

Raman spectroscopy for the 2018 ExoMars mission

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Abstract

We present here the current state of the Raman laser spectrometer (RLS) under development for Exomars rover mission to Mars to be launch in 2018. The paper includes the instrument description, the particular operation mode on powdered samples and the main performances to be expected from this analysis inside the operation cycle of the rover on the red planet.

1. Introduction

The ESA-led 2018 ExoMars mission is now defined as a joint mission with the Russian Space Agency (Roskosmos) and will place on the Mars surface a rover able to perform scientific analysis on samples from the surface and subsurface up to 2 m depth using a dedicated drill. The main objectives of this mission are: to search for signs of past and present life on Mars; to characterize the water/geochemical environment as a function of depth in the shallow subsurface; to study the surface environment and identify hazards to future human missions; to investigate the planet's subsurface to better understand the evolution and habitability of Mars. The RLS instrument is part of the scientific payload inside the analytical laboratory of the rover addressing an important part of these scientific objectives. The operation mode of the Raman instrument will consist in the analysis at the mineral grain scale of powdered samples collected by the drill and crushed and delivered to the instrument's optical head by a dosing station.

2. Instrument definition

The RLS simplified block diagram is depicted in figure 1.

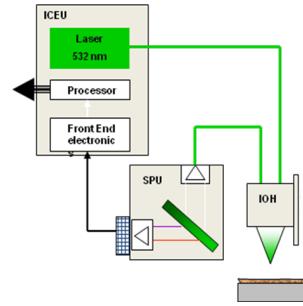


Figure 1. RSL block diagram

The instrument consists in three main units which are accommodated inside the analytical laboratory drawer (ALD) of the rover in a configuration that is presented in Figure 2.

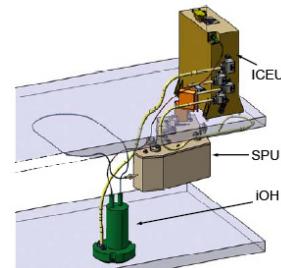


Figure 2. RLS accommodation inside the ExoMars rover's ALD

- Spectrometer Unit. The dispersion of Raman light is obtained by transmission using a holographic grating. The Raman spectral range covered is ~ 150 - 3800 cm $^{-1}$ with a spectral resolution of ~ 6 cm $^{-1}$. The Raman spectrum is registered on a 2048x512 pixel CCD. This CCD requires operating at cold temperature maintained by means of a TEC cooling device.

- Control and Excitation Unit. It includes the DC/DC power converters and the data processing capability (μ controller, RAM, clock and CANBus). Its role is also to capture the RLS health parameters and to run the thermal management. To support other functionalities of the instrument, it comprises the

laser with two redundant excitation outputs, the CCD FEE electronics, and the autofocus driver. The excitation laser is also included in this unit. The selected wavelength is 532nm and the irradiance on sample could range between 0.8 and 1.2 kW/cm².

- Optical head. This unit is connected by optical fibers with the excitation laser and the spectrometer respectively. Mini-connectors are used to connect the fibers. The range of focus is ± 1 mm simultaneously for the excitation and the collection. This optics produces a spot on the sample with a diameter of around 50 μ m. The signal collection is based on a simple aspheric collimator. This unit also contains an interferential filter in the excitation path to filter any unwanted emission but the 532nm light and a notch filter in the collection path which suppress exactly this wavelength allowing only the Raman light to enter in the spectrometer.

3. Operation mode

The operation mode consists on the micro Raman analysis of powdered samples placed in a special container inside the ALD by a dosing device. The sample will move under the Raman optical head and the line reachable with the spot diameter of 50 μ m will be the observable target. A series of points will be automatically selected and analyzed. Also it will be possible to reach particular spots previously identified as of great potential interest by the IR spectrometer, provide these are in the observable line. The operation mode is of high interest in connection with the science the instrument can provide and a specific simulator has been developed in our laboratory to analyze powdered samples with the same size distribution grain than the one obtained by the rover's crusher. The simulator operates in totally automatic mode and algorithms developed for data treatment and data analysis allow the automatic identification of the materials using specific and wide databases.

In Figure 3 and 4 some spectra obtained in different natural and synthetic samples are presented. The Raman instrument can provide definite identification of many mineral phases at the micro scale and also can identify vibrational bands from organics. The limit of detection on the basis of the observed line is about 1% of the bulk sample for many complex samples.

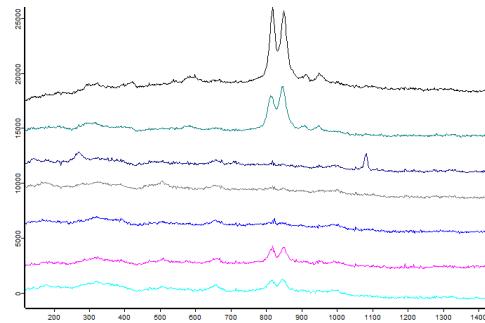


Figure 3. Raman spectra from a powdered sample of basalt from Svalbard Islands (AMASE 2008)

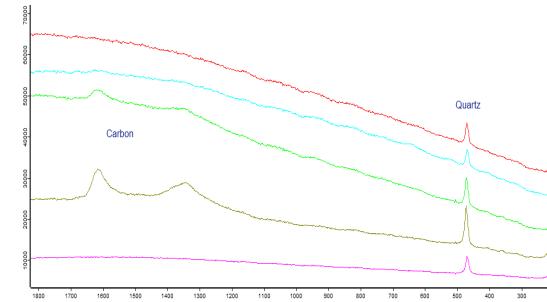


Figure 3. Raman spectra from a powdered sample of chert from Barberton (South Africa)

6. Summary and Conclusions

The Raman spectrometer is a powerful tool for mineral identification at the grain scale and also for identification of many organic compounds and in consequence could play an essential role in the scientific operation cycle inside the Exomars mission.

RLS science team: The development of the RLS instrument is under responsibility of a wide international team. The consortium is led by the science team, in Spain: F. Rull (PI) and J. M. Frias; in France: S. Maurice (deputy-PI) and L. d'Uston; in Germany: E. Jessberger and J. Popp; in United Kingdom: I. Hutchinson and H. Edwards, and with the collaboration in the United States of S. Sharma and A. Wang.

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