The Nature of Remnant Mounds on the Margin of Chryse Planitia

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Abstract #1948

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INTRODUCTION

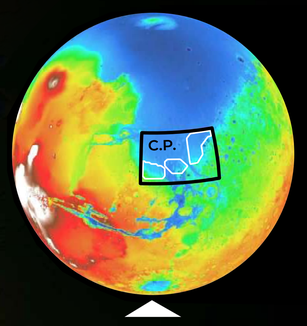
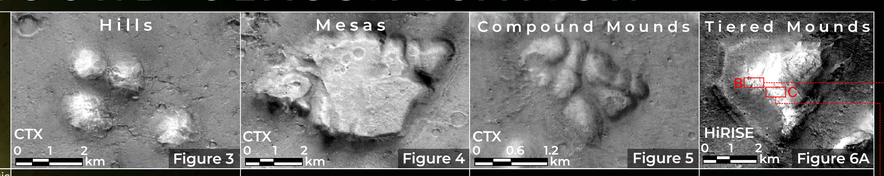


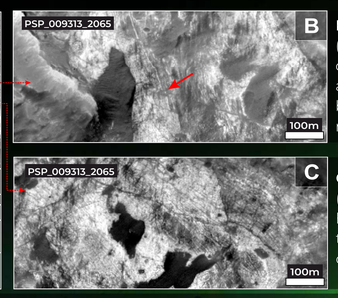
Figure 2: MOLA globe showing global context of Chryse Planitia (C.P.), and the location of **Figure 1**.

- There are thousands of **kilometre-scale mounds** distributed around the southern margin of **Chryse Planitia**, a ~1090 km diameter quasi-circular basin that lies north of the dichotomy boundary (*Pan et al., 2019*, Figure 1A-C).
- Large numbers of mounds are present in **Oxia Colles/Oxia Planum** (Figure 1A), **Hypanis Vallis** (Figure 1B), and atop the **Simud Valles / Ares Vallis channel islands** (Figure 1C).
- Despite being a **widespread geomorphological feature** in this important highland-lowland transitional region, their **origin and stratigraphic position are poorly understood**.
- This study has investigated the **morphology and distribution** of these landforms in order to understand their place in the stratigraphy and their role in the **geological history of the area**.
- Mounds have been identified and digitised using a combination of **CTX**, **HRSC**, and **MOLA** data, and classified based on their **morphologies. Heights** have been determined from the intersection of their high and low points with individual MOLA shot data.

MOUND CLASSIFICATION



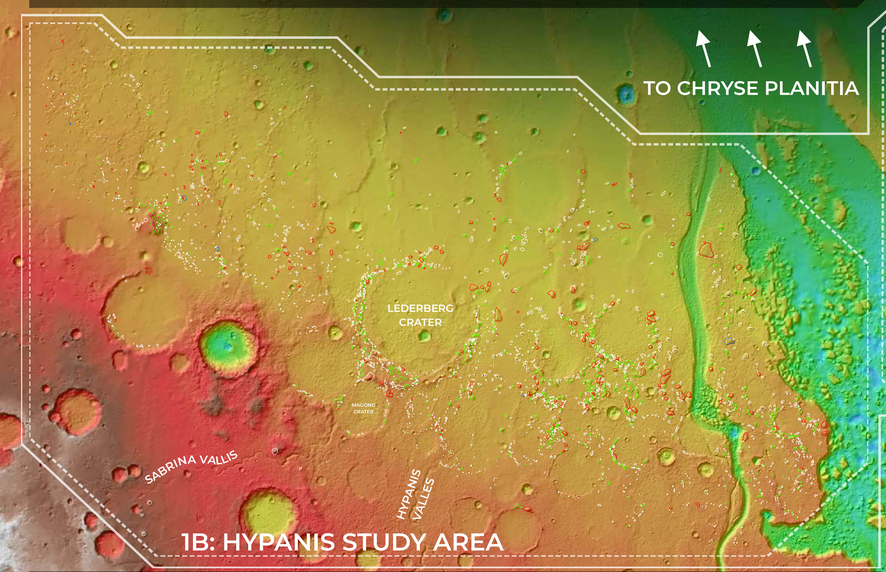
Area	HYPANIS	OUTFLOW	OXIA	HYPANIS	OUTFLOW	OXIA	HYPANIS	OUTFLOW	OXIA	HYPANIS	OUTFLOW	OXIA
Count	2712	570	7973	231	55	743	528	116	1381	6	0	71
% in study area	78.0	76.9	78.4	6.6	7.4	7.3	15.2	15.7	13.6	0.2	0.0	0.7

