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## **Ma\_MISS on ExoMars 2020**

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The ExoMars 2020 launch window opens on 26 July 2020, and ExoMars will touchdown at Oxia Planum, a location with a strong potential for past habitability and for preserving physical and chemical biosignatures. The mission will deliver two science elements to the martian surface: (1) a lander instrumented to conduct environmental and geophysical measurements and (2) a rover with scientific payload to conduct a search for signs of life.

Ma\_MISS is a visible and near infrared (VNIR, 0.4-2.2  $\mu\text{m}$ ) micro spectrometer hosted by the drill system of the ExoMars 2020 rover [1]. The Ma\_MISS instrument has been developed to provide hyperspectral images of boreholes excavated by the ExoMars rover drill. Ma\_MISS will characterize the mineralogy and stratigraphy of the shallow subsurface down to two meters [2]. The main objectives of Ma\_MISS are: (1) determine the composition of the subsurface materials; (2) map the distribution of the subsurface  $\text{H}_2\text{O}$ -bearing and OH-bearing materials and possibly ices; (3) characterize important optical and physical properties of the materials (e.g., grain size); (4) produce a stratigraphic column that will provide information on the subsurface geology.

The drill can reach down to 2 m below the surface, and Ma\_MISS will operate periodically during pauses in drilling activity and will produce hyperspectral images of the drill's borehole. The Ma\_MISS instrument's main driving requirement was its miniaturization because it is embedded within the drill (Fig. 1). The spectrometer is placed in a box on the side wall of the drill box. The spectral range is 0.4–2.2  $\mu\text{m}$ , with a spectral sampling of 20 nm a SNR~100 and a spatial resolution of 120  $\mu\text{m}$ . The light from a 5W lamp is collected and carried, through an optical fiber bundle, to the miniaturized Optical Head, hosted within the drill tip. A Sapphire Window with high hardness and transparency on the drill tip protects the Ma\_MISS optical head allowing to observe the borehole wall.

Different depths can be reached by the use of three extension rods, 50 cm long, each containing optical fibers and a collimator. The first extension rod is connected to the nonrotating part of the Drill, hosted on the rover, through a Fiber Optical Rotating Joint

(FORJ), that allows the continuity of the signal link between the rotating part of the drill and the spectrometer.

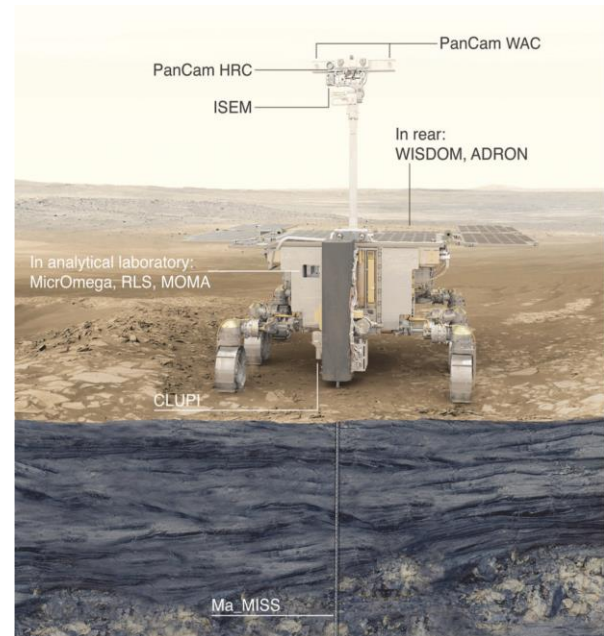


Fig. 1: Artistic view of the ExoMars-Pasteur Rover with instruments allocations. Ma\_MISS is integrated within the drill.

The Ma\_MISS instrument has been calibrated and delivered and is now integrated into the drill.

