NEW IDENTIFICATION OF ANCIENT MULTI-RING BASINS ON MERCURY AND IMPLICATIONS FOR GEOLOGIC EVOLUTION. P. D. Spudis^{1,2} and M. E. Strobell¹ 1. U.S. Geological Survey, Flagstaff, AZ 86001 2. Dept. of Geology, Arizona State Univ., Tempe, AZ 85287

Initial examination of photographs of Mercury provided by Mariner 10 almost a decade ago revealed numerous impact features, including large basin-sized structures [1]. In subsequent studies of these photographs, many workers have attempted a systematic inventory of the large-basin population of Mercury [2-7]. Recent geologic mapping of the Michelangelo (H-12) quadrangle [8] indicates that its regional geology is strongly controlled by four large, nearly obliterated multi-ring basins [9]. Under this impetus, a systematic survey of the entire Mariner 10 coverage of Mercury was made to determine the number, distribution, and dimensions of additional ancient basins on the planet (Table 1).

Ancient multi-ringed basins on Mercury can be recognized by the following criteria: 1) arcs of massif chains and isolated massifs that protrude through younger units; 2) arcuate segments of lobate ridges (rupes) that align with massifs in circular patterns; 3) arcuate scarps that align with ridges and massifs; 4) segments of ancient crater rims that appear, from evidence of relief greater than adjacent segments to have been rejuvenated; and 5) isolated regions of anomalously high topography within the intercrater regions of heavily cratered terrain. All of the newly identified basins predate the mercurian intercrater plains, previously held to be the oldest geologic unit on the planet [10]. The degradational state of these features is comparable to that of ancient lunar basins such as Al-Khwarizmi-King [11, 12] and some nearly obliterated martian multi-ring basins [13]. Thus the current inventory (Table 1) is probably an underestimate due to the relatively poor Mariner 10 photographic coverage of Mercury. The new multi-ring basins are named here for unrelated, superposed craters and named plains regions, following a similar practice for naming degraded lunar basins [12].

Although ancient basins are recognized primarily by photogeology, topographic information from Earth-based radar provides physical proof of their presence [14,15]. Radar profiles of Mercury are available for only a narrow region between -5° and +15° latitudes, so only basins located within this band can be studied (Donne-Moliere, Mena-Theophanes, Budh, and Tir basins; Table 1). Basin rings are discriminated by the radar as topographic highs with relief typically 1 km or less, that are found in otherwise nondescript terrain. Highs on profiles that occur at +8.5°, 21°, +9°, 27°, and -0.5°, 18° lie along portions of rings 2, 3, and 4, respectively, of the Donne-Moliere basin. Ring 3 of the Budh basin is made evident by a 1.5 km peak at +12°, 140° and by a somewhat lower peak at +12°, 163°. Topographic highs at +11°, 128° and 132° on ring 4 of the Mena-Theophanes basin are rejuvenated segments of older crater rims.

Subsequent structural evolution of various regions has been influenced by these basins. A global network of lobate ridges (rupes), interpreted as thrust faults, had been recognized previously [16]. In many cases, the arcuate trend of these ridges outlines an ancient basin ring (e.g., Hero Rupes, part of ring 2 of Vincente-Yakovlev). In other instances, a more-or-less continuous ridge network may encounter a pre-existing basin ring obliquely, follow the outline of that ring, deflect in towards the next ring, and re-establish the circular outline of an inlying ring (e.g., Adventure-Discovery Rupes and rings 3-5 of Andal-Coleridge). These relations suggest that although the ridge system probably is related to global compression, local trends are controlled by pre-existing structural patterns provided by ancient multi-ring basins.

