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David Baratoux, Aline Gendrin, Patrick Pinet, John F. Mustard, L. Kanner,  
Frédéric Heuripeau, H. Clenet, Y. D. Daydou, J. Vaucher, Serge Chevrel, et  
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**TOWARD A 3-D VIEW OF THE MINERALOGY OF SYRTIS MAJOR TROUGH IMPACT CRATERING FROM OMEGA DATA.** D. Baratoux<sup>1</sup>, A. Gendrin<sup>2</sup>, P. Pinet<sup>1</sup>, J. Mustard<sup>2</sup>, L. Kanner<sup>2</sup>, F. Heuripeau<sup>1</sup>, H. Clenet<sup>1</sup>, Y. Daydou<sup>1</sup>, J. Vaucher<sup>1</sup>, S. Chevrel<sup>1</sup>, J.-P. Bibring<sup>3</sup> and the OMEGA Co-Investigator Team, <sup>1</sup>UMR 5562/CNRS/Toulouse III University, Midi-Pyrenees Observatory, 14 Av. E. Belin, 31400 Toulouse, France, Baratoux@ntp.obs-mip.fr, <sup>2</sup>Brown University, Planetary Geoscience Group, 324 Brook Street, Box 1846, Providence, Rhode Island, USA. <sup>3</sup>UMR8617/CNRS/Université Paris-XI, Institut d'Astrophysique Spatiale, 91405 Orsay, France

**Introduction:** The Syrtis Major province is a volcanic province with a complex stratigraphy and evolution [1]. Recent observations from OMEGA demonstrate that the Syrtis lava flows are enriched in High-Calcium pyroxene (HCP) compared to older Noachian crust that is more dominated by Low-Calcium Pyroxenes (LCP) [2]. Moreover, the enrichment in HCP is more pronounced for some lobate ejecta of impact craters. This observation suggests a variation of the mineralogy with depth. Impact craters excavate and redistribute in the ejecta material from depth beneath the impact. The goal of this project is to use mineralogical variations within the ejecta of individual craters and among ejecta from craters of different diameters to assess the mineralogical structure of this volcanic edifice. Recent studies at Meteor Crater [3] demonstrate that remotely sensed data can be used to map material from subsurface layer in ejecta. The thermal signature of some impact craters at Syrtis may also be directly inherited from impact and ejecta emplacement instead of being the result of post-impact erosion processes [4]. These results suggest that the mineralogical composition of ejecta observed by OMEGA may reveal the subsurface composition of Syrtis Major.

**Methodology:** The deconvolution of spectra are realized through Modified Gaussian Modeling [2] and we focus in this study on the band strengths associated with 2  $\mu\text{m}$  pyroxene absorption features considered as a proxy for relative LCP and HCP abundances.

**Radial variation of the ejecta mineral composition:** In order to derive the evolution of the composition radially to the crater within the ejecta layer, a few tens of radial profiles were derived for each of 24 craters greater than 5 km in diameter on Syrtis Major. The ejecta layer is often affected locally by wind streaks and/or ejecta of other craters. The profiles were selected to avoid potential difficulties arising from surface deposits not related to the pristine ejecta mineralogy. Then, in order to increase the signal to noise ratio, these profiles were interpolated and stacked to obtain a mean value of the band strength for LCP and HCP as a function of the distance from the center of the crater (Fig. 1). The standard deviation is given by the two curves above and below the mean values.

**Modeling ejecta composition:** We hypothesize that the radial variation of mineralogical abundances results from the mineralogical composition at depth, that is redistributed on the surface through excavation flow and ejecta emplacement. To first order, the excavation flow and ejecta emplacement can be predicted from Z-modeling [5] and ballistic trajectories. This first step should be considered as an approximation of the real composition of ejecta given a sub-surface structure. The excavation flow is known to be better represented by non-constant Z values. Ejecta emplacement on Mars is modified by oblique impact [6], atmospheric interactions and surface flow. Incorporation of superficial material during ejecta emplacement is known to occur from investigations at the Ries structure [7] and is neglected here. This last effect would decrease the proportion of deep material. The mineralogical abundances in the ejecta are derived by forward modeling of ejecta trajectories. The mineralogical structure is an input of the model and is described by the thickness of each layer associated with a modal composition.

**Observations:** First-order observations indicate two types of ejecta: HCP-rich and HCP-poor ejecta. Their distribution is enigmatic and HCP-rich ejecta are often found close to HCP-poor ejecta. HCP-rich ejecta present an axisymmetry in the mineralogical composition. Radial variations of mineralogical abundances are greater than variations at a given distance indicated by the standard deviation. This suggests that the evolution of the band strengths of pyroxene inside

