SPECTRAL DIVERSITY AND STRATIGRAPHY OF THE CLAY-BEARING UNIT AT THE EXOMARS 2020 LANDING SITE OXIA PLANUM. L. Mandon[1], A. Parkes Bowen[2], C. Quantin-Nataf[1], J. C. Bridges[2], J. Carter[3] and L. Pan[1], [1]Université de Lyon, UCBL, ENSL, CNRS, LGL-TPE, France (lucia.mandon@univ-lyon1.fr), [2]Space Research Centre, University of Leicester, United Kingdom, [3]Institut d'Astrophysique Spatiale, CNRS/Paris-Sud University, France.

Introduction: In 2021, the ExoMars rover Rosalind Franklin of the ESA and Roscosmos space agencies will start investigating Noachian terrains on Mars. The landing site has recently been selected to be Oxia Planum [1], a clay-bearing flat-land located at the Martian dichotomy on the margin of the Chryse Planitia basin. The site exhibits diverse evidence of a strong and pervasive aqueous history during the Noachian, especially a wide (>300 km) stratified and fractured clay-bearing unit of potentially sedimentary origin, and a younger deltaic deposit lying on the top of the clay-rich unit [2, 3]. The clay-bearing unit is exposed in more than half of the landing ellipse [2]. Detailed investigation into the origin and potential habitability of this Noachian aged clay-rich unit using a suite of analytical instruments is one of the main science objectives of the ExoMars rover mission. In this contribution, we investigate the stratigraphy of the fractured clay-bearing unit using Near-infrared (NIR) spectral data and demonstrate that it is composed of a stack of at least three different units in terms of morphology and composition. This allows us to discuss some formation scenarios for this widespread clay-bearing unit.

Datasets and processing: We acquired and processed all of the imagery datasets using the MarsSI application [4]. We used the High Resolution Imaging Science Experiment (HiRISE) color products to map exposures of the fractured clay-bearing unit and to assess its variability using high-resolution texture and color criteria. The spectral variability of the unit was investigated using the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) data acquired in the NIR spectral range between ~1.0 µm and ~2.6 µm. The spectral cubes were calibrated with MarsSI, which implements the CRISM Analysis Tool (CAT) pipeline developed by the CRISM team [5, 6]. Spectral cubes were calibrated to I/F and corrected from the atmospheric contribution with the volcano-scan method [7].

Results: *Stratigraphy of the fractured clay-bearing unit.* The clay bearing unit of Oxia consist of a homogeneous layered unit at least 50 m thick [3], extensively fractured and dominated by Fe/Mg-rich clays [2]. At high spatial resolution, especially in HiRISE visible color products, the unit exhibits textural and color variation. We identified a first member with meter to decameter-sized polygons and an orange to red hue on the HiRISE color images (Fig. 1). A second member is also identifiable and consists of a 10-20 meters-thick unit with decameter-sized polygons and a blue hue on HiRISE color products (Fig. 1). This second member is observed in different parts of the ellipse and always lying on the top of the main "red" member. The relative difference of color in HiRISE color product between the two members may be explained by a variation of dust cover, leading to more bluish layers when they are dusty. However, the two types of subunits have different morphologies, their distinct polygon sizes and always the same stratigraphic relationship. Hereafter, we refer to these subunits as the lower and upper members of the clay-bearing unit.

In the eastern part of the landing ellipse, just below the deltaic deposit and on top of the upper blue member, we identified a third member of the fractured layered unit. This unit is few meters-thick and appears blue in HiRISE with a more massive aspect and wide fractures. So far, this layer is observed only right below the deltaic deposit. As this unit is fractured while the deltaic deposit is not, we believe this layer belongs to the fractured layered unit.

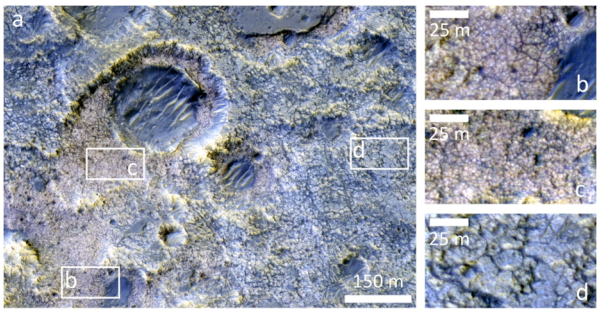


Figure 1. *High resolution morphologies and color variations of the clay-bearing unit, as seen in HiRISE color (IR-RED-BG) ESP_045378_1980.*

Spectral variation of the layered fractured unit. From NIR hyperspectral data, the lower member is associated with a spectrum whose overall shape and absorption band positions are consistent with Fe/Mg-rich phyllosilicate, the closest match being vermiculite [2] (Fig. 2). The several meters-thick layer below the delta is olivine-bearing, either of the fayalite-type or larger forsteritic grains (Fig. 2). The upper member of the clay-bearing unit, located in the stratigraphy above the lower

red member and below this olivine layer, seems to behave as a spectral mixture of these two endmembers enriched respectively in vermiculite and olivine (Fig. 2).

