RLS SCIENTIFIC OPERATION ALGORITHMS FOR ADAPTIVE ANALYSIS OF THE MARTIAN SAMPLES ON EXOMARS

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Abstract

The RLS instrument will operate on Mars with two different modes of operation: automated and collaborative. In automated mode, between 20 and 39 points will be analyzed in equidistant positions along the surface of the sample. In cooperative mode, RLS can be directed to analyze areas of the sample that were previously identified as interesting by MicrOmega, the infrared spectrometer inside the ALD. In either case, the RLS instrument will be equipped with a set of algorithmic tools to automatically optimize the acquisition parameters, considering both the onboard available time and resources. This will provide a self-regulated and unsupervised method for the acquisition of spectra, dealing with fluorescence and cosmic rays, and automatically calculating the optimal integration time (ti) at each sample spot.

1. Introduction

The ExoMars 2020 rover mission will carry a drill able to obtain samples up to 2 meters depth under the Martian surface. It also features a suite of instruments (Pasteur Payload) inside the Rover's Analytical Laboratory Drawer (ALD) dedicated to exobiology and geochemistry research at the mineral grain scale after these samples have been crushed and powdered, then served to the instruments of the ALD (RLS, MicrOmega and MOMA) in a refillable container with a rotating carrousel, that will position the same sample surface below the different instruments of the ALD. This will allow, for the first time in a planetary mission, to have a sample analyzed by several instruments on the very same spot of the sample.

The RLS Raman spectrometer is one of these key instruments [2]. The main ExoMars 2020 mission scientific objective is "Searching for evidence of past and present life on Mars". The RLS will contribute to this scientific goal through the precise identification of the mineral phases and the capability to detect organics on the powdered samples.

2. Automated vs cooperative operation

The analysis performed by RLS can be done in either one of two modes of operation: automated or cooperative. In automated mode, the RLS will analyze a number of equidistant spots on the surface sample ranging between 20 and 39 (if after the 20 spots there is still available resources, the carrousel will move back analyzing the areas between already-analyzed spots). In cooperative mode, RLS will analyze areas of the sample previously marked as interesting by the MicrOmega analysis, allowing some kind of directed measurement of determined regions of interest (ROIs) on the sample surface. Both modes can be commanded in the activity plan.

The cooperative operation mode has been tested with MicrOmega EQM and the RLS ExoMars Simulator [3]. In this test, MicrOmega detected ROIs on a flat surface of sample, later directing the RLS instrument to those areas (Fig. 1). In addition to the cooperative analysis, the RLS was also commanded to analyze the samples in automated mode, for comparison. The results of both cooperative and automated acquisition are shown in Fig. 2.

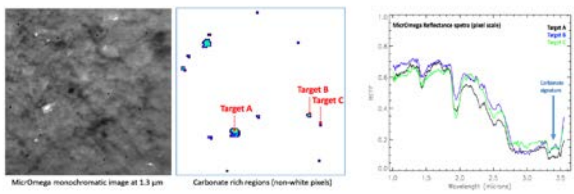

***Figure 1.** MicrOmega analysis results and identification of the regions of interest for RLS analysis*

The resulting analysis demonstrated that the RLS instrument efficiently identified the mineral phases present in the ROIs defined by MicrOmega, being able to confirm and detail the results of the MicrOmega analysis with relatively low resources, thanks to the directed positioning of the sample.

However, interestingly, the RLS automated execution was also able to detect the same mineral phases as detected by the MicrOmega ROIs, but also detected some mineral phases that were not present in the original analysis (see Fig. 2). This is coherent with previous results obtained with the RLS ExoMars Simulator [3] and means that the optimal science return is obtained with RLS operating in both operation modes. Happily, this is foreseen by the implementation and the activity plan will be able to perform this kind of mixed operation modes.

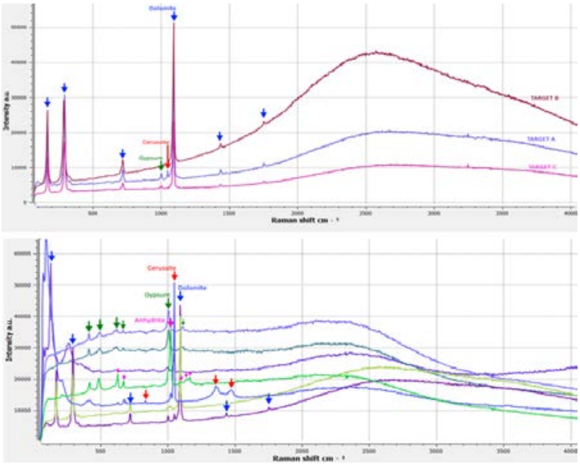

Figure 2. RLS results from the cooperative (top) and automated (bottom) analysis.

3. RLS adaptive analysis

Irrespective of the operation mode commanded on the sol activity plan, the RLS instrument RLS is equipped with a set of algorithmic tools to automatically optimize the acquisition parameters, considering both the onboard available time and resources. This provides a self-regulated and unsupervised method for the acquisition of spectra, automatically calculating the optimal integration time (ti) at each sample spot [4]. The adaptation to the sample under analysis allows saving operation time that can be used to analyze more spots.

This ability to adapt to the sample allows saving operation time that can be used to analyze more spots (therefore the number of spots will range between a minimum of 20 to a maximum of 39). The general algorithm flowchart calculates the following parameters sequentially, on a non-saturated short-time reference spectrum acquired by RLS:

- Fluorescence detection and quenching. Given that the fluorescence background decreases when excited by the laser, RLS will monitor the decrease rate of the background to decide the quenching time in “real time”.
- Detection and removal of cosmic rays: in order to not impair the optimization of the acquisition parameters, RLS implements an algorithm for the detection and removal of cosmic rays or spikes, also adjusting the algorithm parameters as a function of the noise of the spectrum under analysis.
- Calculation of final acquisition parameters. The main acquisition parameters on a Raman analysis are the integration time (ti) and number of accumulations (na). As shown in Fig. 3, for a fixed total acquisition time (ti*na) with low thermal noise CCDs, the higher the integration time, the better spectral SNR is obtained. Thus, RLS will optimize ti for each spot. The number of accumulations is fixed from ground command (no automatic adjustment of na is implemented on RLS).
- Then, the final spectrum with the calculated parameters will be acquired by RLS.

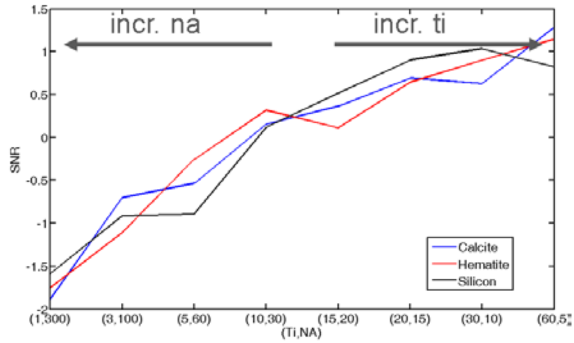

Figure 3. RLS results from the cooperative (top) and automated (bottom) analysis.

4. Conclusions

RLS will optimize the acquisition parameters, adapting them to the sample spot, increasing the quality of the acquired spectra while saving operational time that will be used to analyze further spots on the sample. On the other hand, the cooperative science between the instruments of the ALD is critical in combination with the RLS instrument automated acquisition to optimize the science characterization of the Martian samples

5. References

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6. Acknowledgements

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