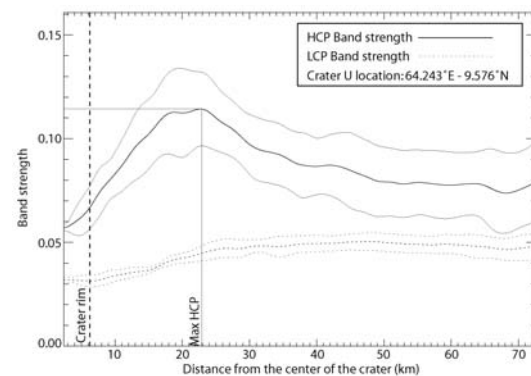


Fig. 1. Band strengths for one of the HCP-rich ejecta crater at few tens of kilometers from Nili Patera.

the ejecta layer are related to variations of mineralogical abundances inherited from the impact and ejecta emplacement. We notice that the HCP band strength presents a maximum at some distance of the rim and the LCP band strength gently increases outward, presenting sometimes a minimum close to the HCP maximum. These observations are systematic for all the HCP-rich ejecta, but the increase of the LCP band strength is considered at the limit of the methodology. The grain size may also affect the radial variation. The grain size distribution is expected to vary monotonically with an increasing amount of fine particles outward due to a stronger shock pressure for distal ejecta and can not be invoked alone explaining the HCP maximum. Thermal inertia of ejecta from night-time THEMIS images do not evidence any systematic radial variation of particule size except at the edge [4]. However, thermal inertia is sensitive to grain size for particles smaller than a few millimeters [8] and the possible contribution of a grain size effect has to be investigated.

**Interpretation:** The simplest sub-surface structure consistent with the gentle LCP increase outward and the HCP maximum is a three layer model with the HCP abundance presenting a maximum at few hundred meters depth (Fig. 2). We have no evidence for a correlation of the range of the maximum and crater sizes. No explanation can be given for the variation of the range of the HCP band-strength maximum with crater size and location but may reflect variations of the HCP-rich layer depth and thickness. The presence of HCP-poor ejecta in the vicinity of HCP-rich structures is difficult to explain by lateral variations in the mineralogical composition. 5 large craters have been dated using crater counting methods. We conclude that HCP-rich craters are all significantly younger than HCP-poor craters (Fig. 3). Older ejecta have been probably weathered to mask the pristine ejecta signature.

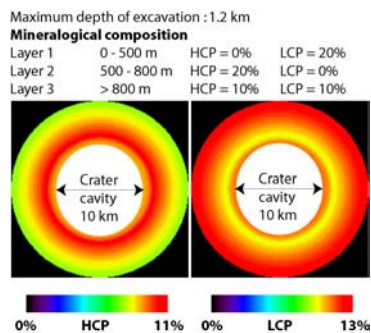


Fig. 2. Mineralogical abundances from a Z-model and ballistic trajectories. Sub-surface is described using 3 layers of different composition.

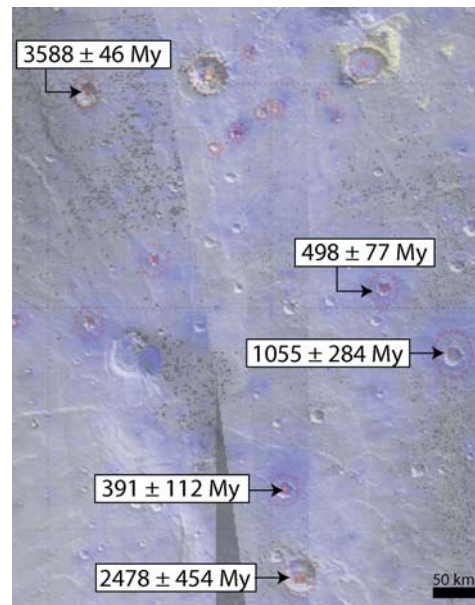


Fig. 3. Band strength map (blue = HCP, yellow = LCP) with ages of HCP-rich and HCP-poor ejecta.

**Conclusions:** Investigation of the mineralogical structure of Syrtis may require the use of only recent craters. Correlation between HCP signature and age suggests that old HCP-rich ejecta have been weathered. The weathering process could have been progressive and active over the last 3 billion years, or conversely more active in the past than now. This question will be addressed by studying the evolution of the HCP signature with time. A selection of the more recent craters for which the weathering effect of mafic minerals could be considered negligible is essential for the derivation of the sub-surface mineralogical structure of Syrtis. The confirmation of HCP enrichment at depth will stimulate discussions concerning the evolution of the magmatic edifice, the chemical evolution, emplacement and thermal history of magmas and magmatic chambers and the relation between magmatism and volcanism on Mars.

**References:** [1] Hiesinger et. al (2004) *JGR*, 109 (E01004) [2] Gendrin et. al, *LPSC XXXVII, this volume* [3] Ramsey. M.S. (2002) *JGR*, 107, E8. [4] Baratoux et al. (2005) *JGR.*, 100, E04. [5] Maxwell et. al (1977), in *Impact Explosion and Cratering*. [6] Anderson et. al (2004) *Meteoritics and Planetary Science*, 39, 2, 303-320. [7] Hertz et. al (1983) *Rev. of Geophys. and Space Physics* 21, 1667-1725. [8] Pelkey et. al. (2001), *JGR*, 106, E10.