WINDOWS INTO NOACHIAN MARS: ERODED LANDFORMS IN CHRYSE PLANITIA AND THE EXOMARS ROVER LANDING SITE. 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 southern margin of Chryse Planitia is the location of more than ten thousand kilometre-scale, isolated, upstanding landforms ('mounds') which resemble terrestrial erosional features such as mesas, buttes, inselbergs and hills (Fig. 1). These mounds are thought to be the erosional remnants of a Noachian-aged circum-Chryse deposit which was up to 500 m thick in places [1]. The propensity for mounds to demarcate the rims of buried impact structures, pervasive fracturing seen throughout the population, and hydrated clay minerals within bright-toned mound flanks indicate that the original deposit interacted with water, prior to erosion into mounds [1]. Excitingly, examples of these mounds are present in and around Oxia Planum, the landing site of ESA's ExoMars 2022 Rover, '*Rosalind Franklin*' [2, 3, 4]. In our study, we have (1) investigated the nature of the mounds in Oxia Planum, (2) analysed CRISM spectra from mounds across the wider circum-Chryse region.

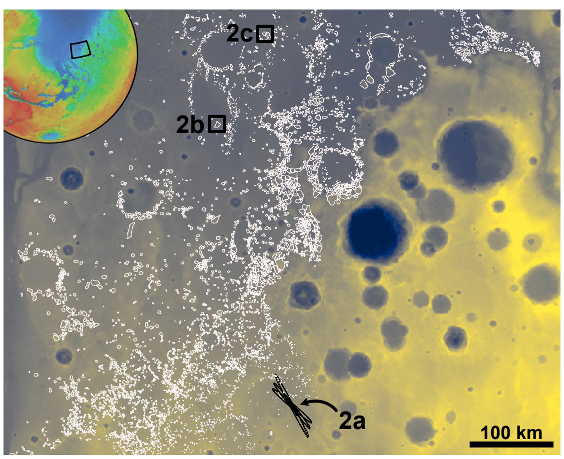

Fig. 1: Locations of circum-Chryse mounds (white) on HRSC [5] DTM. Labels indicate Fig. 2 positions.

Oxia Planum Mounds: In Oxia Planum, we observe that the mounds are bounded by unconformities; the unconformity below the mounds represents a Noachian palaeosurface atop the clay-bearing plains, and the unconformity above represents periods of intense erosion. In Oxia Planum, the original mound-forming layer had a thickness of approximately 140 m – considerably thinner than elsewhere around the circum-Chryse margin [1]. This overburden would not have provided enough vertical stress to hydraulically fracture the underlying clays, suggesting a different deformation mechanism was responsible, or that other unknown materials were emplaced and then removed. The minimum erosion rates for the mounds are comparable to previous Noachian erosion estimates [6], which supports the notion of a more erosive (likely warmer and wetter) past environment than today's. Clay-bearing plains adjacent to remnant mounds are most likely to have been recently exhumed from beneath the mound-forming layer; these represent some of the Rover's best chances of detecting biosignatures in recently exposed surfaces.

Chryse Planitia Mounds: Mounds further out in Chryse Planitia are typically much larger than those in Oxia Planum, so provide opportunities to observe larger-scale geologic features and stratigraphic architectures in their flanks. The primary mound-forming unit is exposed in places where the regionally pervasive mound-capping unit has been eroded away. Usually cropping out as smooth, slope-forming mound-flank topography or through erosional windows at the tops of mesas, the mound-forming unit is immediately recognisable due to its characteristic bright white to off-white tones (Fig. 2). Its appearance is highly variable: it is commonly layered at the metre-scale to the limit of HiRISE [8] resolution, often exhibits multiple fracture styles indicative of different tectonic modes, and is crater-retaining, yet is more sparsely cratered than the capping and embaying units which clearly postdate it. Hyperspectral CRISM [8] data were processed and analysed using the standard approach used in [9, 10, 11]. CRISM spectra acquired from bright-toned areas of mounds almost ubiquitously exhibit absorptions around 1.4, 1.9, 2.3 and 2.4 µm, indicating that they are primarily composed of Mg/Fe-rich phyllosilicates [e.g. 9, 12] (Fig. 2). The 1.9 µm band is broad and ubiquitous, indicating the presence of molecular water in tetrahedral-octahedral-tetrahedral phyllo-silicates. The positioning of the M-OH bands in almost all examples are consistent with Mg/Fe smectites [9], with a more Mg-rich composition being more common. Vermiculite and saponite provide a match many of the spectra, but we cannot also rule out a saponite-vermiculite mix, a saponite-mica mix or another mixed-layer clay.

Mawrth and Oxia Outliers: Clay-bearing stratigraphy is visible in an erosional window atop a mesa in Chryse Planitia. Here, 10–15 metre-thick, blue-toned material containing decametre-scale fractures overlies thicker orange-red material containing smaller

