NOACHIAN LANDSCAPE EVOLUTION AT THE DICHOTOMY BOUNDARY: INSIGHTS FROM MAWRTH VALLIS. J.D. McNeil[1*], P. Fawdon[1], M.R. Balme[1], A.L. Coe[2], S.M.R. Turner[2], [1]School of Physical Sciences, The Open University, Milton Keynes, MK7 6AA, UK; [2]School of Environment, Earth and Ecosystem Sciences, The Open University, Milton Keynes, MK7 6AA, UK, *joe.mcneil@open.ac.uk

Introduction: The highland plateaus surrounding Mawrth Vallis expose hundreds of meters' thickness of mineralogically diverse, phyllosilicate-rich strata which reveal a complex, multi-phase alteration history and chronicle several hundred million years of Mars' earliest aqueous environments [e.g. 1–5]. The lateral and stratigraphic extent of crustal alteration is well-documented in these plateaus [2]. However, the abrupt termination of these plateaus at the hemispheric dichotomy boundary means that the variation in composition, stratigraphy, and the overall shape of the Noachian landscape north of the dichotomy, has mostly been lost. Thousands of isolated, kilometre-scale buttes, mesas, and inselbergs ('mounds') are found in the lowland areas around Mawrth Vallis, and are continuous with a circum-Chryse population of landforms that extends south around the basin [6, 7] (Fig. 1). We explored the composition, stratigraphy, and geometry of mounds along ~150 transects extending NNW from the highlands into the lowlands. Here, we present the relationship of the mounds to the highland plateau, and discuss their importance in the aqueous evolution of the Chryse Planitia basin.

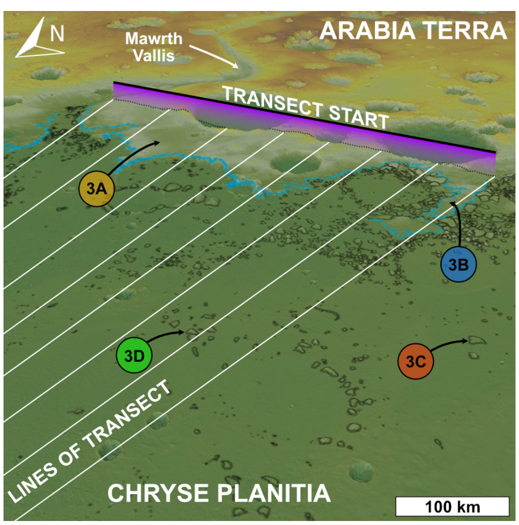

Fig. 1: HRSC MC-11 DTM showing the geography of the Arabia-Chryse dichotomy region, including mounds (black), Mawrth Vallis, and the surrounding highland plateaus. Selected elevation transects (white) and the transect start (purple hue) locations are shown. Stacked transects are shown in Fig. 2. Spectra obtained from the plateau, margin, and mounds are shown in circles, and link to Fig. 3.

Stacked Basin Transect Geometry: To compare the shape of the highland landscape with the mound population, we stacked together the ~150 transects, which show the propensity of elevations to occur at a given distance along the transect length (Fig. 2). In addition, we mapped the location all occurrences of bright-toned, layered exposures in mounds east of Ares Vallis and west of Mawrth Vallis, and analysed CRISM cubes from the plateau-top to determine the elevations and types of phyllosilicates present. Superposing the bright-toned mound exposures and plateau phyllosilicate detections on the stacked transects reveals that the total thickness of both the bright-toned mound exposures and the Fe/Mg and Al-rich phyllosilicate-bearing sections of the Mawrth Vallis plateau are approximately 500 m, and that they show geometric parity (Fig. 2). This, along with the morphostratigraphic similarities in layered exposures in both exposure locations, implies that the mounds once formed a contiguous part of the Mawrth Vallis plateau.

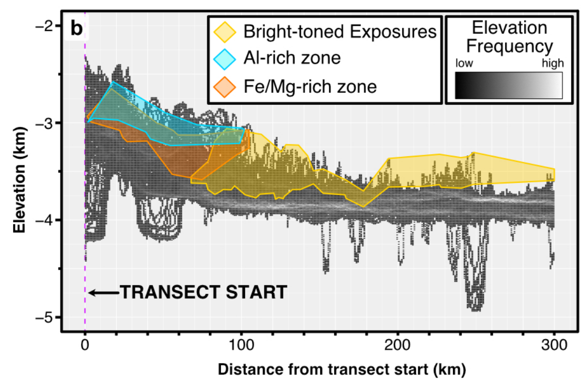

Fig. 2: Stacked transect of the Mawrth Vallis region, showing the topography of the plateau, mounds, and plains. Overlain are the elevations and ranges of Fe/Mg- (orange) and Al-rich (cyan) phyllosilicate mineral detections on the plateau and bright-toned regions of mounds (yellow).

Lateral and Stratigraphic Compositional Variance: To assess the basin-scale lateral and stratigraphic variations in mound composition, and to compare the composition of the mounds with the Mawrth Vallis plateau, we processed and analysed hyperspectral CRISM cubes covering mounds, the plateau, and nearby highlands using the CRISM Analysis Toolkit v7.4 extension to ENVI and the standard analytical approach used in [8–10]. Spectra acquired from bright-toned areas of mounds ubiquitously exhibit absorptions around 1.4, 1.9, 2.3 and 2.4 µm, indicating that they contain Fe/Mg-rich phyllosilicate minerals [e.g. 3, 8] (Fig. 3). The positioning of the 1.4 and 2.3 µm M-OH bands [e.g. 8] in almost all mound examples is consistent with Fe/Mg-rich smectites, with Mg-rich compositions indicative of saponite and vermiculite being most common (Fig. 3).

