MICRO IMAGING SPECTROMETER FOR SUBSURFACE STUDIES OF MARTIAN SOIL: MA_MISS

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Introduction: A Drilling system, coupled with an in situ analysis package, is installed on the ExoMars Pasteur Rover to perform in situ investigations up to 2m in the Mars soil. Ma_Miss (Mars Multispectral Imager for Subsurface Studies) is a spectrometer devoted to observe the lateral wall of the borehole generated by the Drilling system. The instrument is fully integrated with the Drill and shares its structure and electronics. Surface samples of Martian soil are highly influenced by exogenous processes (weathering, erosion, sedimentation, impact) that alter their original properties. Subsurface access, sampling material below the oxidized layer, can be the key to "assess the biological potential of the target environment (past or present)". The analyses of uncontaminated samples by means of instrumented drill and in situ observations are the key for unambiguous interpretation of the original environment that leading to the formation of rocks [1].

Instrument setup: Ma_Miss experiment is perfectly suited to perform multispectral imaging of the drilled layers. Ma_Miss is a miniaturized near-infrared imaging spectrometer in the range 0.4-2.2 μm with 20nm spectral sampling. A transparent sapphire window on Drill Tool protects the Ma_Miss Optical Head permitting the observation of the borehole wall. Hardness of sapphire is the closest to diamond one, thus avoiding the risk of scratches on its surface. Ma_Miss Optical Head performs the double task of illuminating the borehole wall with a spot around 1 mm diameter and of collecting the scattered light coming from a 0.1 mm diameter spot of the target. The Illumination and Collection Relays of the Optical Head (depicted in Figure 1) are interfaced with the illumination bundle and the single fiberoptic signal link, respectively.

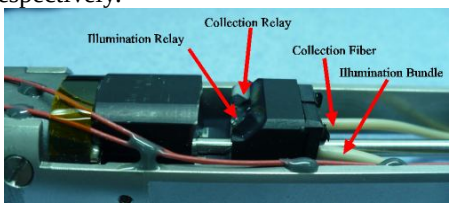

Figure 1: miniaturized optical head with the illumination and collection relays depicted.

The Spectrometer, VIS/NIR detector and Proximity Electronics are integrated in a box placed on the external wall of Drill Box. The signal from the Optical Head to the spectrometer is transferred through the different elements of the Drill by means of fiber optics and an optical rotary joint implemented in the roto-translation group of the Drill.

Observation method: Ma_Miss provides high flexibility in the acquisition of borehole wall spectra exploiting the translational and rotational agility of the drill tool. The spectrometer observes a single point target of the borehole wall surface. Depending on the surface features we are interested in, the observation window can scan the surface by means of the drill tip rotation or translation. When the drill is vertically translated a "Column Image" is acquired; the translation step can be equal to the observation spot. The "Ring Image" can be obtained by rotation of the drill tip. The acquisition of adjacent rings will permit to reconstruct a complete image of the borehole wall. Given the high flexibility in the Ma_Miss operations, a large variety of acquisition strategies (i.e. how to sample the borehole wall) can be implemented, depending on the specific target.

Preliminary test: Ma_Miss Optical Head has been tested in the breadboard to capture the diffused light from the observed target and transfer the signal to a laboratory spectrometer for analysis. Reflectance spectra acquisitions of representative minerals (Gypsum and Olivine) have been performed and reported in Figure 2.

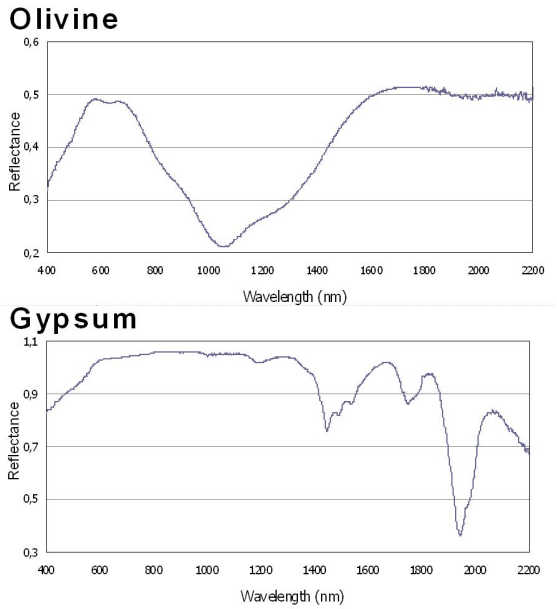

Figure 2: Example of prototype Ma-Miss instrument response signal taken in Olivine (volcanic rock) (top) and Gypsum (bottom). Credit: *INAF-IAPS*

The Optical Head of Ma_Miss has been tested after integration in ExoMars Drill. The drilling experiment has been carried out in realistic media (tuff, red brick). The test shows good performance of Optical Head illumination capability and of the window cleanliness during the drilling. Illumination spot is focused at the nominal distance of 0.2 mm from the sapphire window. The light beam coming out from the drill window is shown in Figure 3.

Figure 3: Two different moments of the Ma_Miss Optical Head tests during the drilling. Left: The light beam comes out from the sapphire window on the Drill wall. Right: No evidence of dust on the window during the drilling Credit: *SELEX Galileo*

Conclusion: During the ExoMars Pasteur Rover mission, the Ma_Miss experiment will allow collecting valuable data of the drilled stratigraphic column, will document "in-situ" the nature of the samples that will be delivered to the Pasteur Laboratory and will be able to identify hydrated minerals, sedimentary materials and different kind of diagnostic materials of Martian subsurface.

References: [1] Coradini, A., et al. (2001): MA_MISS: Mars multispectral imager for subsurface studies, *Advances in Space Research*, Volume 28, Issue 8, p. 1203-1208, 10.1016/S0273-1177(01)00283-6.

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