

INTEGRATING DRILL TELEMETRY IN MA_MISS SCIENCE ONBOARD THE EXOMARS 2022 ROVER.

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Introduction The ESA-Roscosmos ExoMars program is made up by two missions: the Trace Gas Orbiter (TGO) launched in 2016, and a landed mission planned for 2022, composed by a surface platform and a rover named Rosalind Franklin [1]. Both the orbiter and landed mission will address questions related to the past or present presence of life on Mars.

The selected landing site for the ESA ExoMars 2022 mission is Oxia Planum (centered at 334.29°E, 17.28°N), at the transition between the Arabia Terra and Chryse Planitia. At the regional scale, Oxia planum show fluvio-lacustrine landforms and plateaus commonly referred as capping unit. A collaborative morpho-stratigraphic mapping effort is gathering detailed stratigraphic contacts and structures mapped at HiRISE-scale [2].

While the atmosphere and the surface have been extensively studied since the beginning of planetary exploration, the subsurface of Mars is basically still unexplored at the outcrop scale, and now represents a primary candidate environment where to look for evidence of past or present life. In fact, within the shallow underground, potential biosignatures are kept safe from degradation caused by ionizing radiation and erosional processes occurring on the planetary surface.

For this reason, ExoMars mission payload includes a multi-rod drill for collecting subsurface samples down to a depth of two meters. The extracted sample will be analyzed on-board by a suite of scientific instruments [1]. Next to the drill's tip, a sapphire window permits the collection of compositional measurements made by the Mars Multispectral Imager for Subsurface (Ma_MISS) miniaturized spectrometer integrated into the drill's shaft [3].

The drill's telemetry acquired during drilling represents a valuable complement to Ma_MISS and the ExoMars science as a whole.

Combining Ma_MISS the and drill During drilling, the drill tip advances by fracturing the rock. The resistance of being fractured is generally different from rock to rock in relation to different nature and composition. The physical properties of rock are determined by the type of the solid mineral grains, the porosity and the shape and spatial distribution of the mineral grains. All these factors together characterize also the resistance to mechanical stress of the rock.

The mechanical behavior of Martian rocks has been

inferred by the currently active NASA's Mars Science Laboratory at Gale crater, where sediments from fluvial-lacustrine environments are exposed at the surface. Strength of different rocks has been derived by surface imaging and spectroscopy [4], by relating it to the dynamic response of Curiosity wheels [5], and by the evaluation of data from the Rock Abrasion Tool [6].

By using ExoMars drill's response, we will extend these kind of observation into the underground for up to two meters, with the option of adding *in-situ* compositional measurement made by Ma_MISS directly onto the borehole wall. In fact, once the borehole has been drilled, the drill shaft acts as a driver for Ma_MISS by vertical shifts (column acquisition mode) and 360-degree rotations (ring acquisition mode), and Ma_MISS will retrieve VNIR hyperspectral information from spots on the borehole wall surface with spot measurements of 0.1 mm diameter.

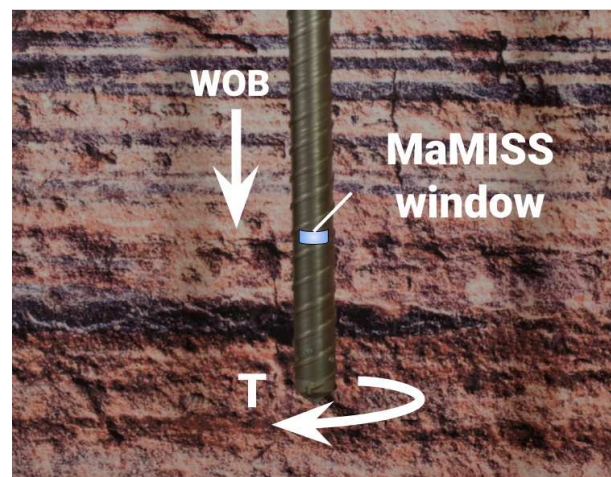


Figure 1: Cross-sectional view of drilling into a sedimentary rock by ExoMars' drill. Borehole diameter is about 1.5 cm, Ma_MISS measurements are made through the 8x4 mm sapphire window. From the telemetry parameters pool recorded by the drill, the weight on bit (WOB) and torque (T) are among the ones which are related to the mechanical properties of rock layers.