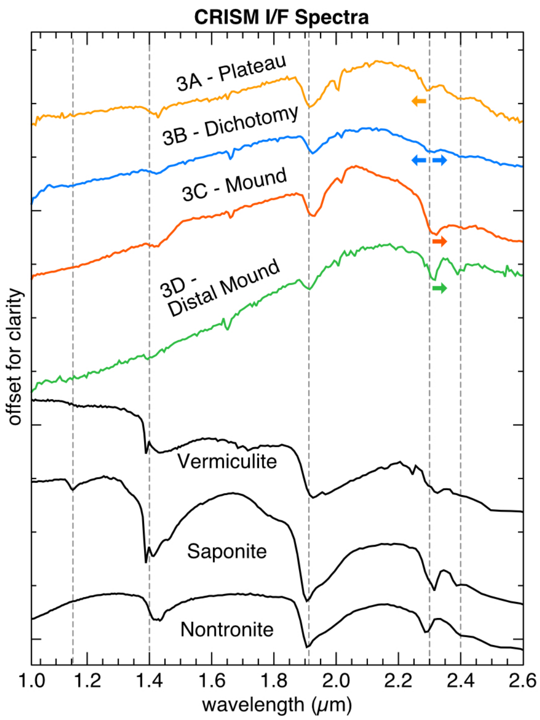

Fig. 3: Representative I/F CRISM spectra of a dichotomy-distal (FRT0000BB21) and dichotomy-medial mound (FRT0000C674), the dichotomy margin (FRT00009CAE), the Mawrth Vallis plateau (FRT0000C18E), and reference spectra for vermiculite, saponite, and nontronite (GDS13_Llano, SapCa-1, and NG-1.a respectively) [11]. Arrows indicate position of 2.3 µm band.

Detections of Mg-rich phases (e.g., saponite, ferrosaponite, or vermiculite) occur more readily in dichotomy-distal mounds; conversely, as is recognised in the literature [e.g. 2, 4], phyllosilicates in the Mawrth Vallis plateau are relatively more Fe-rich, and are typically a match for nontronite. Mounds near the dichotomy boundary are intermediate between the two, or contain both Mg- and Fe-rich phases. This indicates that phyllosilicate geochemistry is affected (or controlled) by geographic location and that the mounds have a different alteration history to the plateau. In addition to these lateral variations in phyllosilicate composition, we also observe stratigraphic changes. A ~450 m tall mound approximately ~300 km NW of the plateau exposes ~300 m of finely stratified, bright-toned material yielding a saponite spectrum at its base and ferrosaponite in its medial and upper sections. This clay-rich unit overlies ~80 m of unaltered, coarsely layered, low-Ca pyroxene-rich material, and is in turn unconformably draped by a thin, spectrally bland ‘capping’ material. The clay-rich and capping units are stratigraphically identical to those seen in the Mawrth Plateau. This mound therefore provides the first reported observation of the base of the Mawrth Vallis plateau sequence in Chryse Planitia. In addition, because it is the only location in the circum-Chryse region where altered material is interposed within unaltered material, it records the Noachian climatic transition; from dry and mafic at its base, through varied aqueous conditions in its clay-rich section, through to highly erosive (to form the mound), and finally to the emplacement of a non-hydrated capping unit (probably deposited as ashfall [4, 12]), which marks the end of significant aqueous alteration in the circum-Chryse region.

Conclusions: This research shows that the mounds here are eroded remnants of the Mawrth Vallis plateau deposit, and provide a comprehensive, well-exposed archive of Noachian activity at the hemispheric dichotomy boundary. Not only do the mounds indicate the original extent of the deposit, but geochemical and stratigraphic variations across the population also record the erosional and aqueous history of the martian landscape in this important transitional region, showing that alteration was occurring hundreds of kilometres north of the dichotomy in the Noachian. The amount of material eroded from above and around the mounds also demands widespread geomorphic processes to have occurred at this time. Our findings offer insight into the nature of the emplacement, modification, and partial destruction of the circum-Chryse phyllosilicate-bearing deposit, and the evolution of the martian dichotomy in this astrobiologically important location [12].

References: [**1**] Loizeau et al., 2007, J. Geophys. Res., 112, E08S08; [**2**] Noe Dobrea et al, 2010, J. Geophys. Res., 115, E00D19; [**3**] Bishop et al., 2013, *Planet. & Space Sci.*, vol. 86; [**4**] Loizeau et al., 2012, *Planet. & Space Sci.*, vol. 72; [**5**] Wray et al., Geophys. Res. Lett., 35, L12202; [**6**] McNeil et al., 2021, *JGR: Planets* vol.126, iss.5; [**7**] McNeil et al., 2022, *JGR: Planets* vol.126, iss.11; [**8**] Ehlmann et al., 2009, *J. Geophys. Res.,* 114; [**9**]; Milliken et al., 2010, *Geophys. Res. Lett.*, 37; [**10**] Turner et al., 2016; *JGR: Planets* vol.121, iss.4; [**11**] USGS Spectral Library Vol. 7, 2017, *U.S. Geological Survey*; [**12**] Poulet et al., 2020; *Astrobiology* vol.20, iss.2.