HIGH-RESOLUTION TOPOGRAPHIC ANALYSIS OF PITTED MOUNDS IN SOUTHERN ACIDALIA PLANITIA, MARS: UPDATES ON MORPHOMETRIC PARAMETERS OF CANDIDATE MUD VOLCANOES. R. Hemmi[1] and H. Miyamoto[2], [1]The University Museum, The University of Tokyo (7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan, hemmi@seed.um.u-tokyo.ac.jp), [2]Depatment of Systems Innovation, School of Engineering, The University of Tokyo.

Introduction: A number of small-scale (100's of meters to a few kilometers wide), near-circular to irregular-shaped mounds with summit depressions (so-called "pitted mounds"), have been commonly observed within northern lowlands and southern highlands on Mars (Fig. 1; e.g., [1,2]). For instance, in southern Acidalia Planitia (32°–49°N, 317°–357°E, Late Hesperian or middle Amazonian lowland units [3]), more than 18,000 mounds (>300 m diameter) were identified, with an estimated >40,000 mounds in total [1]. A variety of terrestrial analogs explaining their occurrence have been proposed: rootless cones, pyroclastic cones, secondary impact craters with inverted relief, pingos, tuff rings and tuff cones, spring mounds, mud volcanoes defined as surface manifestation of mud from depth (summarized in [1,4]); yet none of these hypotheses has been proven decisively. More recently, high-resolution images obtained by the Mars Reconnaissance Orbiter (MRO) show distinct flow-like features and apron-like sloping extensions of smoother, brighter materials emanating from pitted mounds in southern Acidalia Planitia [1], which qualitatively support the hypothesis of mud volcanism in Acidalia basin.

Quantitative assessment of whether mud flows form pitted mounds requires accurate measurement of geometric parameters and cross-sectional profile of mounds, using highest-resolution topography data. Prior morphometric studies of the mounds, however, were limited to Viking-based, photoclinometric measurements of about 400 mounds (>400 m wide) within part of Acidalia and Chryse Planitiae [5,6]. By generating higher resolution digital elevation models (DEMs) from HiRISE stereo images of pitted mounds over the southern part of Acidalia Planitia, we are able to analyze the relationship between height and width of over 1200 mounds to test the mud volcanic hypothesis. By comparing their morphometric parameters with those of terrestrial analogs, we aim to put constraints on possible origin(s) of the mounds.

Methods: We first performed radiometric calibration, bundle adjustment, and shifting, mosaicking, and map projection of MRO HiRISE stereo images [7, 8] (raw Experimental Data Records which include ideal camera pointing, good weather condition, and 1 × 1, 2 × 2 or 4 × 4 pixel binning) using the Integrated Software for Imagers and Spectrometers (ISIS) [9,10] developed by U.S. Geological Survey (USGS). To extract the accurate topography of the areas of pitted mounds in the southern part of Acidalia Planitia, we produced forty high-resolution (1.0, 2.0, or 4.0 m/pixel) DEMs and corresponding orthoimages using NASA's Ames Stereo Pipeline (ASP) [11,12]. Taking into account the expected vertical accuracy (<0.6 m) and post spacing for each DEM as well as the uncertainties in morphometric measurements ascribed to the manual delineations of each mound, maximum errors in height and width are roughly estimated to be 0.6 m and 2.0 m for DEMs at 1.0 m/pixel, 1.2 m and 4.0 m for DEMs at 2.0 m/pixel, and 2.4 m and 8.0 m for DEMs at 4.0 m/pixel.

Results: Morphometric measurements were performed for 1297 pitted mounds within southern Acidalia Planitia (Fig. 2). The basal widths W range from 39 to 1406 m, with a mean and median of 367 and 327 m, respectively, and a standard deviation (std. dev.) of 226 m. The mound heights H are in the range of 1.1–69.5 m with a mean (median) and a std. dev. of 15.2 (12.6) ± 10.8 m.

These geometric parameters also give the H/W ratios of between 0.005 and 0.127 with a mean value of 0.043, which are consistent with those of subaerial mud volcanoes in Azerbaijan ranging from 0.026 to 0.083 with a mean of 0.053 [13], 233 submarine mud volcanoes between 0.006 and 0.25 with an average of 0.069 (compiled in [14]), but cannot preclude other formation hypotheses such as Icelandic pseudocraters (0.063–0.200, mean value = 0.111) and cinder cones (0.063–0.286, mean value = 0.136) [15].