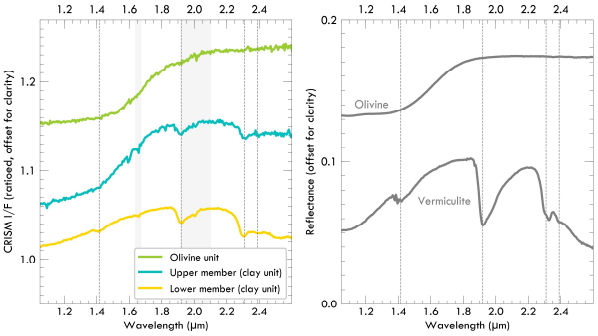


Figure 2. *CRISM targeted spectra of three distinct members of the fractured unit compared to laboratory spectra of known minerals (CRISM Spectral Library).*

Variation over the landing area. Outcrops of the fractured clay-bearing unit are widely distributed in the ellipse, to a wider extent than estimated by the previous clay spectral map [2]. The northern part of the ellipse in particular is extensively covered by superficial deposits that are probably masking any clay spectral signature, but the unit is clearly visible at high resolution outcropping at many places below this deposit. Consistently with our spectral examination at local scale, outcrops associated with the lower red member are located inside of the vermiculite spectral detections of [2], and outcrops located outside of these detections are more often associated with the upper blue member. The western part of the landing ellipse appears homogeneous and consists mostly of outcrops consistent with the lower red member subunit while the eastern part appears more diverse, with the two members often coexisting at the kilometer scale.

Discussion: The variability of polygonal patterns in the different subunits might be explained by various degrees of compaction during burial and/or a different rheology. The apparent spectral mixture between olivine and clay in the upper member can be indicative of spatial mixing, with olivine-rich sand concentrating in the fractures. As the lower and upper members exhibit different fracture sizes and patterns, a spatial mixing might be responsible for their spectral difference. In that case, it is not excluded that the clay-bearing unit shares the same rock composition between its lower and upper members, with olivine-rich sand filling the fractures in the upper member subunit. It could also be the result of true compositional mixture of clay and olivine in the bulk rock composition of the upper blue member. In that case the lower and upper member of the clay unit would have different compositions. Given the CRISM spatial resolution limitation at this scale of observation, it is challenging to conclude on this point. In the case that the lower and upper member have different rock compositions, what we observe is a smooth transition between the lowest visible parts of the fractured unit stratigraphy that are enriched in secondary minerals, and the top of the unit that appears less clay-rich from the orbit. Consequently, the Noachian fractured unit at Oxia Planum may have recorded a gradual transition of conditions during its deposition and/or alteration. [2] favored a pedogenic or lacustrine scenario for the formation of the clays. In the case that the unit was first formed via volcanic eruptions and was subsequently altered with pedogenesis processes, the change of composition would record a decline in the surface weathering rate. This would form low-leaching minerals in the early volcanic deposits, covered by rocks with primary, unaltered minerals and corresponding to the latest eruption events. If the fractured unit was formed by material deposition in a subaqueous environment, this would not necessarily imply a decline of the weathering rate. It would rather involve a decrease of the altered continental inputs and/or an increase of igneous materials, potentially linked with a volcanic activity.

From analysis of global datasets, vermiculite-type spectra happen to be the most representative of clay detections on Mars [8]. Investigation of the western part and center of the landing area, where the percentage of area with vermiculite-rich rocks is the highest, would provide insights into the alteration history of Mars. Investigation of a more diverse geology would be achieved by landing in the eastern part of the landing area, with the different subunits often reachable within a few hundreds of meters-drive. Examination of the diffuse contact between the lower and upper members of the fractured clay-bearing unit would be key observations to understand the continuous transition in Oxia Planum between deposition of a material that is now altered and a material that appears less clay-rich from orbit. Future investigation will rely on additional characterization and distribution of the fractured clay-bearing unit using the multispectral images recently acquired by the Colour and Stereo Surface Imaging System (CaSSIS) that cover the Oxia Planum region [9].

References: [1] Loizeau D. et al. (2019) *LPS L*, Abstract #2378. [2] Carter J. et al. (2016) *LPS XLVII*, Abstract #2064. [3] Quantin-Nataf C. et al. (2019), this issue [4] Quantin-Nataf C. et al. (2018) *PSS*, *150*. [5] Murchie S. et al. (2007) *JGR: Planets*, *112*, E05S03. [6] Pelkey S. M. et al. (2007) *JGR: Planets*, *112*, E8. [7] McGuire P. C. et al. (2009) *PSS*, *57*. [8] Carter J. et al. (2013) *JGR: Planets*, *118*, 4. [9] Parkes Bowen A. et al. (2019) *LPS L*, Abstract #1952.