Mid-Latitude Pedestal Crater Heights: A Proxy for the Thickness of a Past Climate-Related, Ice-Rich Substrate. S. J. Kadish[1], J. W. Head[1] and N. G. Barlow[2]. [1]Department of Geological Sciences, Brown University, Providence, RI 02912 USA (Seth_Kadish@Brown.edu), [2]Department of Physics and Astronomy, Northern Arizona University, NAU Box 6010, Flagstaff, AZ 86011.

Introduction: We have recently provided a range of evidence for a sublimation-driven formation mechanism for pedestal craters (Pd) on Mars [e.g. 1-5]. First recognized in Mariner 9 data [6], Pd are an impact crater morphology on Mars [7] characterized by a crater perched near the center of a plateau, surrounded by an often-circular, outward-facing scarp. Historically, Pd were thought to form by armoring of a fine-grained substrate during the impact event, followed by eolian deflation of the intercrater terrain. This preferential erosion of the non-armored substrate would yield the perched pedestals surrounded by marginal scarps [e.g. 6,8].

Several studies have identified the strong latitude-dependent distribution of Pd, which preferentially form at latitudes poleward of ~40° [1-5,9]. We have mapped all Pd from 60°N to 65°S to firmly establish this trend, and have physically characterized Pd through measurements of their the lobateness values (pedestal sinuosity) and pedestal-crater (P-C) ratios (farthest extent of the pedestal from the crater rim divided by the crater bowl radius) [1-3,5]. We have also identified Pd in Utopia Planitia and Malea Planum that have marginal pits, providing evidence for the sublimation of volatiles from the scarps of the pedestals [4]. This work supports a model that calls on impact into volatile-rich targets to produce Pd during periods of higher obliquity (Figure 1) [5], when mid- to high-latitude substrates were characterized by thick deposits of snow and ice. The area proximal to the crater is armored by an atmospheric blast and high-tempreature thermal pulse [10]. During return to lower obliquity [e.g. 11], the regional volatile-rich unit sublimated, except below the protective cover of the armored pedestal surfaces. These volatiles eventually migrated poleward.

Our model thus predicts that the thick deposits of snow and ice composing the past volatile-rich substrate should be preserved undernearth the surface of pedestals. As such, the heights of Pd should provide information about the thickness of the substrate and how it may have varied regionally, which can be used to establish where snow and ice are preferentially deposited during periods of higher obliquity. Here, we provide preliminary results on the measurements of the heights of mid-latitude pedestal craters, and discuss the implications for a past latitude-dependent, ice-rich substrate.

Pedestal Heights: To date, we have measured the heights of all 384 mid-latitude Pd in the NW part of the northern hemisphere of Mars (30°-60°N, 180°-360°E) (Figure 2). Pd heights were derived from the MOLA gridded data, (462 m/pix at the equator). The Pd height is equal to the elevation of the pedestal surface minus the elevation of the surrounding plains, within ~2 km of the marginal scarp. The elevation of a single Pd surface can, in some cases, vary by more than 50 m depedending on the regional slopes, and the surrounding plains can have even greater differences in elevation. As such, we were careful to avoid extreme values, instead using averages for the Pd and plains elevations. We checked results with individual MOLA profiles for a variety of cases.

The range of Pd heights measured is 24 to 152 m; average Pd height is ~60 m and the median is 56 m. Of the 384 measured, only 19 Pd were higher than 100 m, while 176 were 40 to 60 m high (Figure 3a). Pd heights show some clear regional trends (Figures 1, 3b,c). They are generally higer between 35° and 50°N than between 50° and 60°N latitude. Pd are also higher from 320° to 360°E (Acidalia Planitia) than they are from 180° to 220°E (Arcadia Planitia) (Figure 3b,c).

Past Ice-Rich Substrate Thickness: Pd heights show no statistically significant correlation with their respective crater diameters, P-C ratios, or lobateness values. Plotting Pd height against crater bowl diameter yields a correlation coefficient of only 0.047. This independence of Pd heights from crater diameters is consistent with a sublimation-driven formation model; the substrate thickness is responsible for the Pd heights, regardless of the size of the impact.

On a small scale, there are differences of >60 m between the heights of Pd in close geographic proximity (tens of km). This may be due to Pd forming during different periods of substrate emplacement, variations in the topography of the underlying plains, or erosion and degredation of the Pd since their formation. All of these factors are likely to affect Pd populations, and thus we should be cautious when analyzing any trends in small areas.

