

Automatic definition of spectral units in the equatorial regions of Mars. Stéphane Erard, Priscilla Cerroni, Angioletta Coradini. *IAS-Planetologia, viale dell'Università 11, 00185 Roma, Italy.*

Introduction. ISM was the first instrument that acquired spectra of small areas (25x25 km²) on a planetary surface. The data set consists mainly in images made up of about 3000 such pixels, each one corresponding to a near-infrared spectrum (0.76 to 3.15 μm in 128 spectral channels) with high signal-to-noise ratio [1]. These data were used to define spectral units and to constrain the mineralogy of surface materials in the equatorial regions of the planet [2] [3]. Future spaceborne imaging spectrometers (*e. g.* OMEGA on board the Mars-94 Russian spacecraft) are expected to provide several hundred times as much data as ISM, so there's a strong need for fast and reliable processing methods. The present work is an attempt to define spectral units in the region of Syrtis Major-Isidis Planitia by means of G-mode analysis. The method allows to cluster the spectra according to their similarities; different levels of classification can be achieved by tuning a threshold of confidence [4].

Preparation of the data set. Since the signal doesn't only depend on the surface materials, an analysis of the whole spectra would incorporate features related to the atmosphere (mainly CO₂ absorption bands) to the aerosols (overall spectral slope) and to changes in viewing geometry (spectral slope, radiance). Each pixel must thus be described by a limited number of quantities related to the surface mineralogy, *e. g.*: Reflectance corrected from photometric effects, depth, locations and surface of mineralogical bands... The variations of albedo (up to a factor of 3, see Fig. 2) are huge as compared to those of the absorption bands (in general less than 5%), so they always dominate the variance. To study more subtle features, we parametrized the spectra with 6 quantities: a) Shape of the 0.8-1.0 μm band, indicative of iron mineralogy (ratio of absorptions due to Fe³⁺ and Fe²⁺, *i. e.* ferrous oxides versus mafic minerals). b) Depth of a large band centered at 2.17 μm , typical of Ca-rich pyroxens. c) Depth of the 3 μm band of hydrated minerals. d) and e) Depth of two narrow bands centered at 2.37 and 2.20 μm , related to Mg-OH and Al-OH bindings. f) Estimate of the surface contribution to the spectral slope.

Results. A first order analysis distinguishes between 8 main spectral types that form spatially coherent units (Fig. 1). (i) The bright regions of Isidis and Libya (class 1) cannot be separated on the basis of their spectral properties, while their morphologies are different. This was interpreted as the effect of a thin coverage by bright, hydrated dust with Fe³⁺ features [2] [3]. The craters in this regions (classe 5) have similar spectral properties due to a partial dust coverage. (ii) Conversely, the shield of Syrtis is clearly splitted in 3 main units (east, west and center, classes 4, 2 and 6). As a whole, they differ from class 1 by deep mafic features at 1 and 2.17 μm , and by a shallower hydration band at 3 μm . Previous interpretations of the data identified augite as a major mineral in this region [3]. (iii) Meroe Patera, which is one of the sources of the volcanic materials of Syrtis, appears as a separated unit (class 8) with stronger Ca-pyroxen absorptions and flatter spectra. Figure 2 shows the average spectra of the main five classes. One can see their differences in albedo (not included in the analysis), in spectral slope and in the shape and location of the iron band around 1 μm . Class 4 (east of Syrtis) has a medium reflectance, which is not normal since the albedo distribution is bimodal. This indicates that this class is not homogeneous but gathers together spectra of very different albedos on the basis of a single parameter (their unusually steep spectral slope). A deeper analysis makes appear new spectral units (Fig. 3). The eastern part of Syrtis (class 4 on Fig. 1) that was suspected to be heterogeneous, splits up in 6 sub-units on the basis of small differences in iron mineralogy. Two of this sub-units are relatively bright (classes 9 and 10), the other four are dark (classes 4, 11, 12 and 13). The bright regions remain unchanged, and do so even for high levels of analysis.

Conclusions. The results in the Syrtis Major-Isidis Planitia area, and similar ones in the Valles Marineris region, are very close to those of the previous analysis of the same data set: The bright regions appear homogeneous, hydrated and oxidized; the dark regions exhibit deep mafic features and a shallower hydration band, with a high degree of heterogeneity. The resulting maps of the spectral types are similar to those previously obtained by other means, and are in general highly correlated to the surface morphology. Taking into account an estimate of the aerosols contribution didn't modify the limits of the spectral units. Up to 20 meaningful spectral types can be identified per observation session on the basis of 6 spectral criteria, excluding albedo. The average spectra of the classes and the numeric outputs of the analysis allow to quantify the relative importance of the spectral features and to interpret the surface materials. This qualifies the method for further analysis of ISM data and future analysis of imaging spectroscopy data, provided that the main spectral criteria (absorption features due to the surface materials) are identified prior to analysis.

