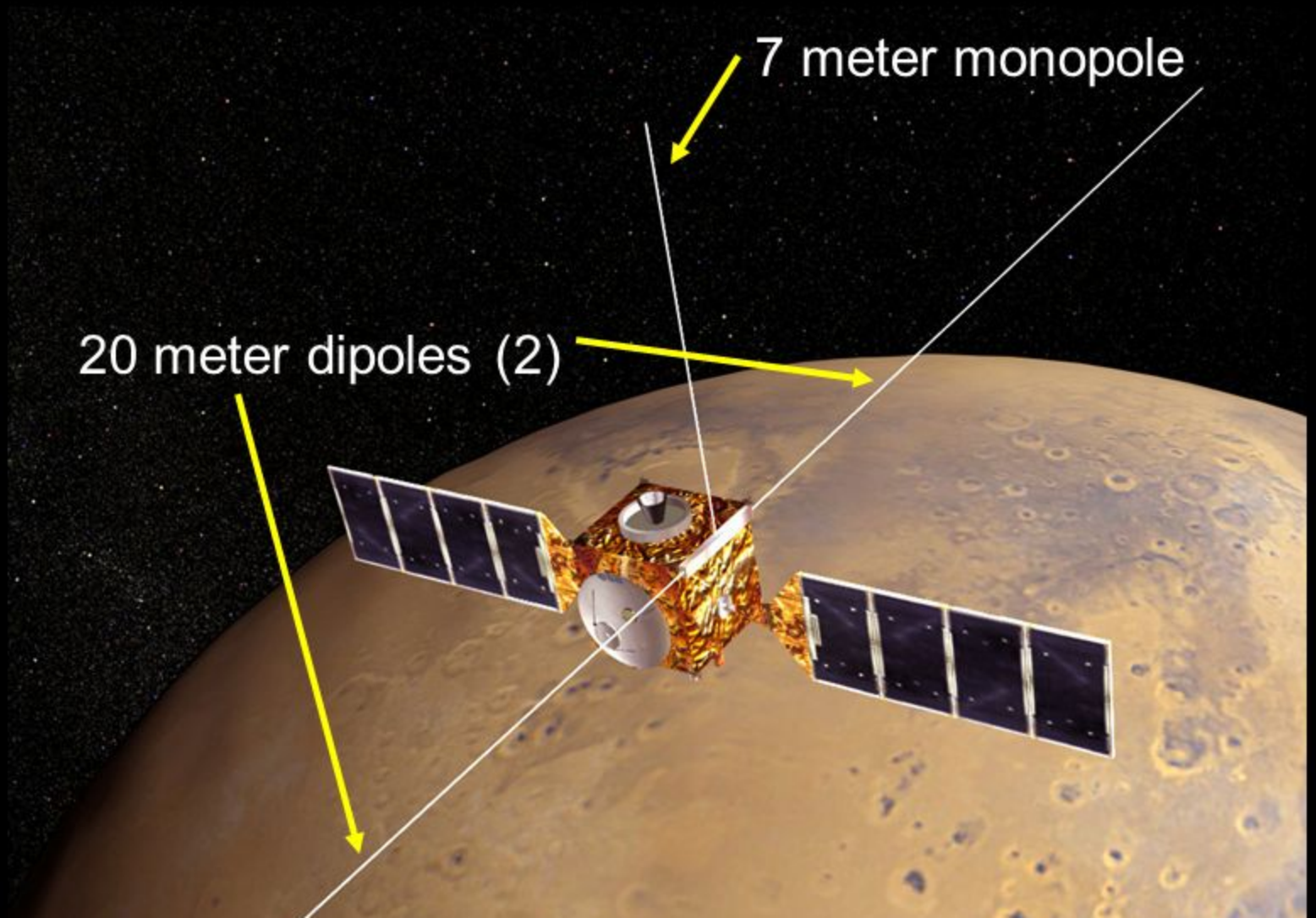
MARSIS Antennas



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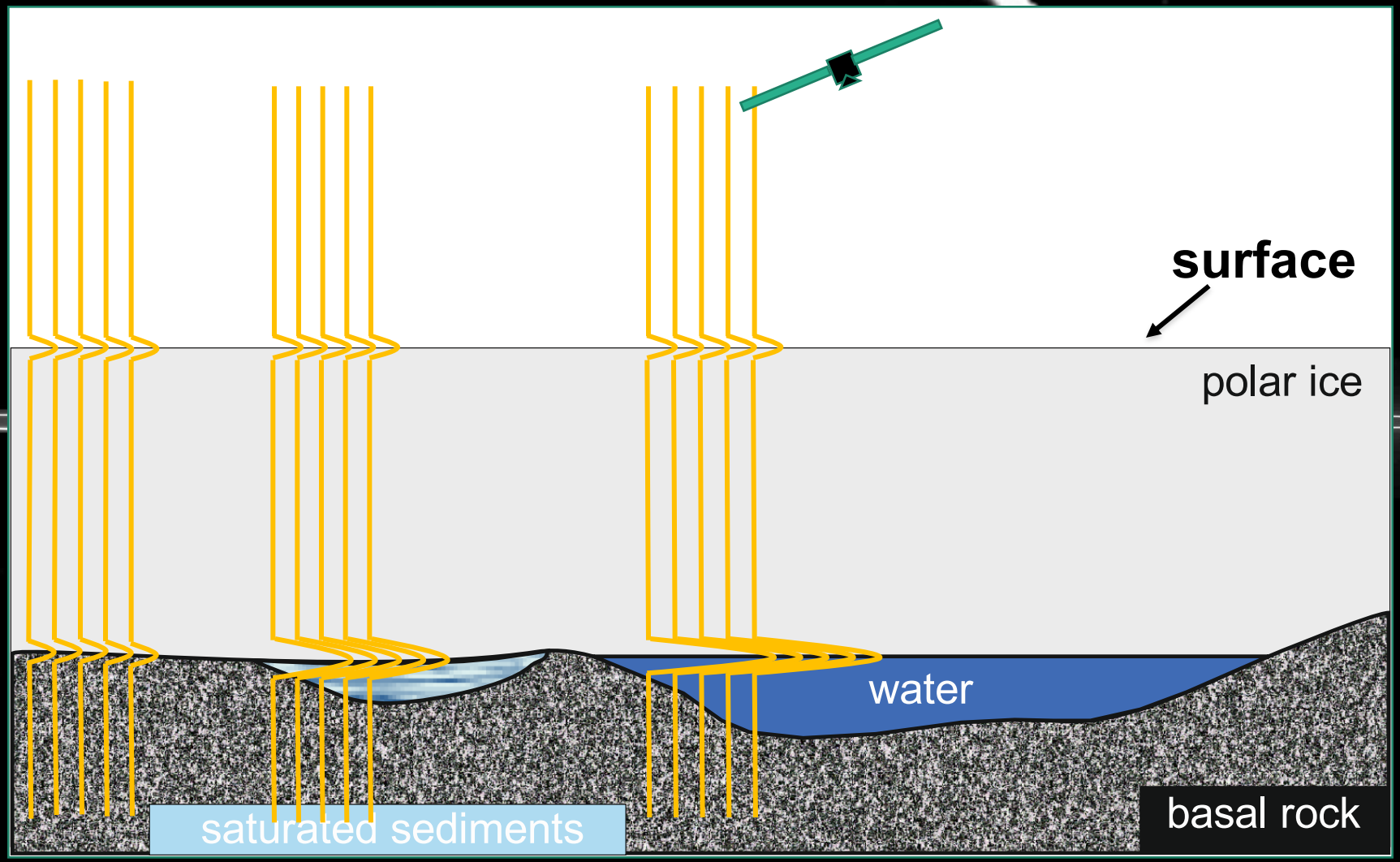