Discussions and Future work: As shown in Fig. 2, the heights and diameters of 50 mounds in Terra Sirenum [16] and those of ~1300 mounds in southern Acidalia Planitia (this study; details described in [17]) are in good accordance with those of terrestrial mud volcanoes in comparison with other terrestrial analogs. Although this H-W plot is not decisive in determining the origins of the mounds, it is helpful to estimate volumes of individual mounds and kinetic energy to produce each mound. In future research, we intend to perform morphometric measurements of mounds in other locations including southern highlands and Valles Marineris. Preliminary results of morphometric parameters of mounds in Chryse Planitia and Melas Chasma are shown in Fig. 2. Their heights and widths are reconciled with those of both Acidalia mounds and mud volcanoes on Earth. These parameters would be valuable for making first-order estimates of the yield strengths of materials forming mounds and depths of source reservoirs (e.g., [10]), and for better understanding of the formation of pitted mounds and surrounding terrains, and the hydrological cycle between northern lowlands and southern highlands.

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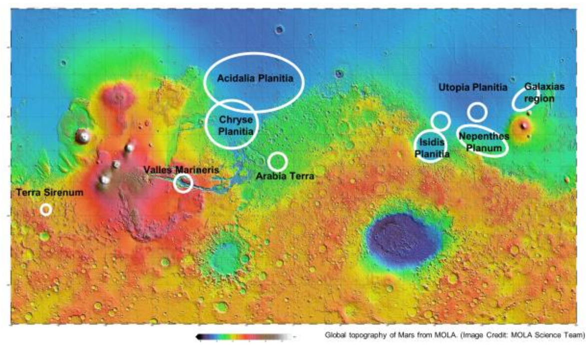

Fig. 1. Locations of pitted mounds previously proposed as mud volcanoes.

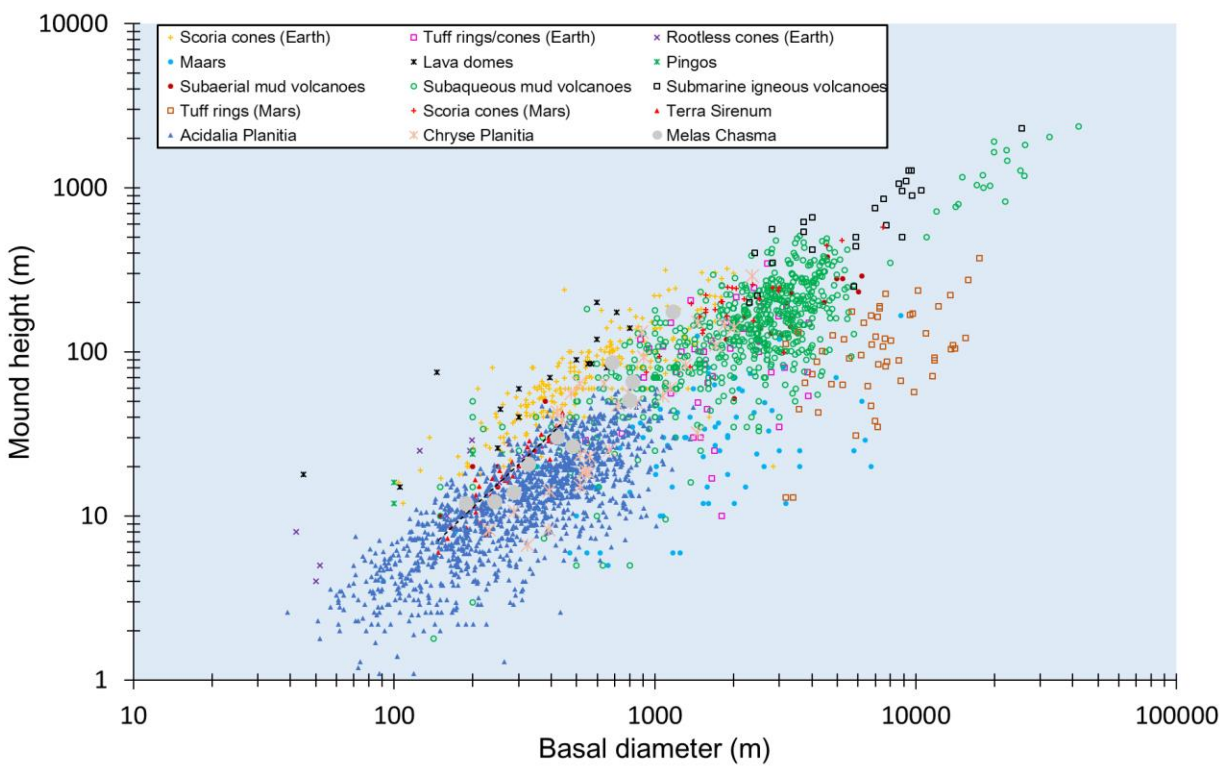

Fig. 2. Plot showing the measured maximum height (*H*) versus basal width (*W*) for pitted mounds on Mars (Terra Sirenum, Acidalia Planitia, Chryse Planitia, and Melas Chasma) and terrestrial analogs ([24, 25] and references therein).