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Looking for water related environments on Mars: analysis of reflectance spectra for present and future exploration

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Abstract

Spectroscopic analyses of basalt epithermal alterations, clay minerals and samples representative of wet sedimentary environments in a broad wavelength range from the ultraviolet to the far-infrared provide new loads of information for present and future exploration of environments that could have been linked to water and gas emission. Specifically, methane emission centers on the Martian surface are high interest targets for Exo-Mars mission since they involve environments where life could have potentially arisen, grown and given a contribution to the degassing phenomenon.

1. Introduction

Mud and water resurgences features on Mars are primary objectives for the astrobiology and climate change studies and investigating the nature of the unconsolidated materials that have been mobilized will lead to step forward in the understanding of the processes that lie behind. Such environments have been recognized in numerous locations on the Martian surface [1], [2], [3] and accordingly various scenarios need to be tackled. Indeed, during the Martian ancient past, sediments could have been deposited and trapped thanks to surficial sedimentary processes, hence hydrous alterations and possibly putative organic matter could be found. Differently, basalts could have experienced alteration linked to fluid circulation in the subsurface, so serpentinisation related to hydrothermal systems should be taken also into account. A suitable analogue for both environments could be the group of the epithermal ore systems [4] due to: (i) characteristic interaction between hydrothermal fluids and groundwater within the first kilometers of crust, (ii) low temperatures ranges of mineral deposition, (iii) surface expression through mud volcanoes, hot springs and pools and (iiii) the connection with loss of methane and other gasses.

2. Materials and methods

21 samples belonging to water related environments were investigated, among which clays, epithermal minerals and siliceous stromatolites. Spectroscopic analyses were coupled to XRD chemical characterization to provide a complete dataset of information. The sample grain size, obtained by grinding and sieving, never excided 100 μm; powders went then through an exsiccation process by means of oven and drier. Acquisitions were thus performed on powdered and dried samples under vacuum at room temperature conditions by means of reflectometric interference spectroscopy at one constant geometry. The chosen setup was fixed at 43° phase angle in a non-symmetric arrangement with illumination and emission disposition set respectively at 30°and 13°. Even conditions were used across all spectral ranges and samples preparation to facilitate reproducibility and comparison. During the analyses the acquisition spot was 4 mm in diameter, resolution was fixed at 4 cm-1 (8 cm-1 in the UV field) and 500 scans were performed for each sample (250 in the far-IR field). Spectralon 99% (LabSphere ®) of reflectance and a gold-plated standard were used as reference for calibrating ultraviolet, visible (VIS) and IR reflectance.

3. Preliminary results

A broad range of wavelengths was investigated in order to widen and enhance spectral libraries. We assigned, in the VIS and near-IR (see Fig.1), the absorptions features to specific crystal field or vibrational processes, identifying diagnostic spectral parameters or indicator to be applied on CRISM (onboard MRO) and OMEGA (onboard MEX)

hyperspectral images [5 and references therein]. Moreover, we have investigated less common windows of analysis (e.g. UV, far-IR) to evaluate if markers and signatures could be there recognized and therefore considered for future planetary probing.

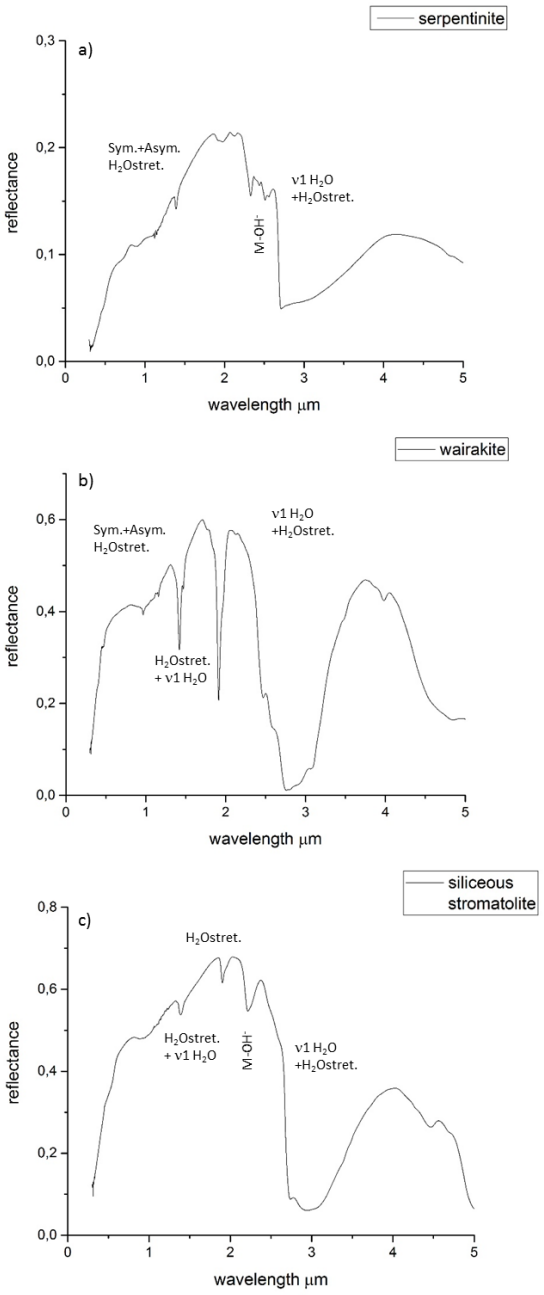

Figure 1: Example of VIS and near-IR spectra of three investigated samples belonging to different alteration processes and biologically mediated concretions. In the plots assignments of the overtone absorptions are reported.

4. Future works

Evidence of absorption and spectral variability, as retrieved in this work for well characterized mineralogies, will be applied to drive the analysis on remotely sensed hyperspectral images of Martian regions where surface expressions of water and sediments resurgences are recognisable such as the mound fields detected in Utopia and Hellas basins and Vastitas Borealis [6].

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