Large Martian Craters with Central Mounds: Global Distribution and Occurrence of Layers K. A. Bennett[1] and J. F. Bell III[1], [1]School of Earth and Space Exploration, Arizona State Univeristy (contact: Kristen.A.Bennett@asu.edu)

Introduction: A subset of Martian craters contain interior mounds of sedimentary deposits. Gale Crater, the landing site for the Mars Science Laboratory (MSL), is an example of a crater containing a central mound [1]. One of MSL's mission goals is to characterize the geologic history of Mars [2]. Gale Crater's central mound, Mt. Sharp, is an ideal location for this investigation because it contains layers that could reveal the progression of geologic processes at work during a significant period of Martian history [3].

However, Gale Crater is merely one of many craters that contain central mounds with the potential to test hypotheses regarding which geologic processes were dominant during their formation [1]. It is important to understand how Mt. Sharp relates to the entire population of central mounds in order to help enable new discoveries by MSL at Gale Crater to be placed in a global context. To address this question, we are conducting a global survey of the locations of all large crater central mounds on Mars. Here we report preliminary results relating to the occurance of layers in central mounds and the offset of mounds with respect to the center of their parent crater.

Background: Central mounds are found in craters of varying sizes, are not always located in the center of their host crater, and at times rise higher than their crater walls. These deposits are postulated to be Noachian and created through either subaerial or subaqueous processes [1]. There have been two possible general formation mechanisms hypothesized for the creation of central mounds. In the first model, an empty crater is filled to the rim with sediments, which are then eroded into the mound shapes we observe today [1]. In the second model, sediments are deposited preferentially into mound shapes [4]. To test which geologic processes influenced the mounds' formation, we compare our survey results to other datasets, including regional wind patterns and local geologic setting. Wind processes could be inferred to affect mound formation if wind directions correlate to the offsets observed in mounds. If all mounds are located near volcanic or fluvial features, those processes could have had a greater likelihood of influencing mound creation.

Methods: Previous surveys of central mounds have either been restricted to a limited area or have been part of representative studies of all sedimentary deposits on Mars [1,5,6]. Our study focuses solely on cataloguing central mounds, at a global scale.

We use Mars Orbiter Laser Altimeter (MOLA) topography maps to construct elevation profiles of craters to identify potential mounds. Specifically, to be classified as a mound, deposits on crater floors must be rounded (as opposed to a typically sharp or jagged central peak) and the area of the mound must be greater than 10% of the crater floor area. Our search area was limited to within ±60° N and to craters above 25 km in diameter.

Once the mounds are identified, we find the distance between the center of the crater and the center of the mound to determine the offset. Using JMARS tools [7], each crater containing a mound is approximated as a circle, and we use the center of this circle as the center of the crater. To find the center of each mound, we draw a shapefile of each mound and find the shape's average latitude and longitude (See Fig 3).

To find layers, we use the available Context Camera (CTX; 6 m/pix [8]) and High Resolution Imaging Science Experiment (HiRISE; ~25 cm/pix [9]) images over each mound. If there is no CTX or HiRISE coverage, we classify its layering state as "unknown".

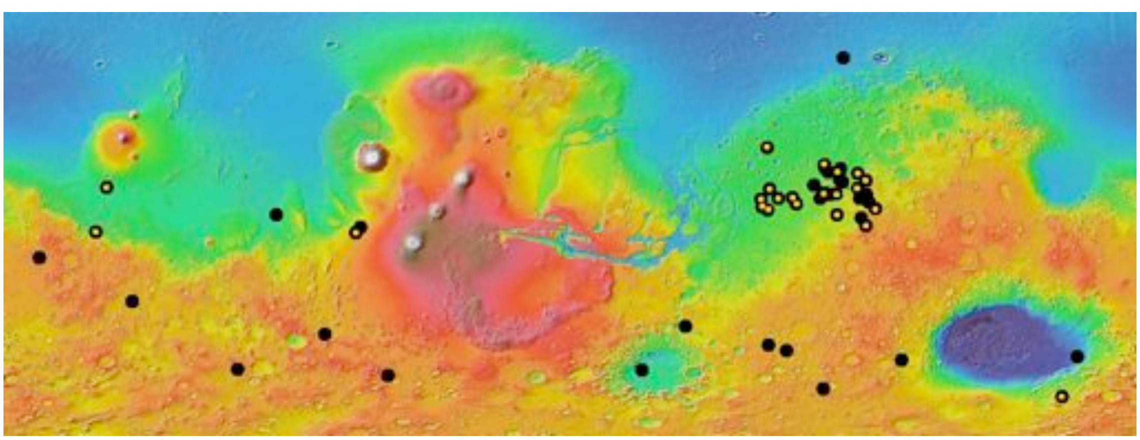

Figure 1: Global survey of craters containing central mounds. Black circles represent each of the 50 mounds. Yellow circles within the black circles represent mounds that exhibit visible layers.

