

COMPLEMENTARY CRISM SPECTRAL SURVEY ON CLAY-BEARING OUTCROPS IN OXIA PLANUM, THE LANDING SITE FOR EXOMARS 2022 “ROSALIND FRANKLIN” ROVER. J. Brossier*, F. Altieri, M.C. De Sanctis, A. Frigeri, M. Ferrari, and Ma_MISS team. Institute for Space Astrophysics and Planetology IAPS, National Institute of Astrophysics, Rome, Italy (jeremy.brossier@inaf.it).

Introduction. ExoMars 2022 mission is scheduled to launch in 2022 and land on Mars roughly nine months later. It will deliver the *Rosalind Franklin* rover to explore Oxia Planum (18.2°N, 335.5°E), a region where biosignatures might be preserved [1]. Oxia Planum bears several morphological and mineralogical evidences of a long-lived aqueous (fluvial, lacustrine and deltaic) activity [2–5] (see Figure 1). Orbital data show extensive outcrops of ancient clay-rich rocks, thought to have been only recently exhumed [2]. These rocks will be accessible to the rover to search for traces of organic matter and possible biosignatures.

Recent analyses on Oxia’s clays [3] reveal narrow absorptions in the near-infrared range, around 1.4, 1.9, 2.3, and a weaker one at 2.4 μm , consistent with Fe,Mg-rich clays. A shallow absorption at 2.5 μm has been also detected, implying a possible mixture with carbonates or other smectites [3,6]. Knowing the precise positions of absorption band centers is crucial to confirm or infirm possible candidate phases, and also search for distinct clay mineralogies linked to differences in geochemical conditions, but also preservation or exhumation bias. Here we examine the infrared data to investigate the spectral signatures of Oxia’s clay-bearing outcrops. We concentrate particularly on the absorptions detected at 2.3, 2.4 and 2.5 μm .

Data & Methods. Spectral signatures of the clay-bearing outcrops are obtained from data collected by the CRISM instrument, with spatial resolutions of 20–40 $\text{m}\cdot\text{px}^{-1}$ and a spectral resolution of 6.6 nm [6]. For this study we use 12 CRISM cubes acquired in the near-infrared spectral range (1.0–3.9 μm), targeting Oxia Planum. They are first processed with CAT ENVI to go through a calibration into reflectance (I/F), a volcan-scan atmospheric correction and a basic photometric correction. Corrected cubes are then denoised (column-by-column ratio) to reduce noise and residual atmospheric contributions, to finally emphasize mineralogical absorptions in the ratioed spectrum [8]. Once the cubes are corrected and denoised, we define our regions of interest (ROIs) to outline Oxia’s clays. We calculate band depths at 1.9 and 2.3 μm [9] to select pixels with strong absorptions and map the ROIs for each cube (pink areas in Figure 1).

Spectral Survey. We retrieve the band centers for each pixel of the ROIs within the three ranges of interest (centered at 2.3, 2.4 and 2.5 μm), after continuum removal to emphasize the absorptions. The band center

does not strongly vary in the range centered at 2.3 μm (2.26–2.34 μm), with overall values spanning from 2.298 to 2.314 μm ($2.306 \pm 0.008 \mu\text{m}$). FRT810D cube shows an average band center of 2.305 μm , characteristic of Oxia Planum [2,3]. FRT9A16 cube shows an average band center at slightly longer wavelengths. Same procedure is used at 2.4 μm (2.36–2.44 μm range) and 2.5 μm (2.49–2.57 μm range). Both absorptions are relatively weak compared to the narrow absorptions at 1.4, 1.9 and around 2.3 μm . In the 2.4 μm range, the typical band center varies between 2.388 and 2.406 μm ($2.397 \pm 0.009 \mu\text{m}$), while it goes from 2.521 to 2.539 μm ($2.530 \pm 0.009 \mu\text{m}$) in the 2.5 μm range.

Possible Clays in Oxia Planum. CRISM cubes reveal several absorptions in the 1.0–2.6 μm range. Absorptions near 1.4 and 1.9 μm are common to hydrated minerals (OH/H₂O stretching), while an absorption near 2.3 μm indicates a (Fe,Mg)-OH vibration. Oxia’s clays are consistent with Fe,Mg-rich clays, combining absorptions at 1.41, 1.92, 2.30–2.31 μm and weaker overtones near 2.39–2.40 μm . Martian Fe,Mg-rich clays generally show spectral variability in the 2.3 and 2.4 μm ranges, from the Fe-rich (e.g., nontronite) to Mg-rich (e.g. saponite) compositional endmembers. Nontronites display typical absorptions near 2.28–2.29 μm and at 2.40 μm , while saponites have absorptions near 2.31–2.32 μm and at 2.39 μm . In Oxia Planum, intermediate band centers are consistent with either vermiculite or Fe-rich saponite [2-3, 10]. Band centers within the 2.3 and 2.4 μm ranges vary little throughout the region. Exact positions therein depend on the relative abundance of iron and magnesium in the clay structure, and oxidation state of iron.

