Search for Spectral Analogue Sites of Martian Meteorites using NIR data. A. Ody[1], F. Poulet[1], J.P. Bibring[1], B. Gondet[1], Y. Langevin[1], C. Quantin[2]. [1]Université Paris-Sud, 91405 Orsay cedex, France.[2]Laboratoire de Géologie de Lyon, ,69622 Villeurbanne, France

Introduction: Martian meteorites are the only samples of Mars that we have. However, their exact source region at the Martian surface is still unknown, which prevents to fully exploite information they give us about the composition and evolution of the surface and mantle of Mars. Several studies have tried to identify the source region of these meteorites using their age as well as our understanding of the dynamics of impacts to constrain geologically and chronologically appropriate regions and/or Martian craters [e.g. 1,2,3]. Alternatively, [4] tried to identify some possible source region of Martian meteorite by comparing their spectral properties with those of the Martian surface in the thermal infrared using TES data. The present study proposes a similar approach, but based on near-infrared data from the hyperspectral imaging spectrometer MEx/OMEGA. This dataset provides a global coverage of the Martian surface at a km-scale resolution making possible the identification and mapping at a global scale of regions with spectral properties similar to Martian meteorites. Without the ambition to find the exact source region of Martian meteorites, this study can give us indications about the type of geological setting, in which their parent rock could have formed, as well as their parent terrain age and their representativeness which are still debated topics [5, 6].

Observations and methodology: This analysis is based on the spectra of six Martian meteorites extracted from [7] and presented on Figure 1: two basaltic shergottites (Los Angeles and Shergotty), one lherzolitic shergottite (ALH77005), one Nakhlite (Nakhla), one Chassignite (Chassigny) and the orthopyroxenite ALH84001. The OMEGA dataset is composed of the entire C channel data (1.0–2.5 μm) acquired since 2004, which corresponds to more than 3 Martian years of observation and more than 7700 data-cubes. OMEGA observations disturbed by surface icy frosts and atmospheric effects (clouds, aerosols) are removed from the dataset thanks to a filtering process based on parameters that gauge the presence of H2O, CO2 ice and dust opacity [8]. In order to reduce the OMEGA dataset compared to Martian meteorite spectra, we have pre-selected OMEGA spectra in function of their spectral properties and those of studied Martian meteorite: we selected only spectra exhibiting a pyroxene signature for the meteorites Los Angeles, Shergotty, Nakhla and ALH84001, and only spectra showing an olivine signature for the meteorite ALH77005 and Chassigny. Olivine and pyroxene signatures are detected thanks to spectral parameters developed in [9] and [8]. In order to take into account spectral effects of aerosol, dust coverage, spatial mixture and photometry, every OMEGA spectrum is fitted by the meteorite spectrum (SNC_spectrum hereafter) with the following free parameters: a continuum offset (**O**), a slope parameter (**Sl**) and a scale parameter (**Sc**). The fitting function is hence:

F = **Sc***SNC_spectrum + **O** + **Sl*** wavelengths

In order to be consistent with aerosol effects, the slope parameter is restricted to negative values. The quality of the fit is evaluated thanks to the χ^2 value calculated between 1 and 2.5 μm for each OMEGA pixel.

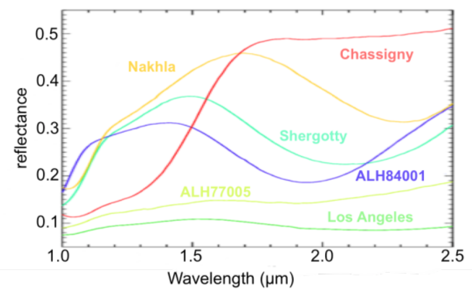

Figure 1. *Spectrum of studied Martian meteorite in the NIR extracted from [7].*

χ^2 global maps with a grid of 40 ppd are derived for each meteorite (by selecting the lowest value of χ^2 for each pixel in the case of overlap). Given the SNR of OMEGA spectra, the fit can be considered as nearly satisfactory for χ^2 values lower than 0.002. Larger values are not considered in this study and thus not mapped. However, χ^2 values being affected by many factors, an additional visual inspection was performed for each meteorite to validate several fits.

Results: Analyses of χ^2 global maps have shown that basaltic shergottites seem to have NIR spectral properties the most representative of the Martian surface. Other Martian meteorites ALH77005, Nakhla, ALH84001 and Chassigny show spectral properties that seem less common on the Martian surface. For instance, ALH77005 shows no satisfactory fit. Nakhla shows few acceptable fits only in the region of Thaumasia Planum associated to olivine-enriched craters floor or crater ejecta which is in agrement with its composition (15% olivine). Only two regions show spectral signatures similar to those of ALH84001. They are located in regions of Syrtis Major and in the northwest of the Hellas basin previously identified as Noachian LCP-enriched terrains [10], which is in good agreement with the Noachian age of this meterorite (4.1 Ga [6]) and its orthopyroxene-rich composition (Figure 1). The spectral properties of Chassigny are dominated by a strong 1 μm absorption band of the olivine (Figure 1) and satisfactory fits are not surprisingly observed in the region of Nili Fossae, well known to exhibit the strongest olivine signatures on Mars. Other satisfactory fits are found in large crater ejecta of the northern plains and in outcrops around Argyre and Hellas basins, which were interpreted to be early noachian or primitive material [11]. The ages of all these regions are however not consistent with the estimated Amazonian age (1.3Ga) of Chassigny [6,12]. Figure 2 shows the distribution of excellent fits obtained with the basaltic shergottites Los Angeles and Shergotty. Except for one unique fit observed in the Amazonian region of Noctis Labyrinthus, all fits are observed in old terrains of the southern highlands with the best fits (χ^2<0.0011) found in the three hesperian volcanic provinces of Syrtis Major, Hesperia Planum and Thaumasia Planum (Figure 2). These fits are illustrated in Figure 3 for the region of Syrtis Major, demonstrating the quality of the fits with χ^2 values that depend on the spectrum noise only.

