EXTENT AND NATURE OF CLAY-RICH DEPOSITS, FROM OXIA PLANUM TO MAWRTH VALLIS.
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Introduction and Objectives: The study of clay-rich deposits is key to understanding past water activity on Mars and its early habitability potential. Strong phyllosilicate signatures have been identified over the Mawrth Vallis plateau based on the OMEGA instrument [1]. Similarly, large clay-rich deposits have been detected in Oxia Planum [2], the landing site of the Exo-Mars Rosalind Franklin rover mission. The rover aims to investigate the Martian surface and subsurface, with its two-meter-deep drill, searching for potential traces of past life preserved in these phyllosilicate-bearing units [3].

Aqueous alteration minerals from the selected landing site exhibit spectral features consistent with Fe/Mg-rich phyllosilicates, best fitted with vermiculite or saponite due to the position & shape of the 2.3μm absorption band, and a Fe2+ oxidation upward slope from 1μm to ~1.7μm [2]. These large clay units date back to the Noachian period [4].

300km northeast, clays found in Mawrth Vallis are consistent with montmorillonite (Al rich) and nontronite (Fe3+/Al rich) smectites, as indicated by spectral absorptions at respectively ~2.2μm and ~2.3μm, as well as their overall shape [5]. These units are also dated to the Noachian period [6].

The proximity of both sites and their similar position straddling the crustal dichotomy calls for the investigation of the relationship between these two significant phyllosilicate-bearing regions. Specifically, we seek to determine the extent of each clay unit (Mawrth Vallis type or Oxia Planum type) and explore potential connections between them.

Datasets: Given the expansive scope of our study area spanning from Oxia Planum to Mawrth Vallis (~600km from East to West, and ~700km from South to North), we used OMEGA hyperspectral data [7]. OMEGA offers extensive coverage of the region, with a resolution from ~300 to ~4000 m/pix and a 14nm spectrel resolution. We focused on the 1μm to 2.6μm region of the spectrum (part of the C-channel).

Method: We developed custom Python scripts to read and correct OMEGA cubes, and map spectral criteria, using open-source libraries such as omega-py [8]. Data extraction and spectral analysis were done using the free and open-source QGIS software. We also contributed to the EnMAP-Box plugin [9] by ensuring compatibility with OMEGA data and adding new features through git pull requests.

Cube corrections. Six correction steps have been implemented: (1) an atmospheric absorption band correction (“volcano-scan” method) [8,10]; (2) a Mars surface thermal contribution correction (gray body subtraction) [8,11]; (3) corrupted pixels and spectels are removed from the cube; (4) each spectrum is fitted and then divided by a linear regression continuum with tie points centered around 1.75μm and 2.14μm, where few clay minerals absorb [12]; (5) each spectrum is normalized by its maximum value to ensure a cube with homogeneous reflectance values and mitigate significant photometric effects resulting from changes in topography; (6) the local neutral mineralogy is removed using a “clean mean” method: first, the 2.3μm-drop spectral criteria is calculated (see the following section) on the cube corrected for up to 5 iterative steps, then, the median spectrum of a 50-pixel-squared region – where pixels positive to the 2.3μm criteria have been masked, hence the “clean” median – is calculated and subtracted from each spectrum. This step improves the detectability of phyllosilicate absorption bands, as their local “neutral” component is removed.

Spectral criteria maps. Spectral criteria are computed for each pixel of the final corrected cube. Our python scripts project the resulting 2D-array to ensure

Figure 1: 2.3μm-drop spectral criteria map on the corrected cube (1% threshold). Basemap: THEMIS-day.
accurate alignment in QGIS. We mapped the following criteria: 1.9\,\mu m band depth of most hydrated minerals [12], 2.2\,\mu m drop of Al-smectite [12], 2.3\,\mu m drop of Fe/Mg-phyllosilicates [12] which are strong clay signatures in both Oxia Planum and Mawrth Vallis (Figure 1), as well as HCP and LCP pyroxenes [13] (green areas in Figure 2).

**Regions of Interest (ROIs).** After generating criteria maps, we convert ROIs (i.e., clusters of contiguous pixels where the detection criterion is higher than a predefined threshold) to shapefiles using QGIS raster functions. Spectral analysis over a ROI is enabled by our contribution to the EnMAP-Box Plugin [9]: by selecting one (or multiple) polygon shapefiles, we can compute the median spectrum of this zone – with an increased signal-to-noise ratio compared to single-pixel analysis. Figure 2 shows spectra from four ROIs.

**Results and Interpretation:** Our 2.3\,\mu m drop criterion map aligns with existing phyllosilicate maps of Mawrth Vallis and Oxia Planum (Figure 1) [14]. Spectral analysis reveals two distinct clay types, as introduced earlier: the “Oxia Planum”-like (red in Figure 2), with its Fe$^{2+}$ oxidation feature and 2.3\,\mu m drop followed by a plateau; and the “Mawrth Vallis”-like (blue in Figure 2) with its 2.2\,\mu m and 2.3\,\mu m drops followed by a downward slope.

**Oxia Planum clays in Mawrth Vallis and vice-versa.** We noticed two areas (ROI n°1 and n°4) exhibiting different characteristics than the region they belong to. Spectrum n°1 (in Mawrth Vallis) shows Oxia Planum-like features: Fe$^{2+}$ upward slope up from 1\,\mu m to 1.6\,\mu m, and the position & shape of the 2.3\,\mu m absorption. Reflectance bumps at 1.6\,\mu m (instead of 1.7\,\mu m) and 2.6\,\mu m (instead of a plateau) can be explained by the presence of pyroxenes in this ROI, which lies above a green zone, as seen in Figure 2. Spectrum n°4 (in Oxia Planum) shows the same shape & absorptions as the Mawrth-Vallis one (n°3). Spectra n°2 and n°3 show less spikes, as signal-to-noise ratio increases with the square root of the pixel count.

**Lava flows covering clays?** Clay detections seem to be anticorrelated with dust (dark shades in Figure 2) and, often, pyroxenes (or with traces of it in their spectra, as in n°1). CTX imaging also reveals wrinkle ridge morphologies over green spots, suggesting that lava flows may have covered ancient clay-rich areas between Oxia Planum and Mawrth Vallis. Layered crater walls, observed with HiRISE, seem to confirm the presence of clays between these two major regions – more closely related than we initially believed, but showing signs of a different ancient aqueous history. We now aim to decipher if there is a stratigraphic relationship between the two types of clays and, later on, broaden the scope of our study to the clay-rich borders of Chryse Planitia.


![Figure 2](image-url)

Figure 2: Mawrth Vallis (blue) and Oxia Planum (red) clay-types over pyroxenes (green). Basemaps: OMEGA dust emission [15] (greyscale in transparency) over THEMIS-day.