The new identifications of mercurian basins may change concepts of cratering histories for the terrestrial planets. All previous studies of mercurian basins have emphasized the apparent deficiency of basins on Mercury relative to the Moon [2-4, 7]. Cumulative basin density on Mercury (D \geq 200 km) is reported by [7] to be only 37 percent of that of the Moon. The Moon has at least 62 basins (D \geq 200 km; [4]), resulting in an average density of 1.72 \pm 0.13 per 10 km². Only about 35 percent of Mercury's surface was photographed with lighting conditions adequate [17] to recognize ancient basin structures. The newly identified basins suggest that Mercury has at least 50 basins (D \geq 200 km) within this area. Thus, the average density of mercurian basins is 1.92 \pm 0.14 per 10 km². This value suggests that Mercury is not deficient in multi-ring basins and may possibly have more per unit area than the Moon. The presence of a large population of multi-ring basins that pre-date the mercurian intercrater plains material

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suggests that basin production was a more-or-less continuous process during the early history of planets, and lends support to hypotheses of continually declining cratering rates [18] rather than to a "late cataclysm" model of basin production.

The recognition of many previously unrecognized ancient basins on Mercury has several implications for the geologic evolution of terrestrial planet crusts. It now appears that all terrestrial bodies with preserved ancient surfaces (Moon, Mercury, Mars) have a large population of multi-ringed impact structures. All of the newly discovered mercurian basins pre-date the intercrater plains planetwide. This relation suggests a distinct epoch of intercrater-plains formation that at least partly erased the pre-existing crater population, leaving remnants of only the largest structures. Thus, the process responsible for formation of the intercrater plains material must have operated planetwide. The hypothesis that the intercrater plains material is a primordial crust [10] appears untenable; a primordial crust would preserve a spectrum of multi-ring basin states. The mercurian intercrater plains material may be at least partly volcanic [19], its surface morphology disrupted by the last phases of heavy bombardment. The tendancy of global tectonic patterns to be locally influenced by multi-ring basin structure seems analogous to similar patterns on the Moon [20] and Mars [13]. Thus, basins appear to provide the broad-scale structural pattern of early terrestrial planetary crusts.

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Basi n 1			Ring Diameters 3 (km)						(F) F E
	Confld.2	Cent	ter	151	2nd	3rd	4th	5th	Comments ⁴
Borealls	2	73*,	53°	-	141	860	1530	(2230)	Partially mapped by [16]
Gluck-Holbeln	3	35*,	19*	240	500	950	•	•	The second secon
Derzhavi n-Sor Juana	2	51*,	27*	-	560	740	890	-	Partially mapped by [4]
Sobkou	1	34*, 1	132*	•	490	850	1420		Partial arcs: 810, 1010, 1280; partially mapped by (61
Chong-Gaugu I n	3	57*, 1	106*	220	350	580	940		
Brahams-Zola	1	59°, 1	172*	340	620	840	(1080)	3.5	Partial arcs: 500, 740, 940
Donne-Mollere	3	4.	10*	375	700	(825)	1060	1500	
Hiroshige Mahler	1	-16*,	23*	150	355	(700)	-	-	
Mena-Theophanes	1	-1", 1	129*	260	475	770	1200	-	Partially mapped by [4]
Tir	1	6*,	168*	380	660	950	1250	-	
Budh	2	17*,	151*	-	580	850	1140	-	
I bsen-Petrarch	2	-31*,	30*	425	640	930	1175	-	
Andal-Coteridge	1	-43°,	49*	(420)	700	1030	1300	1750	
Matisse-Repin	1	-24°,	75*	410	850	1250	(1550)	(1900)	"Haydn-Raphael" of [6]
Bartok-Ives	3	-33*,	115*	480	790	1175	(1500)		MINISTER CONTRACTOR OF THE PARTY.
Hawthorne-Riemenschneider	2	-56",	105*	270	500	780	1050		
VIncente-Yakoviev	1	-52*,	162*	360	725	950	1250	(1700)	
El toku-Mil ton	1	-23.	171*	280	590	850	1180	-	
Boccaccio-Scopas	3	-82.5°,	44*	360	600	930	(1310)	, 1	

TABLE 1. ANCIENT MERCURIAN MULTI-RING BASINS

¹ Basin nomenclature after system developed for ancient lunar basins [12]

Confidence level of identification: 1 - definite; 2 - probable; 3 - possible.

³ Numbers in parentheses reflect uncertain ring continuity; assignment to the five ring rankings is arbitrary.

Partial arcs are concentric structures confined to one side of basin; previous studies that are referenced mapped portions of larger, multi-ring structures recognized here.