INFLUENCE OF LINEAR VERSUS NON-LINEAR MIXTURE ON BIDIRECTIONAL REFLECTANCE SPECTRA USING A LABORATORY WIDE FIELD SPECTRAL IMAGING FACILITY. P. C. Pinet[1], A. M. Cord[1], Y. Daydou[1], F. Boubault[1], S. Chevrel[1] and V. Lapeyrere, [1]UMR 5562 / OMP/GRGS/CNRS, 14 av. E. Belin, Toulouse, 31400 France, Patrick.Pinet@cnes.fr.

Introduction: With the drastic improvement of the spatial resolution of the in situ (e.g. Mars Pathfinder instruments) and soon-to-come orbital multispectral observations (Mars Express, Mars Reconnaissance Orbiter - 2005), a particular effort is needed in the field of experimental imaging spectrophotometric studies to interpret the physical (nature, texture, surface roughness, maturity, degree of cristallinity) and mineralogical properties of the surface at subpixel scale [1, 2].

For this reason, a new spectral imaging facility has been designed and settled since April 2000 at the Observatoire Midi-Pyrenees, France. It is intended to help the definition of new spaceborne instruments and to simulate planetary observations, and consequently to contribute to the choice of orbital and flyby strategies of observation. The objectives are also to improve the understanding of the effects of observational conditions and of the physical properties on the bidirectional reflectance of natural rocky surfaces and soils [3, 5].

In particular, we study on simulated planetary surfaces the role on bidirectional reflectance spectra, of intimate mixtures of materials, of varied grain sizes and roughness, and of shade, resulting from grain mutual shadowing, at microscopic scale, and from local topography and surface roughness, at macroscopic scale. The aim is to document on an experimental basis the impact and interplay of these factors, and to quantify their influence in the deconvolution process of bidirectional reflectance spectra when considering heterogeneous targets with varied mineralogies at subpixel scale and under different viewing geometries [4]. Linear versus non-linear mixture solutions are tested and intercompared.

Instrumentation: The facility (fig. 1) provides with spectral measurements of the bidirectional reflectance, in the 0.40 – 1.05 μm domain, of macroscopic targets (200 x 200 mm). The incidence angle varies between 0 and 50 degrees and the emergence angle between –70 and +70 degrees, reproducing the geometric conditions the most frequently encountered with telescopic earthbased or spacecraft measurements. The camera uses a 1152x1242 CCD array, giving a submillimeter spatial resolution and 19 narrow band filters are available to span the spectral domain.

Target description: We have designed a complex target that is a good analog for simulating the case of a martian crater. The geometric aspect ratios are taken into account in order to approximate at best the photometric variations expected in the real case. Three materials with both varied spectral signatures (fig. 2) and grain sizes are used. The crater structure comprises three stratigraphic layers with a sequence of red tephra, palagonitic soil and basaltic horizons from top to bottom.

Method: Hapke's equation of radiative transfer [5] gives a semiempirical method for determination of the spectral reflectance of a powdered mineral mixture. This method is used to determine the relative proportion of components in a mixture for which the bidirectional reflectance is known [6].

Using this equation of radiative transfer, we apply successively a linear and a non-linear spectral mixture models to multispectral images of the controlled target, in order to quantify the different materials abundance and grain sizes composing the scene [7, 8]. In the mixture modelling, we introduce a shade endmember in addition to the mineralogical endmembers. The shade fraction image exhibits important differences between the models, the non-linear one giving the most realistic case. To discard the effects due to shadowing from those related to the nature of the material, mineralogical abundance fraction maps are renormalized by the shade component. Relying on the quantitative ground truth available for the built-up target, we intercompare the mineral abundance difference fractions derived from the different models and assess the limitations and confidence to be placed on linear versus non-linear mixture modelling, when considering sets of parameters describing the geometric and physical properties of surface constituents [9], such as local topography handled by a digital elevation model or the material angular-width parameter h [5].

