

COMPOSITION OF THE MARTIAN AEROSOLS THROUGH NEAR-IR SPECTROSCOPY Stéphane Erard, Priscilla Cerroni, Angioletta Coradini. *IAS-Planetologia, viale dell'Università 11, 00185 Roma, Italy.*

Introduction. Near-infrared spectroscopy is a powerful technique to study the composition of planetary surfaces, as the main minerals exhibit absorption bands in this spectral range. It gave important informations on the mineralogy and petrology of Mars in the past twenty years [1] although in this case it is well known that a large fraction of light is scattered by the airborne particles before reaching the surface. The measured signal is thus the sum of two different contributions that should be studied separately: One from the surface and one from the aerosols that depends on their density, size distribution and composition. Data from the ISM imaging spectrometer are used here to derive the aerosols spectrum. They consist in sets of spectra (from 0.76 to 3.16 μm) of ~ 3000 pixels $\sim 25 \times 25 \text{ km}^2$ in size [2]. The resulting spectrum exhibits both water-ice and clay minerals features superimposed on a scattering continuum.

Contributions to the measured signal. Under low opacity and near normal viewing geometry (the conditions of ISM observations) the development of the flux reaching the detectors can be limited to the terms of single scattering. The Martian aerosols being very bright and strongly forward scattering in the near infrared, the reflectance can be further approximated as [3]:

$$r \approx r_s + \frac{\tau w_a f(\varphi)}{4\mu}$$

where r_s is the surface reflectance, τ , $f(\varphi)$ and w_a are respectively the vertical opacity, phase function and single-scattering albedo of the aerosols, and μ is the cosine of the emergence angle. This model was previously used together with the ISM data to give a large range of possible estimates of the scattered spectrum, that was then lessened by comparison with telescopic observations [4].

Derivation of the aerosols spectrum. A new method is applied here, exploiting the spatial overlap between two image-cubes acquired on Tharsis, East of Pavonis Mons. 600 overlapping pixels were coregistered. The pixels covering the volcano were rejected because small registration errors could result there in major differences in altitude and because peculiar wind patterns are known to exist around the volcanoes, that could perturb the aerosols opacity. We finally used 284 couples of spectra acquired under low phase angles (from 4° to 11°). In each couple one spectrum was acquired under high emergence (from 38° to 49°) and the other under more normal geometry (from 27° to 37°).

According to the previous studies the aerosols contribution becomes very small at 2.5 μm , so that normalizing the two spectra of a couple at this wavelength corrects for variations of the surface photometric function. Making the assumption that the opacity is uniform and constant, the difference between the two normalized spectra is due to the increase of the aerosols contribution with increasing emergence angle, thus an estimate of the scattered spectrum can be retrieved from each of the 284 selected pixels. The result is shown on Fig. 1 for the spectral channels outside the main atmospheric absorptions.

Analysis. The aerosols vertical contribution at 1 μm is found to be ~ 0.04 ($\sim 25\%$ of the signal coming from the dark regions) which matches the estimates from Viking/IRTM under similar opacity [5]. The resulting spectrum has a strong negative slope related to Mie scattering, but isn't completely smooth. An interesting feature is the difference of reflectance between the two tracks of the instrument, which suggests that the measurements at 1.5 and 1.65 μm are located on the wings of an absorption band. If the scattering continuum can be simulated with an exponential function,

it is then clear that absorption takes place from 1.1 to 1.7 μm . Hence we used the nineteen channels from 0.77 to 1.09 μm and from 1.64 to 1.85 μm to fit an exponential continuum.