The ages of basaltic shergottites are currently debated, with estimates of 165±11 Ma by [12] and 4050±70 Ma by [6]. This study shows that the basaltic shergottites Los Angeles and Shergotty are spectrally similar to early Hesperian volcanic regions, which is more consistent with the age of 4 Ga. In order to put additional constraints on the crystallization age of the basaltic shergottites, maps of other basaltic shergottites as depleted-shergottites shall be built and analyzed.

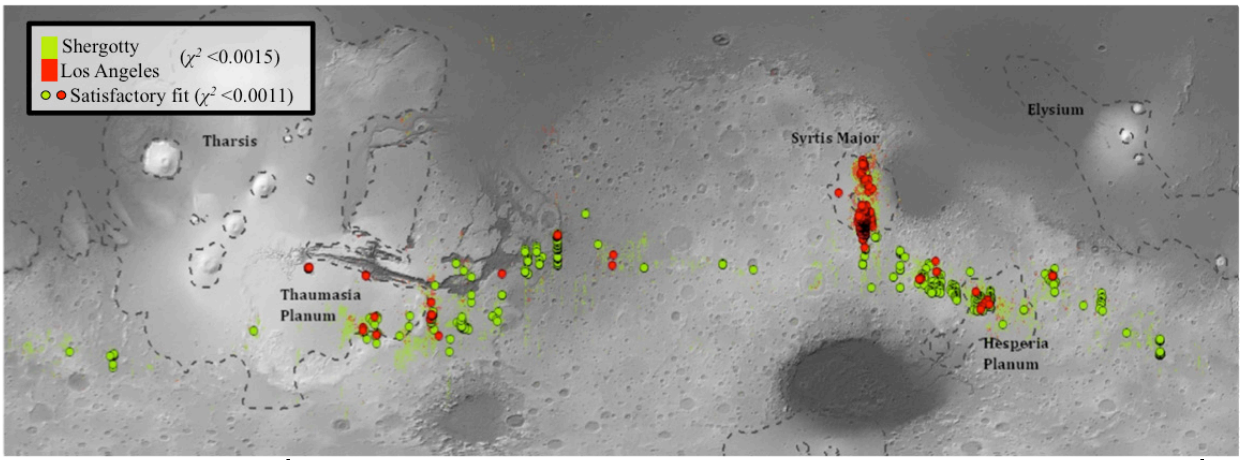

Figure 2. *Global map of χ^2<0.0015 for the Los Angeles (red) and Shergotty (green) meteorites. Best fits with χ^2 <0.0011 are overplotted with red and green points.*

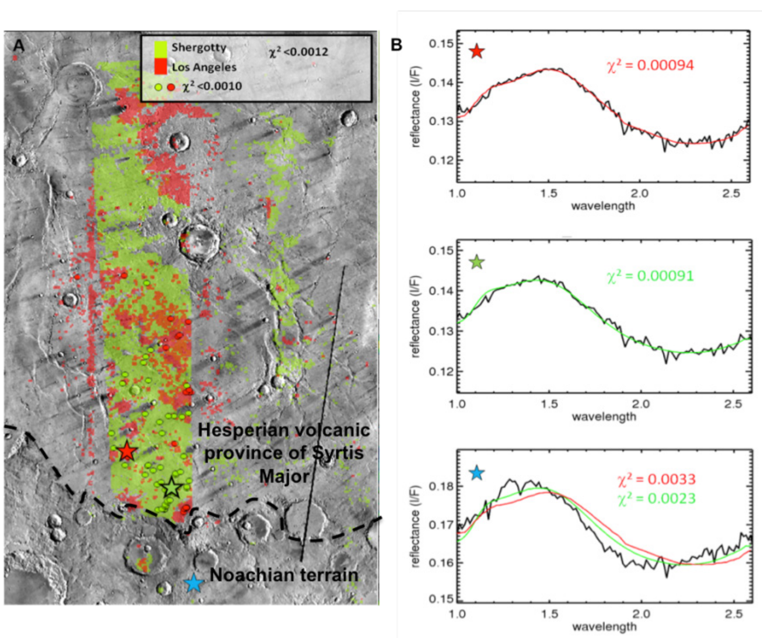

Figure 3. *(A) Map of χ^2<0.0012 for the Los Angeles (red) and Shergotty (green) meteorites in the region of Syrtis Major. Best fits with χ^2 <0.0010 are overplotted with red and green points. (B) Illustrations of best fits for Los Angeles (red) and Shergotty (green) extracted from regions indicated with stars of corresponding color in (A).*

References: [1] Mouginis-Mark et al .,(1992), *JGR*, 97:10213–10225. [2] Treiman (1995), *JGR*, 100:5329–5340. [3] Barlow (1997), *LPSC 28*. [4] Hamilton et al., (2003), *Meteor. & Planet. Sc. 38*, Nr 6, 871-885. [5] McSween et al., (2009), *Science*, 324, 5928. [6] Bouvier et al., (2009), *Earth and Planet. Sc. Lett.*, 280, 285-295. [7] McFadden and Cline, (2005), *Meteor. & Planet. Sc.*, 40,151. [8] Ody et al., (2012), *JGR*, 117, E00J14. [9] Poulet et al., (2007), *JGR*, 112, E08S02. [10] Poulet et al., (2009), *LPSC 40* [11] Ody et al., (2013), *JGR*, in press. [12] Nyquist et al., (2001), *Chronology and Evolution of Mars*, Kluwer, Dordrecht, pp. 105–164.