Noachian Mars: Clay Continuity between Oxia Planum and Mawrth Vallis.

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Scope of the study: The study of clay-rich deposits, or phyllosilicates, is essential for reconstructing past water activity on Mars, assessing its early habitability potential, and understanding broader implications for the planet's climatic evolution. Strong phyllosilicate signatures from the Noachian period have been identified along Chryse Planitia margins using data from the OMEGA [1] and CRISM [2] instruments. Two key sites along the dichotomy exhibit major clay absorption signals: Mawrth Vallis and Oxia Planum, approximately 300km apart (see Fig.1). The latter was selected as landing site for the ExoMars Rosalind Franklin rover mission. The rover will 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].

The proximity of Mawrth Vallis and Oxia Planum, along with their similar position straddling the crustal dichotomy, calls for an investigation of their stratigraphic relationship to reconstruct the sequence of multiple aqueous alteration episodes in the region. We used hyperspectral datasets from the OMEGA and CRISM instruments, applied corrections to the data cubes, and developed new clay-specific criteria.

The resulting spectral maps were integrated with optical imagery from CTX [4] and HiRISE [5] to investigate the relationship between spectral signatures and clay-related morphologies. Finally, we overlaid the maps onto CTX-derived topography to construct cross-sections and infer the stratigraphic relationships between distinct clay-bearing units.

Our research shows that Oxia Planum clays are stratigraphically beneath the Mawrth Vallis ones.

Spectroscopy: Mapping Oxia Planum-type and Mawrth Vallis-type clays with new criteria.

Aqueous alteration minerals from the selected landing site exhibit spectral features consistent with Fe/Mg-rich phyllosilicates, best fitted with vermiculite or saponite (hereafter referred to as "OP-type" clays) due to the position & shape of the 2.3µm absorption band, and a Fe2+ oxidation upward slope from 1µm to ~1.7µm [6,7].

Clays found in Mawrth Vallis are instead consistent with montmorillonite and kaolinite (Al rich) as well as nontronite (Fe3+/Al rich) smectites (hereafter referred to as "MV-type" clays), with spectral absorptions at respectively ~2.2µm and ~2.29µm, as well as their overall shape [8].

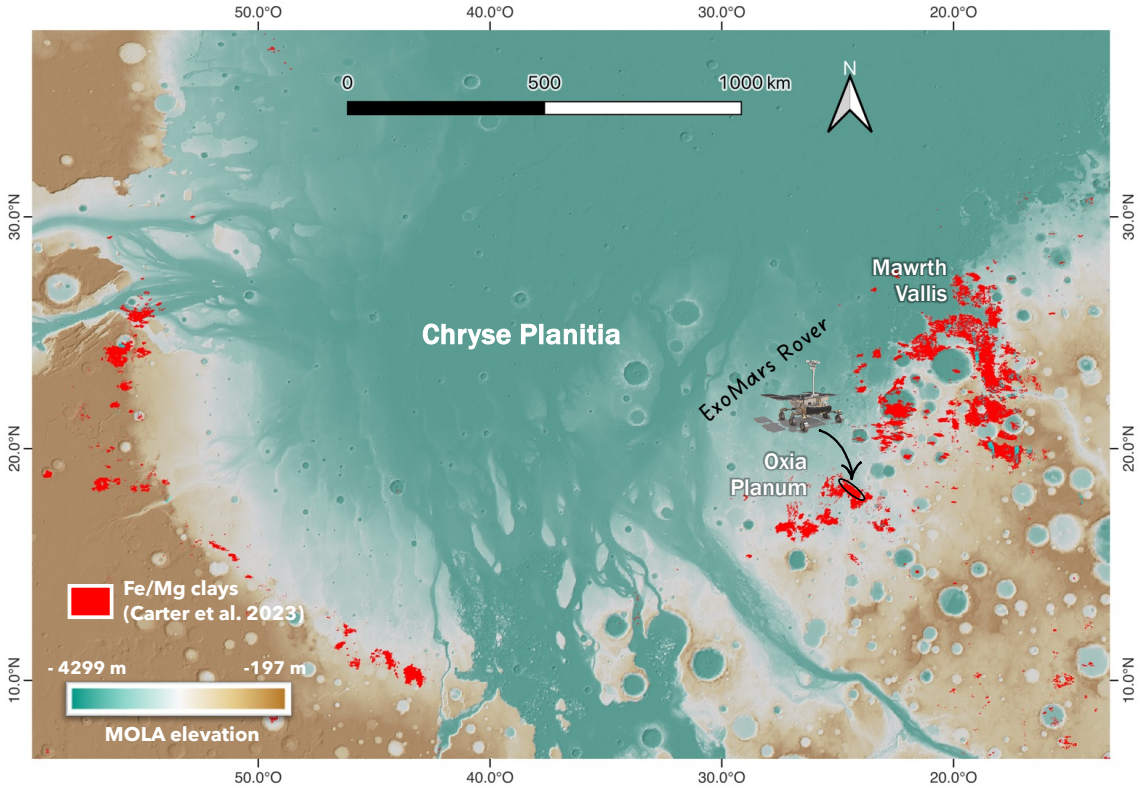

Fig.1 : Context map of Chryse Planitia and Fe/Mg clay exposures.

