ExoMars 2018
Searching for life

M.Cristina De Sanctis and the
ExoMars 2018 Science team
Istituto di Astrofisica Spaziale e Planetologia
Roma INAF

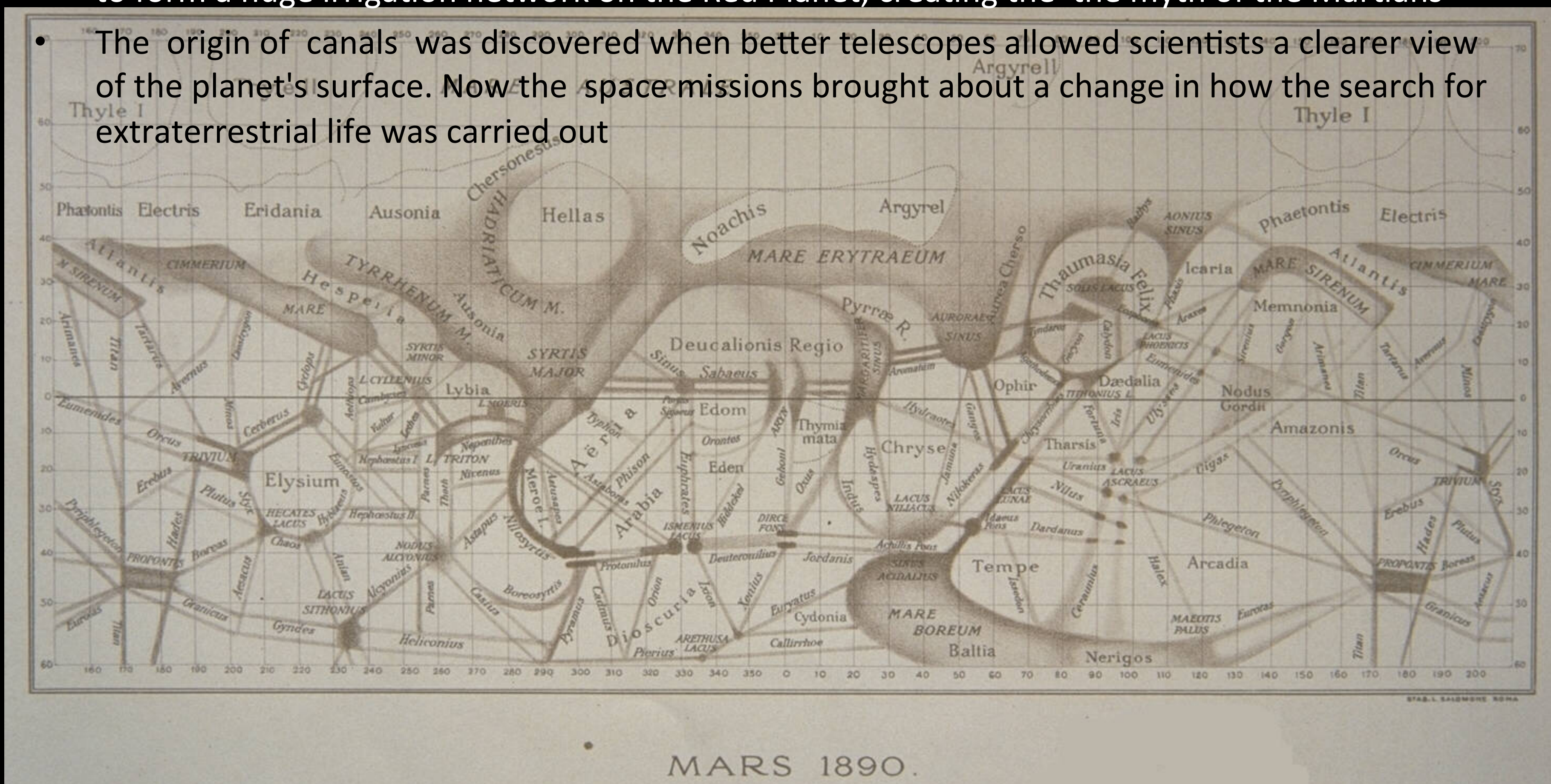
SAIT

Museo della Scienza e della Tecnologia di Milano

15 Maggio 2014

Mars and (exo)life

- The association of Mars with life was reinforced in the 19th century when Giovanni Schiaparelli observed bright and dark straight-line features that he called "canali". This term was associated with the connotation of a manmade construction.
- For a long time, it was popularly believed that these canals had been built by intelligent beings to form a huge irrigation network on the Red Planet, creating the the myth of the Martians
- The origin of canals was discovered when better telescopes allowed scientists a clearer view of the planet's surface. Now the space missions brought about a change in how the search for extraterrestrial life was carried out