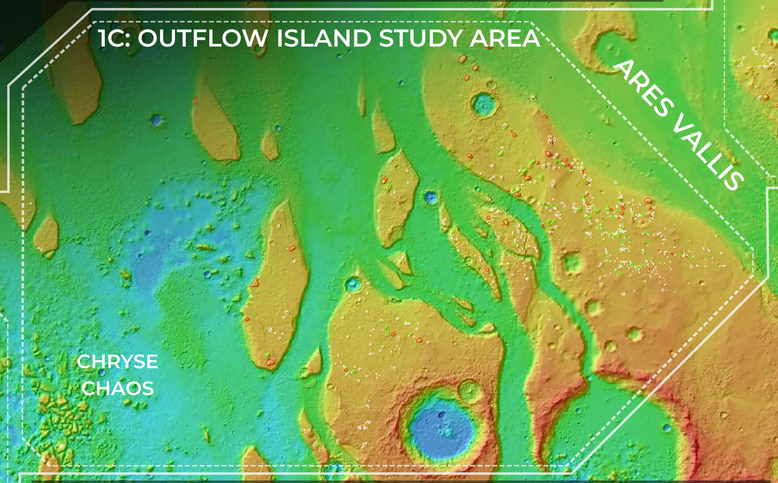


B: Mawrth-like clay-rich material (white), with high-albedo layer cut by WNW-ESE fault (red arrow), disconformably overlain by dark capping unit (far left, right).

C: Mawrth-like clay-rich material (white) containing repetitive high and low albedo layering, topped by a ~10 m thick dark capping unit (upper right).

- **Mounds were categorised** based on the morphology of their highest points, which are either **smooth/peak-topped** (hills, Figure 3), **flat-topped** (mesas, Figure 4), **multi-tiered** (tiered mounds, Figure 6), or **any combination of these** (compound mounds, Figure 5). The distribution of these types are visualised in Figure 1, and their populations are graphed in the statistics section.
- In total, **14,368 mounds** were digitised and categorised using the above classification scheme.