Results obtained in the lab on mineral/rock samples confirm that the Ma\_MISS spectrometer has a spectral range, resolution and imaging capabilities suitable for the Mars subsurface characterization[2,3]. The spectra acquired with the Ma\_MISS fine spatial resolution (120  $\mu\text{m}$ ) show minerals that are not recognizable at coarser resolution (~6 mm) (Fig.2). In the case reported in Fig. 2, a lava from *Montiferru/Bonarcado*, Ma\_MISS is able to identify a great diversity, indicating several different mineralogical phases within the observed area. Phyllosilicate, olivine, opaque phase can be identified with Ma\_MISS but not at coarser resolution.

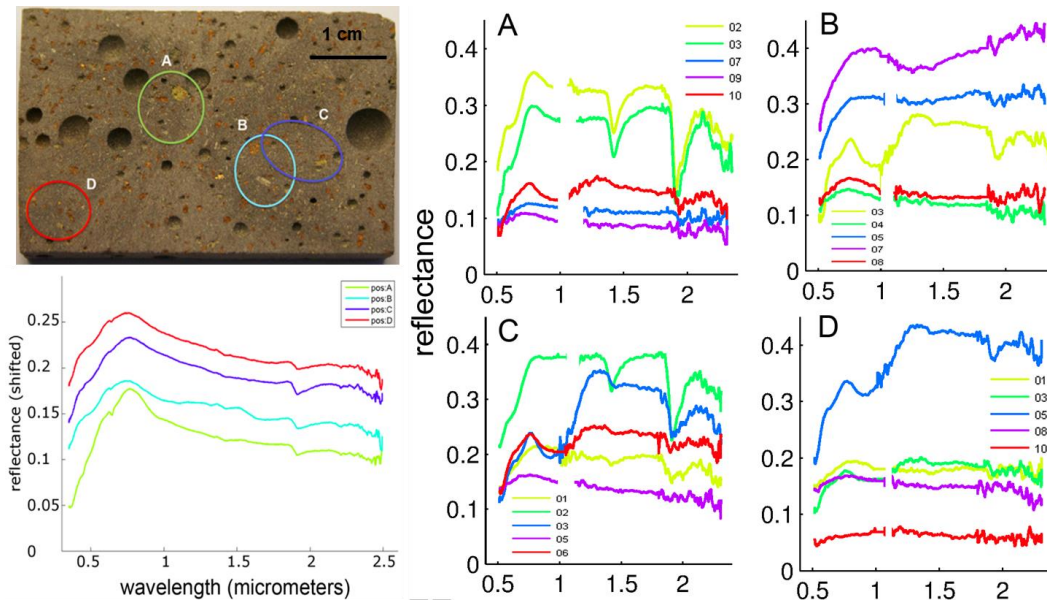


Fig.2 Left Top: slab of Montiferru/Bonarcado Lava. The letters (A,B,C,D) correspond to the areas analyzed with Spectro-goniometer setup. Each area is 6-mm-size; Left bottom: spectra acquired from the regions A,B,C,D, with the spectro-photometer FieldSpec Pro coupled with a mechanical goniometer, having a spatial resolution of about 6 mm. Right: Spectra acquired with Ma\_Miss BreadBoard setup. In each single 6-mm-sized area, spectra in different positions have been acquired with Ma\_Miss BB setup; Data at 1  $\mu\text{m}$  are not shown in several spectra due to high level of detector noise, as well as data  $<0.5 \mu\text{m}$ .

Ma\_MISS is the only instrument in the rover's Pasteur payload able to analyze subsurface material in its natural condition (*in situ*), prior to extracting samples for further analysis. In synergy with other Rover instruments, MA\_MISS findings will help to refine criteria for deciding from where to collect samples.

#### References:

- [1]Vago J.L. et al. (2017): Astrobiology, 17, 6, 7.
- [2]De Sanctis et al. (2017): Astrobiology, 17, 6, 7.
- [3]De Angelis et al. (2017): PSS, 144, DOI: 10.1016/j.pss.2017.06.005