Mars and (exo)life

- The association of Mars with life was reinforced in the 19th century when Giovanni Schiaparelli observed bright and dark straight-line features that he called "canali". This term was associated with the connotation of a manmade construction.
- For a long time, it was popularly believed that these canals had been built by intelligent beings to form a huge irrigation network on the Red Planet, creating the the myth of the Martians
- The origin of canals was discovered when better telescopes allowed scientists a clearer view of the planet's surface. Now the space missions brought about a change in how the search for extraterrestrial life was carried out
- In the mid 20th century, American geneticist Joshua Lederberg, Nobel Prize winner in Medicine, coined the word "exobiology" to describe the study of the existence of life outside the Earth.
- The goal of exobiologists became to find signs of primitive life, and Mars remained the target planet. According to current scientific knowledge about the possible development of life on Earth, the Red Planet could have (or had in the past) the environmental conditions (liquid water and moderate temperatures) capable of supporting complex organic molecules and possibly self-regenerated organisms.
- Scientists no longer look for intelligent beings, but for evidence for the presence of liquid water - an essential element for the formation of life - either on the surface or hidden underground, now or in the past.

ExoMars Programme 2016-2018

Establishing if life ever existed on Mars is a "fundamental" scientific questions. To address this important goal, ESA has established the ExoMars programme to investigate the Martian environment searching for life.

ExoMars program will carried out this main scientific investigations:

- **Search for signs of past and present life on Mars;**
- **Investigate how the water and geochemical environment varies; and**
- **Investigate Martian atmospheric trace gases and their sources.**

The 2016 mission includes a Trace Gas Orbiter (TGO) and an Entry, Descent and Landing Demonstrator Module (EDM). The Orbiter will carry scientific instruments to detect and study atmospheric trace gases, such as **methane**. The EDM will contain sensors to evaluate the lander's performance as it descends, and additional sensors to study the environment at the landing site.

The 2018 mission includes a rover that will carry a drill and a suite of instruments dedicated to **exobiology and geochemistry** research.

Searching for signs of life on Mars

- Mars is an evolving planet. It changed during its evolution and its *climate has been modified several times*. This marks Mars as a primary target for the search for signs of life in our Solar System.
- If life ever arose on the Red Planet, it probably did when *Mars was warmer and wetter*, in conditions similar to those when microbes appeared on the young Earth.
- The best chance to find signatures **of ancient life on Mars** is in the form of **chemical biomarkers** and **fossil communities**, either preserved **underground** or within surface rocks.
- Since *liquid water is a prerequisite for life*, good candidate locations to look for microfossils are terrains occupied by long-lasting bodies of water during Mars' early history.
- ExoMars 2018 Rover will use multiple strategies to search for life, including investigations to characterize potential habitats, visual examination of outcrops and spectrochemical composition analyses performed on well-selected samples.

Exposed layered deposit of probable lacustrine origin within an open-basin lake.
Credits: NASA HIRES MRO