Subglacial liquid water on Mars



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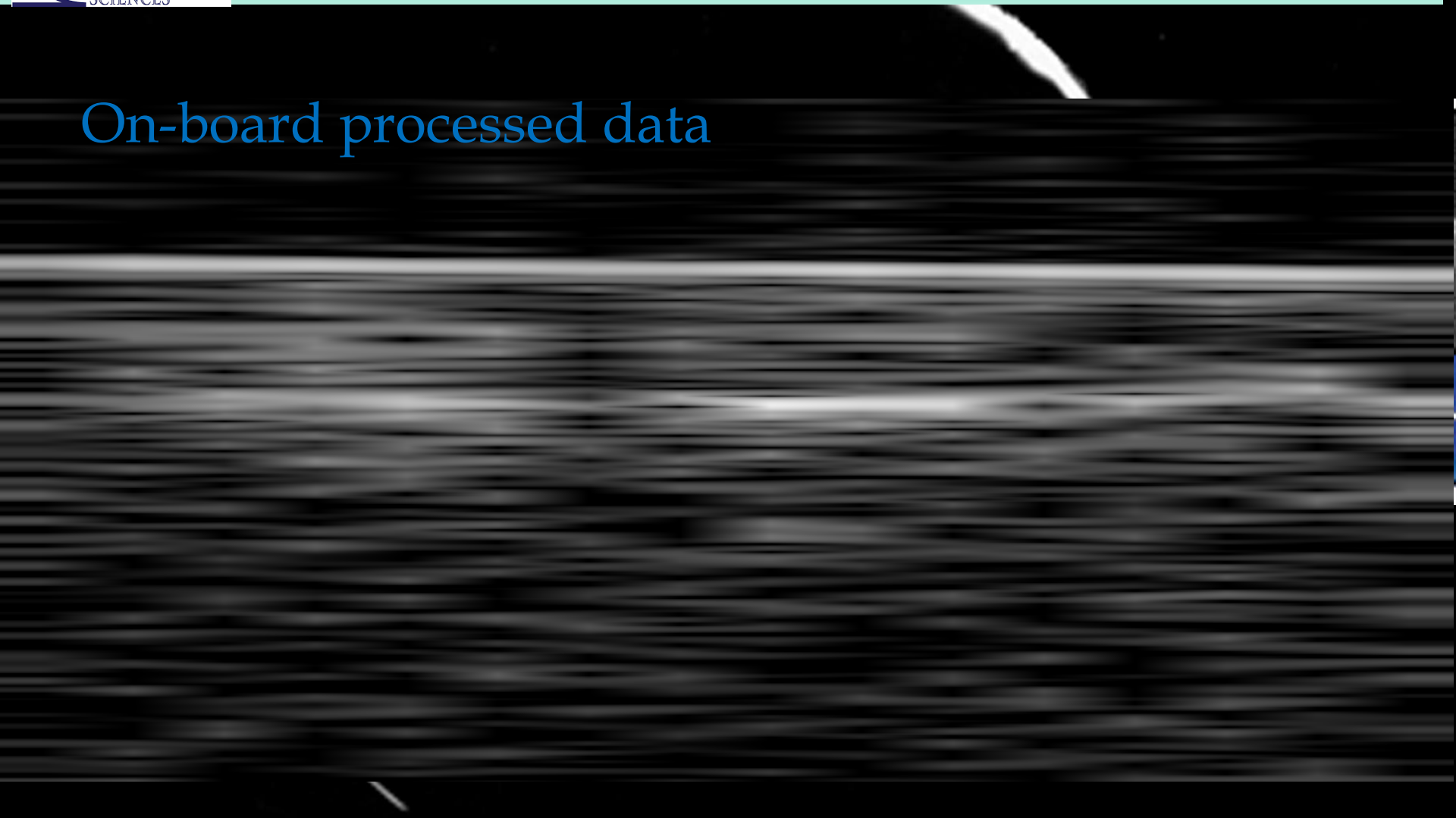
Subglacial liquid water on Mars

