MINERALOGY OF THE MAGNETIC ANOMALY SITE SOUTH OF SYRTIS DERIVED FROM OMEGA/MARS EXPRESS HYPERSPECTRAL DATA. C. Sotin[1], S. Le Mouélic[1], J-P. Combe[1], Y. Quesnel[1], B. Langlais[1], J. Mustard[2], A. Ladaï[1], J-P. Bibring[3], Y. Langevin[3], A. Gendrin[3], S. Erard[3], B. Gondet[3], and the OMEGA Science Team, [1]Laboratoire de Planétologie et Géodynamique, Nantes, France, [2]Brown university, Providence, RI, USA, [3]Institut d'Astrophysique Spatiale, Orsay, France, e-mail christophe.sotin@chimie.univ-nantes.fr.

Introduction: Mars Global Surveyor has detected a strong magnetic field of lithospheric origin on Mars [1]. It is at least one order of magnitude larger than the Earth's lithospheric field. Both its geographical distribution and its high intensity have raised the question of the origin of these anomalies. The possible associated materials are mainly iron bearing minerals (magnetite, hematite, pyrrhotite, pure iron,…). Plausible processes include volcanism or plutonism, i.e. thermal remanent magnetization (TRM), or hydration and weathering, i.e. cristallization remanent magnetization (CRM) [2]. The serpentinization process provides a geological model. Under the assumptions of an hydrated basaltic crust with mantle convection and Earth-like dynamo, the interaction of enstatite with water could produce lizardite and magnetite, which records the magnetic field. Similarily, olivine altered by water produces serpentine and magnetite.

Spectra of mafic minerals (pyroxenes and olivines) and their alteration products (lizardite, serpentine,…) display diagnostic absorption bands in the visible-infrared range. The OMEGA imaging spectrometer onboard Mars Express provides hyperspectral images of the martian surface. We use this unprecedented data set to investigate mineralogical heterogeneities and study the possible link with local magnetic anomalies in the Syrtis Major area. A detailed investigation of the mineralogy of this region is described in Mustard et al. (this volume).

Data reduction: Magnetic measurements have been acquired between 80 and 400 km altitude. While the coverage at 400 km is complete, the lowest one (between 80 and 250 km) is largely incomplete. By combining these two altitude coverages, an altitude normalized map of the magnetic field can be built [3], on which it is possible to laterally characterize the anomalies with a mean resolution of ~250 km [4].

In the first year of operation, OMEGA observed the surface of Mars at high resolution (~300 m/pixel with very narrow swaths) in the southern hemisphere and a medium resolution (2 to 4 km with consequently much larger swaths) in the northern hemisphere. We therefore first focused our analysis in an area south of Syrtis which has both a significant magnetic anomaly and a sufficiently dense spatial coverage with OMEGA (figure 1). OMEGA spectral domain is covered by three different detectors. VNIR (0.36 – 1.08 µm) acquires images in a pushbroom mode whereas SWIR-C (0.92– 2.69µm) and SWIRL (2.25-5.08µm) acquires images in a whiskbroom mode. In order to avoid spatial sampling and registration errors, we first focuss our analysis on the infrared channels. Thermal emission may weaken the spectral contrast. The SWIRL domain will therefore require more modeling work. We therefore restricted our analysis on the 1.0-2.6 µm domain which contains very discriminative absorption bands. The atmospheric component has been removed by using an empirical transmission function (corresponding to the ratio of two spectra acquired at the top and bottom of Olympus Mons) scaled to the depth of the 2 µm CO_2 band.

Results: We first investigated the spectral caracteristics of OMEGA data by using the Pixel Purity Index algorithm. The corresponding endmembers are given in figure 2. These spectra display caracteristic absorption bands of olivine, orthopyroxene and clinopyroxene. Two of these spectra also present an absorption at 1.91 µm that can be interpreted as an hydration band.

In order to quantify the main mineralogical components in this area, we performed a linear unmixing transformation [5] using as input a USGS spectral library containing 25 various component that are expected to be found on Mars (pyroxenes olivines, sulfates, hematite, clays, serpentine, lizardite, magnetite,…). In this process, OMEGA normalized spectra are fitted by finding the best linear combination of the input library spectra. Negative proportions are eliminated using a recursive algorithm. It finally provides an image fraction for each of the component of the input library which have been retained. An example of the fit between OMEGA spectra and the linear model is shown in figure 2.

The dominant constituants found in this area are orthopyroxene (Ca poor) and clinopyroxene (Ca rich), which appear mainly in the dark regions (figure 1 right). The relatively low values in the middle of the orthopyroxene image corresponds to Syrtis major volcanic edifice as mapped by [6]. A good consistency is observed with maps produced by the MGM analysis (Gendrin et al. and Mustard et al., this volume), which reinforces the confidence level in our linear unmixing approach. There is no correlation between the magnetic anomalies and the dominant contituants.