Martian enviroment

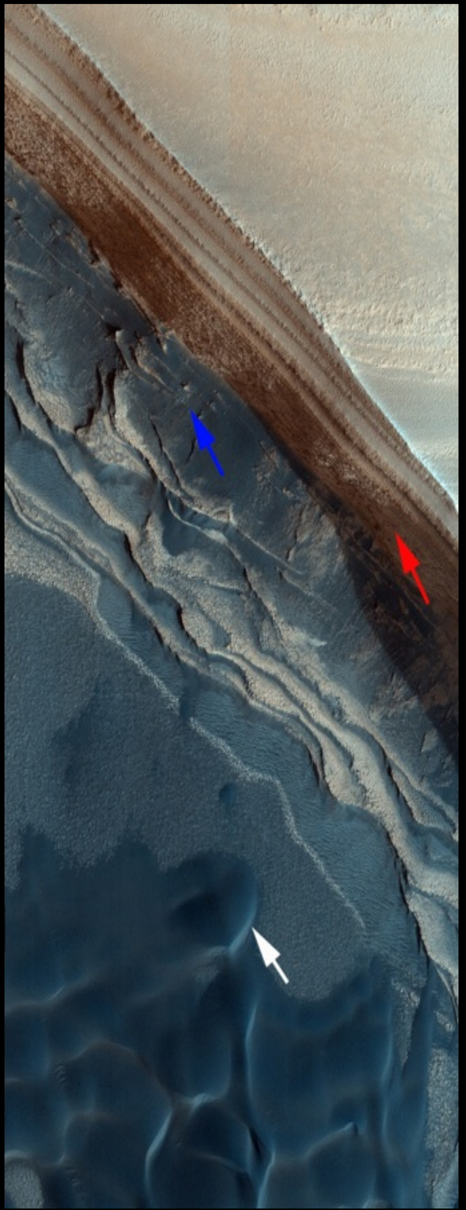
Not only **lacustrine-fluvial terrains** are important for LIFE but also the **enviroment**. Because the Martian atmosphere is more tenuous than Earth's, three important physical agents reach the surface of Mars with adverse effects for the long-term preservation of biomarkers:

1) The ultraviolet (UV) radiation dose is higher than on our planet and will quickly damage potential exposed organisms or biomolecules.

2) UV-induced photochemistry is responsible for the production of reactive oxidant species that can also destroy biomarkers;

3) Ionising radiation penetrates into the uppermost metres of the planet's subsurface. This causes a slow degradation process that can alter organic molecules beyond the detection sensitivity of analytical instruments.

These effects are depth dependent: the material closer to the surface is exposed to a higher dose than that buried deeper.



Need for Subsurface Exploration

- The **record of early Martian life**, if it ever existed, is likely to have escaped radiation and chemical damage only if it is **trapped in the subsurface for long periods.**
- Effective chemical identification of biomarkers requires access to well-preserved organic molecules and underground samples are more likely to include biomarkers
- Studies show that a subsurface penetration in the range of 2 m is necessary to recover well-preserved organics from the very early history of Mars.
- For all the above reasons, the access to the subsurface samples is absolutely needed for search of biomarkers.
- ExoMars drill will be able to penetrate and obtain samples from well-consolidated (hard) formations, at various depths, from 0 down to 2 m.
- This alone is a guarantee that ExoMars will break new scientific ground.

Credits: ESA

ExoMars 2018

- The 2018 mission of the ExoMars programme will deliver a **European rover** and a **Russian surface platform** to the surface of Mars.
- The ExoMars rover will travel across the Martian surface to search for signs of life. It will collect **samples with a drill** and analyse them with next-generation instruments.
- The primary objective is to land the rover at a **site with high potential for finding well-preserved organic material**, particularly from the very early history of the planet.
- The rover will establish the physical and chemical properties of Martian samples, mainly from the subsurface.
- **ExoMars will be the first mission to combine the capability to move across the surface and to study Mars at depth.**