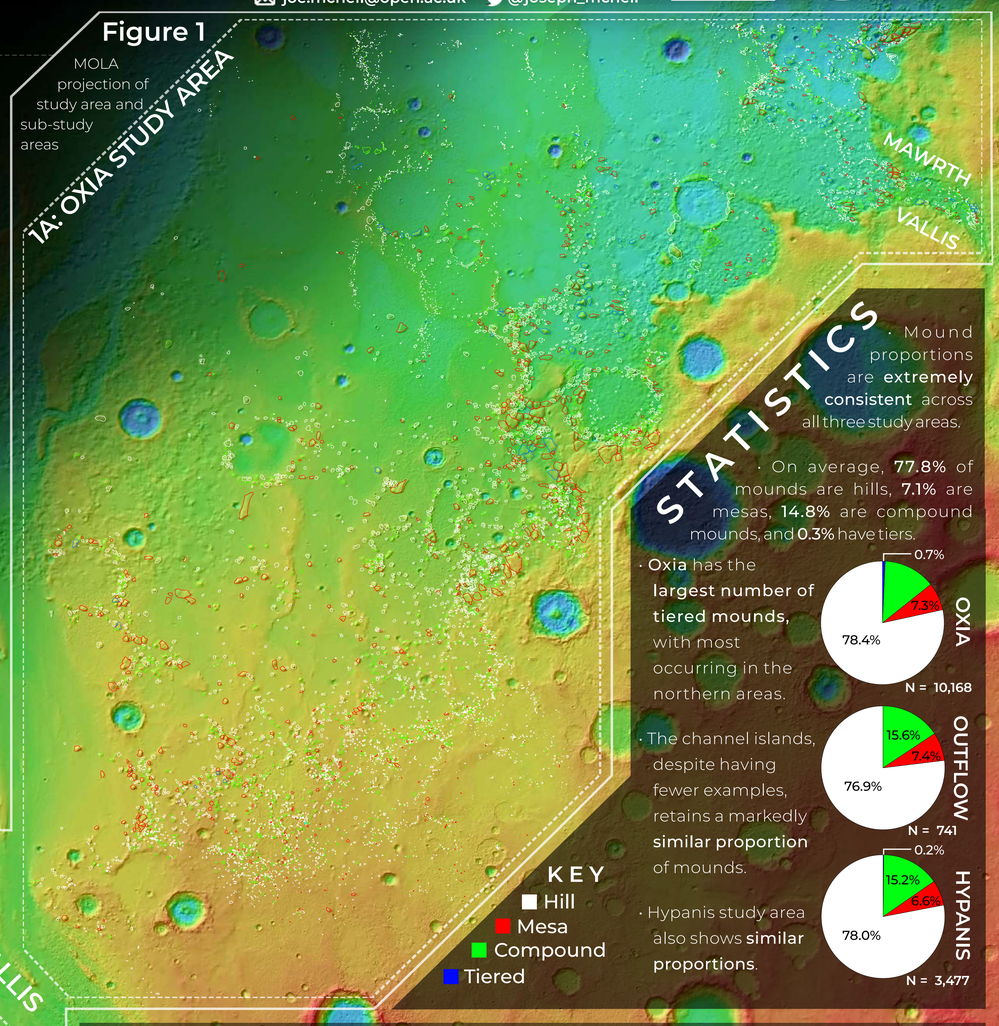


Figure 1 MOLA projection of study area and sub-study areas

STATISTICS

- Mound proportions are **extremely consistent** across all three study areas.
- On average, **77.8%** of mounds are hills, **7.1%** are mesas, **14.8%** are compound mounds, and **0.3%** have tiers.
- **Oxia** has the **largest number of tiered mounds**, with most occurring in the northern areas.
- The channel islands, despite having fewer examples, retains a markedly **similar proportion** of mounds.
- Hypanis study area also shows **similar proportions**.

STRATIGRAPHY

- The nature of the relationship between **mounds** and the **surrounding plains** is **ambiguous due to extensive regolith cover** at the mound margins.
- Despite this, a few examples throughout the Oxia Study Area (Figure 1A) reveal that at least **some of the mounds are embayed by the dark plains** material (Figure 7).
- Some mounds show **intense fractures** (Figure 6A, B) that do not appear to propagate into the surrounding plains, suggesting that **the mounds predate the plains**, although this could be due to extensive regolith cover.
- **High albedo layers** (e.g. Figure 7C) can be traced between mounds up to 100 km away, suggesting that the mounds were once part of a **more contiguous unit**.
- **Mawrth-like stratigraphy** is common in the top tier of tiered mounds in the northern section of the Oxia Study Area (Figure 6A, B), implying that the Mawrth phyllosilicates **extended into the northern lowlands** early in Mars' history.

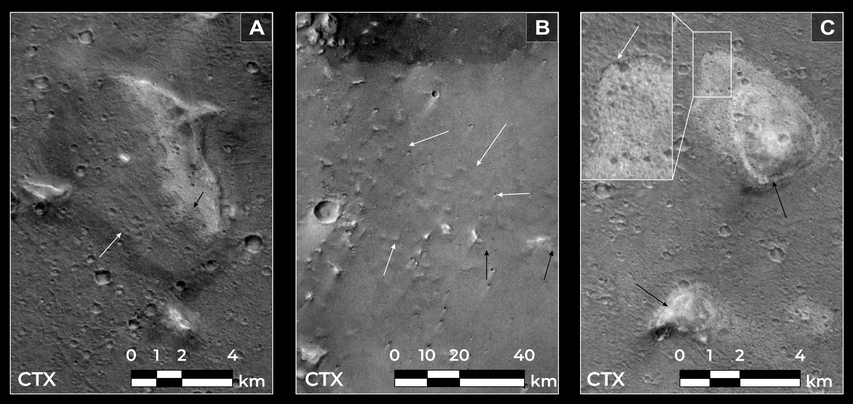


Figure 7: A: Embayment of dark unaltered plains material (white arrow) on top and around highly eroded mound with **bay-like features** (black arrow) around its margin. **B: Buried mound field** (white arrows), with high-albedo material protruding from dark plains material (black arrows). **C:** Mounds with **high-albedo** layers (black), and **clear evidence for embayment** of dark plains material onto mound material (white arrow).

BURIED CRATERS

- Mounds are often associated with **curvilinear wrinkle ridges**. These features sometimes demarcate the rims of **buried impact craters**, suggesting that mounds could be related to an **underlying surface or structure**.
- Wrinkle ridges typically **do not cut through mounds** (Figure 9). Nonetheless, in some areas they **can be seen to truncate mounds**, suggesting that the **most recent tectonic episode post-dates the deposition and erosion of the mounds** (Figure 10).
- All three sub-study areas yield an approximate age of **4.1 Ga**, the **maximum depositional age** of the mound-forming material.
- This age likely represents a **pre-Noachian surface**, upon which the mounds were deposited. Subsequent erosion, likely in the mid-to-late Noachian, created the isolated mounds we see today.
- This surface must be **younger than the Chryse-forming impact, suggesting this impact occurred > 4.1 Ga**, in the pre-Noachian.