On-board processed data



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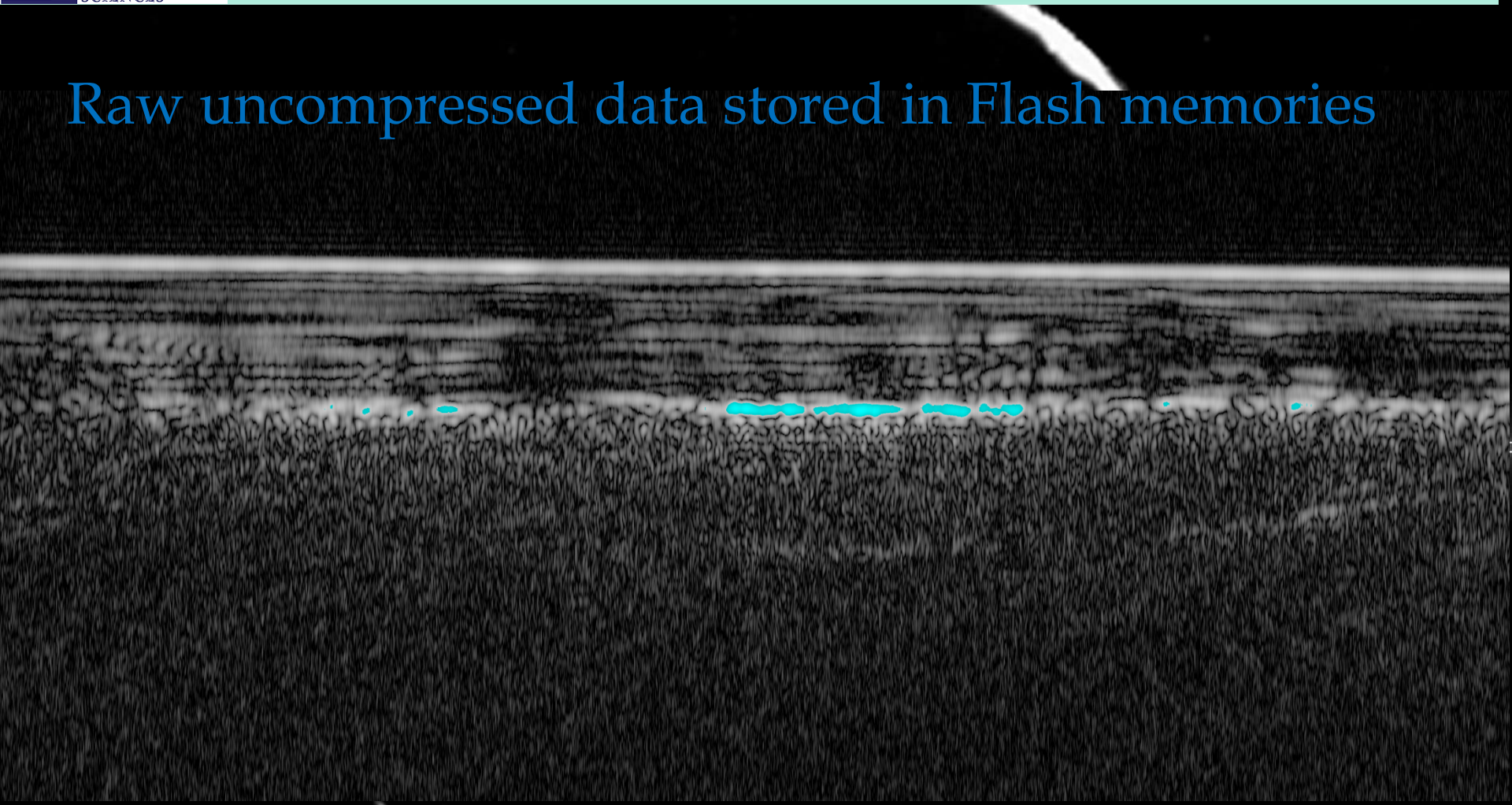
Subglacial liquid water on Mars

