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Analysis of Arctic Carbonates Profiles by Raman Spectroscopy using Exomars Raman Laser Spectrometer

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Abstract

This work details the analysis performed by Raman spectroscopy on carbonate samples from the Svalbard Islands (Norway) in the Arctic. This place is considered a potential Martian analog because the carbonate formation show close similarities with the formation in ALH84001 meteorite. The results obtained illustrate the performances of the Raman instrument included in the Exomars (ESA) mission.

1. Introduction

Raman Laser Spectrometer (RLS) is included in Exomars' payload for the mission to Mars to be launched in 2018[1]. This instrument will analyze samples drilled from until 2 meters deep and crushed as powder. One important topic for the development of this instrument is to evaluate the performance of procedures of analysis, how much science is possible to do and the accuracy, the significance of the results etc. To do this, the RLS science team has developed several field tests in Mars analogs to achieve these skills. In particular, Svalbard islands, is a very special Mars analog place with several scenarios with different geologies. Specially, the Bockfjord Volcanic Complex (BVC), is a unique place on Earth with carbonate deposits similar to carbonates in the Martian meteorite ALH84001. AMASE (Arctic Mars Analog Svalbard Expedition) worked from 1997 in the study of this scenario and performing activities related with the develop of science and engineering for the search of life on Mars[2].

2. Samples

During 2011 campaign, several breccias samples were collected. Samples from this localization, BVC, should be formed eruptions ca. 1 Ma ago behind the permafrost as subglacial eruptions. That activity brings to surface rich magnesium-carbonates fluids that formed those deposits and carbonate globules.

Figure 1: Breccia

The samples were divided in two portions. One for bulk analysis with complementary techniques, mainly XRD and the other crushed by a breadboard of the Exomars' crusher provided by Kayser-Threde. Both samples were analyzed and the results were compared.

3. Instrumentation

The Raman spectrometer used was a B&WTEC Inc. Compass illuminated with a 532nm wavelength laser (Prototype II for ExoMars developed by Monocrom) with about 50mW power on the sample and a spot diameter of 100micron. The Raman probehead coupled over the sample with step-to-step motion system to step of 3 degrees of freedom with the capability of resolution of microns. This system allows simulating so much the motion of the sample in the Exomars rover's sample carrousel and also the possibility of autofocus.

4. Analysis and Results

The sample to be analyzed was cut as it is show in Figure 2. With the system, an automatic analysis was performed and 130 points were taken with 100 micron steps, from the basalt to the carbonate crust. The spot size was 50 microns.

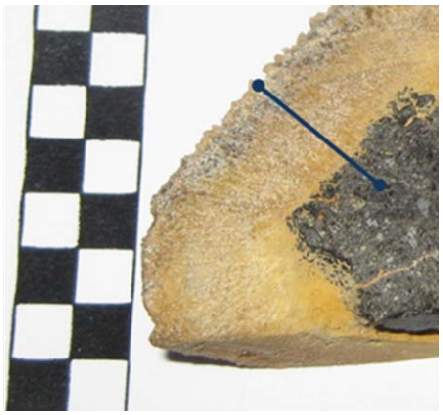

Figure 2: Analysis path on the cut sample

The principal mineral types found were dolomite, and aragonite. Also were found on the basalt, olivines and pyroxenes. Along the path also was found goethite that gave the orange color to the carbonate crust. We can do a coarse distribution of the mineral in the next graph:

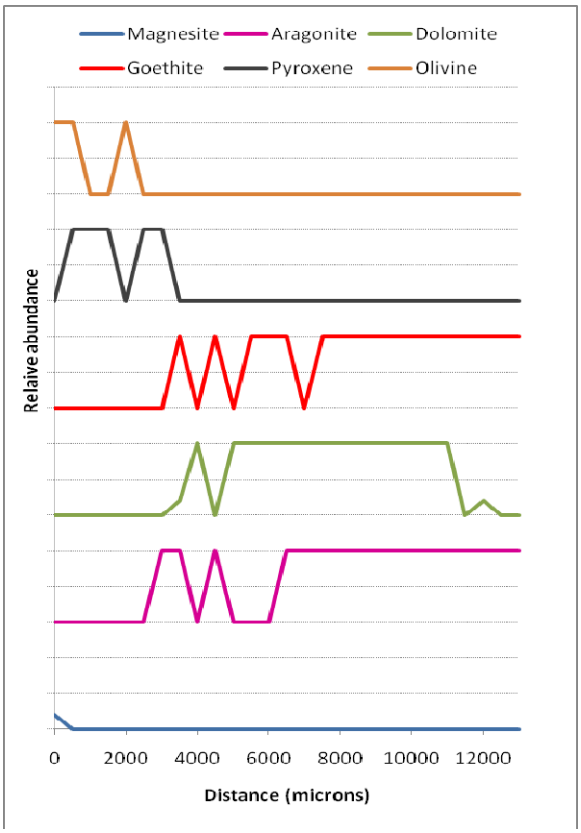

Figure 3: Relative abundance of mineral species

On the other hand, when the powder analysis was performed we found this entire species and some more like ankerite but the spatial distribution of these species was lost.

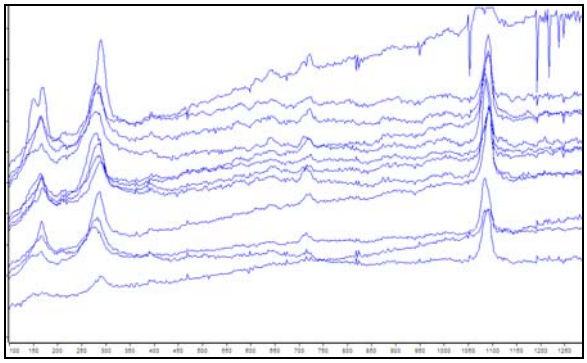

Figure 4: Stack of Raman Spectra of the powered sample.

6. Summary and Conclusions

Both methods were tested on the same samples yielding interesting results. It is clear that the method over the bulk sample give us more info about the spatial distribution of the minerals. In the other hand, the powered sample could give us more information about the relative abundance of the minerals in the sample. Also, the random distribution of the grains allows finding minor species those couldn't be find on the bulk sample.

The development of a chemometric methodology applied to these measures to extrapolate them to a better understanding of the composition of the samples is necessary and it is one of next objectives to deal with.

Acknowledgements

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References

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[2] Blake D. et al. (1999) LPS XXX, Abstract #1683.