THE GEOLOGY OF ISOLATED LANDFORMS ON THE MARGIN OF CHRYSE PLANITIA, MARS

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Introduction: The margin of Chryse Planitia, Mars, contains > 10^5 kilometre-scale mesas, buttes, and plateaus ('mounds'), including ~100 examples in and around the ExoMars 2022 Rover landing site at Oxia Planum [1]. In our study [2, *in review*] we have analysed the morphologies, morphometries, and distribution of 14,386 mounds. We have (1) classified them into geomorphological categories (2) constrained when they formed based on their stratigraphic and spatial relationships; and (3) identified working hypotheses for their geological history. The origin of the mounds remains unknown [3], but understanding their origins and geological evolution is vital in placing the investigations conducted by the rover in a local and regional context, as well as gaining insight into the depositional and erosional processes that shaped this region in Mars' early history.

Morphology: Based on apex morphology, the mounds are categorised into four discrete classes: (1) *Hills* are isolated mounds that have a single prominent peak or smooth crest; (2) *Mesas* are isolated mounds that have a single contiguous plateau with no clear apex at their top; (3) *Clustered mounds* are mounds that have multiple hill peaks and/or mesa plateaus clustered together, but where the lower elevation areas between the apexes do not descend to the elevation of the surrounding plains; and (4) *Compound mounds* are mounds that have distinct tiers at different elevations. These classes are a reflection of the erosional state of the mounds; mesas and compound mounds are the least eroded examples, clustered mounds are moderately eroded, and hills are the most eroded examples (Fig.1).

Morphometry: Analysis of mound heights from MOLA [4] and HRSC [5] topographic data show that the elevations of the mounds increase with the surface area up to a maximum height of approximately 500 m at a mound surface area of 10 km^2. After this point, an increase in mound area does not correspond to an increase in mound height. We therefore interpret this 500 m threshold as the thickness of a previously continuous regionally extensive layer that superposed the ExoMars landing site at Oxia Planum, as well as the lowland areas on the margin of southern Chryse Planitia. The morphometry of individual mounds is also a reflection of their erosional state; hills are the smallest mounds, compound mounds are intermediate in height, and mesas and tiered mounds are the tallest examples (Fig. 2).

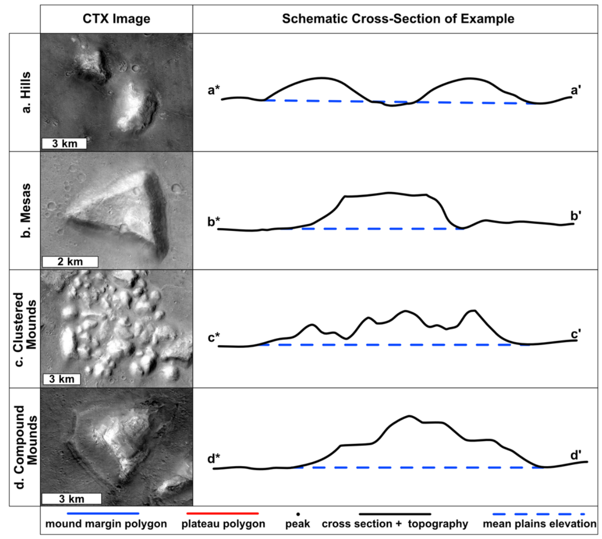

Figure 1: Classes of mounds found in the study area as shown in CTX, alongside schematic cross-sections.

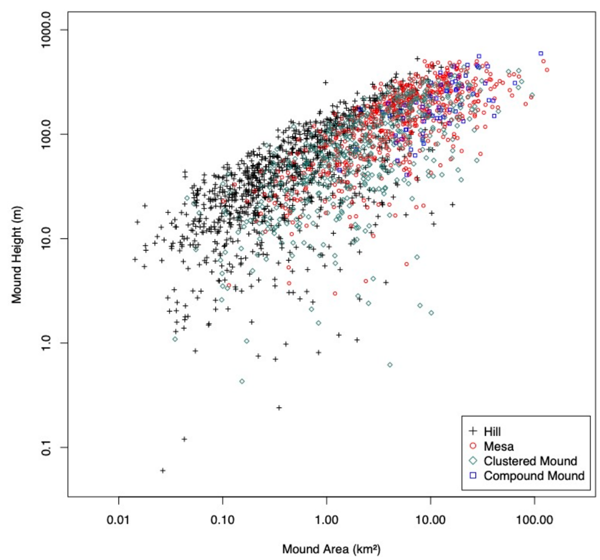

Figure 2: The relationship between height and area for 2366 mounds of different classes, derived from where MOLA points data intersected with bases and peaks of individual mounds. Note the propensity for hills to be small, clustered mounds to be intermediate, and mesas/compound mounds to be large, with the tallest and largest examples (>10 km^2) being a consistent ca. 500 m in height.

