EPSC Abstracts
Vol. 14, EPSC2020-606, 2020
https://doi.org/10.5194/epsc2020-606
Europlanet Science Congress 2020

Near-infrared laboratory measurements of feldspathic rocks as a reference for hyperspectral Martian remote sensing data interpretation.

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1. Introduction

New feldspar detections made by visible-near infrared spectroscopy this year on Mars [1], raise questions on the nature of the rocks involved and the magmatic processes responsible for their formation. Based on lunar studies, the presence of a 1.3 µm absorption band has been so far interpreted, as diagnosis of anorthosites containing more than 90% plagioclase [2]. However, these studies are based on VNIR spectra acquired in the laboratory, on binary mixtures of powders, containing Ca-plagioclase feldspar mixed with a mafic mineral such as olivine or pyroxene [3]. This paper presents our laboratory results regarding VNIR spectra measurements of several (uncrushed) terrestrial rocks containing feldspars of various compositions, in various amounts, and with different grain sizes as we expected all these factors to influence the spectral response. Our results allow us to survey in which cases the 1.3 µm band can be reproduced, and which are therefore possible analogue rock candidates. Finally, the sparse detections that have been recently made in the Valles Marineris region of Mars are compared with our library results.

2. Method

The objective of our study is to use VNIR reflectance spectroscopy to create a new reference spectral library containing reflectance spectra acquired on uncrushed terrestrial feldspathic rocks. Over 40 terrestrial feldspathic rocks of various types (volcanic, plutonic and metamorphic, *Figure 1*) were analyzed in this study.

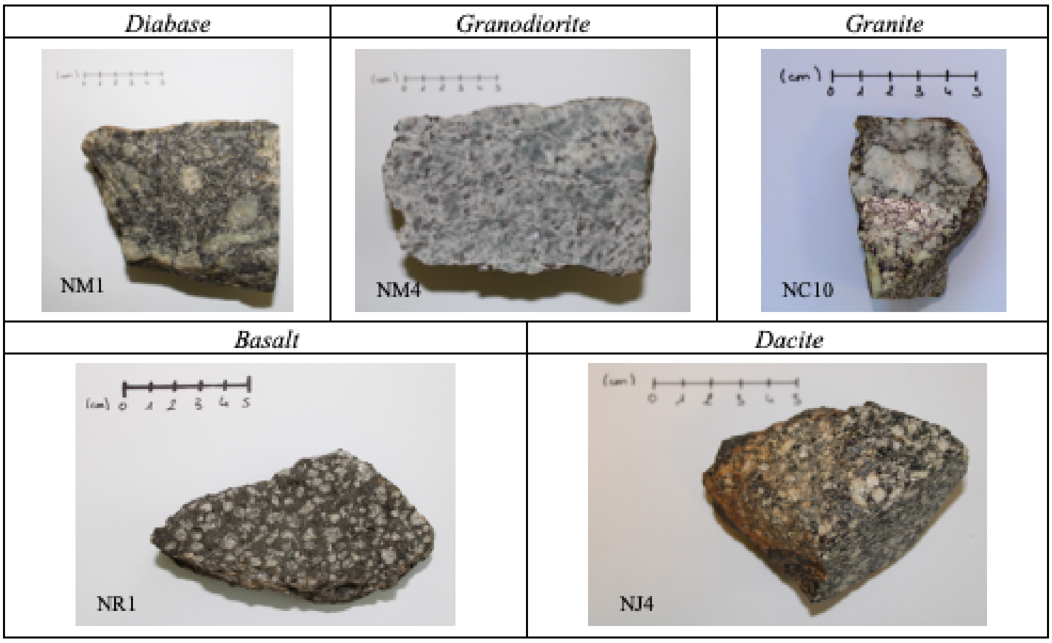

Figure 1: *Pictures of a subset (5 out of 42) of some of the feldspathic analogue rocks analyzed in our study.*

Reflectance spectra of this wide range of rocks was measured with an ASD Fieldspec4 spectrometer in our laboratory. This instrument operates in three different wavelength ranges: VNIR (0.35 – 1 µm), SWIR 1 (1.001 – 1.801 µm), and SWIR 2 (1.801 – 2.5 µm), with a spectral resolution between 3 and 8 nm. Spectra were collected with the instrument bare fiber, contact probe, or Muglight. The distance of the fiber using accessories was ~ 15 mm from the rock, with a phase angle of ~45° and using an artificial light source. Approximately five different spectra were measured on each rock sample. Selected spectra are presented in *Figure 2*.