Raw uncompressed data stored in Flash memories



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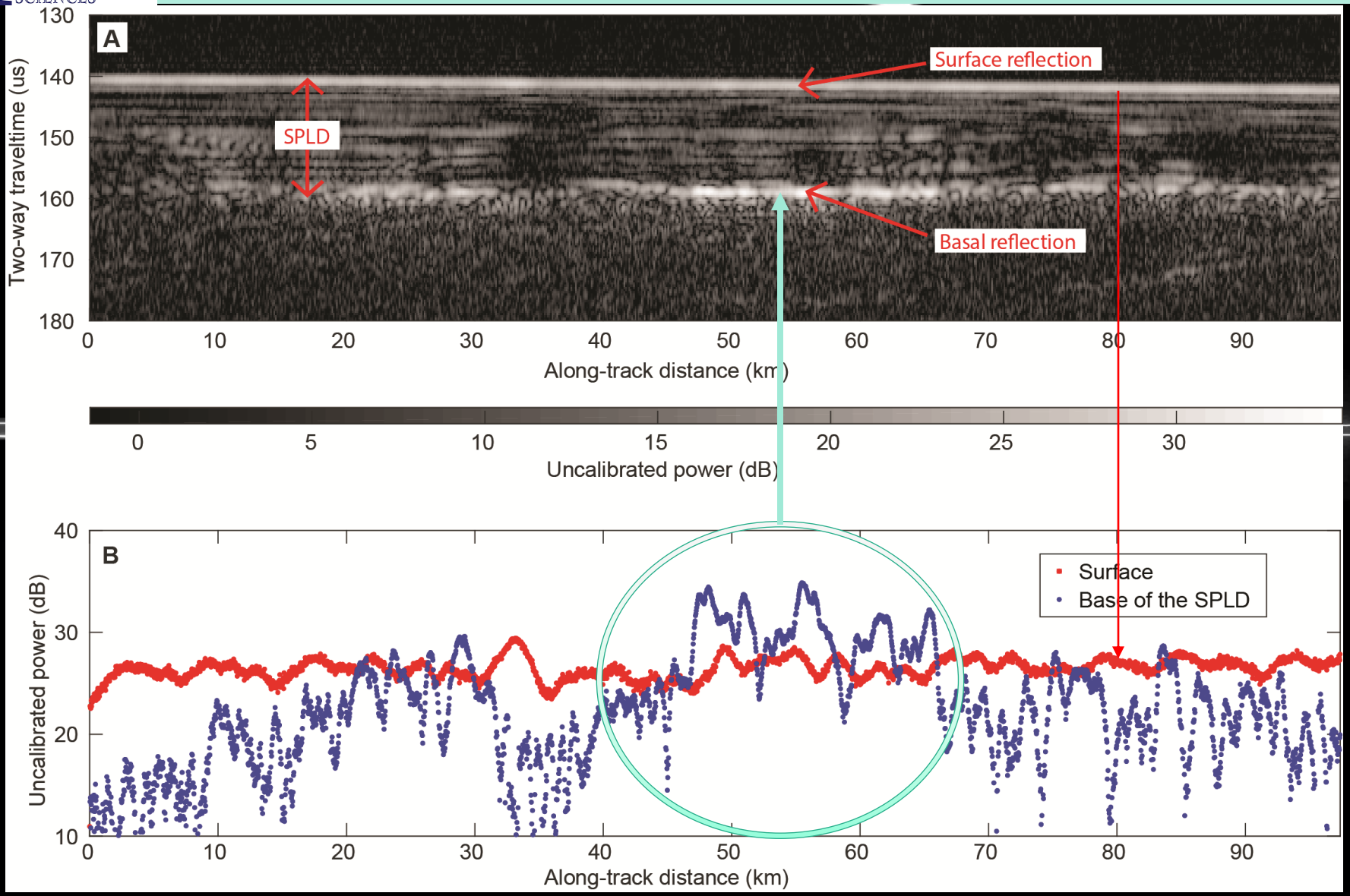
Subglacial liquid water on Mars