It is therefore important to keep track of telemetry carrying information on the resistance to penetration in function of depth. Figure 1 shows a schematized cross-section of a borehole made by the ExoMars drill into a

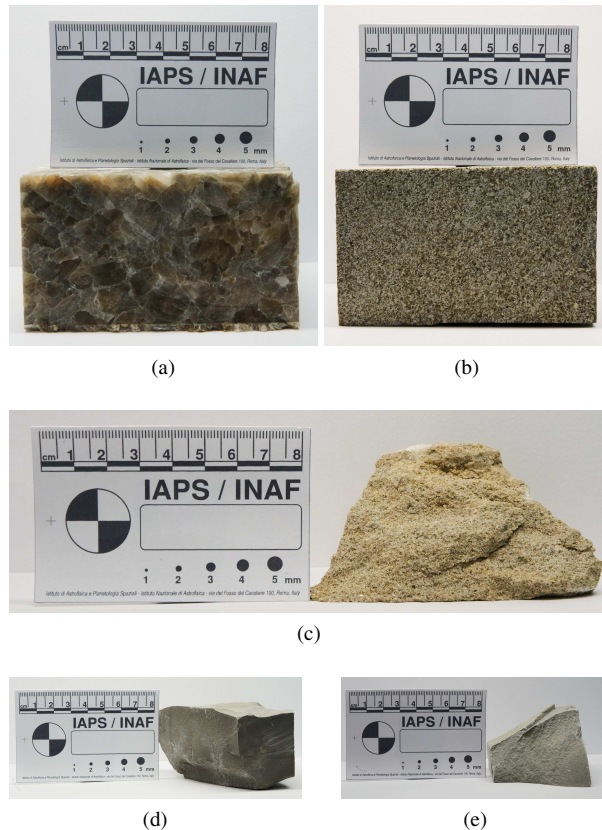


Figure 2: The rock samples drilled during tests by the ExoMars drill Engineering Model (EM); a: gypsum, b and c: sandstones, d and e: marl mudstones.

sedimentary rock sequence. Associating the composition returned by Ma_MISS and the resistance to penetration is mutually beneficial and contribute to maximize the scientific outcome of Ma_MISS and ExoMars mission as a whole.

Drill tests and future work During 2011, the ExoMars drill Engineering Model (EM) has tested drilling in various rock samples. Within these tests, the strengths of the specimen have been evaluated by uniaxial compressive strength (UCS), Knoop hardness and Cerchar Abrasivity Index(CAI), evaluating also drillability of different materials from drill telemetry[7].

Figure 2 shows the same samples being drilled and tested for their mechanical strength by [7]. We will collect spectroscopic measurement of the samples using the Ma_MISS breadboard. This way, we will link the mechanical response and the compositional information acquired with the actual ExoMars payload.

However, mechanical tests made before the ExoMars

landing site selection have inevitably been made on a generic set of rock samples to test the drill on a wide range of geologic scenarios. Now that the landing site is known and the geology is being studied at very high resolutions, EM drill tests can be designed on specific scenarios we expect at Oxia, building an inventory of possible responses we would expect during the mission.

Discussion and conclusions While the objective of the drill system is not to make scientific measurements, the drill's telemetry will complement the compositional analyses made by Ma_MISS. Drill's performance is influenced by the physical properties of the rocks being investigates. By keeping track of the change in composition and mechanical behavior with depth, we define a litho-mechanical stratigraphic sequence at the drill site corresponding to a succession of geologic processes which put in place the terrains being drilled.

Maximizing the knowledge of the geologic context under the topographic surface of Oxia planum is critical because layers and structures define environments potentially associated to the presence of past or current life on Mars, which is ExoMars main goal.

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