THE YOUNG INNER PLAINS OF MERCURY'S RACHMANINOFF BASIN RECONSIDERED. Clark R. Chapman[1], William J. Merline[1], Simone Marchi[1], Louise M. Prockter[2], Caleb I. Fassett[3], James W. Head[4], Sean C. Solomon[5], and Zhiyong Xiao[6,7]. [1]Southwest Research Institute (Suite 300, 1050 Walnut St., Boulder CO 80302; cchapman @boulder.swri.edu); [2]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723; [3]Department of Astronomy, Mt. Holyoke College, South Hadley, MA 01075; [4]Department of Geological Sciences, Brown University, Providence, RI 02912; [5]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015; [6]Lunar and Planetary Laboratory, University Arizona, Tucson, AZ 85719; [7]China University of Geosciences (Wuhan), Wuhan, Hubei, P. R. China, 430074.

Introduction: The smooth plains within the peak ring of Rachmaninoff basin formed long after the basin itself, on the basis of color and crater density differences between the plains and the annular plains (and other basin-related facies) [1]. Also they apparently formed fairly recently, considering the paucity of superimposed impact craters [1]; indeed, an age of <1 Ga has been proposed [2]. These studies were based on images taken during the MESSENGER spacecraft's third flyby of Mercury. During MESSENGER's ongoing orbital mission, images of Rachmaninoff (diameter *D* ~290 km) have been obtained at more than 3 times higher resolution and at better viewing geometries. Here we re-examine the crater population on the inner plains in order to establish the factors that affect estimates of the age of late volcanism on Mercury. This effort instructs us about the reliability of crater population measurements and interpretations at the limits of image resolution.

Data, Methodology, and Assessment: A sequence of nine narrow-angle camera images (binned 2×2 to 512×512 pixels) covers the inner plains of Rachmaninoff (between observation numbers 523931 and 523947). Image scales range from 106 to 113 m/pixel. From a mosaic of these images, craters were identified, measured (position, diameter or axial dimensions if elliptical in shape), and classified (morphology classes 1=fresh to 4=very degraded or shallow, and whether obviously in a chain or cluster). Craters were measured down to about 6 pixels diameter, with counts probably complete to 7.5 pixels or D = 0.8 km. In all, 1,235 craters were measured (D = 0.6 to 2.9 km) within an elliptical (nearly circular) region (Fig. 1) that encompasses most of the inner plains (excluding the portion of the plains that spills out onto the annular plains to the southeast and small areas near the inner boundary of the peak ring).

In the earlier studies [1, 2], just 74 (D > 1.4 km) and 30 (D > 2 km) craters were identified, respectively, pushing the resolution limits of the images. Of the 74 craters of the first study [1] (identified within the same elliptical area used in the present study) it is now clear that 48 were good identifications of individual impact craters. Another 14 were somewhat misperceived (e.g. they are actually double or triple craters in most cases); they are impact craters but were tabulated as single larger diameter craters instead of two or more of smaller diameter. The remaining 12 identifications were mistaken (e.g., junction of two graben or a region between two hills). Just 33 craters with D > 1.6 km were deemed complete and used in the analysis of Prockter *et al.* [1].

In the second study [2], three craters were identified outside of the present study ellipse (two of which now appear possibly to be on the peak ring, not in the plains); 26 of the remaining 27 were also identified in the first study [1]. But the second study [2] interpreted only seven of the craters on the elliptical plains unit as "bona fide" impact craters; the remaining 21 craters were considered to be of endogenic origin, associated with the valleys ("graben"), and were not used in determining the plains age. Because most of the craters studied from the flyby images were near the resolution limit, there are modest systematic offsets in measured diameters from measurements of orbital images.

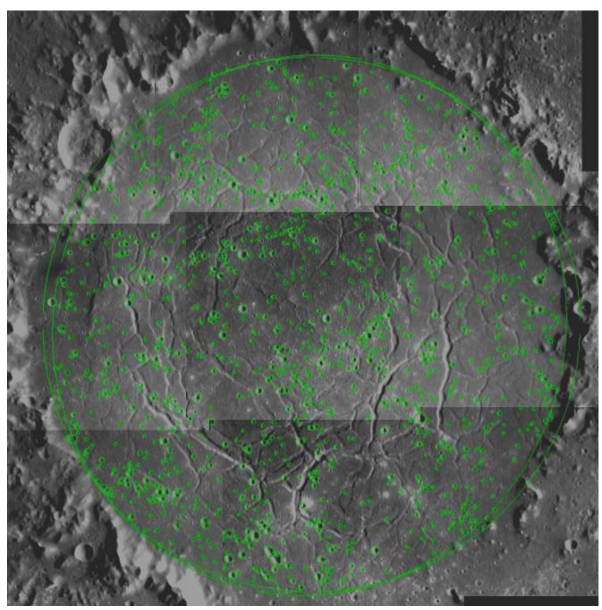

Fig. 1. Mosaic of the inner plains of Rachmaninoff; craters are marked by green circles. Outer near-circular ellipses (D~125 km) are counting areas in the earlier study [1] and the best estimate for the present study.

