IMPACT CRATER POPULATIONS ON MERCURY. Robert G. Strom[1], Zhiyong Xiao[1,2], Clark R. Chapman[3], Brett W. Denevi[4], James W. Head[5], Caleb I. Fassett[6], Sarah E. Braden[7], Sean C. Solomon[8], Thomas R. Watters[9], Maria E. Banks[9]
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Introduction: Two crater populations that differ in their crater size-frequency distributions have been recognized in the inner Solar System [1, 2, 3]. Population 1 is responsible for the period of Late Heavy Bombardment (LHB) and the younger Population 2 represents the post-LHB cratering. Population 1 impactors probably originated from main belt asteroids (MBAs) that were dynamically ejected during the orbital migration of the giant planets about 3.9 to 3.8 or 3.7 Ga [4]. Population 2 probably originated mainly from near Earth asteroids (NEAs) during the past 3.8 or 3.7 Ga [1]. The sweeping of resonances during giant planet migration is size-independent while the disturbance of asteroids by the Yarkoski effect to form the near Earth asteroids is size-dependent, in that smaller asteroids are preferentially ejected (Fig. 1).

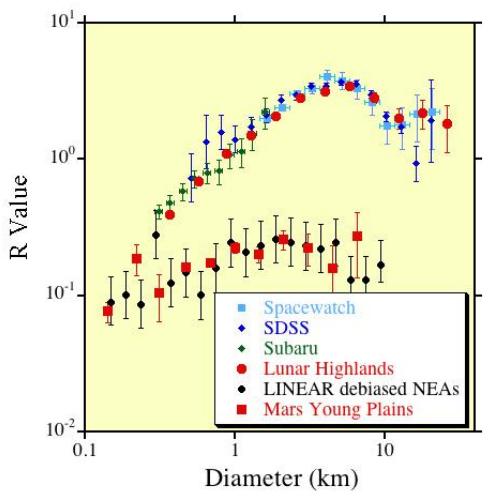

Figure 1. The size distribution of the projectiles (derived from the crater size distributions), compared with those of the MBAs and NEAs. The red dots (upper curve) are for the lunar highlands (Population 1), and the red squares (lower curve) are for young plains on Mars (Population 2). The other colors and point styles are for the asteroids and are derived from multiple sources with SDSS being the Sloan Digital Sky Survey (from [1]).

Population 1 craters have been recognized on the Moon, Mars and Mercury, whereas Population 2 craters have been recognized on the Moon, Mars and Venus [1]. Population 1 is not recorded on Earth or Venus because of more recent resurfacing that obliterated Population 1 craters. On Mercury, Population 2 was not recognized from Mariner 10 data because of the small area (~25%) imaged at Sun angles suitable for morphologic study. Also the area of the youngest smooth plains associated with the Caloris basin and the northern plains was too small to obtain reliable crater counts. MESSENGER has now imaged the entire planet (99%) at 250 meters/pixel, thereby providing the data to search for Population 2 craters.

Crater Counts: Crater counts have been preformed on the relatively young smooth plains within and surrounding the Caloris basin and on the northern plains. The youngest surface (lowest crater density) of these widespread smooth plains is the exterior Caloris plains [5]. The Caloris interior plains and the Northern Plains have indistinguishable crater size-frequency distributions, and, therefore, the same age [6].

Furthermore, the freshest (morphological Class 1) craters have been counted on the heavily cratered equatorial quadrangles (H 06-10) covering an area 2.94 x 10^7 km^2. These craters are the youngest on Mercury and consist of all rayed craters and those with pristine morphologies and well-developed ejecta deposits including well-defined secondaries. The total number counted was almost 1,100 craters.

