Ma_MISS ON EXOMARS ROVER: THE INVESTIGATION OF THE MARTIAN SUB-SURFACE

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Introduction:

The main goal of the Ma_MISS instrument is to study the Martian sub-surface environment. Access to the Martian subsurface is crucial to constrain nature, timing and duration of alteration and sedimentation processes on Mars, as well as habitability conditions. Subsurface deposits likely host and preserve water ice and hydrated materials diagnostic for understanding the water geochemical environment (both in the liquid and solid state) at the landing site.

Ma_MISS instrument:

Ma_MISS is the Visible and Near Infrared miniaturized spectrometer hosted in the drill system of the ExoMars2022 [1] rover that will characterize the mineralogy and stratigraphy of the excavated borehole wall at different depths (<2 m) [2].

Ma_MISS covers a spectral range of 0.5–2.3 μm and, making use of the drill's movement the instrument slit, can scan along rings and columns building up hyperspectral images of the borehole; it can achieve a spectral sampling of about 20 nm and spatial resolution better than 120 μm.

Ma_MISS is split in two parts: the spectrometer and its proximity electronics located outside of the drilling tool and the Optical Head located inside the drill itself.

The Drill consists of a main rod, which hosts the drill tip, the Ma_MISS Optical Head and a sapphire window with high hardness and transparency allowing to observe the borehole wall (Fig.1), plus three additional rods (each 50cm long), which allow to reach a maximum depth of 2m. All the rods are equipped with optical fibres. The first extension rod is connected to the nonrotating part of the Drill, hosted on the rover, separated 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.2).

The light from a 5W source lamp is carried through the optical fibers to the miniaturized Optical Head and from this, through the Sapphire window, illuminates the borehole. The reflected signal is fed, through the Sapphire window, to a collimator and carried by the optical fibers to the Spectrometer outside of the drill.

Ma_MISS provides high flexibility for the acquisition of borehole wall spectra exploiting the translational and rotational dexterity of the drilling tool. The spectrometer observes a single point target on the borehole wall subsurface. Depending on the features of interest, the observation window can scan the subsurface by means of drill tip rotation or translation and thus providing ring or column hyperspectral images.

By combining a number of column and ring observations, Ma_MISS allows the reconstruction of a fairly complete image of the borehole wall.

Fig.1: *Ma_MISS Shapphire Window during drilling tests; illuminated by the lamp; with the rover observing spectral sample and in comparison with a coin.*

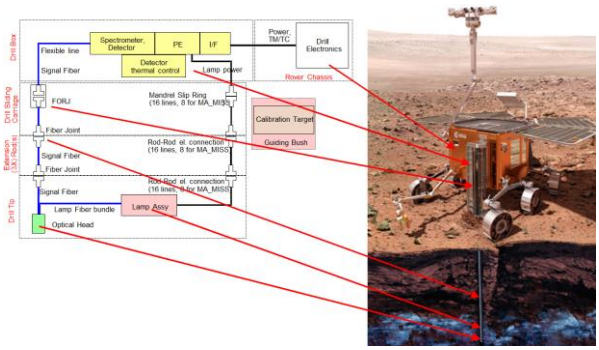

Fig.2: *Ma_MISS functional diagram (left side) and accommodation inside drill parts (right side) and outside, on the drill box.*

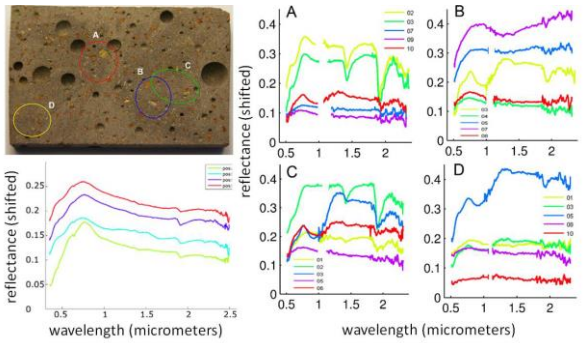

Fig.3: *Left Top: example of a slab of Montiferru/Bonarcado ignimbrite. A, B, C, D circles correspond to the areas analyzed. Each area is 6-mm-size. Left bottom: spectra from the areas A, B, C, D collected with the spectrometer Field Spec coupled with a mechanical goniometer, having spatial resolution of about 6mm. Right: Spectra acquired with Ma_MISS BreadBoard setup. In each single 6-mm-sized area, spectra indifferent positions have been acquired with Ma_MISS BB setup.*

Ma_MISS Laboratory BreadBoard:

Results obtained in the lab with the Ma_MISS breadboard on mineral/rock samples confirm that the Ma_MISS spectrometer has the spectral range, resolution, and imaging capabilities suitable for the Mars subsurface characterization [2,3]. The spectra acquired with the Ma_MISS fine spatial resolution show minerals that are not recognizable at coarser resolution (Fig.3). We should expect to see grains composed by single minerals.
Latest laboratory tests (Ferrari et al., this issue) show that Ma_MISS is suitable to recognize signature of organics in mixtures with clays.

Note that the samples extracted with the drill will be crushed before the analysis in the analytical laboratory of the rover. Thus, 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. This information will be complimented by high resolution images of the retrieved core by CLUPI [4]. The instrument will observe the stratigraphic column providing information on the subsurface geology and composition.

After a successful calibration and testing campaign, the instrument has been integrated into the Drill and into the ExoMars rover. In these last months, the integrated instrument has been subject to several tests in different conditions. The results are satisfactory and the instrument is ready to be launched.

Acknowledgments: This work is supported by the Italian Space Agency (ASI) grant ASI-INAF n. 2017-412-H.0. Ma_MISS is funded by the ASI and INAF.

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