

CRUSTAL COMPOSITION IN THE VICINITY OF VALLES MARINERIS, MARS, AS SEEN FROM THE CENTRAL PEAKS OF IMPACT CRATERS.

H. Clenet¹, C. Quantin¹, X. Ceamanos², J. Flahaut¹, P. Allemand¹, P. C. Pinet³ and Y. Daydou³, ¹Laboratoire de Géologie de Lyon, UMR CNRS 5276, Université Claude Bernard/Ecole Normale Supérieure de Lyon, France (harold.clenet@univ-lyon1.fr), ²Institut de Planétologie et d'Astrophysique de Grenoble, UMR CNRS 5274, Université Joseph Fourier, France, ³IRAP, UMR CNRS 5277, Observatoire Midi-Pyrénées, Université Paul Sabatier, France.

Introduction: Mineralogical composition is essential to further comprehend planetary evolution. As it is linked to mantle properties and crystallization conditions, the chemical composition of each mineral in the primitive crust is related to the igneous processes which have affected the planet. In this respect, detection of mafic minerals and characterization of their respective composition is used to evidence petrological history. In a second time, interactions with water have altered those primitive rocks. Resulting mineral assemblages depends on primary composition and on past environmental conditions. Integrated studies including both igneous and aqueous aspects are required to better understand Mars global evolution.

Because of the Fe^{2+} electronic transition effect, hyperspectral remote sensing in visible/near-infrared delivers very useful information for characterizing the petrology of igneous rocks. Olivine, orthopyroxene and clinopyroxene have diagnostic absorptions in the $1\mu\text{m}$ and $2\mu\text{m}$ wavelength domains and position of their minima are function of the Fe and Ca content [1,2]. In the case of hydrated minerals, vibrational absorption features related to H_2O and OH are used to identify the different species (e.g. [3]). Overtone shifts can also be observed depending on the mineral chemistry.

In the present work, we chose to focus on large impact craters central peaks that excavate material from depth [4].

Methodology: Data used in this study were acquired by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard the Mars Reconnaissance Orbiter (MRO) spacecraft. CRISM observations provide visible and near-infrared (VNIR) spectral coverage (0.32–3.92) with a maximum spatial resolution of ~ 18 m/pixel [5]. CRISM observations were processed as described in *Ehlmann et al.* [6] to account for atmospheric and photometric contributions. If needed, noise was removed using the despiking and destriping algorithms available under CAT 6.7 for TRR3 datasets [7]. Visible and near-infrared channels were also coregistered in order to use the entire available spectral domain.

To deconvolve hyperspectral data in terms of mafic compositions, we use the Modified Gaussian Model (MGM) originally developed by *Sunshine et al.* [8] and adapted by *Clenet et al.* [9,10]. MGM methods aim at

deconvolving the absorption bands in reflectance spectra. It is achieved considering a sum of Gaussian functions and assuming that the spectral continuum can be modelled by a polynomial shape. Each Gaussian function (characterized by its band center, width and strength) or combination of Gaussians permits the identification of a mineralogical absorption band, generally characterizing the predominant mafic minerals.

An automatic procedure involving different numbers of gaussians, depending on the potential complexity of the mixture, has been implemented on the original MGM approach [10]. The starting values for the continuum and the Gaussian strengths and widths are derived on the basis of a spectral shape smoothing analysis, determining the relevant local maxima along the spectrum. Relative coefficients applied to each gaussian parameters are estimated based on [11,12]. The uncertainties are set large enough to give a large degree of freedom on the parameters. Based on laboratory spectroscopic studies addressing separately pyroxene mixtures and olivine suite [2,8,11,12], the produced mathematical solutions are then sorted in order to keep only those which verify the mineralogical constraints. The resulting band parameters (center, strength, width) are finally used to interpret the spectrum in terms of modal abundances and chemical compositions [9,10]. Validation processes have been made on both laboratory and natural data [9,10,13].

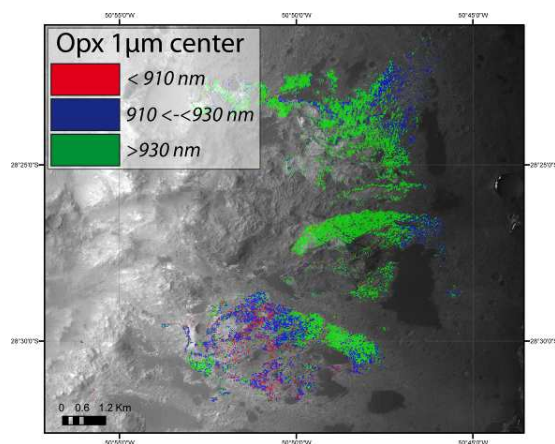


Fig. 1 – Orthopyroxene chemical composition mapping from MGM results in the $1\mu\text{m}$ domain (Ritchey central peak).

Hydrated minerals detection are those made by *Quantin et al.* [4] using summary parameters [14] and spectral ratioing.

