THE SIZE DISTRIBUTION OF IMPACT CRATERS ON MERCURY: A PERSPECTIVE AFTER THE FIRST MESSENGER FLYBY:

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Introduction: The first MESSENGER flyby of Mercury will provide images of about half of the hemisphere missed by Mariner 10. These new images will expand the area for analyzing Mercury's cratering record and improving the first-order crater statistics obtained from Mariner 10 images. The distribution of impact craters provides important information on the source of impacting objects, the relative ages of geologic units, and the processes that affect crater preservation.

Inner Planets Cratering Summary: The terrestrial planets have two crater populations based on their size/frequency distributions on an R-plot, as shown in Fig. 1 [1,2]. The heavily cratered highlands of the Moon, Mars and Mercury all have complex size/frequency distributions (Population 1). For the Moon, the curve slopes downward to the left with a differential -2.2 slope at diameters less than about 50 km, is more-or-less flat (-3) between 50 and 100 km, and slopes downward to the right (-4) at diameters between about 100 km and 300 km. This shape is typical of the old Population 1 size distribution. The slopes are steeper at diameters less than about 40 km due to obliteration of craters by intercrater plains on Mercury, and because of erosion, deposition and volcanism on Mars (Fig. 2). The similar shapes indicate that the same population is responsible for the Late Heavy Bombardment (LHB), which occurred throughout the inner Solar System and ended about 3.8 Ga on the Moon.

Younger post-LHB surfaces on the Moon, Mars and Venus show a different crater size distribution characterized by a differential –3 size distribution (Population 2). A comparison of the size distribution of projectiles derived from the cratering record with those of main-belt and near-Earth asteroids suggests that the LHB was caused by main-belt asteroids and the post-heavy bombardment craters (Pop. 2) were mainly caused by near-Earth asteroids [3]. The dynamics of ejecting objects from the asteroid belt without changing the size distribution indicates that the LHB may have been a catastrophic event, perhaps the result of sweeping of gravitational resonances through the belt associated with orbital migrations of the outer planets [4, 5].

On Mercury, the younger crater population (Pop. 2) has not yet been identified, possibly because of the limited Mariner 10 coverage at Sun angles sufficiently low to permit accurate crater counts. The youngest surface measured is half the Caloris basin and its surroundings. This population appears to be the same as that on the heavily cratered surfaces, but it has a slightly shallower slope that may be caused by a contribution from Pop. 2 craters (Fig. 1). The basin probably formed very near the end of the LHB, but better statistics are needed to verify this inference.

MESSENGER Analysis: Image data collected during the first flyby will provide an opportunity to examine the crater population on the other half of the Caloris basin and its surroundings, and possibly on other young surfaces not imaged by Mariner 10. The new images of the western part of the Caloris basin will be at a resolution of about 250 m/pixel; the Sun will be fairly high so crater discrimination will be more difficult. A reliable determination of post- Caloris craters should nonetheless be possible.

The flyby will provide a major improvement to Mercury's crater statistics. It will provide constraints on the time and extent of resurfacing by intercrater and smooth plains and help determine if there are any major surfaces that post-date the period of the LHB. These findings in turn will place important constraints on the geologic history and evolution of Mercury. The improved statistics will allow more detailed comparison between the impact histories in the entire inner solar system from Mars to Mercury, and will help resolve some of the long-standing uncertainties, such as the extent and origin of the LHB, and the subsequent impact history.

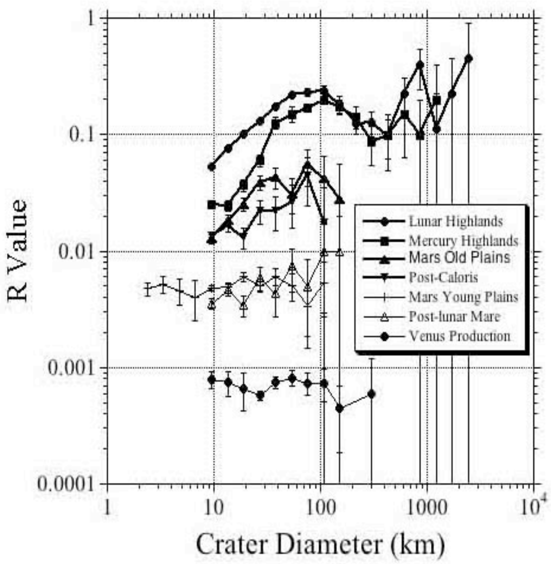

Fig. 1 R plot* of the size distributions of the lunar highlands, Mercury highlands, Mars old plains, Mercury post-Caloris basin, Mars young plains, and lunar post-mare, and the Venus production curve (see Ref. 4 for detailed explanation). The older surfaces have a different size distribution than the younger ones.

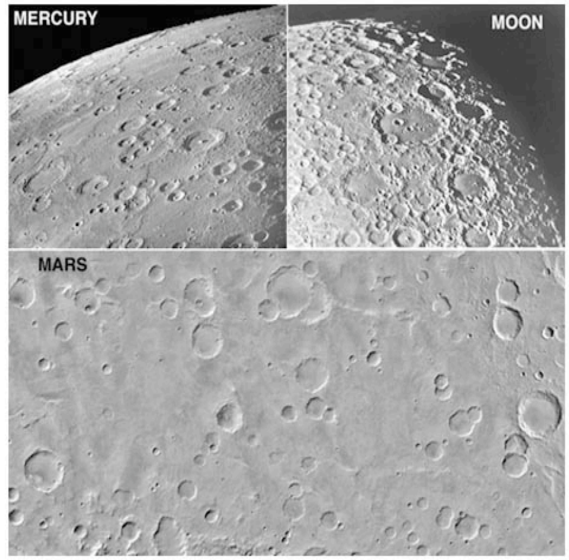

Fig. 2 Images of heavily cratered terrains on Mercury, Moon and Mars. Both Mercury and Mars have large areas of intercrater plains that have obliterated a portion of the cratering record, but the Moon is largely devoid of intercrater plains. The images are not to the same scale.

[1] Strom, R.G., Croft, S.K., and Barlow, N.G. in *Mars*, Univ. Arizona Press, 1992. [2] Strom, R.G. and Neukum, G., in *Mercury*, Univ. Arizona Press, 1988. [3] Strom, R.G., Malhotra, R., Ito, T., Yoshida, F., and Kring, D.A., *Science*, 309, 1847-1850, 2005. [4] Kring, D. A., and Cohen, B.A., *J. Geophys. Res., 107*, 5009, doi:10.1029/2001JE121529, 2002. [5] Gomes, R., Levison, H.F., Tsiganis, K., and Morbidelli, A., *Nature*, 435, 466-469, 2005.

*In the Relative or R plot, the size distribution is normalized to a power-law differential size distribution function, $dN(D) \sim D^p dD$, where N(D) is the number of craters in a diameter bin for which D is the geometric mean of the lower and upper crater diameters, and p = –3. A –3 distribution is used because most crater size distributions are within ± 1 of a –3 distribution.