The DAVIS Instrument: a New Laboratory Model for ExoMars 2022 Ma_MISS Spectrometer.

S. De Angelis[1], M. Ferrari[1], M.C. De Sanctis[1], F. Altieri[1], E. Ammannito[2], A. Frigeri[1], E. La Francesca[1], L. Rossi[1], N. Costa[1], M. Formisano[1], S. Fonte[1], S. Novi[3*], F. Antonacci[3], C. Pompei[3], F. Ruggiero[3], F. Villa[3], M. Giardino[2], R. Mugnuolo[2], S. Pirrotta[2], and the Ma_MISS team. [1]Institute for Space Astrophysics and Planetology, IAPS-INAF, Rome, Italy (simone.deangelis@inaf.it); [2]Italian Space Agency, ASI, Rome, Italy; [3]Leonardo Company, Campi Bisenzio (FI), Italy; [3*] formerly at Leonardo Company.

Introduction: The main goal of the DAVIS facility is to support in the laboratory Ma_MISS spectrometer operations and scientific activities during the operative phase of ExoMars 2022 rover mission. Ma_MISS miniaturized spectrometer, integrated within the ExoMars rover Drill system, will explore the subsurface of Mars in the Visible-Near Infrared range 0.5-2.3 μm. This new laboratory model is constituted by two separate instruments, a manual drill which reproduces the ExoMars Drill functionality (Laboratory Drill, LD), and a measurement tool, reproducing Ma_MISS optical characteristics (Ma_MISS Optical Tool, MOT). LD setup will be used to reproduce boreholes in Martian analogues; MOT will be used to perform Visible and Near-Infrared spectroscopic measurements, with a geometry similar to the real Martian case and with an instrument with optical capabilities identical to Ma_MISS.

The instrument:

DAVIS (Drill for Analogues and Visible-Infrared Spectrometer) is the new laboratory model of Ma_MISS (Mars Multispectral Imager for Subsurface Studies) spectrometer [1,2] onboard ExoMars2022 mission [3]. This laboratory facility is constituted by a Drilling tool [4] and by a measurement tool.

The measurement tool (fig.1) (MOT) consists of a 75 cm long rod that exactly reproduces the ExoMars combined Ma_MISS illumination system + Drilling system in terms of size and geometry, although without drilling capabilities. MOT reproduces instead the optical capabilities of Ma_MISS FM instrument for what concerns the light source, illumination system, Optical Head, Sapphire Window and signal fiber [1,2].

It is constituted by a vertical rod with diameter 25.4 mm equal to the Drill diameter [4]. This vertical rod is manually activated through a knob (fig.1A) allowing to pass through the borehole of a drilled rock sample. The 5W VNIR light source is integrated near the top of the rod; a 25 cm long fiber optics bundle conveys the light through the rod from the lamp to the Optical Head (Illumination Channel), where it is focalized through the Sapphire Window outside the rod at the nominal focus distance of about 0.6 mm. The light spot on the sample is about 1 mm, as for Ma_MISS FM. The signal reflected by the external target is then recollected by the same Optical Head (Signal Channel) and then an internal optical fiber passes the light back through the rod. The output fiber (core diameter 120 μm, spatial sampling) is connected through a mini-Avim connector (fig.1B) to the input fiber of Avantes VIS-NIR spectrometer. A beamsplitter permits the light signal to be acquired by the two separate VIS and NIR Avantes detectors with an FC/PC optical fiber connector as interface. The reference target (LabSphere Spectralon 99%) is mounted on a 3-axis translation stage that is placed in front of the Sapphire Window (fig.1C).