Results: The seven possible configurations, i.e. the different mineralogical combination which can involve olivine and/or orthopyroxene and/or clinopyroxene, are systematically tested on each pixel of the CRISM image. Based on the validated configuration(s), the dominant mineralogy is found and the different units can be mapped (as in [9]).

Calculated Gaussians parameters are then studied to extract specific information on the minerals. Here we focus on pyroxene chemical compositions. We use the position of the absorption center to map variability into each central peak using data from [15]. Small variations can be found (e.g., Figure 1), showing no obvious link with morphology. This may be related to impact process or to different units in subsurface, as impact crater may have sampled rocks over several kilometers in depth. Craters without local variation of compositions can also be found.

At a regional scale, orthopyroxene chemistry seems to be linked to the depth of the sampled crust (Figure 2): the largest craters that have excavated the deepest part of the crust expose in their central peak the more enstatite-like signature. This type of pyroxene may represent martian primitive rocks (e.g. [16]). An increase of orthopyroxene Ca and/or Fe content is observed when looking at outcrops representative of shallower crust. According the up to date processed dataset, no disturbance of this trend is observed around Valles Marineris.

In the case of alteration products, smectite, putative hydrated silicates and putative serpentine have been detected in the observed central peaks. Serpentine are localised mainly in the northern part of the studied area while southeast craters are devoided of any hydrated minerals. Investigations about the possible relationship with igneous compositions or with past environments are ongoing.

Conclusions: Our automatic procedure based on the MGM now allows us to characterize small outcrops observed by CRISM. First results in crater central peaks show orthopyroxene dominant mineralogies associated to the old Noachian crust.

Investigations are ongoing on additionnal central peaks, as well as rock exposures in the walls of Valles Marineris. Their analysis should highlight the petrological history in the region considering the relation with crystallization conditions and help constraint past environmental changes.

References: [1] Burns R. G. (1993), *Cambridge Univ. Press, NY*. [2] Adams J. B. (1974), *JGR 79*,

4829-4836. [3] Clark R. N. et al. (1990), *JGR 95*, 12653-12680. [4] Quantin C. et al. (2011), *LPSC 42th*, #2342. [5] Murchie S. et al. (2007) *JGR 112*, E05S03. [6] Ehlmann B. et al. (2009), *JGR 114*, E00D08. [7] Parente M. et al. (2008), *LPSC 39th*, #2528. [8] Sunshine J. M. et al. (1990), *JGR 95*, 6955. [9] Clenet H. et al. (2010), *LPSC 41st*, #1656. [10] Clenet H. et al. (2011), *Icarus 213*, 404-422. [11] Sunshine J. M. and Pieters C. M. (1993), *JGR 98*, 9075. [12] Sunshine J. M. and Pieters C. M. (1998), *JGR 103*, 13675. [13] Clenet H. et al. (2008), *LPSC XXXIX*, #1918. [14] Pelkey S.M. et al., *JGR 112*, E08S14. [15] Cloutis E. A. and Gaffey M. J. (1991), *Earth, Moon and Planets 53*, 11-53. [16] Mustard J. F. Et al. (2005), *Science 307*, 1594-1597.

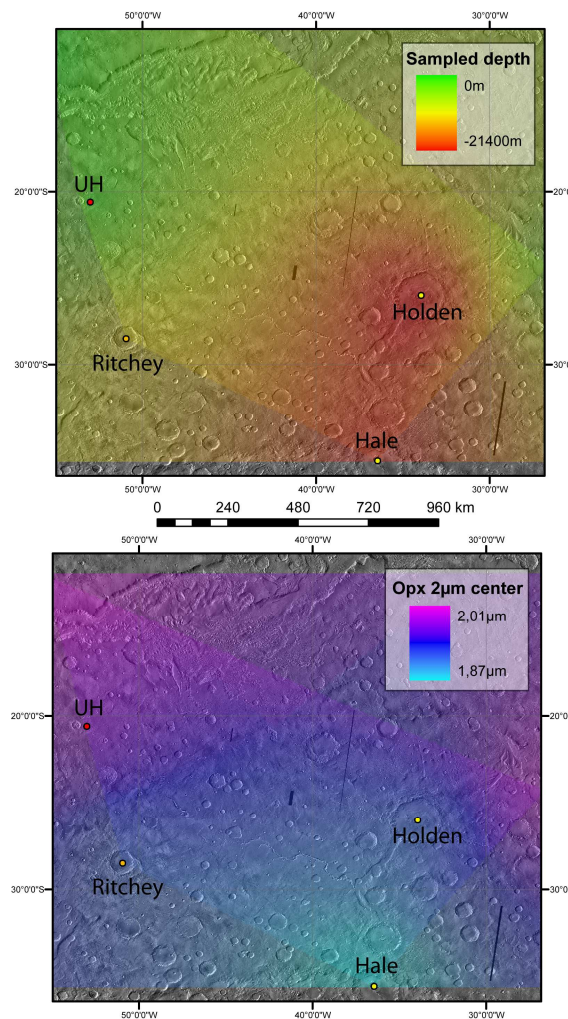


Fig. 2 – Comparison between the sampled depth of crust (top) and the crust chemical composition (bottom). At first order, variation in composition are only related to the variation in depth.