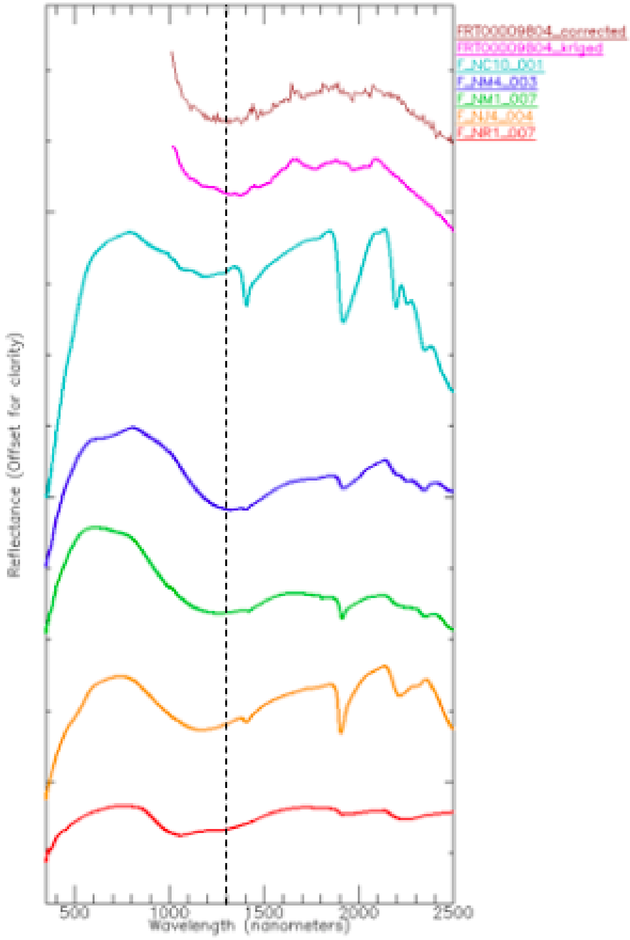

Figure 2: *A CRISM feldspar ratioed spectrum (raw and denoised by kriging) is shown in comparison with spectra of the analogue rocks presented in Figure 1. The dotted line indicates the position of the absorption band center on the CRISM spectrum.*

In parallel, Mars VNIR hyperspectral remote sensing data from the CRISM instrument (Compact Reconnaissance Imaging Spectrometer for Mars) onboard MRO (Mars Reconnaissance Orbiter) where feldspar signatures were recently reported [1] were analyzed. Raw data were downloaded from the PDS, corrected with the ENVI CAT (CRISM Analysis Toolkit) following the method described in [4] and then denoised using a custom-made routine [1].

Spectral criteria [5] are then computed to investigate whether or not an absorption band for a given wavelength was present. The BD1300 criteria was used in this study to highlight pixels which might contain a feldspar absorption band at 1.3 µm.

3. Results

Out of 42 measured analogue rocks, 18 rocks display absorption features around 1.3 µm. The rocks with positive 1.3 µm signatures include dacites, basalts, granodiorites, granites and diabase. Several spectra were measured on these rocks resulting in 82 positive spectra in our new spectral library (*Table 1*). The feldspar-bearing have absorption band centers varying from 1.15 to 1.4 µm.

Rock types	Number of samples	Number of samples on which spectra with the 1.3-microns absorption band were measured	Number of spectra with the 1.3-microns absorption band
Plutonic rocks	17	7	38
Volcanic rocks	19	7	26
Metamorphic rocks	6	4	18
TOTAL	**42**	**18**	**82**

Table 1: *Overview of analyzed rocks.*

A similar absorption is observed on eight analyzed CRISM cubes (*Figure 2*). The position of the center of the absorption band in the CRISM data is around 1.25 µm. If we compare the CRISM data to the spectra of our library, the right and left shoulders of the absorption band are very often equidistant from the center of the band, although the CRISM spectra here are limited at wavelengths >1 µm, making the left shoulder difficult to examine.

4. Discussion and Perspectives

Spectra collected on entire terrestrial feldspathic whole rocks show diagnosis plagioclase signatures which are similar to the ~1.3 µm absorption feature observed on Mars. Other candidate minerals, however, could show broad absorption bands centered between 1.1 and 1.3 µm, such as garnet, micas or volcanic glass. Still, spectral characteristics of both our library spectra and Mars CRISM spectra are more consistent with plagioclases.

Future work includes a detailed petrographic characterization of the analyzed samples. It is already shown, however, that some of our samples do not contain more than 40% plagioclase crystals and still display absorption band centered at 1.3 µm on the reflectance spectrum. These results are in contradiction with previous analysis of powder mixtures [6] which determined that the presence of 90% of calcic plagioclase is necessary in a rock for its band to be observable in a reflectance spectrum [3]. We argue that presence of an absorption band can also be influenced by the grain size which is an important factor to take into account: the larger the grain size, the deeper the absorption band, and most of our studied rocks do contain feldspar phenocrysts.

We conclude, from the comparison of our library spectra with the Mars CRISM spectra, that a range of effusive and cumulate rocks could correspond to the observed signatures. Previous studies suggested that these spectral signatures correspond to anorthositic primary crust [2], or felsic tertiary crust [7]. Although these hypotheses are plausible, our results suggest that it is virtually impossible to use feldspar detections to infer the presence of a primary or tertiary crust until we further constrain the true nature of the rocks and the exact geological context of these peculiar signatures.

5. References

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