



Model VNIR optical constants of igneous powder rocks

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Abstract

In this paper we present preliminary results of the determination of the optical constants of complex silicates mixture obtained applying the Hapke radiative transfer model to visible-near infrared reflectance spectra. The selected silicates mixtures are representative of possibly igneous co-genetic rocks. We first calculated optical constants of the end-members represented by plagioclase samples and an assemblages of mafic minerals. The optical constants of the end-members were derived from the known composition of minerals and their grain-size ranges. Subsequently we modeled mixtures between the end-members and we compared the results with the measured spectra of those mixtures.

1. Introduction

Silicate mineral phases have been recognized on the surface of different Solar System's body. Planetary surfaces as well as moons or asteroids surfaces show morphological and spectral characteristic typical of effusive rocks, with heterogeneity that could be indicative of genetically related rocks. Different approaches were used to quantify and to model those important phases in mineral mixtures with the aim of characterizing the surface compositions. One approach was proposed by [1] considering the bidirectional reflectance to derive optical constants from powdered materials. Several papers have been published about the modeling in the VNIR range of the optical constants for pure mafic silicates like olivine and pyroxene [2] considering the effects of composition and grain-size variations. Recently [3] used a similar approach to calculate the optical constants also for plagioclase considering only a Ca-variation to calculate the real part of the imaginary refractive index. Some authors successfully modeled mixtures of those mineral phases taking into account the optical constants of each end-member [4,5], but only few works modeled spectra of mixed material where some of the end-members could not be individually characterized.

1.1 Our approach

We have applied the Hapke model to silicate minerals to obtain the optical constants of single phase end-members (three plagioclase) and two mafic end-member characterized by mixtures of pyroxenes and olivine (Fig.1).

Applying the Hapke equation of bidirectional reflectance [1] to the laboratory spectra we have retrieved the single scattering albedo (w) for each wavelength under the assumption of the isotropic single scattering. Then, fixed the grain-size distribution and the real part of the refractive index ($n+ik$) we inverted the formulation of w given in [1] to compute the imaginary part (k) for the entire wavelength range. The resulting k values have been used to model spectra of intimate mixtures of plagioclase and mafic assemblages.

2. Mineral suites and mixtures

Exploring possible systematic variation in composition of basic igneous rocks we prepared mixtures of mafic phases and three plagioclase with different iron contents. In fact, though the effects of Fe^{2+} absorptions in various clinopyroxene (cpx), orthopyroxene (opx) and olivine (ol) mixtures have been already studied, the spectroscopic effects of plagioclase (pl) has been less considered.

The multi mineral mafic grains and pl were separated from cumulate rocks of a layered intrusion belonging to the anorthosite kindred. Two different compositions of the multi mineral grain assemblages, were considered, representing the Fe, Mg components of the mixtures. One (B1) includes cpx En45-Wo46 (43.9%) and opx En77 (56.1%). The second one (B2) consists of opx En82 (27.6%), cpx En45-Wo46 (3.3%), ol Fo84 (66.9%). For both series, three distinct pl compositions were used, with FeO% concentration of 0.1, 0.36 and 0.5, respectively. For each plagioclase composition, mixtures varying from 20 to 90 wt.% pl and multimineral grains were

prepared, in two grain size classes (63-125 μm and 125-250 μm), for a total of 64 samples.

3. Methods

The bidirectional reflectance spectra were measured with a Fieldspec-Pro spectrophotometer mounted on a goniometer in use at the SLAB (Spectroscopy LABORatory) at IASF-INAF, Rome. The spectra were acquired with 1 nm spectral sampling between 0.35 and 2.50 μm with $i=30^\circ$ and $e=0^\circ$. The source used was a QTH lamp. The calibration was performed with Spectralon optical standard (registered trademark of Labsphere, Inc.). The illuminated spot was $< 0.5 \text{ cm}^2$. Relative mineral abundances of the mafic assemblages were counted looking the thin section of original rocks with a point counter. Major element geochemical compositions of the minerals were determined by Electron Microprobe Analysis (CAMECA SX50, CNR-IGG laboratory, Padova).

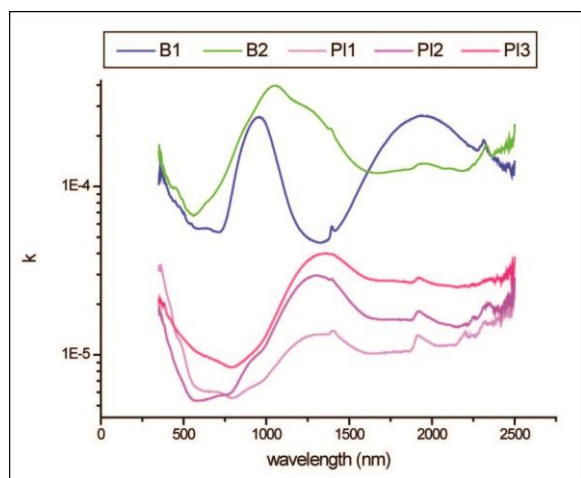


Figure 1: k optical constant of plagioclase minerals (PI1, PI2, PI3, 0.1, 0.36, 0.5 FeO wt.%) and an effective k for B1, B2 mafic assemblages.

4. Preliminary results and Future work

Preliminary results indicate that optical constant of plagioclase can be consistently calculated considering Na-Ca variation as in [3] only for plagioclase with FeO content $\leq 0.36\text{wt.}\%$. In fact the pl with highest iron shows a higher uncertainty for wavelength longer than 1.0 μm . The optical constants of the olivine-free assemblages are successfully calculated considering the composition of the

different pyroxenes with only a slight migration of band minima towards longer wavelength. In contrast, the olivine bearing assemblages give a higher error in k value determination.

Modeled mixture spectra show a good match with measured spectra for pl-B1 mixtures except for a general reflectance underestimate for samples with 90% pl, in particular for pl with 0.5wt.% of FeO. On the contrary, the pl-B2 mixture modeled spectra show a good correlation with the band minima and spectral shape but systematically underestimate the reflectance in particular for the bigger grain-size range and the plagioclase phases with $\geq 0.36 \text{ wt.}\%$ FeO.

To improve our modeled spectra we will implement a different way to calculate the real part of the refraction index n at different wavelengths and considering FeO effect for plagioclase. Moreover, we will explore more in depth the reflectance underestimation of modeled spectra for the 125-250 μm grain-size of the pl-B2 mixtures.

Acknowledgements

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