Geophysical Research Abstracts,
Vol. 11, EGU2009-11540-2, 2009
EGU General Assembly 2009

Study of the Martian Subsurface with a Fiber Optics Spectrometer: the Ma_Miss Experiment

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In this presentation is described the investigation that we intend to do with a small imaging spectrometer that will be inserted in the drill of the Exomars- Pasteur rover. This spectrometer is named Ma_miss (Mars Multispectral Imager for Subsurface Studies). The Ma_Miss experiment is located in the drill ,that will be able to make a hole in the Mars soil and rock up to 2 m. Ma_Miss includes the optical head of the spectrometer, a lamp to illuminate the borehole walls, and the optical fiber that brings the signal to the spectrometer. The multispectral images are acquired by means of a sapphire window placed on the lateral wall of the drill tool, as close as possible to the drill head. The images are gathered by means of an optical fibre system and analyzed using the spectrometer.

The Ma_Miss gathered light containing the scientific information is transferred to the array detector and electronics of the instrument by means of an optical rotary joint implemented in the roto-translation group of the drill, as shown in the next pictures In the figure is schematically represented the Ma_Miss- Dibs architecture.

This experiment will be extremely valuable since it will allow, for the first time, to have an idea of the mineralogical composition of the Martian subsurface and to study freshly cut rocks.

The study of surface and subsurface mineralogy of Martian soil and rocks is the key for understanding the chemico-physical processes that led to the formation and evolution of the Red Planet. The history of the water and other volatiles, as well as the signatures of weathering processes are important to understand present and past environmental conditions associated with the possibility of life. Surface samples are highly influenced by exogenous processes (weathering, erosion, sedimentation, impact) that alter their original properties. So, the analyses of uncontaminated samples by means of instrumented drills and in situ analytic stations are the key for unambiguous interpretation of the original environment that leading to the formation of rocks. Analysis of subsurface layers is the only approach that warranties measurements on samples close to their original composition. The upper few meters of the surface materials on Mars play a crucial role in its history, providing important constraints geologic, hydrologic, and climatic to the history of the planet. Drilling into the near-surface crust will provide an opportunity to assess variations in composition, texture, stratification, unconformities, etc. that will help define its lithology and structure, and provide important clues regarding its origin and subsequent evolution.

The subsurface material can give information on the evolution of surface sediments (erosion, transport, deposition), on the relation between sediments and bedrock, on the relation between environmental conditions and surface processes permitting to “investigate planetary processes that influence habitability.”

Investigation of mineralogical composition of near-surface geological materials is needed to fully characterize the geology of the regions that will be visited by the Rover at all appropriate spatial scales, and to interpret the processes that have formed and modified rocks and regolith.

Subsurface access, sampling material below the oxidized layer, can be the key to “assess the biological potential of the target environment (past or present)”. To date, we have direct observations relative only to the Martian surface. Little is known about the characteristics of the first subsurface layers. The possibility to sample subsurface materials to be delivered to other instruments, and to record the context of the sampled soil doing in situ borehole mineralogical analysis, is fundamental to search for traces of past or present life on Mars. The spectrometer observes a single point target, having 0.1 mm diameter, on the borehole wall surface. Depending on the surface features we are interested in, the observation window can scan the borehole’s surface by means of drill tip rotation or translation. When the drill is translated, a “Column Image” is acquired. This translation step can be equal to the observation spot (0.1 mm). The “Ring Image” can be obtained by rotation of the drill tip; a rotation step of about 0.5° (corresponding to 720 acquisitions in the ring) is sufficient to assure the full coverage of the ring.