A NEW LABORATORY MODEL FOR MA_MISS: THE DAVIS SETUP AND ITS LABORATORY DRILL.

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Introduction: Ma_MISS (Mars Multispectral Imager for Subsurface Studies) is the miniaturized VNIR spectrometer embedded in the drill system of the ExoMars 2022 rover, set to explore the Martian subsurface [1, 2]. Ma_MISS will perform spectral reflectance measurements inside holes bored into the surface of Mars up to a depth of 2 m. It will characterize the mineralogy and stratigraphy of the borehole walls and will allow the *in-situ* study of the subsurface environment, before any samples are collected and extracted. To support its operation, a new laboratory model has been developed and named the Drill for Analogues and Visible Infrared Spectrometer (DAVIS). Its goal is to drill holes in Martian analogues and other rock samples and to perform spectrometric measurements inside them. The Laboratory Drill is one of the two instruments of the new DAVIS setup, and it is designed to reproduce the main features of the rover's drill tool.

The DAVIS instrument: DAVIS aims at simulating Ma_MISS operation in the lab. The setup is made up of two independent instruments: the Laboratory Drill (DAVIS-LD, shown in Figure 1), and the Ma_MISS Optical Tool (DAVIS-MOT, further described in [3]). DAVIS-LD is a manually actuated drill system used to bore holes through rock samples, to be later analyzed with DAVIS-MOT. The drill tool, whose cutting head is shown in Figure 2, is a replica of the flight model one. With respect to the flight model drill bit, the LD one is however missing the coring system and the Ma_MISS optical head. The drill is driven by the same electric motor unit used on the flight model, controlled by a commercial EC motor controller unit. The controller regulates the motor current to keep its rotational speed at the desired value. It is programmed to run the drill tool at the nominal speed of 50 rpm. The vertical motion of the drill tool is manually actuated by means of a lever system.

Figure 1: DAVIS Laboratory Drill

Figure 2: Close-up of the drill bit

Figure 3: Drilling a rock sample

Operation: After placing the rock sample on the baseplate of DAVIS-LD and fastening it with the dedicated sample holding clamps, the drilling operation can begin. The drill motor is turned on with a switch on the control panel of the unit. The drill tool can then be lowered onto the sample. Usually, the drilling operation is carried out until the drill tool has bored a pass-through hole into the rock sample. Figure 3 shows the drill tool while drilling a rock sample. Once drilled, the sample can be taken out of the LD and measured with the MOT, which includes a replica of the optical system of Ma_MISS. To test the functionality of the new laboratory model, a first rock sample (*Tufo Lionato,* a tuff from the Colli Albani Volcanic District in Italy) from our catalogue of analog samples [4] was drilled with the

LD (Figure 4). This drilled specimen was then measured with the MOT, as described in [3].

Figure 4: Rock sample drilled with DAVIS-LD

Drill telemetry recording: While drilling, the motor control unit of DAVIS-LD can provide some useful data such as rotational speed and current drawn by the motor. As an example, the plot in Figure 5 displays the rotational speed and the current drawn by the motor as recorded during the start of the drill operation, when, with the drill tool lifted up, the unit is turned on and it ramps up to the nominal speed. The current drawn by the motor can be correlated to the torque applied. These quantities (together with other parameters) provide valuable information on the mechanical properties of the rock being drilled. The capability to provide this kind of data could make the LD a useful tool also in aiding the development of interpretation techniques to combine the knowledge of the mechanical behavior of the material being drilled with the spectrometric measurements provided by Ma_MISS. The rover's drill system will indeed provide a wealth of telemetry data from which a mechanical characterization of the Martian soil can be inferred. This data can complement Ma_MISS optical observations and help outline an accurate stratigraphy of the Martian subsurface [5].

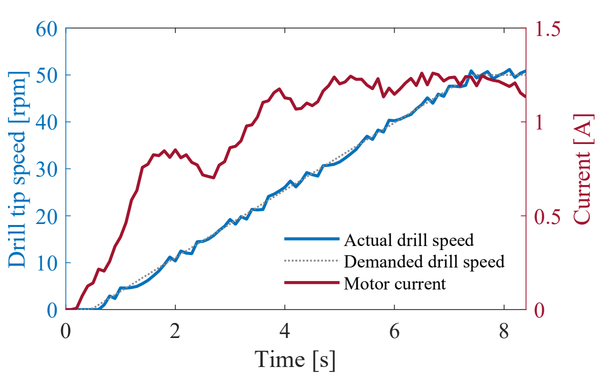

Figure 5: Drill tip rotational speed and current drawn by the motor during a turn-on transient (with no load).

Conclusions and future work: The new DAVIS laboratory model is a valuable asset for the scientific operation of the Ma_MISS experiment. It provides the means to test and operate Ma_MISS optical system inside an actual borehole, drilled in Martian analogues with a replica of the drill tool. The DAVIS Laboratory Drill is instrumental in reproducing holes that are representative of the actual boreholes the rover will drill on the Martian surface.
The DAVIS setup will be used to experiment Ma_MISS operation on various samples, performing hyperspectral imaging of the boreholes, and reconstructing their stratigraphy and mineralogy. These activities will enable the Ma_MISS team to benchmark the system's performance and to develop, test, and optimize observation strategies to be used at Mars during the ExoMars 2022 mission.

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