Fig. 1 Low-level analysis of the Syrtis-Isidis image-cube.

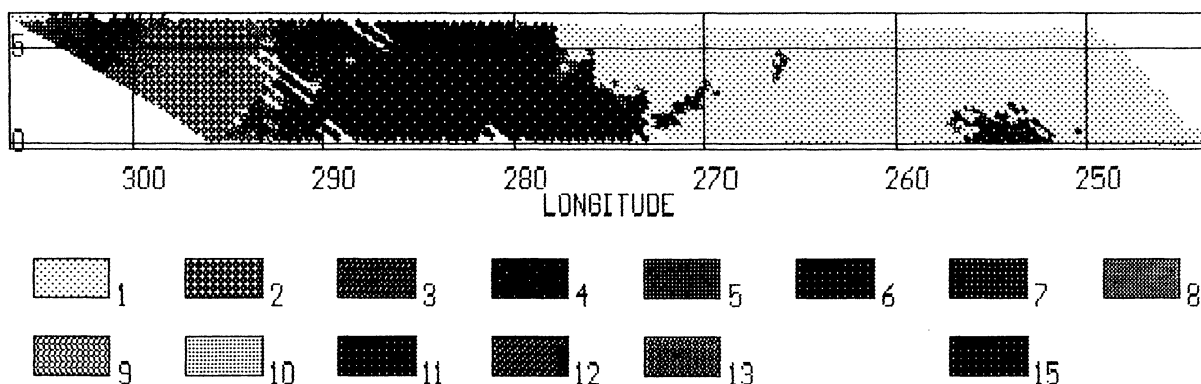


Fig. 3 High-level analysis of the same image-cube.

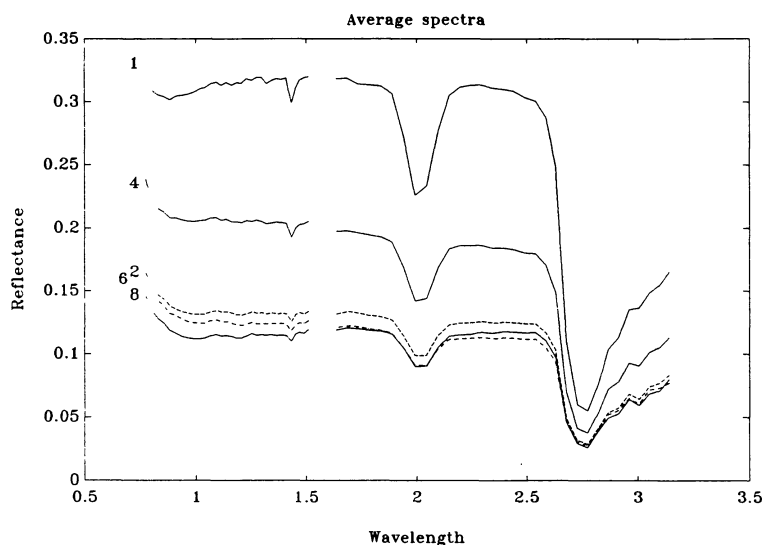
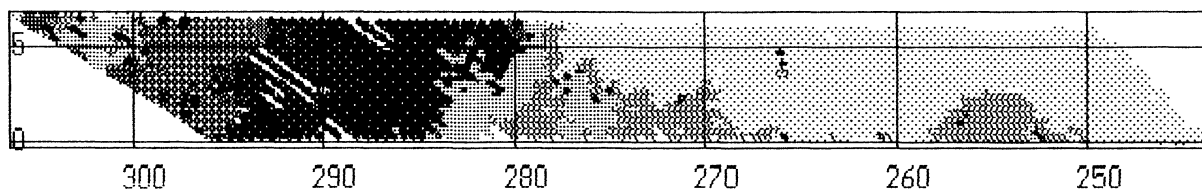


Fig. 2 Spectra of the main units in Fig. 1: 1-Isidis. 2-West Syrtis. 4-East Syrtis. 6-Syrtis center. 8-Nili Patera.

References: [1] Bibring *et al.*, *Proc. Lunar Planet. Sci. Conf. 20th*, 461-471, 1990. [2] Erard *et al.*, *Proc. Lunar Planet. Sci. Conf. 21st*, 437-455, 1991. [3] Mustard *et al.*, *J.G.R., MSATT issue*, 1993 in press. [4] Coradini *et al.*, *Comput. Geosci.* 3, 85-105, 1977.