Introduction: Impact crater shape characteristics have long been used to gain insights about the processes shaping planetary surfaces [e.g.,1-4]. In the present study, we use a large database of simple crater DTMs derived from high-resolution stereo topography (20 m/px) to measure variations across surface environments, in order to identify settings in which the modification sequence is statistically distinctive. We have focused on the low latitudes in order to examine the influence of dry processes (wind, impacts, and mass wasting), and have removed craters modified by episodic volcanism. A companion abstract for this meeting [5] makes use of the same data set and addresses rates of change through time based on crater counting statistics and a topographic diffusion model.

Methods: We generated over 80,000 DTMs of nearly 28,000 previously-mapped craters [6] in the latitude range ±30° from Context camera (CTX) stereo pairs [7] using the Ames Stereo Pipeline [8]. Image pairs with significant overlap were chosen according to criteria suggesting a good chance of high-fidelity results [9], although significant noise and spike artifacts appeared in many cases. A suite of more than two dozen quality metrics were used to evaluate these products and rule out defects, leaving between 14,000 and 21,000 crater DTMs for analysis, depending on the measurement.

Quantitative morphometric parameters were used to characterize the shapes of crater rims (aspect ratio, sharp vs. round) and cavities (to distinguish flat-floored from bowl-shaped or cone-shaped). Crater planforms (rim trace and cavity elevation contours) were also extracted and characterized as in previous work [10]. We also manually inspected all of the craters for a set of qualitative attributes such as the presence of ejecta and obvious cavity fill, signs of excellent preservation, and signs of formation and modification via processes not under study (e.g., secondary cratering, volcanism, collapse pits, and exhumation). The population of craters was subdivided by geologic contexts of varying material strength, age, and thermal inertia.

Results: Figure 1 shows plots of rim aspect ratio (Fig. 1A: rim height/diameter, h/D) and shape (Fig. 1B: curvature radius at the rim, λ, divided by crater radius, R) versus rim-to-floor depth over diameter (d/D). Plots of this kind capture the simple crater “modification sequence,” here sampled from settings distinguished by thermal inertia. The plots in Figure 1 show a running median of these quantities, surrounded by a shaded band that spans the interquartile range; d/D decreases to the right to evoke the sense in which this quantity always decreases over time. Regions of the plot with a significant offset in the medians or the interquartile range suggest statistically significant variations corresponding to meaningful differences in the modification sequence and governing surface processes. We have divided the low-latitude band according to thermal inertia (TI) because the abundance of sediment supply (high for low-TI and low for high-TI) may be expected to have a significant impact on the sequence.

We find a marked tendency for rim heights to be taller for any given d/D < 0.15 in low-TI regions (Figure 1A). We interpret this as meaning that cavity fill outpaces rim erosion as craters in these regions are modified over time. Similarly, as nonlocal fill increases and cavities become shallower, the rims of craters in low-TI regions tend to remain slightly sharper (lower λ/R), again likely because of nonlocal sedimentary fill playing a greater role in driving down d/D than rim erosion.

We find no statistically meaningful difference in these relationships across units of different age. As expected, however, we find that rims exhibit better preservation in high-strength lava plains units (as in e.g., [11]), where cavities are also more bowl-shaped until they become filled (d/D < 0.05). We also find that the dependence of rim rim shape (λ/R) upon rim aspect ratio (h/D) is remarkably uniform across the low latitude band: we find no statistically significant distinction when binning by age, material strength, or TI. Comparing with model predictions for a range of initial conditions based on measured crater profiles, this latter relationship also suggests that rims remain sharper as they erode than is anticipated by linear topographic diffusion.

Roughly 9% of craters in our dataset have visible ejecta. The aforementioned morphometric measurements were combined with this and other attribute flags to identify unusual craters whose presence may imply specific surface conditions. For example, ~100 craters having deep cavities (d/D > 0.19) without visible ejecta are plotted in Figure 2, alongside images of two examples. Many of these craters have clearly been present on the surface a long time, so that ejecta deposits have been erased by wind and small impacts. On the other hand, the near absence of fill over long peri-
ods implies a sediment-starved environment. In Figure 2, we include a map of thermal inertia [12], demonstrating that these craters cluster in high-TI settings, consistent with sediment-starved areas where more bedrock tends to be exposed and wind-mediated erosion and infill are not efficient.

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**Figure 1:** Plots of rim parameters versus rim-to-floor depth/diameter in regions of different thermal inertia ($N = 21,672$). The error band spans the interquartile range. “Low thermal inertia” corresponds to $TI \leq 120$, “medium” to $120 < TI \leq 250$ and “high” to $TI > 250$ (units: JK$^{-1}$s$^{-1/2}$m$^{-2}$). We suggest that rims exhibit better preservation (taller and sharper) in low-TI regions for a given $d/D$ because nonlocal fill primarily drives the decrease in this quantity.

**Figure 2:** (A) Map of the positions of $N = 99$ impact craters having deep cavities ($d/D > 0.19$) and no visible ejecta blankets, plotted on a map of thermal inertia (derived from Thermal Emission Spectrometer nighttime measurements [12]). These tend to cluster in high-TI regions (low sediment supply). (B-C) Examples of craters in this subset (IDs from the Robbins-Hynek catalog [6]): (B) crater 15-00223 with a diameter of $\sim 2$ km; (C) crater 11-004126 with a diameter of $\sim 2.5$ km. Both exhibit minimal infill with heavily modified surroundings and no visible ejecta deposits.