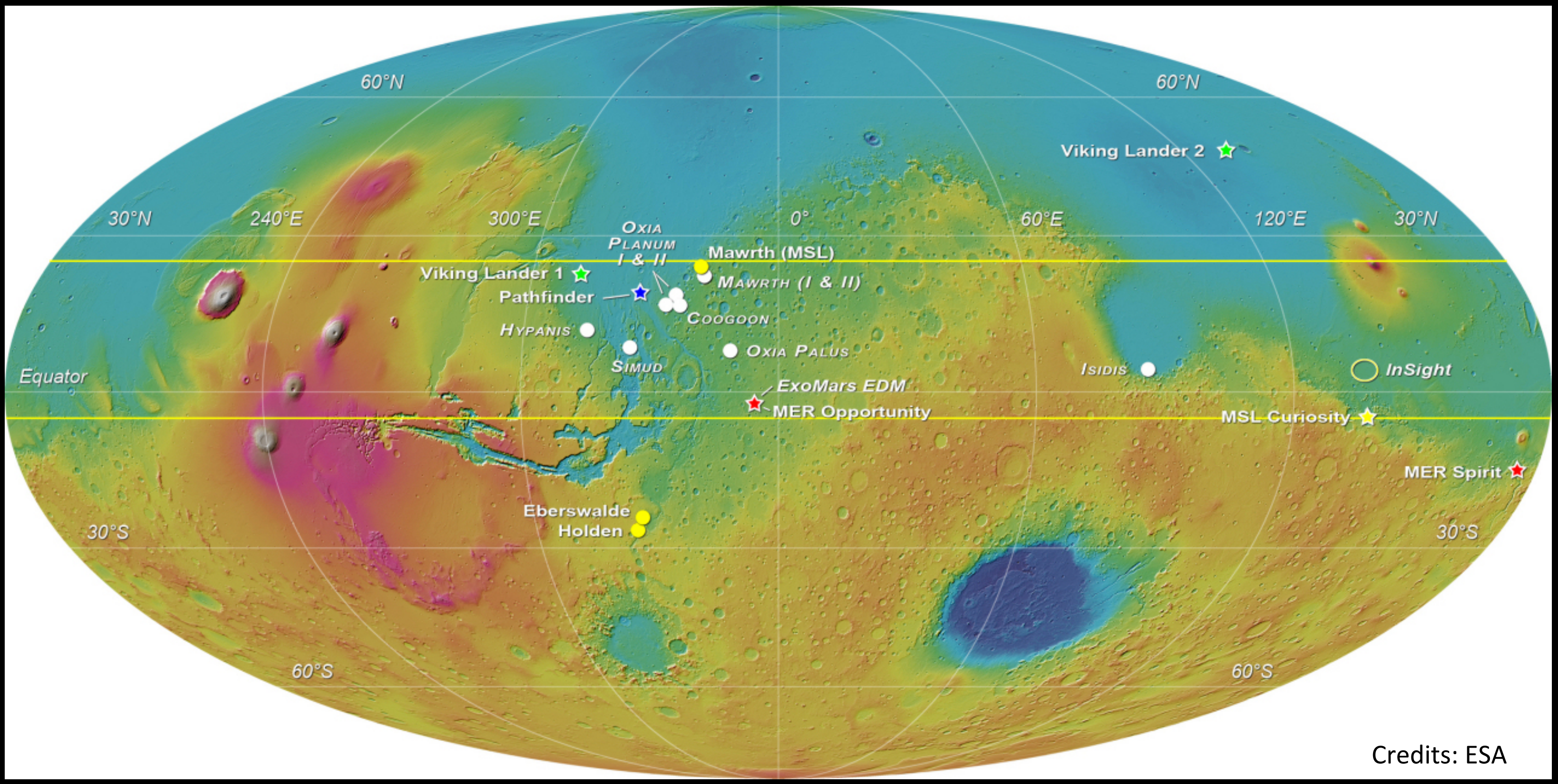
The ExoMars Rover Instrument Suite: Looking for signatures of life on Mars

- An accurate visual and spectral characterization of the surface of Mars is fundamental to establish the geological context at the sites that the Rover will visit.
- The ExoMars Rover provides **key mission capabilities**: **surface mobility, subsurface drilling and automatic sample collection, processing, and distribution to instruments**.
- It hosts a suite of **instruments dedicated to exobiology and geochemistry** research: this is the Pasteur payload.
- Data from the novel suite of instruments on-board the ExoMars rover will help scientists to conduct a step-by-step exploration of Mars, beginning at panoramic (metre) scales and progressively converging to smaller (sub-millimetre) studies, concluding with the molecular identification of possibly organic compounds.
- The **Rover DRILL** will then autonomously drill to the required depth while **investigating the borehole wall mineralogy, and collect small samples.** This sample will be delivered to the analytical laboratory, hosting four **different instruments that will perform mineralogical and chemistry determination investigations.**

The landing site

The scientific success of **ExoMars depends also on the scientifically interest of the landing site**. Since ExoMars is a "search for life" mission, candidate sites must contain evidence of a past or present habitable environment, supported by both morphology and mineralogical composition information.