Possible Mixture. All CRISM cubes studied here exhibit an additional, shallow absorption centered near 2.53 μm . It appears to correlate well with strong absorptions near 1.9 and 2.3 μm , and is therefore detected over the clay-bearing outcrops. Such an absorption in the 2.5 μm range indicates the presence of carbonates and/or other smectites (e.g., serpentines, chlorites) together with the Fe,Mg-rich clays [6]. Carbonates are usually best identified by paired absorptions at 2.3 and 2.5 μm , although these features are hidden by the clays (notably at 2.3 μm). An absorption centered near 2.53 μm would be consistent with Fe,Ca-rich carbonates (siderites, calcites), whereas an absorption at shorter wavelengths is often associated with

Mg-rich carbonates (magnesites or even dolomites) [11]. To complement this detection, we search for a specific pattern in the 3–4 μm range, where a broad peak near 3.6–3.7 μm is expected by deep absorptions (x-CO_3^{2-} vibrations) at 3.4–3.5 μm and 3.8–3.9 μm . A clear absorption near 3.4–3.5 μm is missing in our spectra, likely due to the deep water absorption near 3 μm induced by the clays, masking the carbonate absorption. This prevents a definitive identification and characterization of the carbonates. Nonetheless, we calculate a parameter [11] to highlight the feature characteristic of carbonates and support their co-occurrence with Fe,Mg-rich clays in Oxia Planum.

Conclusions. We provide supplemental information on the clay-bearing outcrops found in Oxia Planum, to complement recent analyses [2,3]: (1) report exact positions of the 2.3, 2.4 and 2.5 μm band depths, (2) locate possible shifts in the outcrops' spectra, and (3) better describe the 3–4 μm region. We also map the “freshest” clays in the targeted areas, in context with the morphology and topography. This allows for further investigations, from orbital data to laboratory experiments. Clays are detected in a light-toned fractured bedrock [3,4], where fractures exhibit different geometries and orientations [12]. In lab, terrestrial analogues

are being analyzed to test and prepare the Ma_MISS instrument [13], one of the nine instruments onboard *Rosalind Franklin* rover [14].

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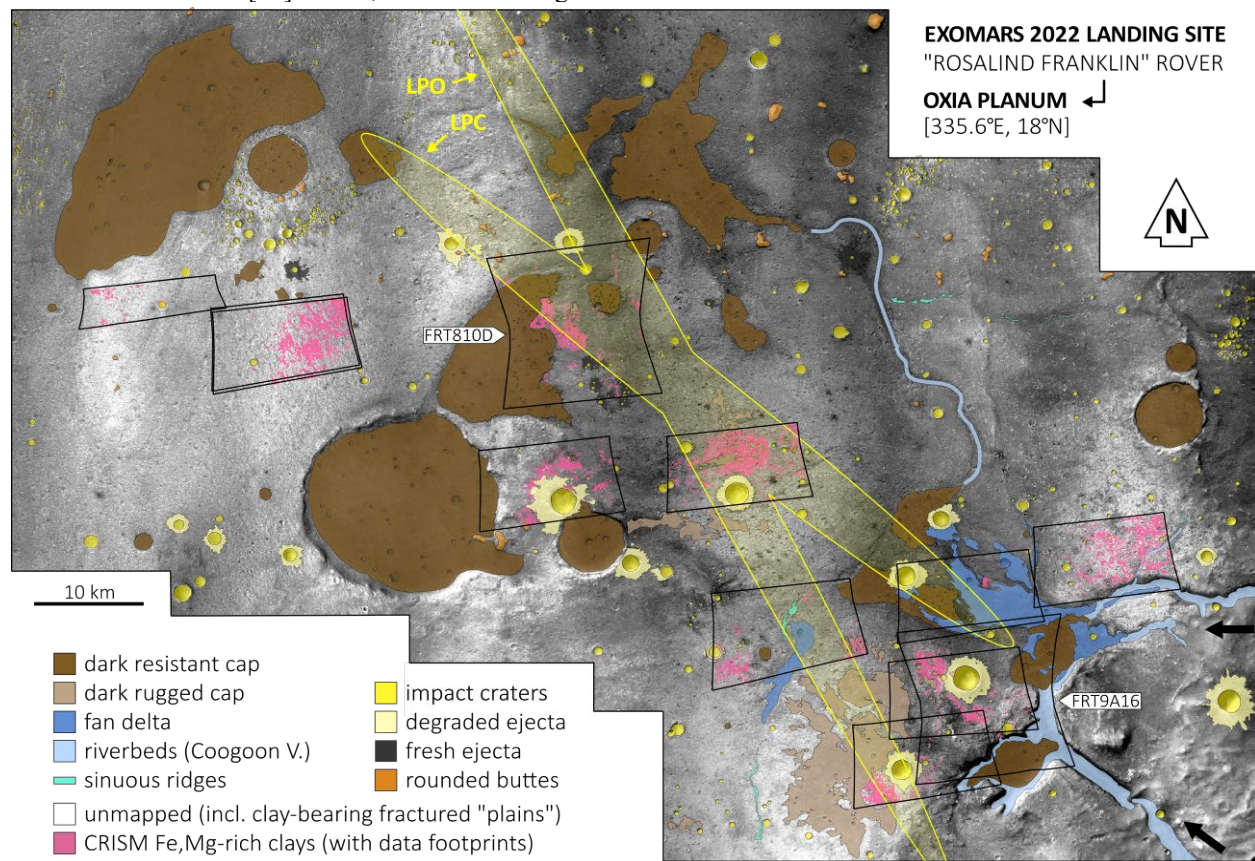


Figure 1 – Geologic map of Oxia Planum (18.2°N, 335.5°E). Morphological units are mapped from CTX imagery, like in [4,5]. Black footprints indicate the CRISM targeted data with clay-bearing outcrops (in pink).