CRUSTAL FORMATION, VOLCANISM, AND ALTERATION IN THE SYRTIS MAJOR REGION REVEALED BY OMEGA DATA J. F. Mustard[1], F. Poulet[2], A. Gendrin[2], J. W. Head[1], N. Mangold[2], J-P. Bibring[2], Y. Langevin[2], B. Gondet[2], C. Sotin[3], S. Le Mouelic[3], P. Pinet[4], and the OMEGA Science Team [1]Dept.of Geological Sciences, Box 1846, Brown University, Providence, RI 02912 John_Mustard@brown.edu. [2]IAS, Orsay Campus, France. [3]Planétologie, Université de Nantes, France, [4]Observatoire Midi-Pyrénées, Toulouse, France.

Introduction: The Syrtis Major region, with its volcanic construct, position on the rim of the Isidis Basin, and astride the boundary of the hemispheric dichotomy, occupies an important position for understanding Mars geologic evolution [1]. Remotely sensed data from the OMEGA experiment on the Mars Express spacecraft provide a new perspective on the formation and evolution of this region. Here we show the distributions of mafic minerals olivine, low-Ca pyroxene, and high-Ca pyroxene on the volcanic shield and surrounding highlands. We also map the distribution of hydrated silicate minerals and their association with the volcanic regions.

Methodology: Basic reduction of OMEGA data from radiance to reflectance including atmospheric removal are treated in companion abstracts (e.g. [2]). Mafic minerals are recognized and mapped on the basis of crystal field transition absorptions in the 1-2.5 µm region and procedures for this recognition and mapping are presented in companion abstracts [2, 3]. The recognition and determination of mineralogy for hydrated silicates is treated by Poulet et al. [4].

Results: The distribution of mafic minerals in the Syrtis Major region are shown in Figure 1, superimposed on a MOLA shaded-relief background. Regions not colored are either not measured by OMEGA or show no diagnostic mafic mineral features. The olivine distribution shows a high concentration in the northeast part of the region, known as Nili Fossae. This region was identified as olivine-rich by Hoeffen et al [5] using data from the Thermal Emission Spectrometer (TES). This region is analyzed in greater detail by Poulet et al [4]. On Syrtis Major olivine-enriched deposits are observed on the southeastern floor of Nili Patera and the sand dunes that run to the south and west from the caldera, as well as in the ejecta blankets of craters in the north- and south-central parts of the volcanic shield. Olivine-rich regions are also observed in the floors of craters in the highlands to the south of Syrtis Major.

Previous analyses of the composition of the volcanics on Syrtis Major concluded that their spectral properties are consistent with 2-pyroxene basalts, analogous to the basaltic SNC meteorites [6] and basalt composed dominantly of plagioclase feldspar and high-calcium pyroxene [7]. The primary difference between these compositions is that SNC-like basalts [6] imply an Al-depleted source region while the other composition implies a more fertile mantle source region. TES data also indicate another compositional type along the western and north eastern borders of Syrtis Major which is interpreted as andesite [7] or altered basalt [8]. In this analysis no distinct compositional differences are observed in the mafic mineralogy for these areas.

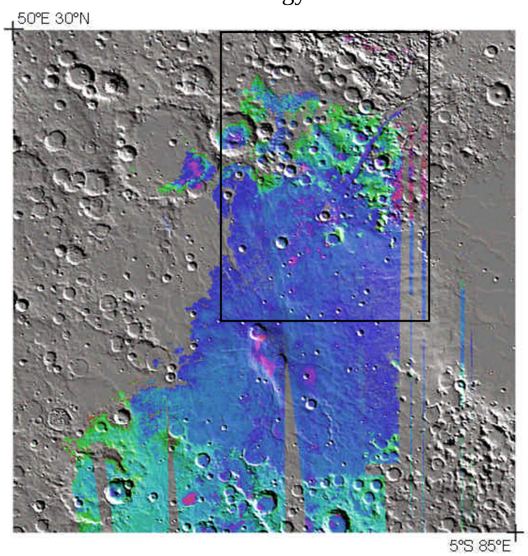

Figure 1. Map created from OMEGA data showing the distribution of areas relatively enriched in olivine (red), low-Ca pyroxene (green) and high-Ca pyroxene. The pyroxene-rich regions contain both high and low Ca pyroxene, where the blue-green color indicates the relative dominance of HCP and LCP respectively. Box shows the location of Figure 2.

Modeling of OMEGA spectra [3, 9] show that the volcanics on Syrtis Major require both low and high Ca pyroxene with a relative proportion 60-80% high-Ca pyroxene (of the total pyroxene content) based on the relationships of [10]. The increase in olivine content for regions near Nili Patera suggest exposures of more mafic lavas and the increased olivine content for some crater ejecta suggest a distinct compositional difference for early lavas.