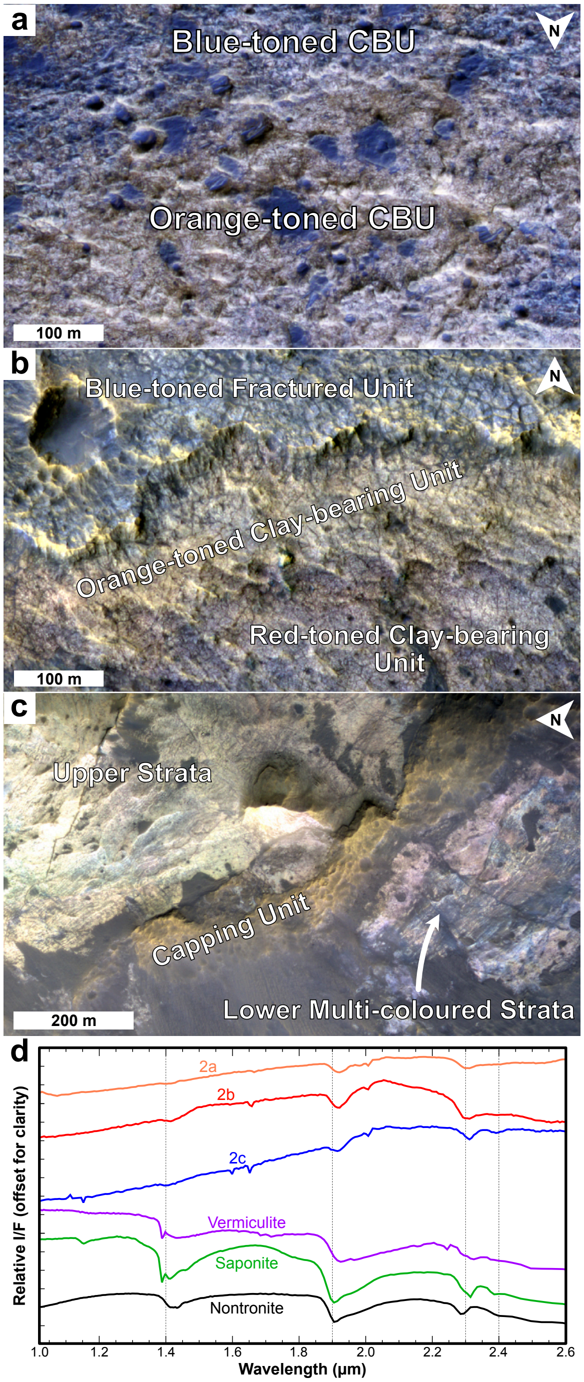

Fig. 2: HiRISE images of a) Clay-bearing units at Oxia Planum [PSP_009880_1985], b) Oxia-like clay-bearing strata atop a mound in Chryse Planitia [ESP_071806_2045], c) thick Mawrth-like deposits in a mound in Chryse Planitia [ESP_063905_2065]. d) CRISM spectra collected from each location (image ID a: FRT0000810D, b: FRT0000C674, c: FRT0000BB21) with reference spectra for Vermiculite, Saponite and Nontronite (GDS13_Llano_BECKa, SapCa-1_BECKb and NG-1.a_BECKb respectively) [13].

metre-scale fractures (Fig. 2b). The orange and red-toned sections of the exposure yield a strong Fe/Mg phyllosilicate signal in CRISM images (Fig. 2d), which we have interpreted as vermiculite or mixed-layer clays, similar to spectra observed in the orange clay-bearing unit in Oxia Planum [14, Fig. 2d]. Despite being >350 km from Oxia Planum and more than 400 metres lower in elevation (Fig. 1), these stratigraphic relationships and compositions [3, 14] are similar to the stratigraphy observed at Oxia Planum (Fig. 2a).

Similarly, a ~400 m tall mound which lies ~300 km from the mouth of Mawrth Vallis (Fig. 1) exhibits stratigraphic and spectroscopic similarities to the clay-bearing deposits of the Mawrth plateau. It is dominated by finely layered, fractured bright-toned material and yields a strong Fe/Mg smectite spectrum in CRISM (Fig. 2c,d). This spectrum is a close match to ferrosaponite and is clearly different to the spectrum acquired from the aforementioned “Oxia-like” mesa. Due to its location, its compositional and morphologic similarities with the Mawrth Vallis clay-bearing strata [12], and its overlying of unaltered material clearly different to it, we interpret the MFU in this mound to be an outlying exposure of the base of the “Mawrth plateau” stratigraphy.

Conclusion: The mounds in the circum-Chryse region reveal a complex geologic history with multiple phases of deposition and erosion, as well as morphologic and compositional evidence for interaction with liquid water. Margin-distal mounds indicate the original extents of various clay-bearing deposits prior to erosion. Examples of margin-distal mounds with strata geomorphologically and compositionally similar to both Oxia and Mawrth are seen. These indicate the original pre-erosion extents of these highland deposits.

References: [**1**] McNeil et al., 2021, *JGR: Planets* vol.26, iss.5; [**2**] Vago et al., 2017, *Astrobiology* vol.17 iss.6-7; [**3**] Quantin-Nataf et al., 2019, *Astrobiology* vol.27 iss.3; [**4**] Fawdon et al., 2021, *Journal of Maps* vol.17 iss.2; [**5**] Jaumann et al., *Planet. & Space Sci.* vol.55, iss.7-8; [**6**] Golombek et al., 2006, *JGRE: Planets* vol.111 iss.12; [**7**] McEwen et al., 2007; *JGRE: Planets* vol.112 iss.5; [**8**] Murchie et al., 2007, *JGRE: Planets* vol.112 iss.5; [**9**] Ehlmann et al., 2009, *J. Geophys. Res.*, 114; [**10**] Milliken et al., 2010, *Geophys. Res. Lett.*, 37; [**11**] Turner et al., 2016; *JGR: Planets* vol.121, iss.4; [**12**] Bishop et al., 2013, *Planet. & Space Sci.*, vol. 86; [**13**] USGS Spectral Library Vol. 7, 2017, *U.S. Geological Survey*; [**14**] Mandon et al. 2021, *Astrobiology* vol.21 iss.4.