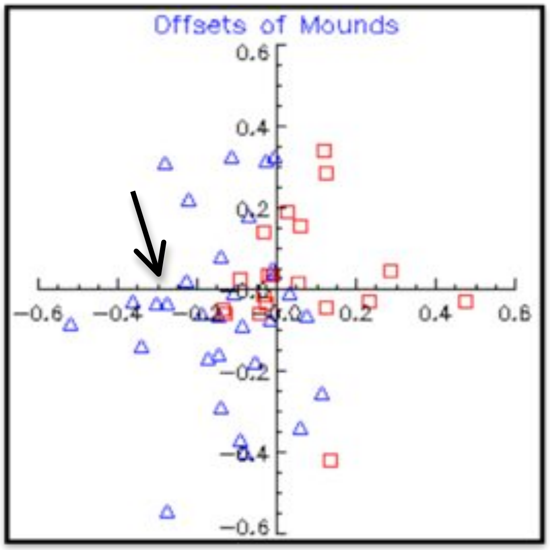

Figure 2: Plot showing the offset of each mound from its crater center. The distance from the center is normalized by the crater radius. Blue triangles represents mounds located in Western Arabia Terra. Red squares represent all other mounds. The arrow points to the offset of the mound in Figure 3.

Results: *Global Survey.* Our survey identified a total of 50 mounds (Fig 1), 31 in the northern hemisphere and 19 in the southern hemisphere. Western Arabia Terra (from -10° to 30°N and -20° to 30°E) contains 31 mounds, which is more than 60% of the total population. The rest are mostly scattered throughout the southern highlands.

Offsets. The overall population of mounds does not appear to be offset from the center of their craters in a particular direction (Fig 2). However, almost all of the mounds in Arabia Terra (blue triangles in Fig 2) are offset to the western side of their host crater while the remaining mounds' offsets (red squares in Fig 2) are biased towards the northeastern side of their craters.

Layers. Out of the 50 mounds, 22 exhibit layers, 24 do not, and 4 were "unknown" (Fig 1). Western Arabia Terra contains 18 out of the 22 mounds that contain layers. Of the four other mounds with layers, three reside close to Elysium Planitia (including Gale Crater) and the fourth (Spallanzani Crater) lies on the rim of Hellas Basin. Interestingly, all mounds containing visible layers occur in transition areas between the southern highlands and a large nearby basin: 21 of 22 are close to the northern lowlands/southern highlands dichotomy, and Spallanzani is on the Hellas Basin rim. The lack of evidence for layers in some mounds does not mean they do not exist: they could be obscured by dust or be smaller than we can detect. The number of mounds exbiting layers found in this study should thus be considered a lower limit.

Interpretations: Arabia Terra has the only cluster of large crater central mounds on the planet (over 60% of the mounds occur there), the highest concentration of mounds with layers, and the mounds there are all offset to the western side of their crater.

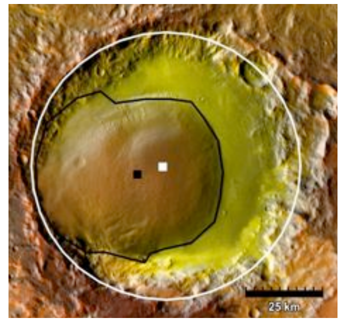

Figure 3: Arabia example of obtaining mound offsets. The white circle and dot are approximated as the crater and its center. The black outline traces the topographic edge of the mound. The center of the mound (black dot) is the average latitude and longitude of the mound shapefile.

One possible reason for the Arabia Terra offsets could be the regional wind direction. According to a recent General Circulation Model (GCM) [10], the prevailing annual net wind direction in Arabia is slightly south of west, currently as well as for past lower and higher obliquities [10]. The prevailing winds could have either caused sediments to be deposited preferentially to the western sides of craters, or could have helped to preferentially erode sediments into mounds towards the western sides of craters.

However, prevailing wind directions do not appear to explain mound offsets beyond Arabia. For example, Gale Crater's mound is offset to the north, but the prevailing wind direction is to the south [10].

A possible explanation for the high concentration of mounds with layers in Arabia Terra could be related to the region's relatively gentle transitional highlands to lowlands topographic slopes, potentially enabling more efficient transport of fine-grained sediments than across the sharp topographic boundaries often associated with the north-south dichotomy boundary, or the rim of Hellas. Sediments transported by either wind or groundwater upwelling of an ancient water table [*e.g.,* 6] may simply have been able to be more widely dispersed throughout Arabia.

An alternate explanation for the concentration of layered mounds in Arabia Terra is that all mounds contain layers, but for some reason erosion (potentially by wind) at Arabia Terra exposes the layers more efficiently than in the rest of the population.

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