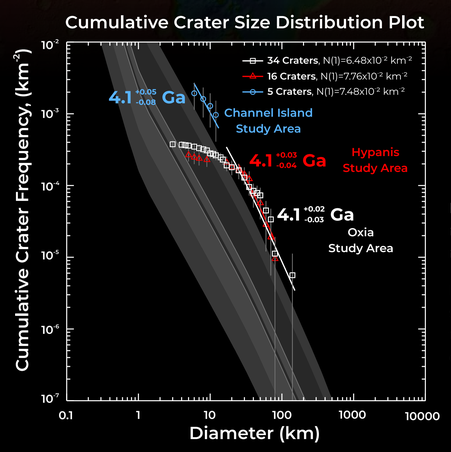


Figure 11: Cumulative crater counts for buried craters in the three study areas (coloured). The quoted age of 4.1 Ga is the approximate age of the buried surface on which the mounds are deposited, and the maximum age of the mounds. Chronology function: *Hartmann (2005), production function: Hartmann & Daubar, 2016.*

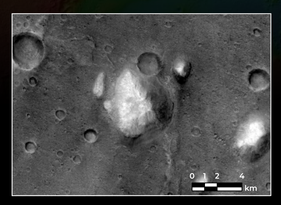
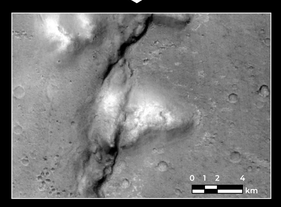


Figure 9: CTX image of mound that is not affected by the curved wrinkle ridge that runs diagonally under it.

Figure 10: CTX image of a north-south wrinkle ridge in Oxia Colles that truncates the rounded hill in the centre of the image



MORPHOMETRICS

- The elevations of **2236 mounds** were calculated using **MOLA shot data**.
- Mound height **increases with area**, up to a maximum of ~500 m, where they plateau (Figure 8), suggesting that 500 m was the **original maximum thickness of the layer** that these mounds eroded from.
- Mesas and tiered mounds are typically the tallest and most extensive, with **compound mounds intermediate**, and **hills usually being the smallest** examples. This implies that hills are a more advanced erosional state and likely eroded from antecedent mesa and compound stages.

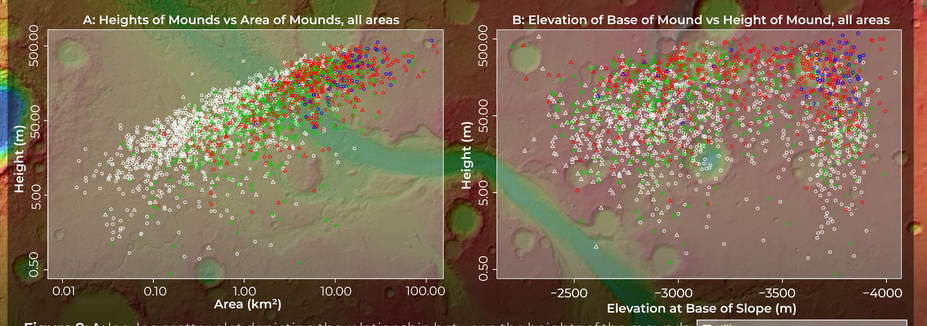


Figure 8: A: log-log scatter plot depicting the relationship between the heights of the mounds and area of the mounds. **B:** Scatter plot depicting the heights of the mounds (log-scale), and the elevation of the base of the mounds (a proxy for their location on the regional slope).

PRELIMINARY CONCLUSIONS

- The **different morphologies** of mounds are likely to represent **different erosional states**. Hills are likely to be derived from compound mounds, which in turn are likely to be derived from mesas.
- Mound **morphometries are diverse**, and their heights converge towards elevations of 500 m above the surrounding plains, suggesting that this was the **thickness of the layer from which the mounds eroded**.
- The dark plains material **embays the mounds, and is therefore younger**.
- Crater counting the buried craters that the mounds delineate reveals that the **maximum depositional age of the mounds is approximately 4.1 Ga**, which is the **age of the buried surface** they are deposited on. This age is also therefore the **minimum age of the Chryse-forming impact**.
- Where the mounds demarcate buried craters, the implied crater is **consistently above the minimum simple-complex crater diameter** of 3 km (*Pike, 1980*).
- There are two possible explanations for this observation: simple crater margins are also delineated by mounds, but are **not seen due to burial/ambiguity**, or, **mounds only form around complex craters**.
- If the latter is true, this could suggest some **relationship to fracturing associated with complex craters** on Mars. One possibility is that **impact-related hydrothermalism indurates the mound material** above fractures in large enough craters, causing those areas to be **preferentially shaped into mounds during periods of erosion.**

REFERENCES

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Pike, R.J.; *Formation of Complex Impact Craters: Evidence from Mars and Other Planets, 1980*, Icarus 43, 1-19

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