Mars mud volcano database using JMARS and interpretation on distribution. Ji-Eun Kim[1] and Chris H. Okubo[2], [1]School of Earth Sciences, The Ohio State University, Columbus, OH (kim.6501@osu.edu), [2]U.S. Geological Survey, Flagstaff, AZ.

Introduction: Mud volcanos occur on Earth in fluid-rich and fine-grained sedimentary regions where subsurface sediments are overpressured or undercompacted with relatively high porosities [1, 2]. Mud volcanos can form various shapes (cone or pie-shaped) and sizes (up to tens of km in diameter and hundreds of meters in height). Similar mud volcano-like features have been found on Mars [3, 4, 5, 6, 7, 8, 9, 10, 11], with alternative interpretations being igneous volcanos [12, 13] or pingos [14]. Previous studies focused on documenting, categorizing, and inferring processes that could be responsible for forming small mound features on Mars that resemble mud volcanos. Investigations into the origins of these features have been hindered due to a limited understanding of the spatial distribution of small mound features at the regional scale on Mars. Most previous studies investigated these features in geographically restricted areas, which raises questions on the applicability of these specific results on a global scale. Therefore, as a first step toward understanding regional trends in mound formation, we mapped the distribution of small mound features across Valles Marineris, as well as Isidis Planitia and southwestern Utopia Planitia regions, to further improve our understanding of potential formation processes of these landforms.

Categorizing small mound features: Five categories of small mound features on Mars (Figure 1) were identified based on observations from [9, 11]. Mounds (M) have a cone or knob shape and pitted mounds (PM) have a depression at the top. Mound complex (MC) and pitted mound complex (PMC) were used for overlapping mounds and pitted mounds that are observed in clusters.

Landforms were first identified in CTX data using JMARS, and their locations marked using the shape layer tools in JMARS. Elevation was extracted from the HRSC-MOLA global DEM [15] in ArcGIS Pro using Add Surface Information tool for every landform identified and mapped in JMARS.

Mud volcano feature distributions: Figure 2 shows that M and PM are common features in Valles Marineris and Utopia Planitia. In Valles Marineris, each M and PM are 44% and 49% of the small mound features, respectively. In Utopia Planitia, M and PM are 34% and 60% of the small mound features. In Isidis Planitia, PMC are dominant features.

The overwhelming majority of small mound features were identified at elevations that are below proposed "shorelines" [16] as shown in Figure 2. Further, M and MC are observed in a wider range of elevations than PM and PMC, which are largely restricted between -3000 to -4000 m (Figure 3).

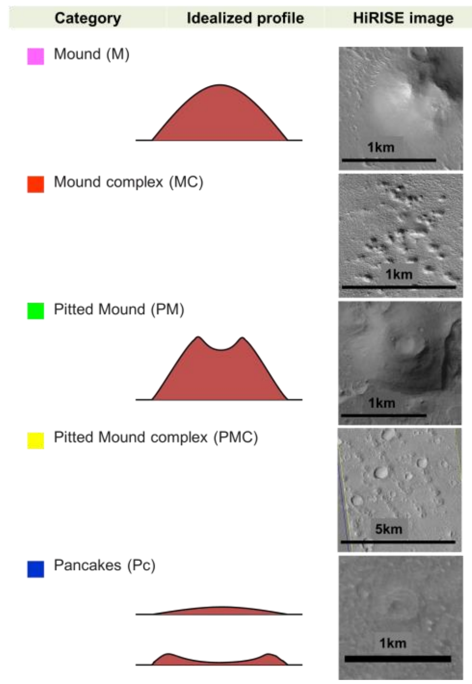

Figure 1. Small mound features categories modified from [9, 11] are used to construct the volcano database for Valles Marineris, Utopia Planitia and Isidis Planitia. Top four images are from High Resolution Imaging Science Experiment (HiRISE) and last Pc image is from Context Camera (CTX). HiRISE images for M: ESP_048103_2030, MC: ESP_014371_2185, PM: ESP_036109_1675, PMC: ESP_037369_1980, and Pc: ESP_027400_2110

Discussion: Results of our mapping suggest that elevation may be an important factor that influences the morphology of the mud volcano feature, specifically for M, PM, and PMC in the southwest Utopia/Isidis Planitia region. This regional scale, elevation dependence strongly supports the mud volcano interpretation for these features, where the source deposits and driving stresses are part of a regionally extensive system that is water-saturated and hydrologically connected. The existence of a water-saturated sediment reservoir is entirely consistent with these areas having been depositional basins prior to landform development. Conversely, the igneous volcanic interpretation for these landforms would seem to require a regionally connected, near-surface magma source to explain these observations. Such a magma source appears unlikely given current understanding of the regions' geologic histories. The pingo interpretation is also not clearly supported by these findings because the landforms do not show a latitudinal dependence (climatic zone) [17].

