DOES MARS HAVE A PRISTINE, -2 CUMULATIVE POWER LAW DISTRIBUTION FOR CRATERS >5 KM IN DIAMETER? K.L. Tanaka[1], J.A. Skinner, Jr.[1], and N.G. Barlow[2]. [1]Astrogeology Team, U.S. Geological Survey, Flagstaff, AZ 86001 (ktanaka@usgs.gov); [2]Dept. of Physics and Astronomy, Northern Arizona Univ., Flagstaff, AZ 86011.

Introduction. Crater densities have been instrumental in determining relative ages of surfaces on Mars and other cratered planetary bodies. Fundamental to this technique has been the cumulative bombardment of the surface over time of projectiles supplied from the population of Mars-crossing asteroids and comets. Diameters of craters are a function of impact energy determined by the velocity and mass of the projectiles [e.g., 1].

Accumulation of craters over time eventually results in a statistically defined crater size-frequency production function (PF). For larger crater diameters, larger surfaces and greater time spans are needed to accrue sufficient craters to precisely define the PF. For craters > 5 km in diameter on Mars, this requirement generally limits meaningful counts to surfaces Early Amazonian and older and covering > 10^5 to 10^7 km^2, depending on crater density.

Results for the form of the PF range significantly, particularly in the ~2 to 20 km diameter size range for intermediate age surfaces on Mars. Results by Tanaka [2] suggested a -2.0 cumulative PF power-law slope between 1 and 5 km diameter and a -1.8 slope between 5 and 16 km diameter. The Hartmann PF [3] as calculated from his lunar PF by Ivanov [1] yields a slope of -1.72 for the 1 to 32 km diameter range. The Neukum PF [3] shows a much smaller slope of ~-1.2 in the ~6 to 14 km size range, steepening at larger and smaller diameters. At larger diameters, the Neukum PF steepens to ~-2.5 and the Hartmann to -2.2 [1]. Frey [4] finds a slope of -2 for combined large craters and quasi-circular depressions inferred to be craters at diameters >25 km; the slope in this case might be related to saturation. These discrepancies result in significant uncertainty in the interpretation of relative ages for a host of surfaces and geologic units. Complicating these results is the relative degree to which crater obliteration processes may have affected the data used to define the PF.

Crater counts of Vastitas units. Geologic mapping of the northern plains of Mars has defined the boundaries of two widespread, contemporaneous units tentatively named the Vastitas marginal and interior units [5-6]. Possibly the two units represent different morphologic manifestations of the same deposits. This is a revision of the previous global mapping, for which the units were variously mapped as members of the Vastitas Borealis and Arcadia Formations [7]. The new map proposes that the base of the Amazonian Period now be defined by the timing of formation of the Vastitas units. These units have been suggested to be the result of a plains-filling ocean [e.g., 8]. However, morphologies within the unit, including thumbprint terrain, sinuous valleys with medial ridges, and polygonal fractures, indicate that the units have been heavily modified, in association with or soon following their formation [e.g., 5].

Crater counts for the Vastitas units have been performed by merging the present version of the crater database of Barlow [9] with the mapping. We include counts of pristine only and all craters (Figure 1, Table 1). The non-pristine craters are the heavily modified ghost craters that are nearly rimless, flat-floored, and lack preserved ejecta morphologies [10]. We find that the pristine crater distribution follows a –2 power law slope between 5 and 16 km diameter (Table 1). The slope is not constant but steepens slightly with increasing diameter. Werner et al. [11] find even steeper distributions (~-2.2 to -2.3) for counts within parts of the Vastitas units where polygonal terrain is present. The general consistency of the crater counts across varying elevation and latitude ranges that we have tabulated indicates that the Vastitas units essentially reflect the same distribution and relative age throughout.