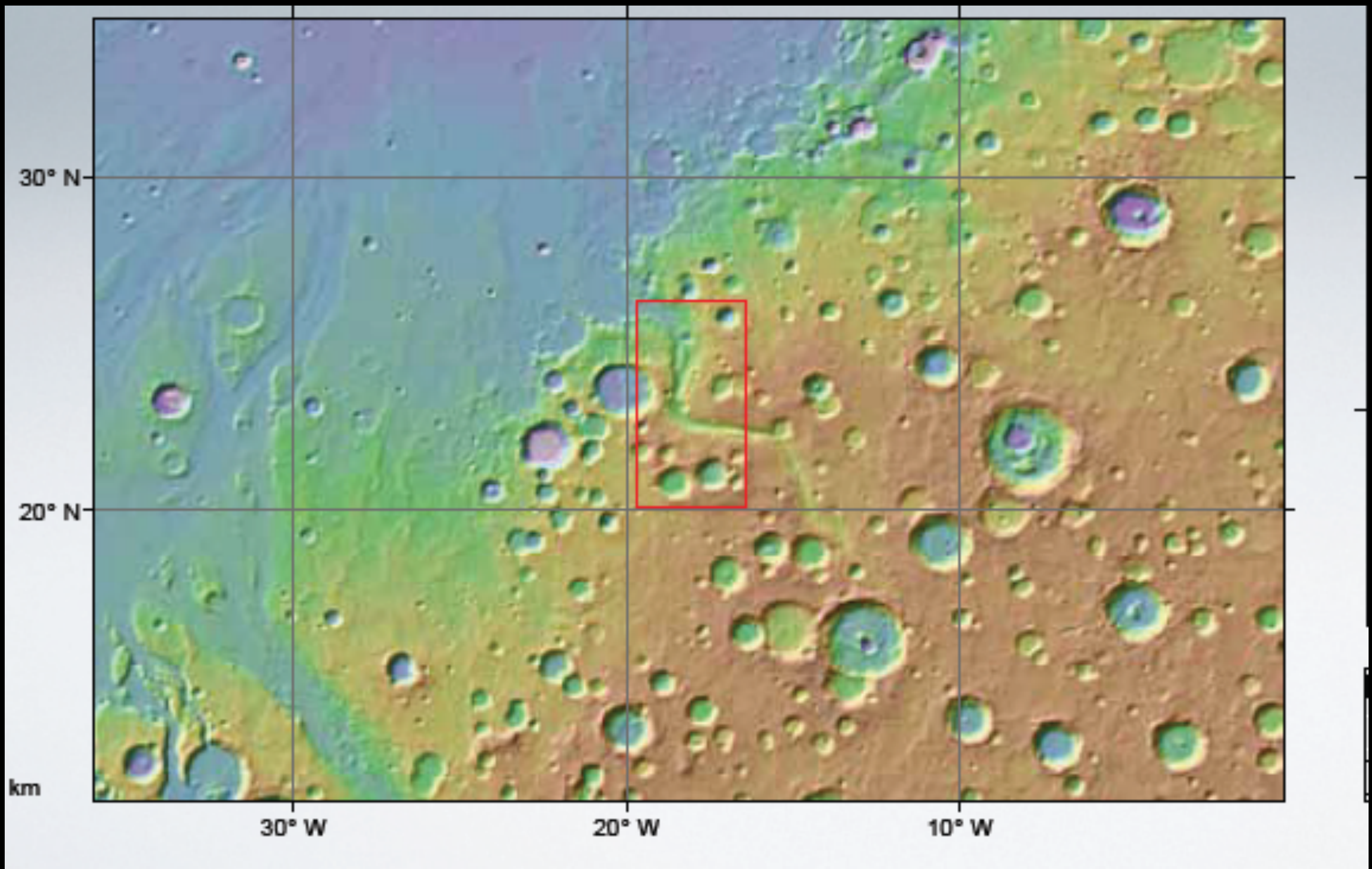
A good landing site includes outcrops whose composition is considered suitable for the long-term preservation of biomarkers (e.g. clays, sulphates, etc.) in association with long-lasting fluvial, lacustrine, or hydrothermal signatures.