From detailed examination of the higher-resolution images, it is clear that the intricate network of "graben" (linear or curving valleys) are rarely, if ever, composed of endogenic craters or pits. Because of the abundance of small impact craters, these valleys (and small ridges near the center of the inner smooth plains) intersect some craters, apparently always in the sense that the craters are superposed on the valleys and ridges. Thus the processes that formed the volcanic and tectonic features ceased operating fairly quickly.

From the high fraction (~57%) of craters that, on the basis of visual inspection, appear to belong to either a chain or cluster of craters, it is clear that craters on the inner plains are predominantly secondaries. The fact that ~82% of all craters have somewhat degraded or misshapen morphologies (classes 2 – 4) is an additional indication that most of these relatively recent craters were formed with less-than-pristine shapes, further suggesting that they are secondaries. A final indication that they are mainly secondaries is their very steep size distribution (see below). Thus the spatial densities of these craters can provide only a very crude indication of the age of these plains compared with other places on Mercury.

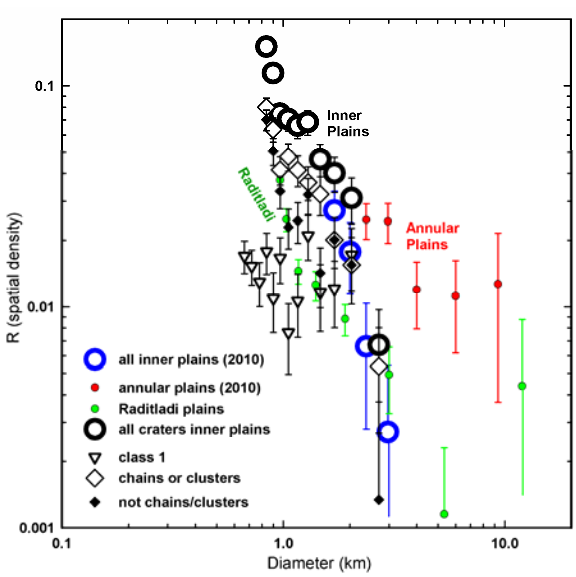

Fig. 2. R plot of size-frequency distributions for craters on the inner plains of Rachmaninoff for all craters (open circles represent a population of 669 craters above the completeness limit of D=0.82 km) and subsets (class 1, craters in chains or clusters, craters not in chains or clusters) and comparisons with older data (in color) from flyby images [1] for inner plains, annular plains, and plains in Raditladi.

Size-Frequency Distributions: As shown in the R plot (Fig. 2), the size-frequency distribution (SFD) for all craters on the inner plains is unusually steep, although between 1 and 2 km diameter it is shallower and more similar to SFDs for typical secondary crater populations (power-law exponent of differential SFD between -4 and -5). Near 2 km diameter, the spatial density is nearly double that estimated in the earlier study [1], mostly because some craters interpreted before as single, relatively large craters are now recognized as groupings of smaller craters.

Note that craters that are *not* parts of obvious chains and clusters have an SFD nearly as steep as those in chains and clusters (i.e. secondaries), so most of them are likely to be secondaries as well. Fresh, class 1 craters have a shallow SFD (approximately horizontal in the R plot), similar to the Population 2 impactors on inner solar system bodies of Strom *et al.* [3]. But some class 1 craters are parts of chains or clusters, so they cannot be regarded as a pure sample of primary impact craters. At best, the class 1 SFD may be an upper limit to the numbers of primary impact craters.

Compared with the floor of the more recently formed peak-ring basin Raditladi [4], the density of small craters on the Rachmaninoff inner plains is at least 4 times higher, suggesting an age difference of approximately a factor of 4 (for a constant cratering rate by secondaries). Since secondary cratering is clustered in both space and time, such age estimates are highly uncertain. The earlier estimate [2] that these inner plains formed about 1 Ga seems to be ruled out, in any case, because these craters are impact craters, not endogenic craters; we are revising our model age estimates for the inner plains.

Conclusions: Nothing in this study changes the earlier conclusion [1,2], mostly based on comparisons of craters D > 2 km between the annular and inner plains, that volcanism persisted in Rachmaninoff long after the basin formed. But the surprising abundance of small impact craters 0.8 – 2 km in diameter suggests that we should look elsewhere on Mercury for unusually recent volcanism, unless Rachmaninoff has been preferentially subject to enhanced, recent secondary cratering compared with Raditladi. Of course, the Raditladi plains are probably significantly more recent than the Rachmaninoff inner plains, but they are not distinguishable in age from the Raditladi basin itself [4], so they may be impact melt rather than produced by volcanism.

References: [1] Prockter L. M. et al. (2010) *Science, 329,* 668–671. [2] Marchi S. et al. (2011) *Planet. Space Sci., 59,* 1968-1980. [3] Strom R. G. et al. (2005) *Science,* 309, 1847-1850. [4] Strom R. G. et al. (2008) *Science*, 321, 79-81.