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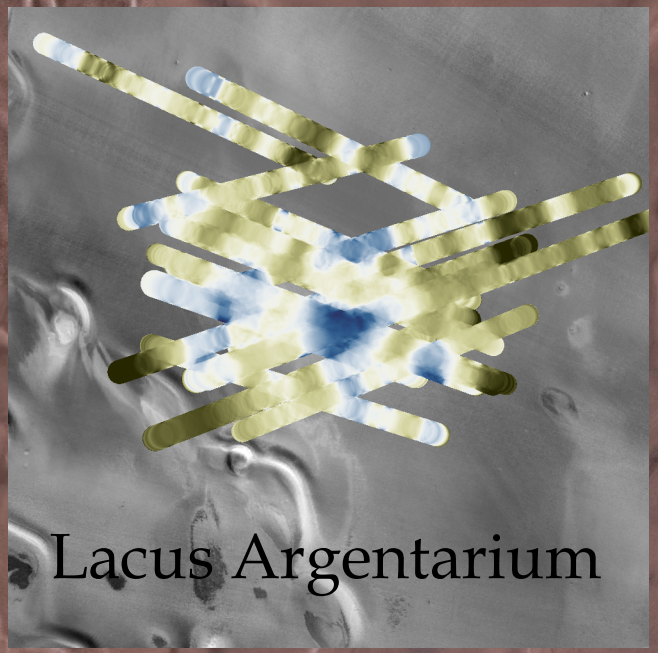
Subglacial liquid water on Mars



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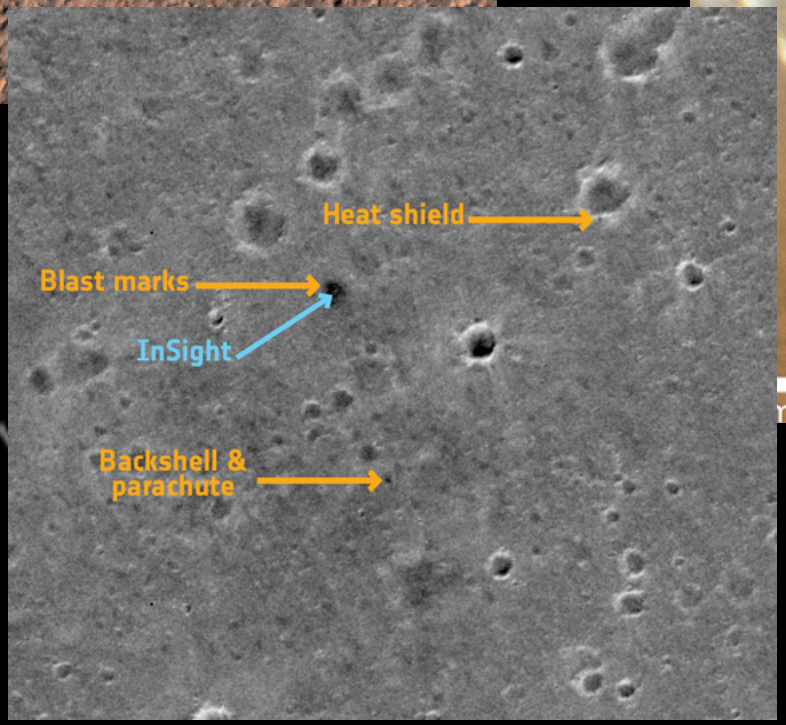
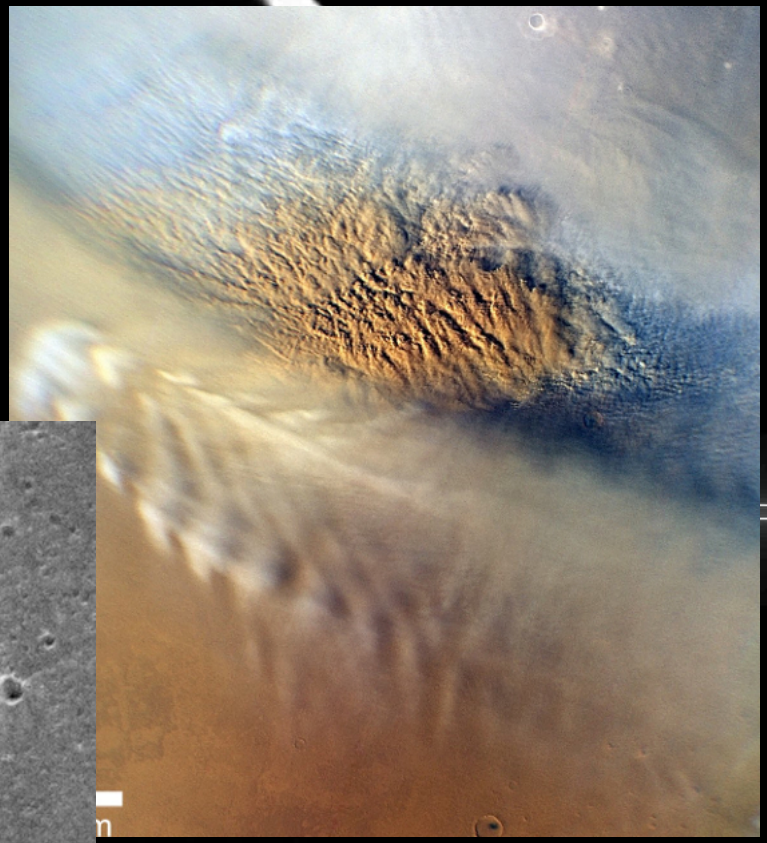
Today around Mars: TGO