On a broad scale, the differences in Pd heights are likely to be due to variations in the thickness of the volatile-rich substrate, which results from geographically heterogeneous accumulation rates of snow and ice at the mid-latitudes. Climate models [e.g., 12,13] show that volatiles can accumulate at the northern mid-latitudes to high latitudes during periods of higher obliquity.

The increased heights of Acidalia Pd may therefore indicate that Acidalia is exposed to higher accumulation rates. Conclusions about global trends, however, will be clearer after completion of the measurements, when we have a better understanding of the relative differences in pedestal heights in all regions where the mid-latitude, ice-rich substrate forms.

Conclusions: Measurements of the heights of 384 Pd, in conjunction with our past work [1-5], has provided prelimanry results on possible variations in the thickness of a past mid-latitude, ice-rich substrate. Within the area studied, we find that: (1) Pd average ~60 m in height, with the majority (237 of 384) between 40 and 70 m, (2) Pd heights generally decrease as latitude increases from 35°N to 60°N, and (3) on average, Pd heights are ~15 m greater from 320° to 360°E than from 180° to 220°E. The regional increase in Pd heights in Acidalia may suggest that this region is subject to higher accumulation rates of ice and snow than Aracadia, producing a locally thicker, volatile-rich substrate. Completion of the measurements of all mid-latitude Pd heights, however, is necessary to establish firm trends about variations in the regional thickness of the substrate.

References: [1] N. Barlow (2005) RVAMIC #3041. [2] S. Kadish and N. Barlow (2006) LPSC 37 #1254. [3] S. Kadish and N. Barlow (2007) B-V 46 #31. [4] S. Kadish et al. (2008) GRL 35, L16104. [5] S. Kadish et al. (2008) JGR, submitted. [6] J. McCauley

(1973) JGR 78, 4123. [7] R. Arvidson (1976) Icarus 27, 503. [4] G. Osinski (2006) MAPS 41, 1571. [8] P. Schultz and Lutz (1988) Icarus 73, 91. [9] P. Mouginis-Mark (1979) JGR 84, 8011. [10] K. Wrobel et al. (2006) MAPS 41, 1539. [11] B. Levrard et al. (2004) Nature 431, 1072. [12] J. B. Madeleine et al. (2007) LPS XXXVIII, Abstract #1178. [13] M. A. Mischna et al. (2003) JGR 108, 5062.

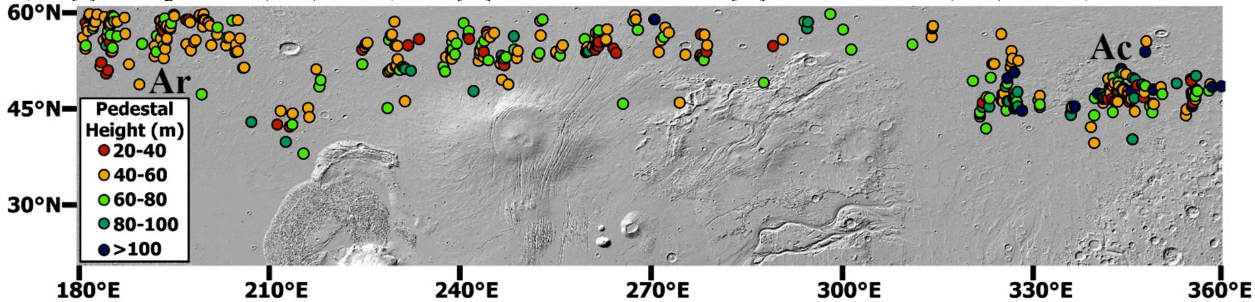

Figure 2 - The heights of mid-latitude pedestal craters in the NW hemisphere of Mars, showing taller pedestals concentrated in Acidalia Planitia (Ac), and shorter pedestals in Arcadia Planitia (Ar).

