SIZE FREQUENCY DISTRIBUTIONS FOR VERY SMALL CRATERS ON MARS.

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Introduction: Mars is a complex world, as has been increasingly revealed by the numerous missions to that planet during the past decade. Conclusions about the planet's global geological processes of cratering and erosion (e.g. as reviewed by Chapman & Jones [1]), as inferred from early global imaging (e.g. Mariner 9 and Viking Orbiters) may retain some generalized credibility, but as the resolution has increased by orders-of-magnitude, the diversity and complexity of landforms deserve a fundamental new examination.

Our studies of small-scale cratering on Mars, were originally motivated to evaluate the role of secondary cratering (cf. McEwen et al. [2,3]). Secondaries become very numerous at small sizes, but are poorly recognized in lower resolution images. Because they are produced episodically in time (when sizeable primaries form on the surface of Mars) and their spatial distribution is markedly non-uniform (in rays and clusters of various sorts), their presence threatens the relative age-dating of Martian units, especially smaller regions where there are insufficient larger, clearly primary craters to assess a statistically meaningful crater density.

It has also become clear that the Martian surface has been modified at very different scales at various times, emphasizing the need to speak of "crater retention ages," which may vary enormously for the same unit as determined for craters of different sizes. One always hopes that as imaging resolution is improved, features seen in earlier images will become sharper and more well-defined...but this is often not the case. It was hoped that higher resolution images of inferred shoreline features of a putative northern ocean on Mars would be seen more clearly and definitively, but other subsequent processes had disturbed those features at the smaller scales revealed by the higher resolution images.

Our goal was to determine the relative contributions of pristine primary or secondary crater populations and the variety of effects of modification by one or more endogenic processes. We derived crater statistics from measurements mainly using publicly released HiRISE images, using traditional crater-measurement techniques made more efficient by preliminary processing by an "automated assistant" based on template correlation techniques. We find remarkable diversity in the characteristics of small-scale crater populations, even on the somewhat "simpler" geological localities we chose to study, raising questions about how well generalized conclusions can be drawn about the chronology of Martian geological evolution.

Methods: We selected seven localities on Mars for study. Our aim was to find small regions that were geologically homogeneous – lacking in complex variations within the study locality. We also wanted to study places that were comparatively simple, with only a few processes contributing to the cratering or degradation. Many regions at high latitudes seemed unduly complex, so our seven study localities are all located within 33 degrees of the equator. The HiRISE images used for our research have, of course, unusually high resolution compared with previous imaging of Mars. Our statistics generally concern craters ranging from under 2 meters to ~1 km in diameter. We have classified the craters into four degrees of degradation, ranging from fresh (class 1) to highly degraded (class 4). Because of the infrequency of class 1 craters, we have generally lumped class 1 and 2 craters into a single class. Most of the study regions have been evaluated at four resolutions, within nested rectangles with full resolution, ¼, 1/16, and 1/64 native resolution (typically about 25 cm per pixel). We plot our data using the standard R-plot format [4].

Results: The localities show diverse SFDs, reflecting differences in the recent history of both cratering and crater erasing processes. One locality (see figures), in an evident cluster of secondaries, exceeds the typical empirical saturation spatial density by more than a factor of 6 near 10 m diameter. The total-crater SFD for another locality follows the empirical saturation density between 3 and 150 m diameter. Yet another region is undersaturated by meter-scale craters by more than an order-of-magnitude. Common to many of these local regions is a significant population of craters a couple of hundred meters in diameter that have been subjected to an episode of crater degradation, erasing all craters <10 m in size but leaving craters larger than 0.5 km unscathed. In most localities, there has been recent re-cratering by a very steep SFD between 1 and 10 m diameter, leaving a marked deficiency in craters 10 to 20 m in size. One locality, just west of the locality being explored by the Opportunity MER, is covered with endogenic pits, which are difficult to distinguish from numerous tiny impact craters, rendering interpretation difficult. The craters are being degraded by a variety of processes, including crater overlap, active dunes, and a mound-forming process. We are cautioned by the diversity in our results that generalized interpretations of Martian chronology from studies of these small craters would be very problematical.

References: [1] Chapman C. R. and Jones K. L. (1977) *Ann. Rev. Earth Planet. Sci.*, *5*, 515-540. [2] McEwen A. S. (2003) *6th Intl. Conf. on Mars*, Abstract #3268. [3] McEwen A. S. et al. (2005) *Icarus*, *176*, 351-381. [4] Crater Analysis Techniques Working Group (1977) *Icarus*, *37*, 467-474.

Figs.: R-plot, automated, context, marked images.