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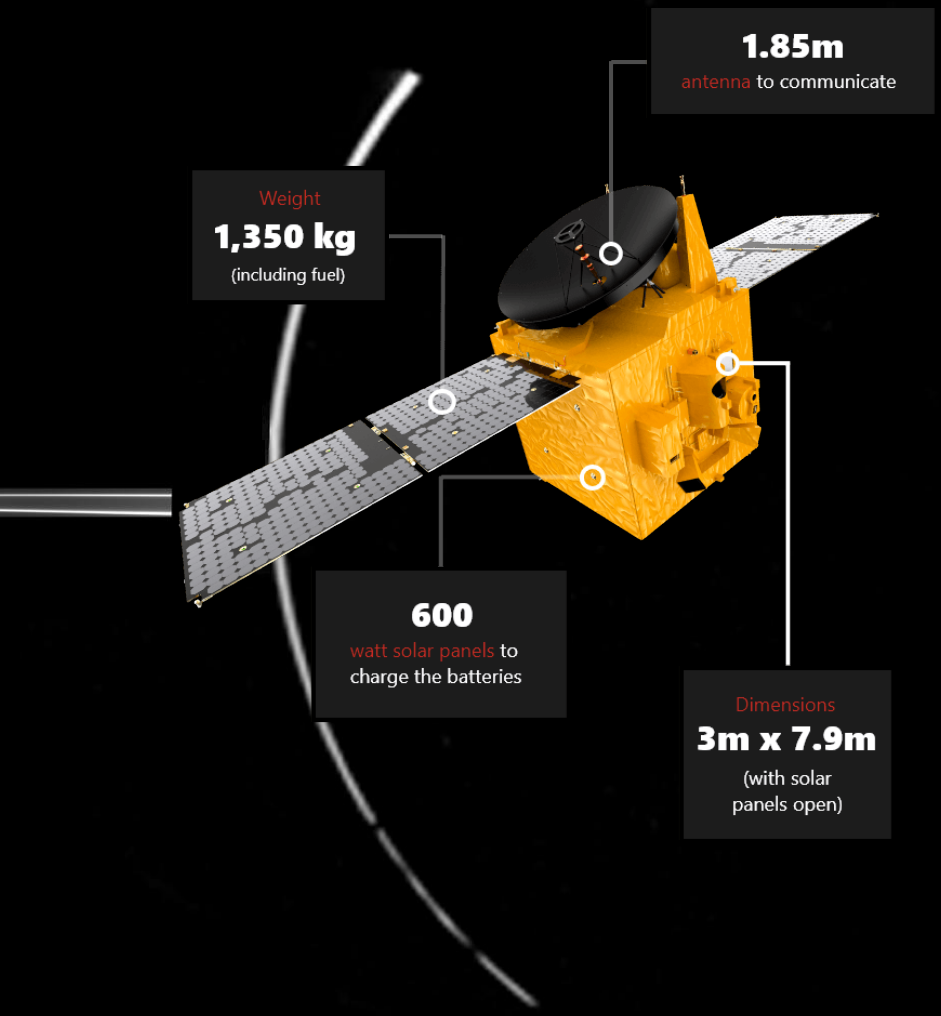
The last 10 days : Hope



Launch 19, July 2020

OBJECTIVES

The First Complete Picture of the Martian Atmosphere.

01

Understand climate dynamics and the global weather map through characterizing the lower atmosphere of Mars.

02

Explain how the weather changes the escape of Hydrogen and Oxygen through correlating the lower atmosphere conditions with the upper atmosphere.

03

Understand the structure and variability of Hydrogen and Oxygen in the upper atmosphere, as well as identifying why Mars is losing them into space.

