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CANDIDATE MUD VOLCANOES IN THE NORTHERN PLAINS OF MARS. E. S. Kite[1,2], N. Hovius[1], J. K. Hillier[1], J. Besserer[3]. [1]Cambridge University, Department of Earth Sciences, Downing Street, Cambridge, CB2 3EQ, United Kingdom. [2]University of California, Berkeley, Department of Earth and Planetary Science, 309 McCone Hall, Berkeley, CA 94704, United States. [3]Université de Nantes, 2, rue de la Houssinière, BP 92208, 44322 Nantes Cedex 3, France. kite@berkeley.edu

Summary: Moated, shallow-sided domes in a Martian basin centred on 76N 160W (the 'Borealis back-basin') resemble the products of submarine mud volcanism (MV) on Earth.

Description of domes: A dome is an approximately circular or elliptical region raised with respect to its surroundings. Geomorphological mapping shows ~30 Early Amazonian domes (~50 x 40 km, height ~300 m; $\Sigma A = 5.4 \times 10^4$ km^2, $\Sigma V = 3.7 \times 10^3$ km^3) in our study area. Features include marginal and central peaks (~7 x 5 km, height ~400 m), multiple rings, and moats ~2.5 km wide. Dome surfaces, rough at km-scale, show evidence for (formerly more complete?) marginal and interior annular ridges. Larger, more northerly domes have central depressions, perhaps due to collapse. By averaging numerous profiles drawn from dome centres to a hand-picked dome margin, we confirmed the visual impression of multiple ridges in many domes. Mean rise/run was found to be (0.93±0.22)%. Individual dome orientations, and alignments of multiple domes, run parallel to the continuation of grabens associated with Late Hesperian / Early Amazonian Alba Patera diking [1]. Distributary channels are found in association with one of the domes. Slope-aspect relationships in the domes region show significant deviations from randomness. After detrending, the relative frequency of slopes facing S or N exceeds other aspects; this excess has local maxima at (S±5°) and (N±5°). Because N-facing slopes are more abundant than S-facing slopes, S-facing slopes must be, on average, steeper. A control region at the same latitude shows no comparable anomaly.

Interpretation: All bodies with silicate crusts and diameters >10^3 km in our solar system show widespread basaltic volcanism, but only Earth has confirmed MV. Therefore, when assessing an extraterrestrial construct, one should assign a high prior probability to igneous volcanism. However, (1) The suite of dome morphologies can be matched one-for-one with MV in the S Caspian Basin and Gulf of Cadiz [e.g., 2], although Martian domes have diameters ~5 times greater than their largest terrestrial counterparts. (2) Moat morphometry excludes flexural origin and suggests collapse during withdrawal of material from a subsurface reservoir. Collapse moats are found in association with major submarine MV on Earth. We consider them diagnostic for MV. (3) The slope-aspect anomaly suggests that near-surface dome material has been subject to incomplete insolation-driven processing, and that dome near-surface material was partially volatile [e.g., 3]. However, it is possible that dome near-surface material is compositionally distinct from material making up the bulk of the domes. (4) Few volcanic constructs are found closer to Alba Patera, inferred to have triggered dome construction. So there must be a major increase in the fusibility of materials overlying dykes in our study area. In the absence of Martian granites, volatile-rich deposits could satisfy this requirement. (5) Mars has thick sediment piles, permitting MV. Crater fill studies suggest that the Scandia and Borealis back- basins contain the greatest thickness of post-Late Noachian cover in the entire Northern Plains, making these preferred MV locations [4]. We infer that domes probably result from MV.

Outstanding puzzles: The dome-hosting basin is adjacent to outliers of the north polar ice cap, which may record cap retreat [5]; possible interaction between MV and ice sheet dynamics remains an open question. We currently lack a compelling mechanism for mud expulsion in the extensional tectonic setting required by the observation of dykes. One possibility is direct triggering of MV through intersection of hot hydrothermal fluids circulating above dykes with a thick, volatile-rich sediment column. OMEGA spectra of the domes show no significant differences between dome and non-dome terrain. Both band depth methods and linear unmixing models [6] yield compositions dominated by ferric oxides and pyroxenes, everywhere in the region. This may be due to recent mantling, or MV may tap a source layer of similar composition to the adjacent plains, believed to have been reworked from Late Hesperian flood deposits.

Implications: MV is both a probe of the past vertical distribution of volatiles, and a tracer of past redistribution of volatile-rich material. Since depth of post-Hesperian cover in our study area is likely insufficient for MV, older sediments are probably the source. These may record catastrophic flooding or (ephemeral?) Late Noachian oceans. Our results have implications for the ease of future drill-rig access to these ancient deposits. There is also a tempting geographic link with young evaporates [7].

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