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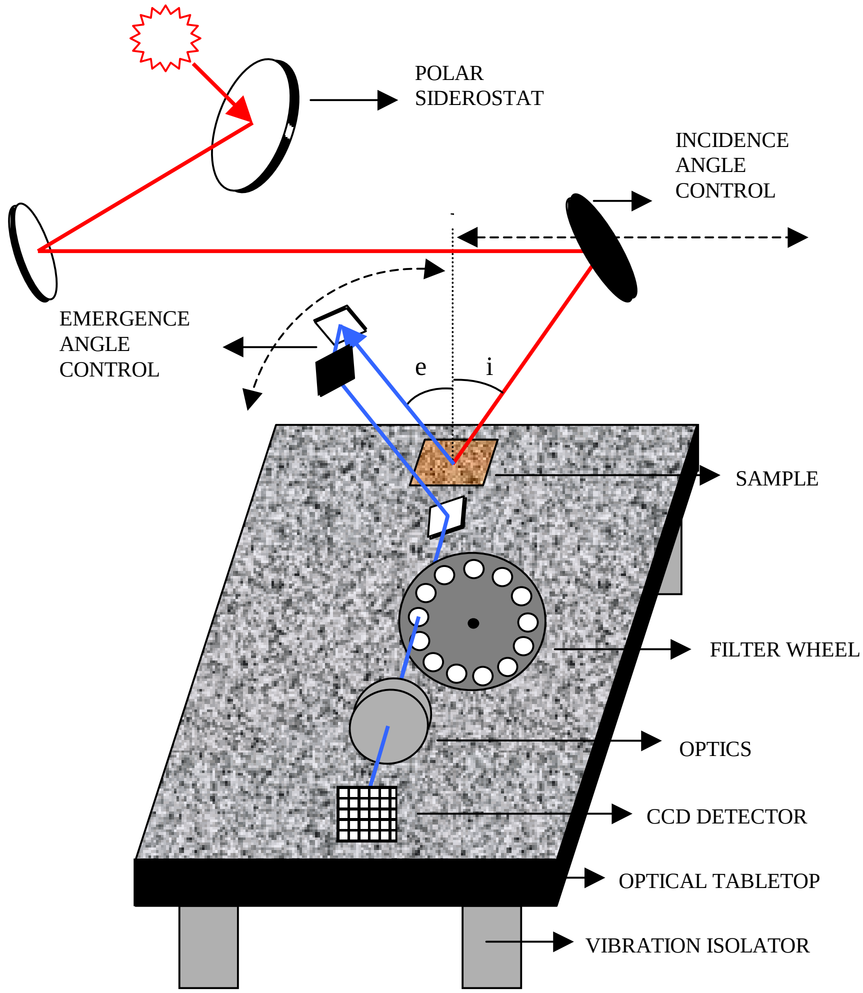

FIGURE 1: DIAGRAM OF THE SPECTRAL IMAGING FACILITY

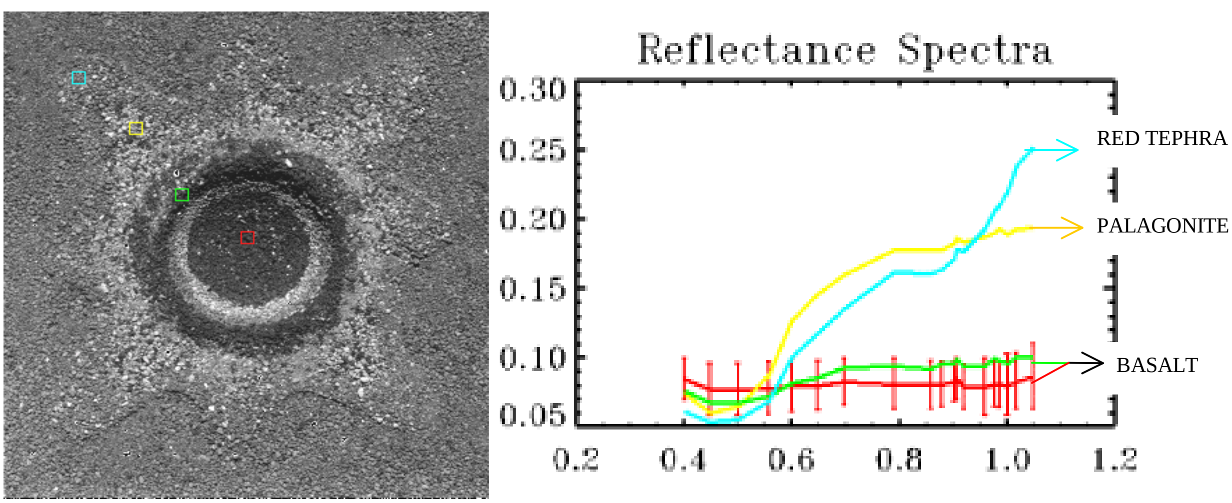

FIGURE 2: DIFFERENT MATERIALS' SPECTRA LINKED WITH THEIR POSITIONS IN THE TARGET