These results suggest that surveying small mound features across a larger areas of Utopia Planitia, the northern plains, and elsewhere on Mars may yield novel information that will help decipher the origin of these enigmatic landforms.

Acknowledgments: HRSC-MOLA global DEM was obtained from the NASA Planetary Data System.

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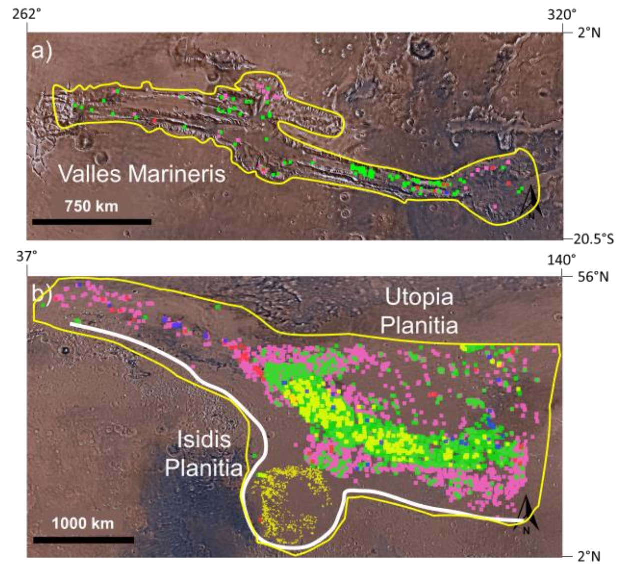

Figure 2. Small mound features marked for a) Valles Marineris, b) Utopia/Isidis Planitia. Refer to Figure 1 for color legend of features. White lines are approximate "shorelines" from [16]. Yellow lines mark the boundaries of the areas surveyed for this study.

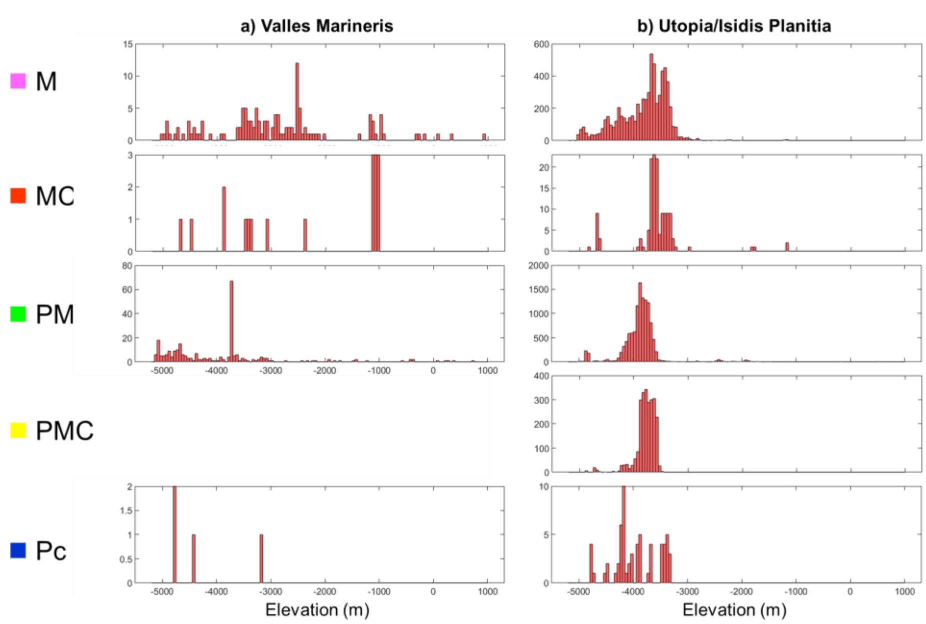

Figure 3. Small mound features by elevation distribution for a) Valles Marineris and b) Utopia and Isidis Planitia.