

Spectral classification and MGM-based mineralogical characterization of SAS-corrected OMEGA data: Nili Fossae case.

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Introduction

In literature, mineralogical classifications of Martian surface are performed using spectral summary parameters that map areas exhibiting spectral structures of interest [1]. According to this method, mineral identification considers band shape and position. Sometime, this method can be improved dividing the measured spectrum by a reference spectrum of the same session in order to remove residuals due to atmospheric components and systematic instrumental artifacts. Differently from this method, here, the mineralogical mapping is performed considering the entire spectral region from 0.5 to 2.5 μm , and using a set of sequential steps, comprising image-derived spectral library collection, supervised classification and spectral band assignment. In particular, the supervised classification combines the pixel purity index-PPI for end-member collection [2] and the spectral angle mapper-SAM [3]. Finally, The Modified Gaussian Model-MGM [4] is applied for the mineralogical interpretation. Here, we apply MGM on OMEGA data considering the wide spectral range from 0.5 to 2.5 μm for the mineralogical interpretation giving, for the first time, particular emphasis on hydrated phases.

For this approach, Surface Atmosphere Separation (SAS)-corrected data [5] are used, as they proved to provide the most accurate atmospheric correction in the SWIR region. Nili Fossae is a widely studied area, thus, it is selected as a test case to prove, by comparison with previous results, the effectiveness of applying MGM on SAS-corrected OMEGA spectra.

Spectral classification

14 end-members are selected from MEX orbit 0422_4, and, based on their spectral characteristics, 5 main spectral units are recognized. The identified spectral units are:

- 1) Spectral unit A is characterized by red slope and high reflectance spectra in the NIR region. It shows two absorption bands at 0.95 and 2 μm and exhibits a drop-off in reflectance in the VIS region;
- 2) Spectral unit B has a horizontal slope in the 0.7-1.5 μm spectral range and intermediate reflectance spectra. Two principal absorptions, at ca. 0.95 and 2 μm , describe the unit;

- 3) Spectral unit C shows a blue slope in the NIR and is characterized by lower reflectance spectra and two absorption bands shifted at longer wavelengths than spectral unit B;

- 4) Spectral unit D shows a broad absorption band from ca. 0.75 μm to 1.65 μm , while E is characterized by a weak 1 μm band. Both spectral sub-units D2 and E show narrower absorptions at 1.9 μm and 2.3 μm , that can be associated to vibrational processes.

A mosaic of four-georeferenced orbits covering Nili Fossae (MEX orbit 0422_4, MEX orbit 0232_2, MEX orbit 0988_5 and MEX orbit 0966_5) shows how the selected end-members describe the entire region, with the only exception of a small region in MEX orbit 0988_5. Spectra from the unclassified region can be interpreted as belonging to spectral unit D, even if with a slightly different spectral signature.

Mineralogical classification of mafic units

MGM deconvolution and Gaussian positions concur to interpret:

1. Spectral unit A composed of orthopyroxene and iron hydroxides (e.g., limonite);
2. Spectral unit B and C constituted by a mixture of orthopyroxene and clinopyroxene, with the former dominant in unit B and the latter dominant in unit C, and
3. Spectral sub-unit D1 dominated by olivine and some amount of orthopyroxene and clinopyroxene.

Mineralogical classification of hydrated minerals

Regarding D2 and D3 sub-units, MGM fitting supports an olivine interpretation with alteration. Among the products formed by aqueous alteration of olivine, CRISM detected both serpentine and carbonates in Nili Fossae [6,7]. We compare MGM deconvolution of spectral units D and E with the fitting of lab. serpentine and carbonates [8]. Results suggest that spectral sub-unit D2 can be compared with serpentine, while spectral sub-unit D3 match with a synthetic Fe, Mg carbonate. The deconvolution of spectra belonging to spectral unit E can be divided in to two groups:

- 1) Spectra fitted with G14 related to Fe^{2+} -OH, interpreted as a chlorite family phase, i.e. chamosite; and

2) Spectra fitted with G13 due to Fe^{3+} -OH and related to the ferric member of the smectite group, nontronite.

Most of the spectra belong to the second group, i.e., to the nontronite family.

To strengthen and improve our interpretation of the spectral units characterized by hydrated features, a set of spectra detected by CRISM are chosen from the CRISM library [9].

Fig. 1 compares OMEGA spectra (black) here recognized with spectra from the CRISM library (magenta and green), showing good correspondances.

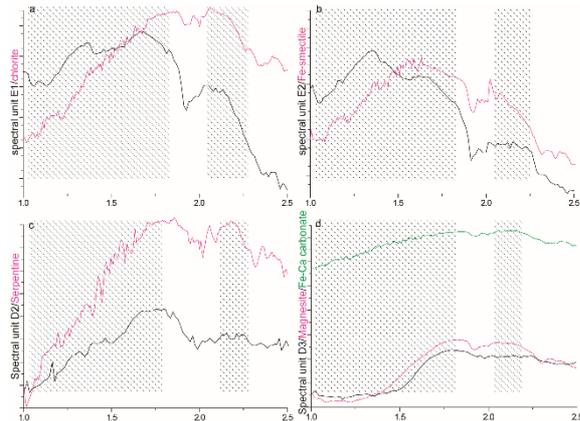


Figure 1: Comparison between OMEGA spectra (black) and spectra from CRISM library (magenta/green).

Spectral sub-unit E1 and chlorite-CRISM spectrum are characterized by a broad band in the NIR with a shoulder in the 1.6-1.7 μm range and by vibrational bands at ca. 1.9 μm and 2.35 μm . Both in spectral sub-unit E2 and Fe-smectite-CRISM spectrum the shoulder of the 1 μm mafic absorption is between 1.4-1.5 μm , and vibrational modes produce bands at 1.9 μm and 2.3 μm .

Spectral sub-unit D2 and serpentine-CRISM spectrum have the 1 μm shoulder shifted at 1.7 μm , and the 1.9 μm band is broad with the minimum shifted towards 2 μm . Additional vibrational bands are found at ca. 2.3 μm and 2.4 μm .

Magnesite-CRISM spectrum seems to be the most suitable candidate for comparison with spectral sub-unit D3. However, the 1.9 and 2.3 μm vibrational bands are shallower in D3 than in magnesite-CRISM spectrum and slightly shifted towards longer wavelengths and, so, more comparable with Fe, Ca-carbonate spectrum. Spectral sub-unit D3 can therefore be interpreted as a mineralogy belonging to the magnesite-siderite solid solution.

Conclusion

The methodology here applied combines SAM and MGM and is applied to OMEGA SAS-corrected spectra.

Differently from previous method described in literature, here we work using all the wavelengths of the spectrum, from 0.5 to 2.5 μm . Furthermore, we apply MGM for the mineralogical identification of spectral units. This allows the mapping of spectral units, the mixed composition of which can be described as a mineral association, with a significance depending on the geological context.

The combination of SAS, SAM and MGM allows us to recognize not only the mafic mineralogies, but also phyllosilicates with different compositions, and products of alteration processes of olivine. The main mafic phases recognized are iron hydroxides, pyroxenes and olivine.

MGM deconvolution of hydrated phases confirms the presence of different type of phyllosilicates, such as nontronite and chamosite, in accordance with results from literature. Our approach also permits us to recognize phases detected by CRISM using OMEGA data. In particular, serpentine and carbonates are identified.

References

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Acknowledgements: We thank the Italian Institute of Astrophysics INAF for the financial support within the project PRIN-INAF 2011 and the European Community for the financial support within the project UPWARDS.