A VNIR spectral database of Mars analog rocks to guide future analyses of hyperspectral data

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Résumé

Rock compositions at the surface of Mars are mostly studied with reflectance spectroscopy in the visible near-infrared range (VNIR: 0.4 – 3.0 μm). Spectral imagers like CRISM onboard satellites orbiting the planet acquire VNIR hyperspectral cubes with typical spatial resolutions on the order of tens of meters (e.g., *Murchie et al, 2007*). Analyzing the characteristics of VNIR reflectance spectra (e.g., the position and shape of absorption bands) enables the determination of the mineralogical composition of rocks present on the surface of Mars. To achieve this, Mars remote sensing data are usually compared to reference spectral libraries acquired in laboratory (e.g., USGS spectral library in *Kokaly et al., 2017*; https://crustal.usgs.gov/speclab/). This approach has led to many discoveries regarding the red planet's geological history; for instance, the detection of both hydrated clays and sulfates was interpreted as evidence for a past, warm and wet climate (e.g., *Bibring et al., 2006; Carter et al., 2013*).

In this study, 67 terrestrial magmatic rocks were characterized in the laboratory. Our collection comprises rocks of various nature: volcanic rocks such as basalts and dacites, as well as plutonic rocks including anorthosites and granites. A detailed protocol was established to combine the petrography and geochemistry of the rocks with spectral data (*Barthez et al., 2023*). Initially, the mineralogy and texture of the rocks were determined using optical microscopy. Subsequently, the chemistry of specific minerals was determined using an electron microprobe (plagioclase feldspars especially). Finally, the rocks were characterized spectrally using two instruments: a point-spectrometer, the *ASD Fieldspec 4*, and two hyperspectral cameras, the *HySpex VNIR-300N* and *SWIR-640*, which the CRPG laboratory is equipped with. These instruments operate in the visible near-infrared range: between 0.35 μm and 2.50 μm for the *ASD Fieldspec 4* (at 3 nm/channel for the VNIR detector, and 8 nm/channel for the SWIR1 and SWIR2 detectors), between 0.40 μm and 1.00 μm for the *HySpex VNIR-3000N* (at 2 nm/channel), and between 0.96 μm and 2.50 μm for the *HySpex SWIR-640* (at 4.38 nm/channel). While the point-spectrometer enabled the acquisition of an average VNIR reflectance spectrum of each rock (**Figure 1**), the hyperspectral cameras allowed the acquisition of individual reflectance spectra for all the different grains composing the rocks (with a spatial resolution of 15 μm with the *HySpex VNIR-3000N* and 32 μm with the *HySpex SWIR-640;* **Figure 2**). Using the *ENVI* image processing software, the hyperspectral cubes acquired with the hyperspectral cameras were then processed and analyzed to obtain the VNIR spectral signature (between 0.40 μm and 2.50 μm) of each mineral composing the rocks (**Figure 3**) and analyzed their contribution to the whole rock spectrum.

*Intervenant

The numerous VNIR spectra acquired in this study were then compiled into a reference spectral library named *Mirabelle*, available in open access on SSHADE (https://doi.org/10.26302/SSHADE/MIRABELL This reference spectral library is unique as it is, contrary to most existing libraries (e.g., USGS spectral library in *Kokaly et al., 2017*; and RELAB https://sites.brown.edu/relab/) acquired on whole rocks instead of powders of single minerals. The selected range of terrestrial magmatic rocks is broad and can be used for relevant comparison with Martian hyperspectral data acquired from orbit by the CRISM instrument. The diversity of freely available data should contribute to further understanding the mineralogical composition of Martian rocks, as well as their origin and formation mechanisms (*Barthez et al., 2024, in prep.*). The use of hyperspectral cameras coupled with petrologic analyses demonstrated its high potential for identifying rock compositions remotely, and for future spectral unmixing studies.

Acknowledgements: The authors acknowledge the support of the French Agence Nationale de la Recherche (ANR), under Grant ANR-21-CE49-0003 (MARS-Spec).