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Emissivity and reflectance measurements of particulate mixtures for the interpretation of planetary remote sensing data

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Abstract

Without laboratory measurements, most of the planetary data are ambiguous and difficult to be interpreted. So far, many data collected in laboratory for several materials under various environmental conditions have been used to develop spectral libraries, analytical models, and databases for the interpretation of remote sensing data. But as planetary observations and instrumentation become more diverse and sophisticated many laboratory studies are needed to support the interpretation of these ever-expanding data sets. We are performing a systematic study on the spectral behavior of particulate mixtures of planetary analogues materials. This study is a key for a better interpretation of the planetary orbital data resulting in a careful detection of the materials present on a planetary surface.

1. Introduction

The fundamental question connected to the study of any Solar System object is: what is it made of? In addition, the composition of the surface of planetary objects records the history of their formation and the subsequent alteration over time. The mineralogy and chemistry of a planetary surface is also connected to other valuable information about the planet, ranging from its interiors to the potential habitability.

Spectroscopic data collected remotely using orbital instrument provide a powerful tool of investigation of a planetary surface mineralogy [1,2,3]. Many spectroscopic instruments are already in orbit around Mars, as for example: OMEGA (Observatoire pour la Mineralogie, l'Eau, le Glace e l'Activite, Mars Express spectrometer); CRISM (Compact Reconnaissance Imaging Spectrometer for Mars, Mars Reconnaissance Orbiter instrument); the most recent NOMAD spectrometer (Nadir and Occultation for MArs Discovery) and its ancestors TES (Thermal Emission Spectrometer, Mars Global Surveyor instrument) and PFS (Planetary Fourier Spectrometer, onboard Mars Express).

Other planetary bodies have been visited from orbital spectrometers: for example, the comet 67P/C-G (Visible and InfraRed Thermal Imaging Spectrometer VIRTIS, Rosetta instrument), the dwarf planet Ceres (Visual and Infrared Imaging Spectrometer VIR / Dawn instrument). In the next 5 years, new spectral instruments will be sent for orbital and in-situ analysis of planetary bodies: as for Mercury (MErcury Radiometer and Thermal infrared Imaging Spectrometer, MERTIS instrument payload of BepiColombo mission), the C-type asteroid (Hayabusa II mission), the Mars Phobos satellite (Mars Moons eXploration, MMX mission) and the upcoming Martian rovers that will perform in-situ IR spectroscopic instruments of the planet surface (ESA ExoMars and NASA Mars 2020 missions). However, while remote sensing and in situ data can allow us to address the surface composition of planetary surfaces, laboratory measurements are required to translate those data into knowledge. In fact, band shapes and depths are affected by composition and structures of the materials, but also by their physical/textural properties, including grain size distribution, surface roughness, packing density, crystallinity, and preferential orientation of crystals [4]. Detailed information is needed about wavelength positions, shapes and contrasts of absorption or emission bands of relevant materials.

Since any planetary surface is composed by mixtures of different materials and rocks, a good understanding of their spectral behavior, both in reflectance and in emissivity, is necessary for a good interpretation of orbital data. So far not many studies on the spectral behavior of particulate mixtures both in reflectance and/or emissivity for planetary analogues materials have been done [5, 6, 7, 8]. A systematic study of the spectral behavior of mixtures with different grain size, percentage of mixtures etc., is needed for a better interpretation of the high quantity remote sensing data continually obtained from the orbital instruments.

2. Data and methods

The main steps of our study are: - Emissivity and reflectance characterization of particulate mixtures; - Comparison between emission, bidirectional and hemispherical reflectance spectra of particulate samples; - Systematic study of parameters influencing the spectral behavior of laboratory mixtures; - Interpretation of remote sensing data of the planetary surfaces.

The samples were prepared starting from the bulk material and reducing it in powders with different grain size. To do that each material was sieved in several granulometric classes.