An R-plot comparison of the crater size-frequency distributions for heavily cratered surfaces on the Moon, Mars, and Mercury with those for Class 1 craters on the Moon and Mercury is shown in Fig. 2. The heavily cratered surfaces have a complex size distribution similar in shape to that of main belt asteroids (Fig.1). However, the Mercury Class 1 craters have a uniform differential -3 slope similar to that on young plains units on Mars and Venus. Therefore, Mercury's Class 1 craters represent Population 2. On the Moon Class 1 craters on the lunar highlands occur at a higher crater density than Class 1 craters on Mercury's heavily cratered terrain. Since these heavily cratered surfaces formed during the LHB, the lower density on Mercury is probably due to the lower impact frequency of near Earth asteroids at Mercury compared with the Moon. Crater densities of Population 2 craters cannot be compared between planets to derive relative or absolute ages between the planets unless the impact frequency is taken into account. The impact frequency of Near Earth asteroids is greatest at Mars and least at Mercury. For instance, the Mercury Class 1 craters and the Mars Northern Plains in Fig. 2 have the same crater density, but that is probably due the higher impact rate at Mars. In reality, the Mars Northern Plains are surely younger than the Class 1 crater surface counted in the heavily cratered terrain on Mercury.

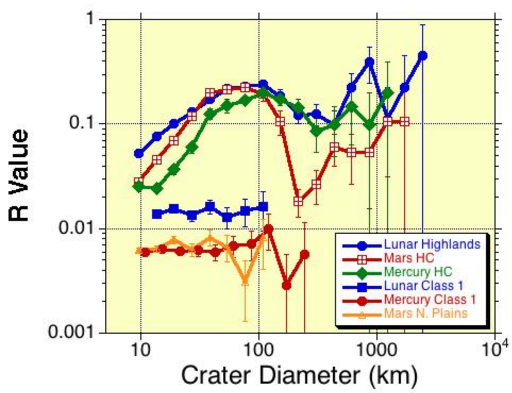

Figure 2. R-plot comparison of the crater size-frequency distributions for heavily cratered surfaces (HC) of the Moon, Mercury and Mars with those for lunar Class 1 craters on the front-side highlands, and Class 1 craters on the heavily cratered terrain of Mercury and the northern plains of Mars. See text for discussion.

A comparison of crater size-frequency distribution for the smooth plains exterior to the Caloris basin (the youngest large area of smooth plains on Mercury) with that for Class 1 craters on Mercury is shown in Fig. 3. The Caloris exterior plains display a higher crater density than the Class 1 craters and a distribution that slopes gently to the left on an R plot. The slope of the curve is consistent with a mixture of 95% Population 2 craters and 5% Population 1 craters [5]. This indicates that the Caloris exterior plains fromed very near the end of LHB and, therefore, are about 3.8 or 3.7 Ga.

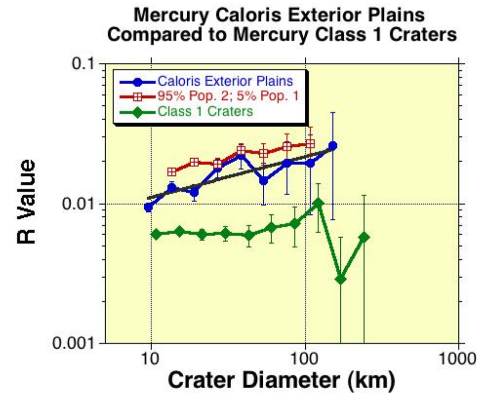

Figure 3. R-plot comparison of the crater size-frequency distributions for the smooth plains exterior to the Caloris basin and the for Class 1 craters on Mercury. The slope of the distribution for the Caloris exterior plains is consistent with a mixture of 95% Population 2 and 5% Population 1 craters as shown by the red line. The solid black line through the distribution for the Caloris exterior plains is a power law fit to the data.

Conclusion: For the first time a "pure" Population 2 distribution has been found on Mercury. This result strengthens the conclusion that there are two different crater populations in the inner Solar System, probably formed by the impacts of main belt asteroids for Population 1 and near Earth asteroids for Population 2.

References: [1] Strom, R.G. et al. (2005), *Science*, 309, 1847-1850. [2] Head III, J.W., et al., (2010), Science, 329, 1504-1507. [3] Fassett, C.I., et al., (2011), Geophy. Res. Lett., 38, L10202. [4] Gomes, R. et al. (2005), *Nature*, 435, 466-469. [5] Strom, R.G. et al. (2008), *Science*, 321, 79-81. [6] Head, J.W. et al. (2011), *Science*, 333, 1853-1856.