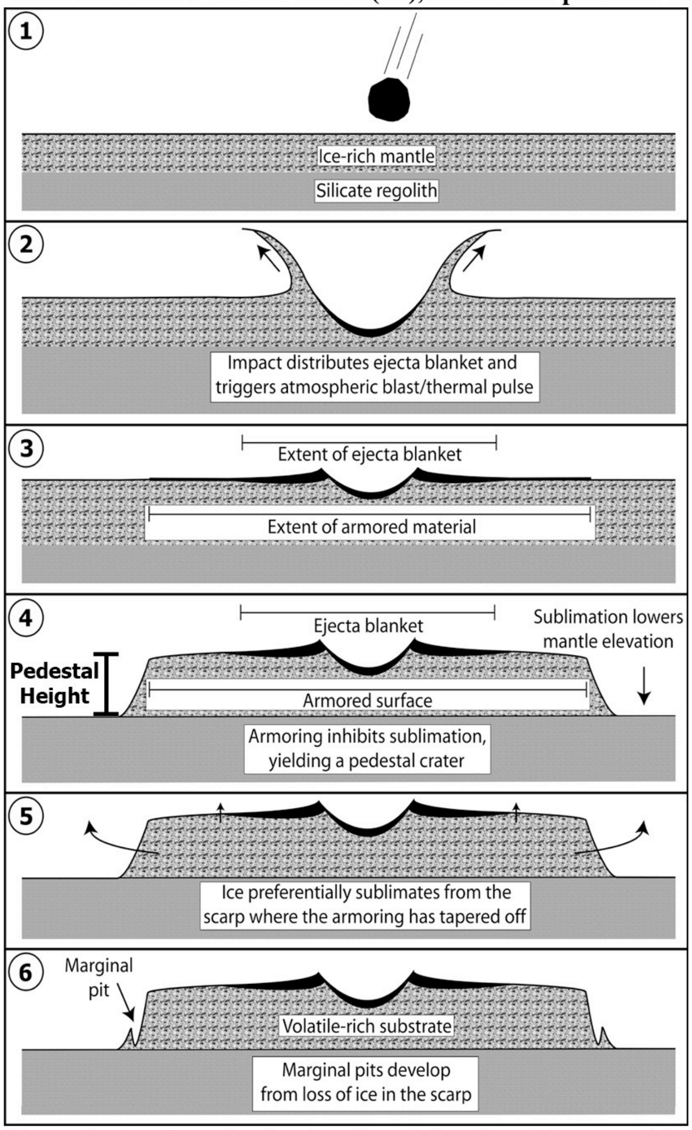

Figure 1 - A schematic showing the sublimation-driven model for the formation of Pd. The Pd height is marked in step four.

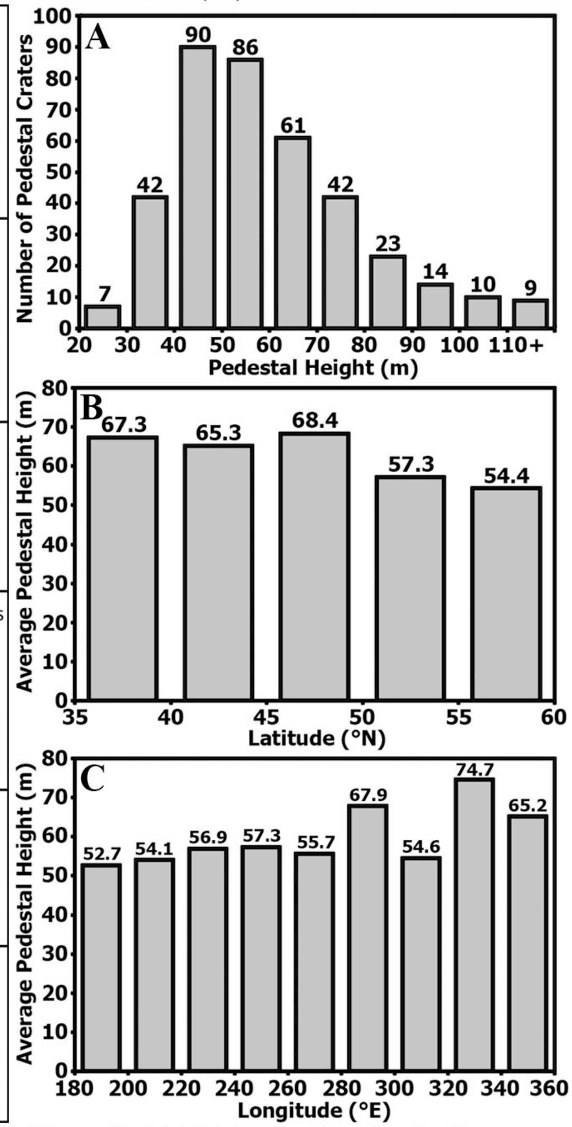

Figure 3 - A) A histogram showing the frequency of Pd heights. B) The latitudinal trend of average Pd heights. C) The longitudinal trend of average Pd heights.