Mem. S.A.It. Vol. 92, 148

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Ma_MISS on Exomars rover:

access to the Martian sub-surface

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Abstract. The instrument Ma_MISS on the Rosalind Franklin Rover/ExoMars2022 is a novel miniaturized spectrometer built with the aim to investigate Mars shallow subsurface composition and locate minerals of astrobiological interest. Ma_MISS will perform spectral reflectance investigations in the 0.4–2.2 μm range to characterize the mineralogy of the excavated borehole wall at different depths (between 0 and 2 m). Access to the subsurface is essential to constrain the nature of the subsurface materials and its relevance for habitability conditions. Subsurface layers likely host and preserve water ice and hydrated materials, which are diagnostic for understanding the geo-chemical environment at Oxia Plaum, the ExoMars rover landing.

Key words. Mars, EXOMARS, organics, astrobiology

1. Introduction

The Ma_MISS (Mars Multispectral Imager for Subsurface Studies, De Sanctis et al. (2017)) experiment is the Visible and Near Infrared (VNIR) miniaturized spectrometer hosted by the drill system of the ExoMars 2022 rover.

Ma_MISS spectral sampling is about 20 nm while the spatial resolution over the target is 120 μm. The instrument will make use of the drill's movement to scan the subsurface, building up hyperspectral images of the borehole.

The main goal of the Ma_MISS instrument (fig.1) is to study the Martian subsurface environment in terms of terrains composition. Access to the Martian subsurface is crucial to constrain nature, timing and duration of alteration and sedimentation processes on Mars that are essential to understand the habitability conditions (Vago et al. 2017).

Subsurface materials could preserve hydrated materials and water ice diagnostic for understanding the water geochemical environment (both in the liquid and solid state) at the landing site. The Ma_MISS spectral range and sampling have been carefully selected to allow studying minerals and ices in situ, prior to collecting samples.

2. Ma_MISS scientific goals

The main Ma_MISS scientific objectives are the following: 1) determine the mineralogy

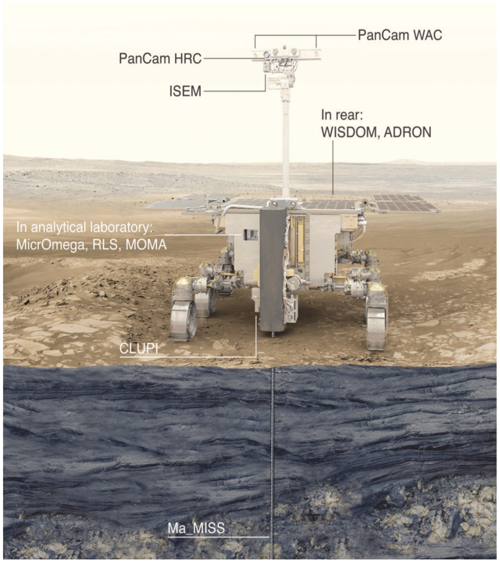

Fig. 1. Artistic view of ExoMars rover with the different intruments indicated by arrows.

of subsurface materials; 2) determine the distribution of hydrated material and possibly subsurface water and volatiles; 3) reconstruct a stratigraphic column to obtain clues about subsurface geological processes; 4) determine the changes in oxidation state of the material with depth; 5) characterize important optical and physical properties of materials (e.g. grain size); 6) characterize the subsurface in terms of habitability potential.
Ma_MISS findings will help refine criteria for deciding which are the most interesting subsurface formation form which to collect sample.

3. Ma_MISS instrument structure

The spectrometer and proximity electronics are hosted in a box on the external wall of the drill box. The spectral range is 0.4–2.2 μm, with a spectral resolution of 20 nm and an expected signal-to-noise ratio of about 100. These characteristics are suitable to investigate martian mineralogy (e.g De Angelis et al. (2017)). The optical head (OH) is accommodated on the drill tip, with the tasks of focusing light from an integrated 5W lamp onto the target and collecting the reflected signal (fig.2). The illumination spot on the target is about 1mm in diameter at a focal distance of 0.6 mm and the reflected light is collected through a 120 μm spot, that defines the instrument. An antireflective coated sapphire window (SW) with high hardness and transparency on the drill tip tool protects the Ma_MISS OH while observing the borehole wall. To reach different depths the drill make use of three extension rods, each 50 cm long. Each of them contains Ma_MISS element consisting of optical fibers and optical collimator. The first extension rod is connected to the non-rotating part of the drilling system hosted on the rover through a fiber optical rotating joint.

4. Operational Modes

Ma_MISS instrument observes a single point target on the borehole wall subsurface. However depending on the features of interest, the observation window can scan the subsurface by means of drill tip rotation or translation providing ring or column hyperspectral images. Ma_MISS operational modes have a high flexibility in terms of the number of points, sampling and exposure times to be set, depending on the scientific objective of the measurement and available resources in terms of time and data volume.

- Ring operational mode. A ring profile is collected during a rotation of the drill tip at a fixed depth. A smaller sector of a ring can also be acquired or different spot spacing can be used.

- Column operational mode. A column profile is performed during a vertical translation of the drill tip tool, typically while extracting the drill.

The combination of a number of column and ring observations enables Ma_MISS to build up a complete image of the wall. Being Ma_MISS operated through the drill, exploitation of drill's telemetry will be also crucial for the characterization of Ma_MISS performaces (Frigeri et al. 2020).

Fig. 2. Ma_MISS optical window

5. Conclusions

Ma_MISS instrument spectral range, resolution, and imaging capabilities are suited for investigating subsurface environments of the samples that will be delivered to the rover's analytical laboratory. Ma_MISS outcomes, synergies with the other rover payloads, will be crucial to refine criteria for sample selection.
A full understanding of the composition and distribution of shallow subsurface materials on Oxia Planum, the rover landing site, will be essential to support Exomars 2022 mission to accomplish science goals focused on the search of traces of past and present life.

Acknowledgements. The instrument Ma_MISS on ExoMars mission has been founded by ASI (Agenzia Spaziale Italiana) and INAF (Istituto Nazionale di Astrofisica).

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