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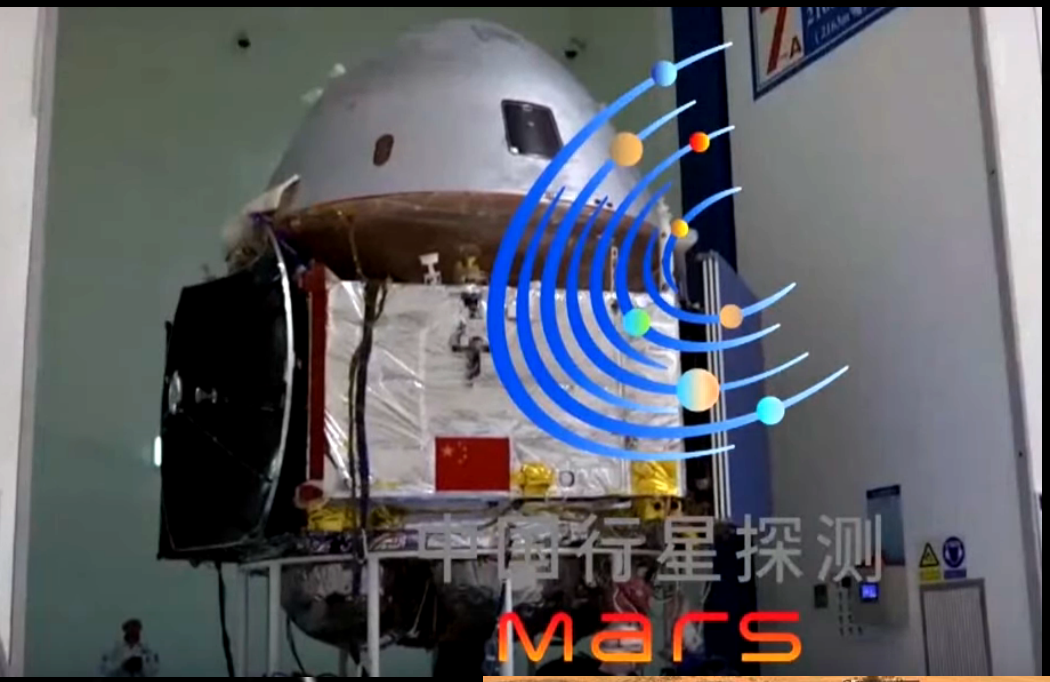
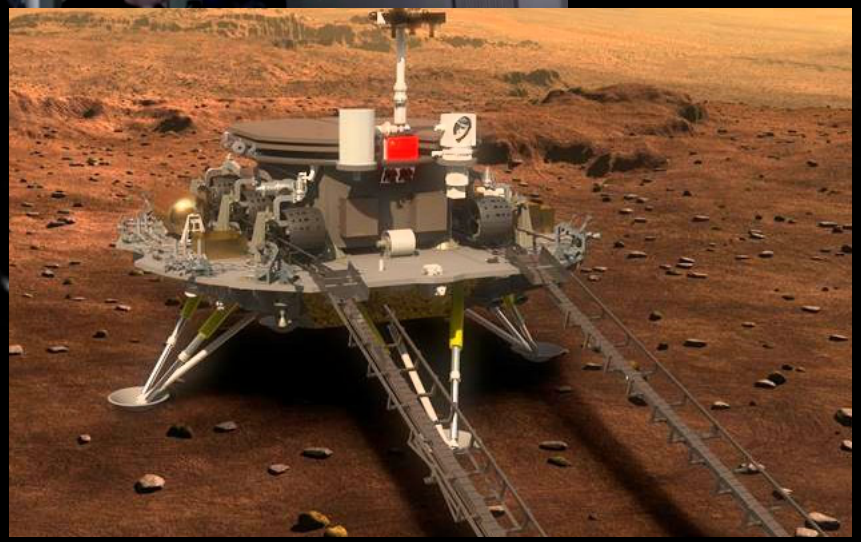
The last 10 days : Tianwen-1





Launch 23 July 2020

Objectives
- Find evidence for current and past life,
- produce Martian surface maps,
- characterize Martian soil composition and water ice distribution,
- examine the Martian atmosphere, and ionosphere

