# Mars Profound


## Abstract

Mars Profound will provide access deeply beneath the Martian surface, to understand the evolutionary steps followed by the early Mars and determine whether they unblocked the phenomenon of life. Mars Profound consists of a surface platform that will drill for the first time on another planet 20-meter deep and perform state of the art analytical analyses of a long and ancient, ~4 Ga old, stratigraphic sequence.


## Mission Statement

The geological record of Mars and the Earth has the fundamental property to be structured in strata, i.e., superimposing layers of materials. Thick, layered, sedimentary sequences preserve long intervals of time and allow for paleoenvironmental reconstructions. On Earth, cross-sections of thick sedimentary sequences are exposed at the surface due to cycles of orogenesis and erosion, and can be accessed easily on a horizontal surface. Due to the lack of plate tectonics on Mars, such horizontally exposed, and thus save to access cross-sections do not exist. Previous missions have shown that in this 3D Martian context, using a rover is highly inefficient because of the need to travel for many years across many 10s of kilometers between successive strata fortuitously exposed by (e.g., eaolian) erosion. Where stratigraphic cross-sections are exposed on highly inclined (~40°) slopes, like crater walls and cliffs, they are inaccessible using wheels and are impractical for sampling. Thus, the only way for sampling sedimentary sequences is by drilling.

By penetrating perpendicular to the sub-parallel layers, we are able to understand each stratum as well as the entire stratigraphy. Sedimentary rocks that formed on early Mars in the presence of liquid water are the most interesting archives to investigate the possible existence of past extraterrestrial life and the climatic changes that transformed Mars from a potentially habitable into a progressively drier and inhospitable environment. Thus, deep drilling is the only approach for addressing fundamental questions about the Mars geosphere and biosphere. Roving technology, despite its top TRL, is fundamentally inadequate for this goal.

Deep drilling is required from the programmatic and strategic point of view as well. It is foreseeable that in the quest for space research, Europe will act together with partners. These partners have their own technological capabilities that, in many instances, are developed at a more advanced level. Thus, it is important for Europe to focus on engineering means that are the most needed in a cooperative context, rather than in a stand-alone situation. In this respect, drilling technologies are an essential capability that has seen minor advancement in space-faring countries. In Europe, instead, first steps toward mature drilling technologies have been already undertaken, at least for penetrating in the first few meters of the Martian subsurface.

## High Level Mission Requirements

Technology: Mars Profound needs deep drilling capabilities that are miniaturized and function with minimum power consumption. To reach such requirements, considerable technological development is needed and several drilling techniques, including the extensions rods of ExoMars, needs to be evaluated. The trade-off to determine the maximum drilling depth should include information of the estimated thickness of interest (and corresponding time span) for a given landing site and associated layer sequence. For example, the sequence of layers should be sufficiently thick in order to sample unique climatic changes not due to the periodic Mars' obliquity changes. Thus, the sequence should span at least 1 million years (i.e., ~10 obliquity changes). The currently known sedimentary strata recording environmental changes that are likely unique are 10s of meters thick. Thus, drilling capabilities in the order of 20-meter deep are necessary. In addition, the drill system needs to be able to extract samples at selected depths and store them on the surface platform. Due to horizontally extensive (few 10s of km) sedimentary sequences, Mars Profound does not need pin-point landing nor roving capabilities. Nevertheless, landing capability should include close-range obstacle avoidance, in order to land in regions with localized high slopes, e.g., meter-wide mounds and meter-wide scarps. The capability to land at an elevation lower than -1 km MOLA is required. Notional landing sites could be the layered deposits around Mawrth Vallis and the ocean or glacial deposits within Isidis Basin.

Science: Once samples have been extracted and stored on the surface platform, these samples need be analyzed for their mechanical, mineralogical, and isotopic properties, as well as for their content in organic matter. Such laboratory could be based on the heritage of the Pasteur analytical laboratory of ExoMars 2022, with its suite of instruments including hyperspectral near-infrared, Raman, laser desorption mass spectrometry and gas chromatography-mass spectrometry. During drilling, in-situ physical and chemical measurements in the borehole need be performed, for example with temperature and thermal conductivity measurements, and observations covering the wavelengths from the ultraviolet to the thermal infrared.

**Mission Architecture**

The surface craft will have a high heritage from the ExoMars 2022 platform and rover mission. The payload for analytical analysis, as well as a ground-penetrating radar, will be integrated directly into the platform, instead of on the rover as in ExoMars. The payload for science of proximity of the ExoMars rover i.e., optical cameras and IR spectrometer, will be reduced and converted into a payload for microscale observations of extracted samples. Mass and power budget allocated to the mobility and 2-m drill systems on the ExoMars rover will be fully dedicated to the deep drill system in Mars Profound. By merging the subsystems of the platform and rover into a single craft, unnecessary redundancy will be minimized. With a similar total mass as ExoMars 2022, Mars Profound will be reach Mars with a single launch.

**Relevant related activities**

- ExoMars 2022 platform, rover and drill.
- PROSPECT on Lunar-27
- HP3 thermal probe.
- Philae/Rosetta with SD2 and Mupus.

**Direct and indirect end users or customers**

First, the scientific community will be involved directly with scientific experiments on the surface platform. Second, by collecting and preserving samples from depth, Mars Profound will allow future missions, likely with astronauts, to analyse them in detail.

Future communities building habitat on Mars will learn considerably from the drilling activities performed by Mars Profound.

Community interested in in-situ resources utilization will benefit from the drilling operation and from the nature of samples at depth.

**Mission Cost**

2B€

**Mission Timelie**

Launch mid 2030's

This short proposal was presented to the ESA call "What's next: New space missions and ideas", 4 October 2020. The concept was discussed among the following researchers:

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