Ma_MISS ON ROSALIND FRANKLIN ROVER ACTIVITIES FOR THE EXPLORATION OF THE MARTIAN SURFACE AND SUBSURFACE

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Introduction: Mars is a primary destination to search for signs of life in our Solar System and probing the subsurface is a key element in this quest. ExoMars 2022 mission was designed with the aim of searching life into the Martian subsurface, accessing to sequences of buried layers that may host biomarkers. Unfortunately, the ExoMars rover mission, in collaboration with ROSCOSMOS, was cancelled last year due to the geo-political situation and it is now re-configured for a departure in 2028, using European technology to land. The Rosalind Franklin rover will remain almost the same as in the 2022 configuration, while the platform will be completely re-designed and built. Accessing the unaltered subsurface by using a Drill has been the innovative approach of the ExoMars mission. Such an approach has been recently adopted also for the NASA mission concept called MLE (Mars Life Explorer): it foresees a lander with a drill capable to reach subsurface layers, extracting samples to the be analyzed by a payload very similar to ExoMars' one.

Here we will describe the scientific and technological activities to support the Martian exploration, in the context of the rover mission, specifically for the Ma_MISS instrument, as well as in a broader context.

Rosalind Franklin rover: Access to the Martian subsurface is the distinguishing element of the ExoMars mission. The drill is the crucial element of the mission, exploring and collecting samples down to 2 m in the subsurface. Moreover, the rover includes has a complex payload to conduct detailed investigations of composition, search for organics, and recognize indicators of past or extant life [1]. An essential part of the payload is Ma_MISS (Mars Multispectral Imager for Subsurface Studies) experiment hosted by the drill system [2,3]. Ma_MISS (fig.1) is a miniaturized spectrometer (VNIR) with an optical head inside the drill tip, capable of observing the borehole walls from where the samples are collected to be successively analyzed by a suite of instruments on the rover.
Given the political context, ExoMars has been re-designed for a "European" mission and will be launched in 2028. In the next 6 years, many activities are planned in support of Ma_MISS science and the scientific return of Martian missions. The workplan is broadly illustrated hereafter.

Optimization of the Ma_MISS performance: Ma_MISS measurements will be the deepest compositional measurements made on Mars. Ma_MISS can detect compositional gradients with depth, changes in type and abundance of minerals, weathering fronts or rinds, and diagenetic veins or nodules, changes in granulometry. The spectral range of Ma_MISS (0.4-2.3 microns) is optimal to detect changes in the occurrence and crystal chemistry of olivines and pyroxenes as well as Fe(II)/Fe(III) in silicates, oxides, and salts, that record different environments. Similarly, we expect to see changes in the hydration state, with uppermost surfaces more desiccated than interiors. We will test different minerals, mixtures, and stratigraphic sequences with our laboratory breadboards, in order to:

- Optimize the acquisitions based on the expected mineralogy and stratigraphy
- Develop a reference database to interpret the collected data
- Relate the spectral data with the mechanical data inferred from the engineered data from Rover subsystems, in particular drill telemetry that can provide information on the mechanical properties of the drilled rocks.

Thermal Modelling of the Martian surface and subsurface: The investigation of the Martian subsurface requires the knowledge of the thermal properties of the surface and subsurface. Water ice is present only under specific condition of temperature and pressure, thus thermal modelling is an essential part of the subsurface investigation. Moreover, hydration of the minerals should change with depth and local condition (diurnal and seasonal variation). Thermal modelling can be applied not only to Oxia planum (Exomars landing site) but to several other Mars' sites of interest, providing surface temperature distribution and interior temperature profiles.

Data analysis of previous and ongoing missions: The data acquired by past and ongoing missions are extremely useful for understanding if and where life could have been present on Mars. The landing sites of the most recent rover missions have been selected only after careful evaluation of the "astrobiological potential" of the area, in a process lasting about 5 years for each mission. Such evaluations have been done using the available remote sensing data. However, new data and techniques can be adopted to better understand the context of the landing sites, refining our knowledge of the areas in which the rovers operate. Such a detailed knowledge of the context is absolutely needed to firmly identify any area as promising from an "astrobiological" perspective. Moreover, the knowledge of the areas is the base to locate areas on Earth where to directly observe the geological processes and minerals similar to what we expect on Mars (terrestrial analogues).

Laboratory and fieldwork activities: Terrestrial analogues of the landing sites of in-situ missions are critical to improve our ability to understand the data collected remotely by the rovers. Rosalind Franklin in particular focuses on the exploration of the layers of rock within the first two meters below the ground, which are not exposed and thus not observable from remote sensing instruments. For this reason, studying analogs on Earth is critical to build experience in interpreting the widest possible reasonable shallow subsurface scenarios we may find underneath the landing site [4]. We plan to organize fieldwork focused on studying areas on Earth with a geologic context similar to Oxia Planum on Mars. We are locating the analog field site with the support of the geologic map [5] and orbital spectroscopic observation [6,7]. During fieldwork, we will localize key outcrops where we will observe the stratigraphic context, record in situ spectra, and extract samples to be measured in the laboratory with the DAVIS copy of Ma_MISS [8].

Some examples of activities in the field are the VIS-NIR measurement campaign at Río Tinto [9], the one for the selection of the analogous sample CAP-1 [10] in southern Tuscany and others carried out for structural geological studies.

Conclusions: The delay in the ExoMars' launch can represent an opportunity to improve our knowledge of the landing site, using remote sensing data and terrestrial analogues. Moreover, the laboratory breadboard is the key element to optimize the scientific return, in terms of acquisition strategy and data analysis of the Martian unaltered subsurface.

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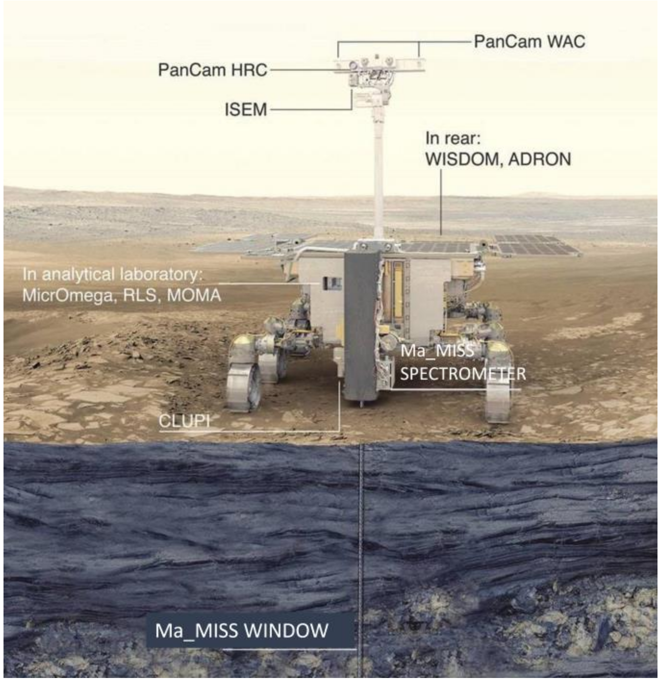

Fig.1 View of the rover payload and Ma_MISS instrument. The different parts of the instruments are located in the rod/tip (window) and on the Drill box (spectrometer and electronics). The different parts are connected with optical fibers and optical joints.