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Raman Spectroscopic Measurements of Martian Analogue Material with Different Moisture Contents

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Abstract

Two Martian soil analogues, JSC Mars 1 and bentonite, have been tested in view of the influence of moisture on their Raman spectra. Bentonite, a clay with a high abundance of montmorillonite, was detected on Mars by the OMEGA spectrometer of Mars Express [1]. JSC-Mars 1 is a volcanic ash with a similar chemical composition like Martian soil [2]. Both materials show fluorescence in the Raman spectra when excited at a wavelength of 532 nm. It is shown that moist soil can be distinguished from dry soil by comparing the relative bahaviour of the intensity in the spectral range 2500 – 3500 cm^{-1} with the relative bahaviour of the intensity in the spectral range 100 – 2500 cm^{-1}. The relative Raman intensity around 2500 – 3500 cm^{-1} increases with increasing soil moisture. This effect is more pronounced for bentonite than for JSC Mars 1.

1. Introduction

The moisture content of soils significantly influences their chemical, physical and biological properties. The influence of the moisture content on the Raman spectra is of particular interest, because a Raman spectrometer will be part of the scientific payload on the ExoMars-Rover. This Raman spectrometer will provide geological and mineralogical information complementary to that obtained by MicrOmega-IR.

Two Martian soils, bentonite and JSC Mars 1 have been investigated with respect to the influence of moisture on their Raman spectra. Bentonite, a clay with a high abundance of montmorillonite, was detected on Mars by the OMEGA spectrometer of Mars Express [1]. JSC-Mars 1 is a volcanic ash with a similar chemical composition like Martian soil [2]. The Raman spectrometer on the ExoMars-Rover will be equipped with a laser operating at an excitation wavelength of 532 nm, where both materials show fluorescence in the Raman spectra. Therefore it is of particular interest to investigate whether moist and dry soil can be discriminated.

2. Sample Preparation and Raman Measurements

Three samples of bentonite and JSC Mars 1 were prepared with a relative humidity (r.h.) of 0% r.h., 26-28% r.h. and 70% r.h., respectively. That leads to a moisture content of 5.5% weight by weight (w/w), 8.5% w/w and 20% w/w. All samples were stored in a special sample holder to keep the moisture stable during the measurement time. The samples were only flattened and not compressed.

The Raman measurements were performed with a confocal Raman microscope Witec alpha300 R [3] at room temperature under air at ambient pressure. The Raman laser excitation wavelength was 532 nm. The spectral resolution of the spectrometer was 4-5 cm^{-1}. A Nikon 10x objective was used. The spot size on the sample was in focus less than 1.4 µm. The laser power was 0.013 mW on the sample. Values of the integration time between 10 s to 20 s were chosen and 1 to 60 iterations of one point on the sample were taken.

3. Results and Conclusions

The measurements were normalized to the maximum around the intensity of 1800 cm^{-1}. The relative Raman intensity in the range of 2500 – 3500 cm^{-1} was compared with the corresponding Raman intensity in the wavenumber range from 100 – 2500 cm^{-1}. An increase of the Raman intensity around 2500 – 3500 cm^{-1} with increasing soil moisture has been found for bentonite. For JSC Mars 1 this effect exists as well but is weaker. It is most pronounced for measurement parameters of 10 s integration time and 60 iterations. In this case the driest sample could be discriminated from the moist samples.

The analysis demonstrated that the described approach has the potential to provide information about moisture status even for fluorescent soils like bentonite and JSC Mars 1.

References

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