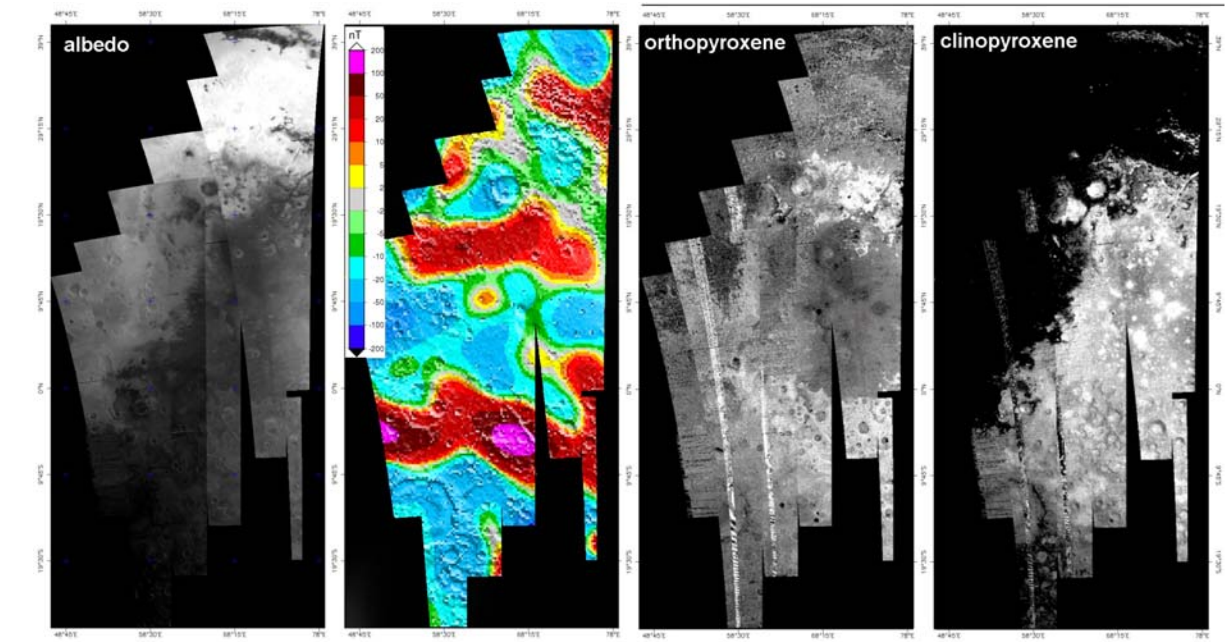

Figure 1 : (a) albedo (b) radial component of the magnetic field (c) orthopyroxene (Ca poor) fraction image derived from the unmixing (d) clinopyroxene (Ca rich) fraction image.

This method allows us to detect other constituants in specific areas like olivine exposures in the Nili Fossae and to a lesser extent in Nili Patera regions. These observations are in good agreement with [7], Mustard et al., this volume. The presence and nature of hydrated minerals and iron-bearing magnetic mineras require more robust evaluation and is underway. Whatever they are, they don't correlate with the magnetic anomaly, even in places where the crust has been excavated by impact craters, suggesting that the magnetic anomalies is several kilometers deep.

Conclusion : No obvious wide scale correlation with the magnetic anomaly has been found in the Syrtis major area, which is dominanted by clinopyroxene and orthopyroxene in various amounts. However, very localized exposures of olivine are unambiguously observed. This provides additional constrains which could help understand the origin of the observed magnetic anomalies on Mars and discriminate between surface and deep seated processes. The OMEGA data acquired during the second year will be very helpful to investigate areas in the southern hemisphere, where an alternation of positive and negative anomalies have been observed.

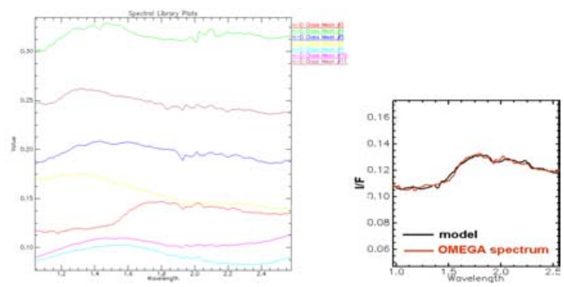

Figure 2 : OMEGA spectral endmembers and fit of the OMEGA spectrum by the linear mixing model near Nii fossae. These spectra indicates the presence of clinopyroxene (cyan), olivine (red), orthopyroxene (green). Hydrated minerals (blue) are chosen by the inversion process to explain the OMEGA spectrum but the solution may not be unique (see text).

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