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Effect of grain size distribution on Raman analyses: consequences for ExoMars-C measurements

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Abstract

Most of the ExoMars-C instruments will make analyses on powdered drill samples. Apart from loss of context textural information, the crushing process also leads to changes in the physical properties of materials. These modifications could limit correct interpretation of the data. Here, we study the effect of the grain size distribution on the Raman spectrum of three minerals, silicon, quartz and graphite, and one basalt rock sample.

1. Introduction

ExoMars-C will search for ancient traces of life on Mars in 2018. The analyses carried out by ExoMars-C will be made on crushed drill cores. The homogenous powder thus obtained will be transported by carrousel to the different instruments. The crushing process causes loss of structural context, e.g. stratification in the rocks and could lead to modification of the physical properties of the studied material. These changes could result in misinterpretation of the data.

We are investigating the influence of granulometry on the Raman spectrum of three minerals and one rock. The aim is to determine if the crushing process will influence correct identification of minerals and, thus, of possible traces of life.

2. Chosen materials

Three minerals were chosen: silicon, quartz and graphite, and one basalt rock. The materials were crushed and sifted in order to obtain powders with various grain size (see Figure 1).

Silicon was chosen as a model because of its simple Raman spectrum (only one peak at 520.6 cm^{-1}). Potential microfossils dating back to the Noachien on

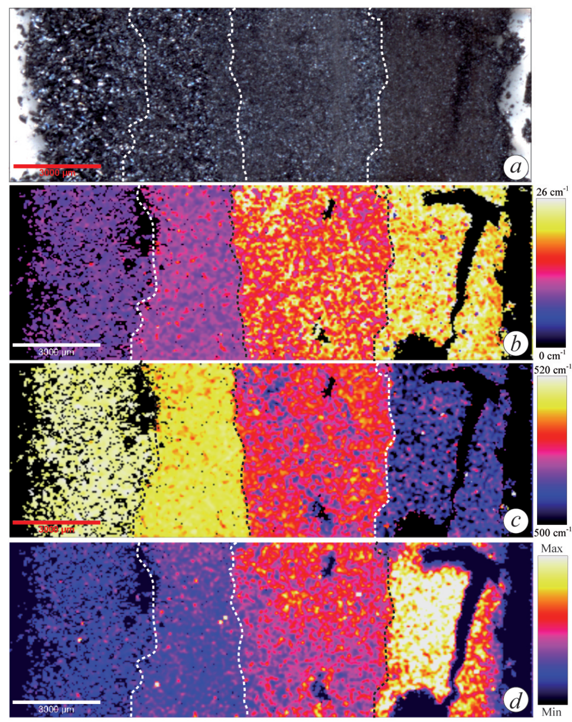

Figure 1: a- optical image of the silicon powder of 4 different size of grains, decreasing size from left to right. b and c- Raman maps showing the position and the full width at half maximum of the main silicon peak respectively. d- Raman map of fluorescence.

Mars (-4.5 to -3.5 Ga) may have been silicified by hydrothermal fluids and could thus be very similar to the oldest traces of life found on Earth in cherts from Australia and South Africa (3.5 Ga old) [1, 2]. Quartz was chosen because it is the main constituent of chert. Graphite was used since the spectrum of disordered graphite can mimic that of kerogen associated with ancient microbial remains [3]. Finally, basalt was chosen as a reference rock since it is the most common rock on Mars [4]. Moreover, this basalt from Etna volcano can be considered as a good geochemical analogue of basalt analysed by Spirit in the Gusev crater on Mars [5, 6].

The analyses on graphite and basalt are in progress and the results will be presented.

3. Results

Fluorescence increases and the spectra are modified with a decrease in grain size. In particular new peaks appear in the silicon spectrum, implying a change in microstructure, and the main peak is shifted and broadened, as shown in Figure 1. Since mineral identification using Raman spectroscopy is made by comparison with databases, this kind of change could lead to misinterpretation of the spectra. On the contrary the quartz spectrum is not significantly modified. However, the fluorescence induced by the crushing dramatically decreases the signal/noise ratio.

4. Summary and Conclusions

We have demonstrated that the crushing process used during the ExoMars mission before analyzing the samples will induce several changes in the Raman measurement. This method leads to an increase in fluorescence, a shift of the peaks and can even induces changes in the crystallinity. These alterations will have to be taken into account when interpreting the in situ measurements.

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