The Surface Mission of the ExoMars

The mission strategy to achieve the ExoMars Rover's scientific objectives is:

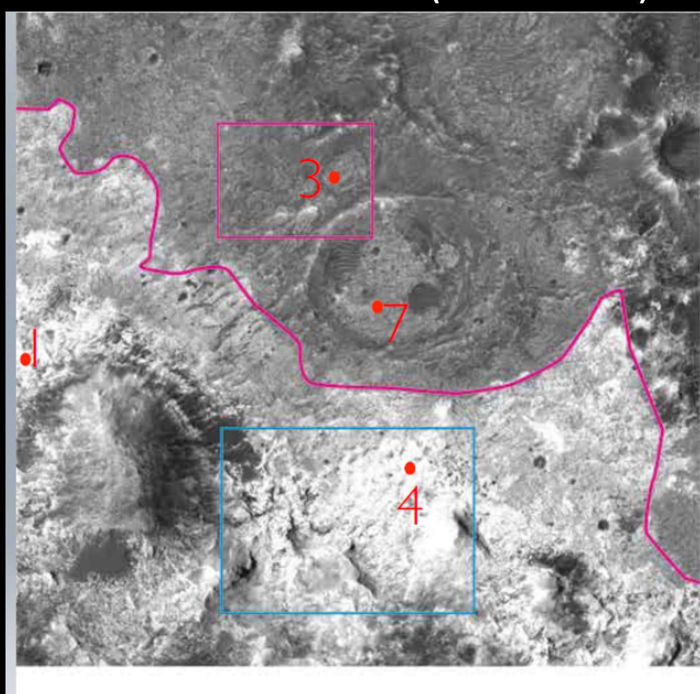
1. To land, or to be able to reach, a location possessing high exobiology interest for past or present life signatures, i.e. access to the appropriate geological environment.

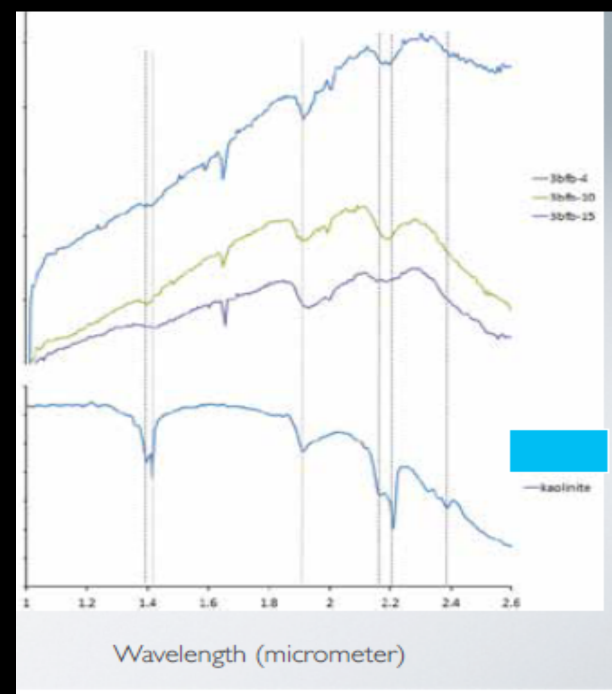


The Surface Mission of the ExoMars

The mission strategy to achieve the ExoMars Rover's scientific objectives is:

