Spectral characterization of H2020/PTAL mineral samples: Implications for in situ martian exploration and Mars sample selection

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The **PTAL** project *[1]* aims at building and exploiting a **database** *[2]*, the ***Planetary Terrestrial Analogues Library,*** in order to characterize the mineralogical evolution of terrestrial planets and small Solar System bodies. We started the study with Mars.

Natural Earth rocks (~100) have been collected on selected locations around the world to get the best analogues for martian geology. Each sample will be studied with several techniques to allow a broad spectral characterization. Samples undergoing different alteration experiments are also studied to test the influence of the atmospheric composition on the alteration process during the early period of Mars.

The objectives of the spectral characterization of the PTAL samples are:

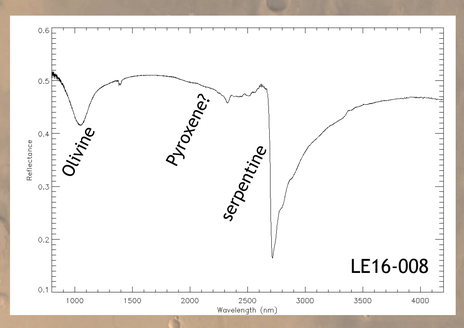
- To acquire optical and **XRD** measurements of the samples (UiO/Oslo),
- To acquire **LIBS** spectra of the characterized samples (IRAP/Toulouse),
- To acquire **NIR** spectra of the characterized samples (IAS/Orsay),
- To acquire **Raman** spectra of the characterized samples (UVA/Valladolid).

These techniques are similar to the instruments on board of current and forthcoming martian missions. Such combined analysis will give the opportunity to prepare and understand ExoMars/ESA and Mars2020/NASA *[3]* observations.

NIR spectra

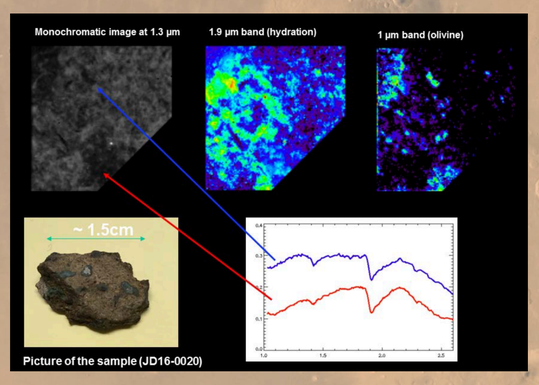
We have two types of instruments for characterizing the mineralogical assemblage of any sample:

- A laboratory Perkin Elmer **point spectrometer** with a FOV of 500 µm and a wavelength range of 0.9-4.1 µm. For homogeneous sample (powder) the spectral information provided by this setup will be sufficient to characterize it.



Point NIR spectrum of LE16-008.

- Flight Spare (FS) of **MicrOmega** *[4]* with a FOV of 3.2 mm², IFOV of 25 µm, and a wavelength range of 1-3.5 µm. MicrOmega will be very useful when the sample to be analyzed will be heterogeneous (e.g. bulk samples).



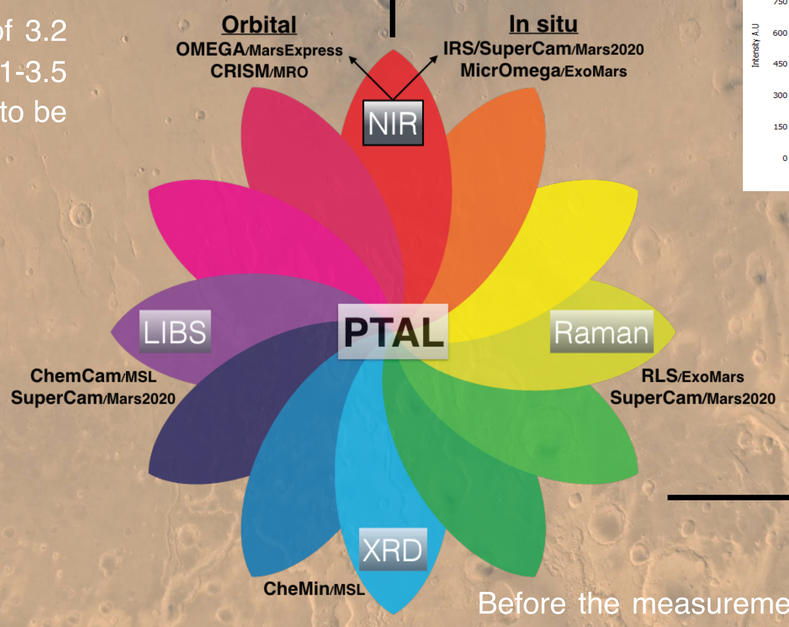
Example of measurement with MicrOmega on sample JD16-020.

NIR multi scale analysis

Thanks to these NIR instruments working at different scales, we will be able to highlight the link between microscopic and macroscopic measurements of martian analogue samples combining identification and quantification. This will help coordinated analyses of the martian surface from both orbital and landed platforms (the technique is part of both payloads).