However, local anomalies exist: OP-type clays were found in Mawrth Vallis, and vice-versa. We developed spectral criteria to differentiate OP-type of clays from the MV-type ones based on the description above: ferrous slope, shape and minimum of absorption around 2,3µm.

Morphology & Stratigraphy: An OP-type paleosurface lying beneath the MV-type clay unit. Patches of a fractured and cratered paleosurface were identified in Mawrth Vallis by Loizeau et al. (2020) [9]. The surface is dark in albedo, with many craters sometimes infilled with a lighter toned unit (see Fig.2). By overlaying our spectral maps onto these paleosurface footprints, we found that they correspond to the OP-type clay signature. Additional paleosurface patches with similar characteristics were identified in Mawrth Vallis. Cross-sections derived from CTX elevation data confirm that the paleosurface lies beneath the MV-type clay units.

These findings suggest the identified paleosurface represents the upper boundary of an OP-type clay unit, underlying the MV-type clay deposits. The depositional hiatus between these discontinuous units is marked by remnants of paleocraters, where OP-type craters (brown) are partially infilled with MV-type material (yellow) (see Fig. 2).

Figure 3 summarizes the proposed sequence of events that formed both clay-bearing units.

Conclusion: Clay-specific criteria developed in this study, supported by the identification of Loizeau et al. (2020)'s paleosurface matching the OP-type spectral signature, suggest: (1) a stratigraphic continuity between OP-clay deposits in Oxia Planum and the base of Mawrth Vallis; (2) OP-clays may represent a widespread regional or global deposition event; and (3) a significant time gap allowed the formation of a cratered paleosurface before the deposition of younger Mawrth Vallis units. Ongoing work aims to refine mapping and quantify this depositional hiatus.

References: [1] Bibring, J.-P. *et al.*, *Science* **307**, 1576–1581 (2005). [2] Murchie, S. L. *et al., J Geophys Res Planets* **114**, (2009). [3] Vago, J. L. *et al.*, *Astrobiology* **17**, 471–510 (2017). [4] Malin, M. C. *et al., J Geophys Res Planets* **112**, (2007). [5] McEwen, A. S. *et al., J Geophys Res Planets* **112**, (2007). [6] Carter, J. *et al.*, in *47th Annual Lunar and Planetary Science Conference* 2064 (2016). [7] Quantin-Nataf, C. *et al.*, *Astrobiology* **21**, 345–366 (2021). [8] Bishop, J. L. *et al.*, *Science (1979)* **321**, 830–833 (2008). [9] Loizeau, D. *et al.*, *Icarus* **205**, 396–418 (2010).

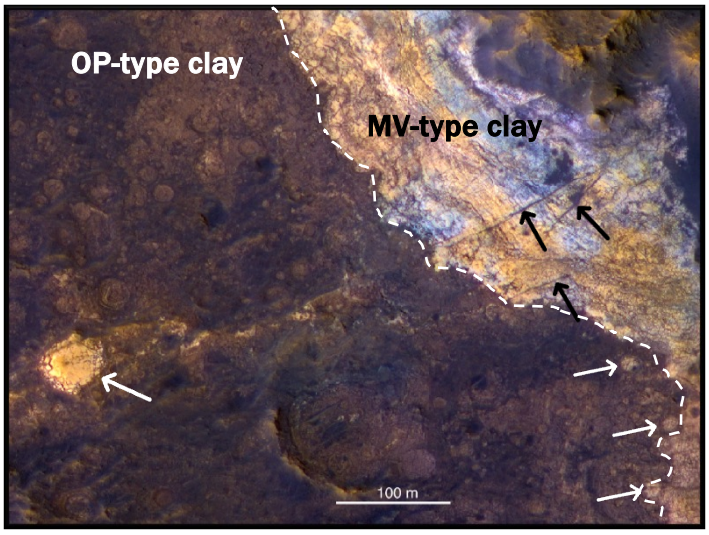

Fig.2 : Morphologies of OP-type, MV-type clays, and the paleosurface described in [9].

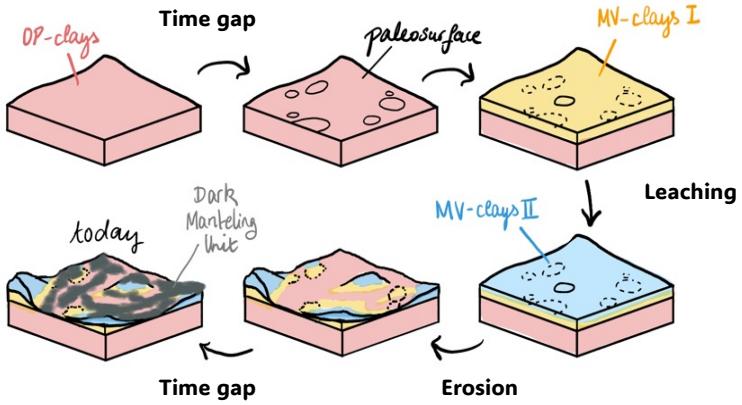

Fig.3 : Proposed sequence of events.