Stratigraphy: The mounds are embayed (and in some cases, completely buried) by the late Noachian-early Hesperian [6] dark plains material of Chryse Planitia, but overlie the upper surface of the early Noachian (Fig. 3a-b; [1]) clay-bearing material at Oxia Planum. These stratigraphic relationships constrain the deposition and erosion of the pre-mound layer to the early-middle Noachian, coincident with the initial deposition of the Mawrth Vallis plateau. In some mounds, metre-scale layering, inverted linear features and faults are seen, similar to those seen in the strata of the Mawrth Vallis plateau (Fig. 3c-d). This suggests there may be a genetic relationship between the two. This further implies that the clay-bearing strata that are a primary target for the ExoMars 2022 rover [7] are older than the part of the Mawrth Vallis phyllosilicates represented in the mounds. Given that the embayment of the mounds by the dark plains material occurred after the mound layer was eroded, the erosion must have taken place between the early-middle Noachian and the late-Noachian-early-Hesperian.

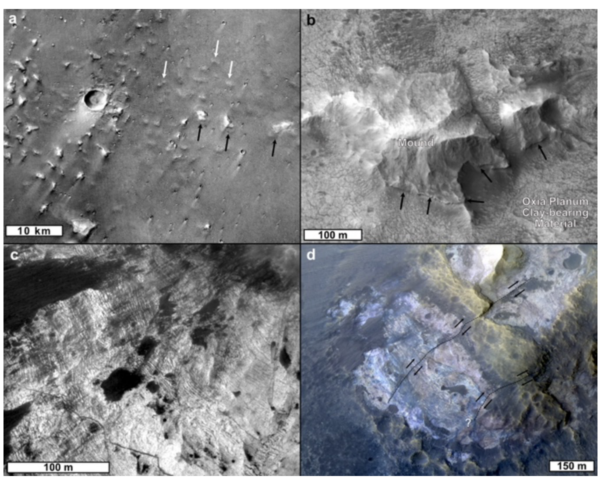

Figure 3: (a) CTX of mounds partially embayed (black arrows) or entirely buried (white arrows) by the dark plains material; (b) HiRISE of mound in Oxia Planum with clear contact (black arrow) on the underlying clay bearing material; (c) HiRISE of layering similar to Mawrth Vallis in mound ~150 km from Mawrth; (d) HiRISE of clay-bearing layers in the same mound. A fault with throw of ~60 m cuts through the strata; direction of movement shown by arrows.

Distribution: The distribution of mounds within the study area appears to be mostly random, however, some mounds occur in curvilinear arrangements or even arcuate patterns (Fig. 4). We interpret these arrangements as the locations of buried impact craters. The local distribution of mound-associated buried impact structures supports groundwater processes as part of the preferential preservation mechanism.

Processes: We propose that: (1) the crater-delineating and ridge-proximal mounds overlie regions of relatively more permeable fractured crust that once acted as a conduit for groundwater outflow; (2) mineral precipitation would therefore have preferentially affected the material overlying the fractured locations; and (3) once emplaced in the host layer, the precipitated minerals (e.g. iron oxides, carbonates or sulphates) would have improved the mechanical competence of these regions, making them more resistant to erosion a mound-formation model in which the precipitation of minerals by groundwater caused induration of the pre-mound layer, predominantly in areas superposing underlying crustal weaknesses such as at buried crater margins. Subsequent differential erosion of this layer in the Late Noachian-Early Hesperian left mounds in those areas where induration was most extreme.

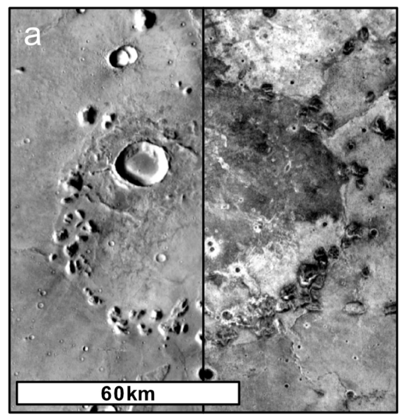

Figure 4: left: daytime infrared THEMIS and right: night time THEMIS infrared image of a 70 km-diameter quasi-circular arrangement of mounds, showing their characteristic low thermal inertia.

Conclusions: The population of mounds represent abundant 3-dimensional exposures of ancient sedimentary deposits that are likely to have formed in an aqueous sub-surface environment, potentially with the influence of groundwater and/or hydrothermal systems at a later time. Therefore, these mounds can provide information about the depositional environment of early Mars, as well as the habitability of these environments and their potential for preserving biosignatures.

References: [**1**] Quantin-Nataf et al., 2020; in press, Astrobiology, [**2**] McNeil et al.; in review, JGR: Planets, [**3**] McNeil et al., 2021; LPSC52 Abstr.#1417, [**4**] Smith et al., 2001; JGR: Planets Vol.106-E10, pp.23689-23722, [**5**] Jaumann et al., 2007; Planetary and Space Science 55, pp.928–952, [**6**] Tanaka et al., 2005; USGS, [**7**] Vago et al., 2017; Astrobiology Vol.17.