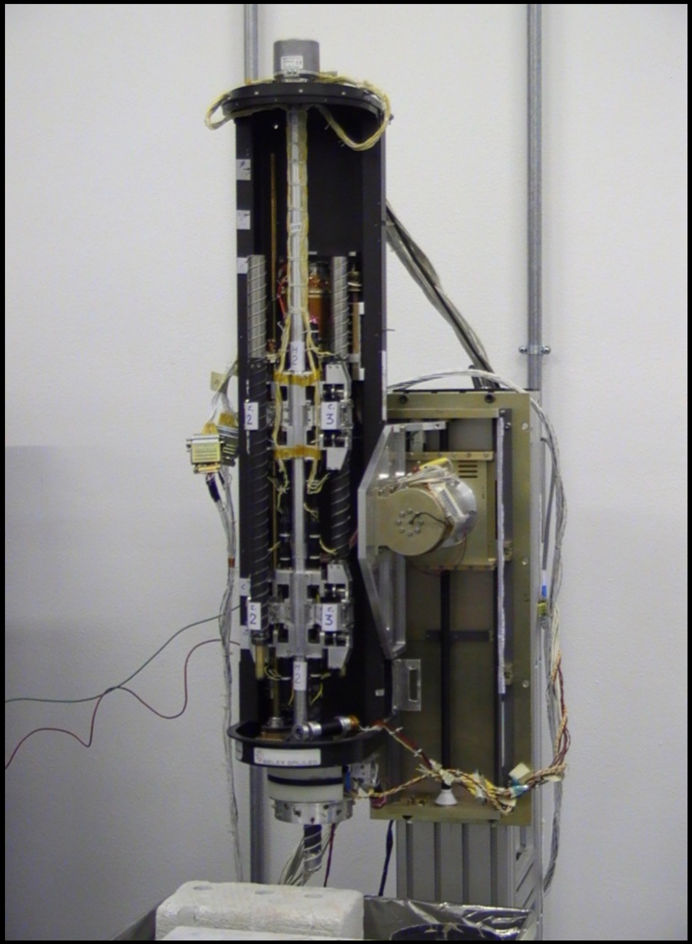
1. To land, or to be able to reach, a location possessing high exobiology interest for past or present life signatures, i.e. access to the appropriate geological environment.
2. To collect scientific samples from different sites, using a drill capable to reach well into the subsurface and into surface rocky outcrops.
3. At each site, to conduct an integral set of measurements at multiple scales, from the panoramic assessment of the geological environment, to the smaller scale investigations on surface outcrops, and culminating with the collection of well selected subsurface (or surface) samples





The Subsurface Mission of Exomars

- The investigation of **subsurface layers is the only approach that permits measurements on samples close to their original composition.**
- The ExoMars Drill is devised to acquire soil samples down to a maximum depth of 2 metres, in a variety of soil types.
- Its main function is to penetrate the soil, acquire a core sample (reference is 1 cm in diameter × 3 cm in length), extract it and deliver it to the inlet port of the Rover Payload Module, where the sample will be distributed, processed and analyzed by the Analytical Laboratory Drawer.
- The ExoMars Drill embeds the Mars Multispectral Imager for Subsurface Studies (Ma-Miss) which is a miniaturised VIS-near IR spectrometer devoted to the borehole exploration.



Credits: SELEX Galileo

Ma_Miss: Mars Multispectral Imager for Subsurface Studies

- The instrument main science objective is to study the Martian subsurface. This is key to understanding the chemical and physical processes that led to the formation and evolution of the site being investigated.
- In-situ analysis of the Martian subsurface provides information that can be used in the following investigations:
  - Assessing the habitability of the drilling site and searching for possible indicators of life.
  - Determining the presence of ice or water at the drilling site.
  - Documenting the mineral distribution and composition, and identifying the nature of local geology and chemistry.
  - Studying the Martian surface layers in terms of hazards and resources relevant to the potential for survival of humans on the surface.

Ma_Miss: How it works

- Ma_Miss is very miniaturezed and based on fiberoptics : an optical fibres bundle carries the light from the lamp (5 W) to Optical Head, which focuses the light on the target and re-collects the scattered light.
- The light spot on the target is 1 mm: the light is recollected from a 120 µm spot. An optical fibre carries the collected light from the Optical Head to the spectrometer. The interface between the Optical Head and the subsurface wall is a Sapphire Window.
- As the Rover drills into the upper surface of Mars, Ma_MISS will illuminate the hole's cylindrical wall through a transparent window situated in the drill tool. It will capture the reflected light, analyse its spectrum, and transfer the data on the hole stratigraphy to the Rover computer for further analysis and relay to Earth.

ExoMars

- **ExoMars program is the key to establish if life ever existed on Mars.**
- **Search for biomarkers in the subsurface (2018) and evidence of methane that could be signatures of active biological (2016) are the main goal of the ExoMars program**