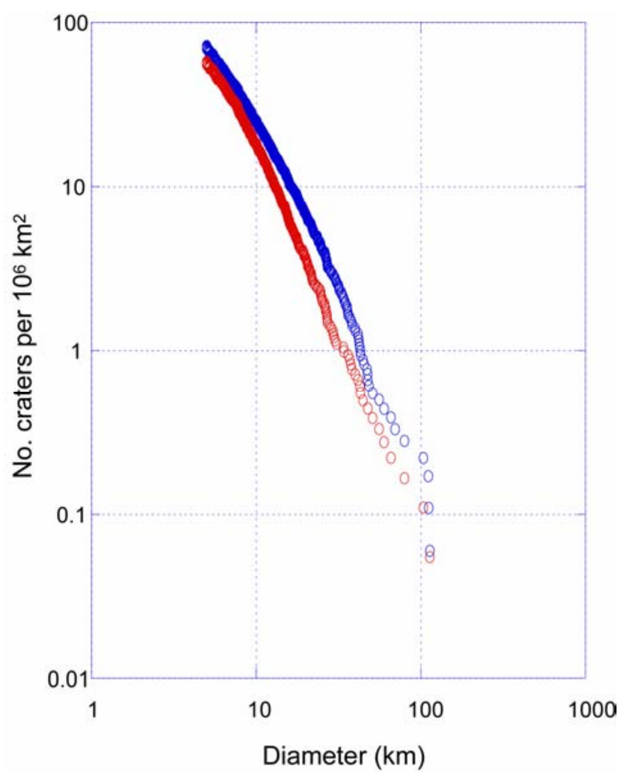

Figure 1. *Log-log plot of cumulative crater density for Vastitas units on Mars. Red, pristine craters only; blue, all craters.*

Table 1. Crater counts for the Vastitas units[a].

Unit	Slope[b]	N(5)[c]	N(16)[c]
pristine	1.96±0.13	57.6±1.8	5.9±0.6
total	1.67±0.10	72.1±2.0	10.3±0.8

[a]Total area = 18.1 x 10^6 km^2
[b]Power-law fit for N(5)/N(16)
[c]N(x)=no. craters >x km diameter per 10^6 km^2

Discussion. The steep crater size-frequency distribution for the Vastitas units may either represent a PF or it may have a paucity of larger craters. The Vastitas units occur at moderate to high northern latitudes. We have no reason to think that latitude somehow affects the distribution, nor do we see any latitude dependence for the power-law slope for the Vastitas units. A steeper size-frequency slope could also result from obliteration of larger craters relative to the smaller ones. This might occur if, for example, the larger craters were destroyed by relaxation of ductile target material. However, we find virtually no craters >5 km in diameter, especially larger craters >10 km, that appear to be partly destroyed that would demonstrate the operation of some such process. The ghost craters are extremely degraded and thus appear to be buried by the Vastitas units [5, 10]. Alternatively, Werner et al. [11] suggest that target property effects led to different crater morphologies and sizes; however, they did not explore how this might work. Some areas of the interior unit include pedestal craters generally < 5 km in diameter, indicating that thin mantles have occasionally covered at least parts of the units. However, if pedestal craters are preferentially destroyed, they would cause the PF to be shallower, not steeper. We do not detect any other signs of substantial resurfacing or mixing of surface ages, such as flow lobes within the unit. Younger units that partly bury the Vastitas units have been identified and mapped separately. Some of these younger units are thin and illustrate how resurfacing preferentially buried smaller craters. For example, flows from the western flank of the Elysium rise bury eastern and central Utopia Planitia. They have buried all but the larger craters tens of kilometers in diameter. Some of these have large ejecta ramparts that provided topographic obstacles to the Utopia flow materials. MOC images and MOLA topography demonstrate that the flows postdate the crater ejecta, whereas Viking images could not resolve these relations.

Other surfaces have been used to define the PF for intermediate-age on Mars. Typically, these are lava flow units, such as Alba Patera flows [3]. In such cases, at least several to dozens of flows of varying age are combined to define a surface. Because of this, 5 km craters, which typically have rim heights of about 200 m, require fewer flows (ranging typically from tens to a couple hundred meters thick) to bury them than larger craters. Thus larger craters will be preferentially preserved.

Given the apparent uniform crater size-frequency distribution across the broad Vastitas units and the lack of evidence for crater obliteration in the >5 km diameter size range, a possible interpretation is that the –2 slope power law between 5 and 16 km diameter represents the true PF for that diameter range for Mars. We propose that the –2 power-law slope for this size range applies for younger and intermediate age surfaces (Amazonian and Hesperian). Less certain is the PF for Noachian materials, which have been subjected to more obliteration and possible saturation.

Our hypothesis might be tested by crater counts for similar surfaces elsewhere on Mars or other cratered bodies such as the Moon and Mercury. It will be necessary to have ideally high-resolution image and/or topographic data to unequivocally map the extent of a broad, pristine surface of uniform age in which superposition of impact craters can be readily verified. We also need to explore existing crater-count data to see if such counts already exist and how they might verify or contradict our conclusions. This will likely be problematic, as crater counts have tended to yield conflicting results particularly in the 2 to 20 km size range for both the Moon and Mars.

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