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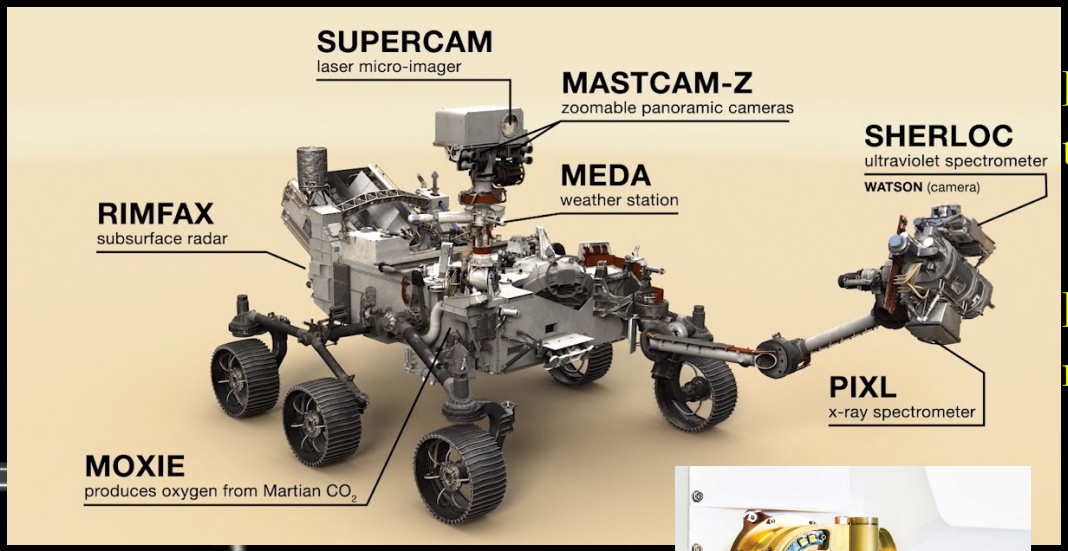
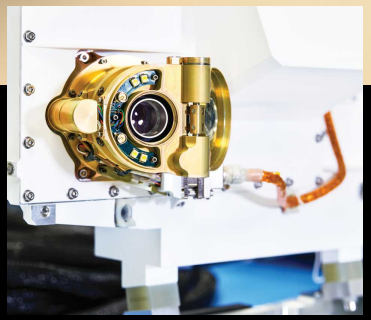
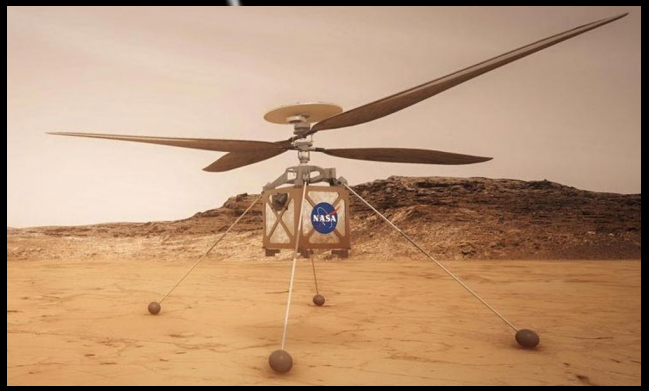
The last 10 days : Perseverance







Launch 30 July 2020

Habitability — Identify past environments capable of supporting microbial life

Biosignatures — Seek signs of possible past microbial life in those habitable environments, particularly in special rocks known to preserve signs of life over time

Caching Samples — Collect core rock and "soil" samples and store them on the Martian surface

Preparing for Humans — Test oxygen production from the Martian atmosphere

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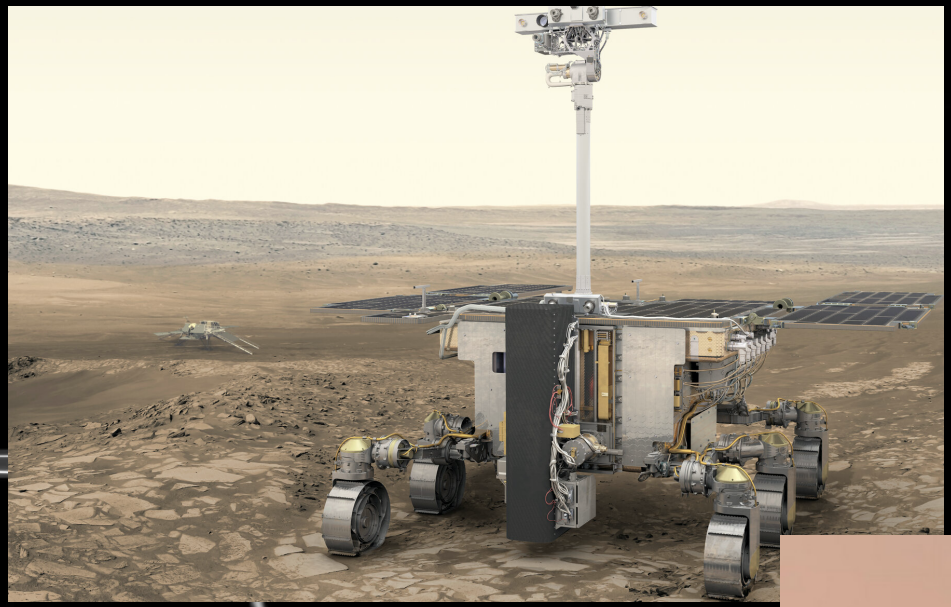
What next?



ExoMars 2022

Mars Sample Return

Being Prepared for the Mars Exploration Future

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Universita' d'Annunzio
Campus di Pescara

Indirizzo in Planetary Sciences
Laurea Magistrale in Scienze e Tecnologie Geologiche della Terra e dei Pianeti

2 anni: 3 Semesetri di Lezioni, 1 semestre per tesi e tirocinio

Escursioni in analoghi marziani e planetari: Marocco, Spagna, Grecia e Dolomiti

Insegnamenti in Planetary Geology, Exploration of the Solar System, Planetary Astrophysics, Geological mapping, 3D digital field mapping, Planetary Materials, etc. etc.

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