Materials considered as Martian analogues such as silicates, carbonates, oxides and sulfates have been selected for the first part of our work. We prepared samples of pure materials and mixtures of them. In particular: (1) mixtures of a phyllosilicate with two end-member of carbonates with different grain size, for granulometric and spectroscopic analysis; (2) mixtures of oxides with silicates to analyze the effect of oxides on silicates spectra.

We performed our emissivity and bi-directional measurements at the Planetary Spectroscopy Laboratory (PSL) facility at the DLR (Deutsches Zentrum für Luft- und Raumfahrt) in Berlin. The selected samples were measured in emissivity in two different configurations: in the vacuum chamber; in the air chamber. In the first case the sample was heated up to 200°C, and four different measurements were taken at the temperatures 50°C, 100°C, 150°C and 200°C. The progress of each experiment was monitored using an internal webcam and two temperature sensors: one located at the base of the sample holder and another at the sample surface. A picture of the sample was taken at each step.

Then the same sample was heated again but in air up to 150°C and measurements was performed at 50°C, 100°C and 150°C. Finally, all the heated samples were measured in reflectance to study any possible spectral change in the spectra after the heating process.

The hemispherical reflectance of our samples was measured at the Planetology Laboratory of Lecce by means of two spectrometers: one in UV-VIS and NIR range 0.2-2.5 µm and one in 2-25 µm.

3. Spectral parameters retrieved

We analyzed spectral parameters relative to absorption bands in reflectance spectra. Each absorption band was isolated by fitting and removing the spectral continuum. Spectral parameters as Band Center (BC), Band Depth (BD), Band Area (BA) and Full Width Half Maximum (FWHM) were measured. The BC is the wavelength corresponding to the minimum reflectance value in the isolated absorption bands and the BD is obtained as $1-R_b/R_c$, (R_b is the reflectance at the band center and R_c is the reflectance of the continuum) [9]. The BA was estimated as the sum of rectangles included in the absorption band, with a width corresponding to the spectral sampling. The FWHM is the width of absorption band estimated at a distance from the level of continuum that is half height of isolated absorption band. As preliminary results, a shift in the band center position is observed when samples are progressively heated and even band depth, band area and full width half maximum show interesting trends.

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References

[1] Ehlmann B.L. and Edwards S.E.: 2014, Mineralogy of the Martian Surface, Ann. Rev. Earth Planet. Sci., 42, 291.

[2] Farmer V.C.: 1974, in The Infra-Red Spectra of Minerals, ed V.C. Farmer.

[3] Clark R.N.: 1995, in Rock Physics & Phase Relations: A Handbook of Physical Constants, ed. T.J. Ahrens.

[4] Maturilli, A., Helbert, J., D'Amore, M.: 2009, Phyllosilicates detection in Syrtis Major and Mawrth Vallis of Mars from PFS measured spectra, EPSC Conference, Abstract # EPSC2009-106.

[5] Roush T.L. and Orenberg J.B.: 1996, Estimated detectability limits of iron-substituted montmorillonite clay on Mars from thermal emission spectra of clay-palagonite physical mixtures. Jou. Geophys. Res., 101, 26111.

[6] Fonti S. et al.: 2010, Infrared reflectance spectra of particulate mixtures, Jou. Geophys. Res., 115, 1.

[7] Carli C. et al.: 2014, Spectral variability of plagioclase-mafic mixtures (2): Investigation of the optical constant and retrieved mineral abundance dependence on particle size distribution. Icarus, 235, 207.

[8] Roush T.L. et al.: 2015, Laboratory reflectance spectra of clay minerals mixed with Mars analog materials: Toward enabling quantitative clay abundances from Mars spectra. Icarus, 258, 454.

[9] Clark and Roush: 1984, Reflectance spectroscopy - Quantitative analysis techniques for remote sensing applications. Jou. Geophys. Res 89, Nr B7, pp.6329-6340