The ratio of the estimated aerosols spectrum to this continuum is showed on Fig. 2, emphasizing the absorption features due to the airborne particles. All the broad features (concerning more than two channels) are meaningful according to the statistical error (that accounts for both the instrumental noise and the spatial variability of the aerosols). Most of these features are actually very similar to those observed in water-ice spectra (*e. g.* [6]): The weak absorption from 1.09 through 1.39 μm followed by a much stronger one up to 1.69 μm , the strong absorption from 1.83 to 2.20 μm and finally the drop-off below 2.20 μm . The small inflexion from 1.74 to 1.83 μm is also meaningful, although it doesn't appear in water-ice spectra. [6] suggested that it is indicative of very hydrated mineral, such as montmorillonite or kaolinite mixed with water. Conversely, this minerals don't exhibit all the water-ice absorption features that match the aerosols estimate, namely at 1.6 and 1.8 μm . This would imply that two separated phases are actually responsible for the backscattered contribution, water-ice and dust composed of hydrated minerals.

To constrain more closely the latter, we made a systematical comparison of this spectrum to those of the minerals that have been proposed as major components of the Martian soils and dust, on the basis of the Viking landers analysis and spectral observations. The best fits are given by several clay minerals (montmorillonite, nontronite, saponite) and one iron oxide (gibbsite) that thus appear as the more likely components of suspended dust. No convincing similarity is found with spectra of carbonates, micas or plagioclases.

Figure 1: Aerosols contribution and modeled continuum.

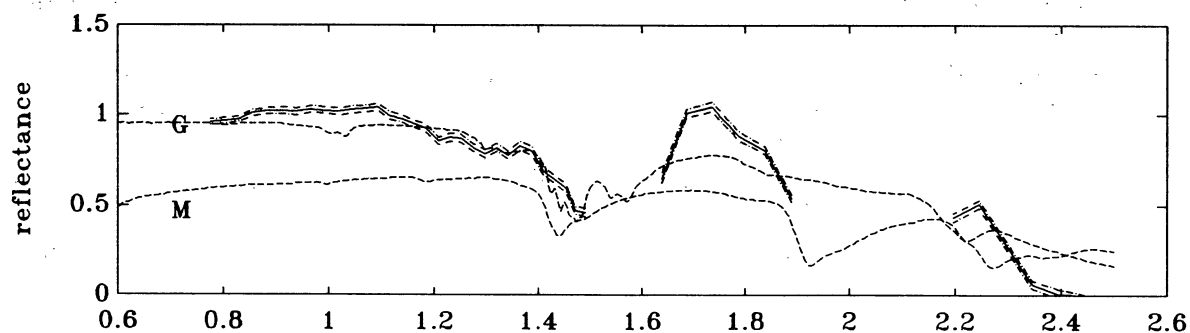
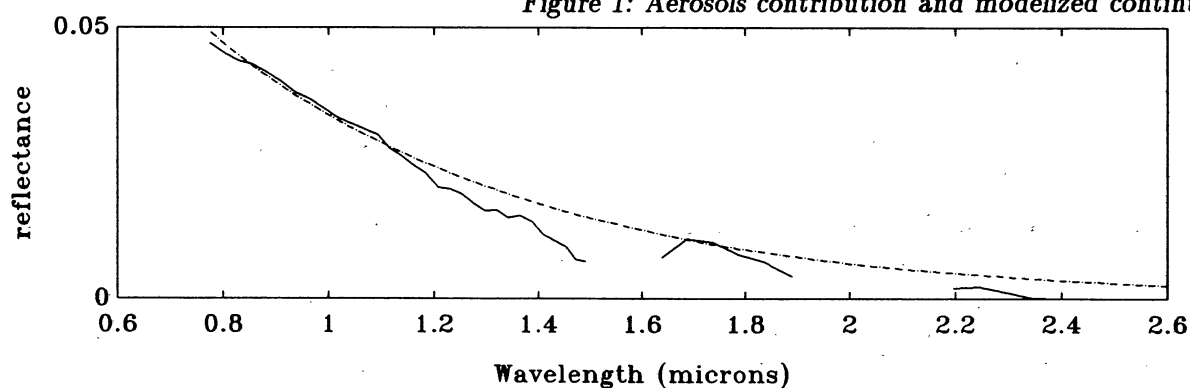


Figure 2: Aerosols to continuum ratio, gibbsite and montmorillonite spectra.

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