In contrast to the Syrtis volcanic region, the Noachian-aged highlands to the north and south are enriched in low-Ca pyroxene. The mafic absorption bands here are among the strongest observed on Mars and compositional modeling [3, 9] indicates a relative proportion of low-Ca pyroxene of 60-80%. Such a distinct compositional difference in the ancient crustal material may be related to igneous processes during crustal formation. The olivine-rich region to the east [4, 5] of these Noachian-aged outcrops appear more deeply eroded, perhaps exposing a lower crustal level. Regardless, the association of olivine-dominated and low-Ca pyroxene dominated terrains in close proximity indicates that this is an important region for understanding crustal formation and evolution.

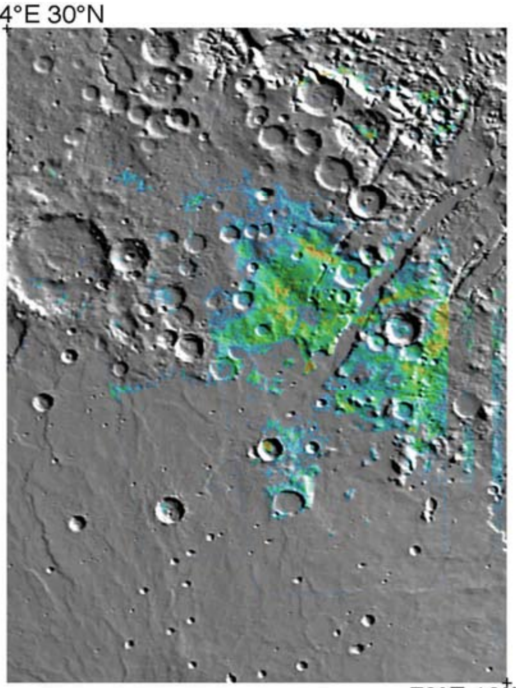

Figure 2. Strength of 1.9 µm hydration band superimposed on MOLA shaded relief where yellow-red indicates strong bands and blue weak.

The broad area enriched in olivine and low-Ca pyroxene also exhibits an increased 1.9 µm absorption band strength which is indicative of the presence of hydrated minerals (Figure 2). A distinct deposit in the Nilotosyrtis region along the lowland-highland boundary shows the 1.9 µm band and vibrational overtone absorptions near 2.28 µm consistent with the mineral nontronite. MOC narrow angle images of this deposit show the presence of layered materials. Throughout the broad hydrated region immediately north and east of Syrtis Major a 2.3 µm vibrational band is commonly observed that is consistent with iron-rich smectite clays including nontronite and glauconite. In several of these areas of enhanced hydrated silicate absorption features MOC narrow angle images show layered material, though in other regions layered materials are absent. Two craters immediately to the south of the main region of enhanced hydration are within the volcanic flows of Syrtis Major but show enhanced hydration and the presence of hydrated silicate minerals. The more southerly crater is filled with lava and its ejecta is embayed indicating it predates the Syrtis Major volcanism. The other crater superposes the volcanic flows and thus postdates the volcanism. A deposit on the floor of this crater exhibits the strongest hydration and vibrational overtone bands in the region. This shows that water-related processes capable of depositing hydrated silicates were active post-Syrtis Major. It is interesting to note that there are many lobate ejecta deposits around the craters in Syrtis Major yet the only signature of enhanced hydration in ejecta occurs on the craters described above.

THEMIS daytime thermal and visible images in the eastern hydrated region show evidence for fluvial channels, deltas, and lacustrine systems [11]. Furthermore, there is morphologic evidence for interactions of volcanic flows and volatile rich materials at the boundary between Syrtis Major and the Noachian terrains, as well as between Syrtis Major and the Isidis Basin [12]. These observations combined with new mineralogic data from OMEGA suggest that this has been an intense region of interaction between volcanic processes and volatile rich material. The broad hydrated region in the Noachian terrains could thus retain a detailed record of hydrothermal alteration of the crust and rocks. In contrast to the acidic waters required for the formation of jarosite in the sulfate-rich deposits in Meridiani [13], the hydrated minerals identified in this region require much more neutral pH conditions, and thus may be an important target for astrobiological investigation.

Conclusions: OMEGA data of the Syrtis Major region reveal that the dominantly volcanic surface is consistent with a 2-pyroxene basaltic composition. Olivine-rich volcanics exposed near the central caldera and in ejecta blankets indicate an evolution in the composition of the lavas. Exposed Noachian-aged crust exhibit enhanced concentrations of low-Ca pyroxene and olivine in distinct regions suggesting diverse processes of crustal formation. Hydrated silicates are recognized across a wide area, sometimes associated with layered material. The association of these deposits with morphologies consistent with the interaction of volcanism and volatile-rich substrates indicates that this may have been an active site of hydrothermal activity and thus of astrobiological importance.

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