LIBS spectra

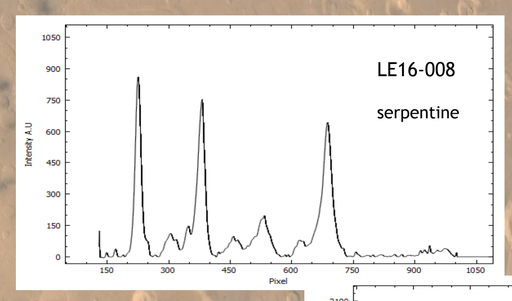
The setup was implemented several years ago in the framework of the Curiosity mission. The powder samples are placed under 70°C for 1 night (when pumping to get vacuum, powders are used to degas and "explode", so heating them helps a lot to avoid this degassing). 3 to 5 observation points are performed per sample and each observation point is 30 laser shots, which corresponds to 30 spectra



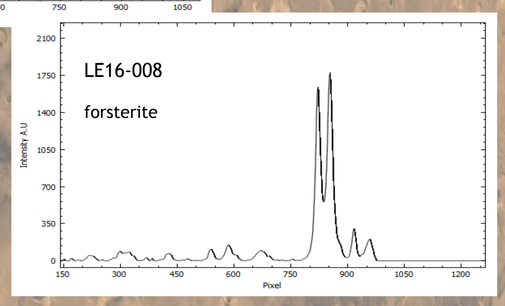
Raman spectra

The following Raman systems are used in a complementary way:

- **Micro Raman 633 nm**: The instrument is composed by a He-Ne excitation laser and a HoloLab 5000 (Kaiser Optical Systems) spectrometer. For micro Raman it is coupled to a Nikon microscope (objectives of X50 and X100 producing a laser spot on the samples of 10 and 5 µm in diameter).
- **RLS simulator 533 nm**: System provided with a neodymium-doped (1%) yttriumaluminum garnet ceramic (Nd:YAG) excitation source and a transmission-volume-phase holographic grating (1800 lines/mm).

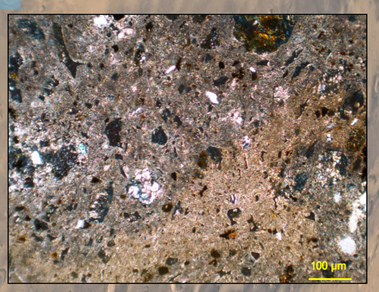


Raman spectra (laser 633 nm) of LE16-008. Signatures of forsterite (bottom right) and serpentine (top left).

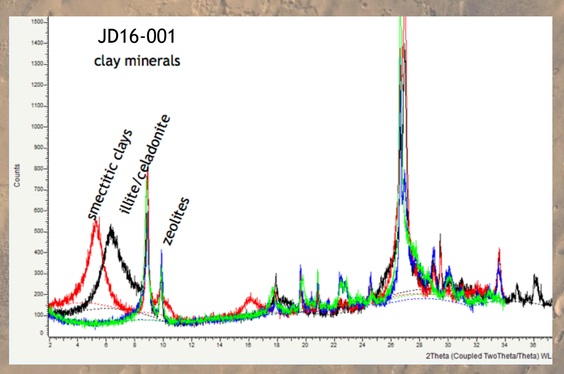


XRD measurements

Before the measurement, an **optical analysis** is performed. This additional step provides support for mineral identification. Thin sections are cut and polished to a thickness of about 30 µm and about 2 to 3 cm size.



An example of thin section image (sample JD16-001).



The **XRD** analyses are executed on crushed, randomly oriented samples. They are performed on a Bruker D8 Advance instrument using CuKα radiation (40 kV, 40 mA, and wavelength of 1.5418 Å)

An example of XRD analysis (same sample JD16-001).

COORDINATED ANALYSIS

The analysis of all the samples is still ongoing. However we have started the very exciting step of coordinated analysis including compositional comparison. This is a new scientific field not yet explored at such a large and systematic scale.

We present here an example of such combined analysis for experimental samples and a terrestrial analogue:

Results for three experimental samples 3 weeks at 120°C with 100% N_2 / 10% CO_2 + 90% N_2 / 100% CO_2					
	Clays		Amorphous glass	Carbonates	Zeolites
	Di-	Tri-			
XRD	-/+/+	+/+/+	+/+/+	-/+/+	+/-/-
NIR	-/+/+	+/+/+	-/-/-	-/+/+	-/-/-
Raman	-/-/-	-/-/-	+/+/+	-/+/+	-/-/-
LIBS	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-

Results for analogue LE16-008		
XRD	**Raman**	**NIR**
forsterite	forsterite	Olivine
augite		Pyroxene?
amphibole		
plagioclase		
serpentine	serpentine	Serpentine
hematite		
pyrite		

References: *[1] Werner et al. 2018, this issue. [2] Veneranda et al. 2018, this issue. [3] Wiens et al. 2016, LPSC, No. 1903, 1322. [4] Bibring et al. 2017, Space Science Reviews 208.*

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