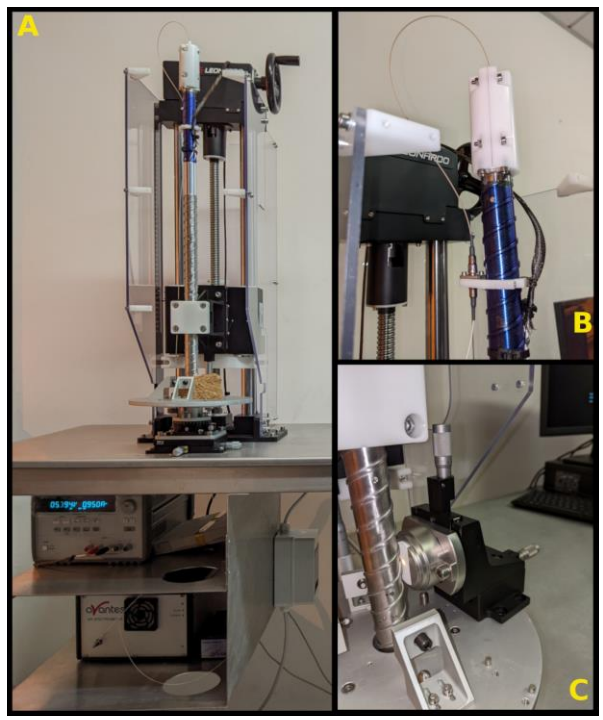

Fig.1: *DAVIS measurement setup. A: MOT -measurement setup, with the lamp power supply and Avantes spectrometer visible in the lower part. B: exit optical fiber connected through mini-Avim connector to spectrometer input fiber. C: translation stage for reference target and sampleholder.*

Preliminary Measurements:

In fig.2 pictures of a first drilled sample are shown: a Lionato Tuff from Colli Albani Volcanic District (Italy) has been perforated and successively analyzed with the measurement tool. In fig.2A the drilled sample is shown, with clearly visible the 26-mm diameter borehole representative of the ExoMars case. In fig.2B

MOT entering the borehole is shown: the light exiting the Sapphire Window and illuminating the sample is also visible. Several acquisitions have been taken with the Avantes spectrometers inside the borehole at different depths and locations, using the LabSphere spectralon as reference target; here an average reflectance VIS-NIR spectrum is displayed (fig.3). The spectrum is characterized by the presence of absorption features due to H_2O (1.4 and 1.9 μm) in the sample, and by the band near 1 μm due to some iron-rich phase.

Fig.2. A: an image of the drilled sample (Lionato Tuff), where the excavated borehole is clearly visible. B: the Tip illuminating inside the sample borehole. The light cone exiting the Sapphire Window is visible.

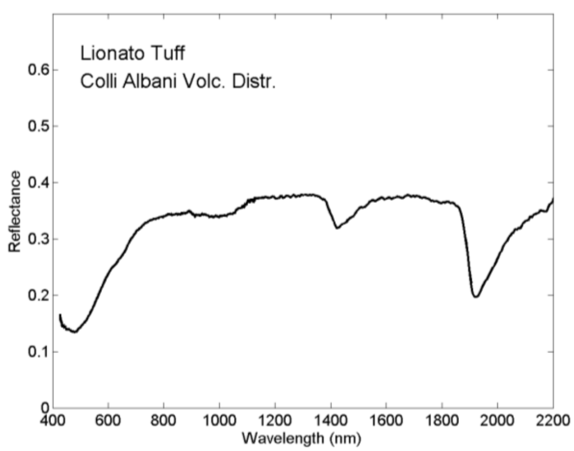

Fig.3. The VIS-NIR spectrum acquired with the measurement tool coupled with Avantes spectrometer, on a Lionato Tuff rock sample. The spectrum is the average of about 6 acquisitions taken at different points in the borehole.

Conclusions:
This instrument will allow to perform VIS-NIR spectroscopic measurements in rock samples excavated with the Drill tool [4]. It will be possible to reproduce rings, columns, and imaging acquisitions of the borehole, thus simulating in the laboratory with known (or also unknown) samples the performances and the scientific operations of ExoMars-Ma_MISS FM spectrometer; it will be possible to reconstruct the borehole stratigraphy and mineralogy in association with hyperspectral imaging of laboratory samples, thus also helping in the definition of observations strategies.

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References: [1] De Sanctis M.C. et al. (2017): Astrobiology, Astrobiology 17(6-7):612-620. [2] De Sanctis M.C. et al. (2021): Astrobiology, subm. [3] Vago J.L. et al. (2017): Astrobiology, 17, 6, 7. [4] Rossi L. et al. (2021): this issue