Updated Catalogs of Peak-Ring Basins and Protobasins on Mars

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Motivation:

- The morphology of peak-ring basins (exhibiting a rim crest and interior peak ring) in the complex crater to basin transition on the Moon and Mercury have been well characterized based on data from recent missions to these planetary bodies [e.g., 1].
- Although global crater catalogs have recently been produced for Mars [e.g., 2], the detailed characteristics of the crater to basin transition on Mars has not been fully re-examined since basin ring catalogs and measurements were produced over two decades ago by Pike and Spudis [3], among others.
- Here, previous basin catalogs [3] and the global crater catalog of Robbins et al. [2] are re-analyzed using topographic and image datasets to provide updated catalogs of peak-ring basins and protobasins on Mars.
- These updated catalogs are important for comparisons with other planetary bodies [1], constraining basin formation models, and understanding the original morphology of the abundant degraded craters on Mars.

Findings:

- A total of 16 peak-ring basins and 8 protobasins were identified, ranging in rim-crest diameter from 101 to 446 km (peak-ring basins) and 89 to 298 km (protobasins).
- Nine of these basins are newly added to the catalog and not included in the previous catalog of [3]. Nine basins from [3] are also removed from the present catalogs, as current topography and image data do not support the presence of interior rings within these basins.
- Although it has a larger surface area, Mars has nearly an order of magnitude fewer peak-ring basins than Mercury (N=110), which can be attributed to the planet's much higher resurfacing and erosion rates.
- Like Mercury, the rim-crest diameters of both complex craters with central peaks and protobasins overlap those of peak-ring basins over a much larger range than on the Moon.
- As noted by previous researchers, protobasins, such as Lyot, occur at anomalously large diameters on Mars compared to Mercury and the Moon. The effect of volatiles on the basin-formation process is often used to explain this feature, but more modeling work is needed to fully explore this problem.

Acknowledgements

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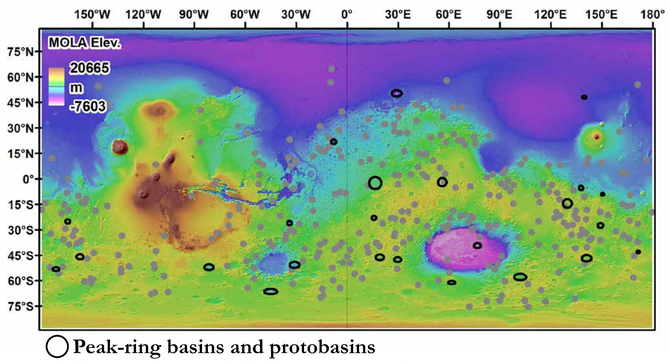
References: [1] Baker, D.M.H. and Head, J.W. (2013) Planet. Space Sci. 86, 91–116. [2] Robbins, S.J. and Hynek, B.M. (2012) J. Geophys. Res. 117, E05004. [3] Pike, R.J. and Spudis, P.D. (1987) Earth Moon Planets 39, 129–194. [4] Allen, C.C. (2015) LPSC 46, no. 2787. [5] Baker, D.M.H. et al. (2011) Icarus 214, 377–393. [6] Baker, D.M.H. et al. (2011) Planet. Space Sci. 59, 1932–1948. [7] Edwards, C.S., et al. (2011) J. Geophys. Res. 116, E10008.

I. Global Distribution

Peak-ring basins and protobasins are mainly located within the cratered southern highlands of Mars. Below is an equidistant cylindrical map of MOLA colored topography on a MOLA hillshade basemap.

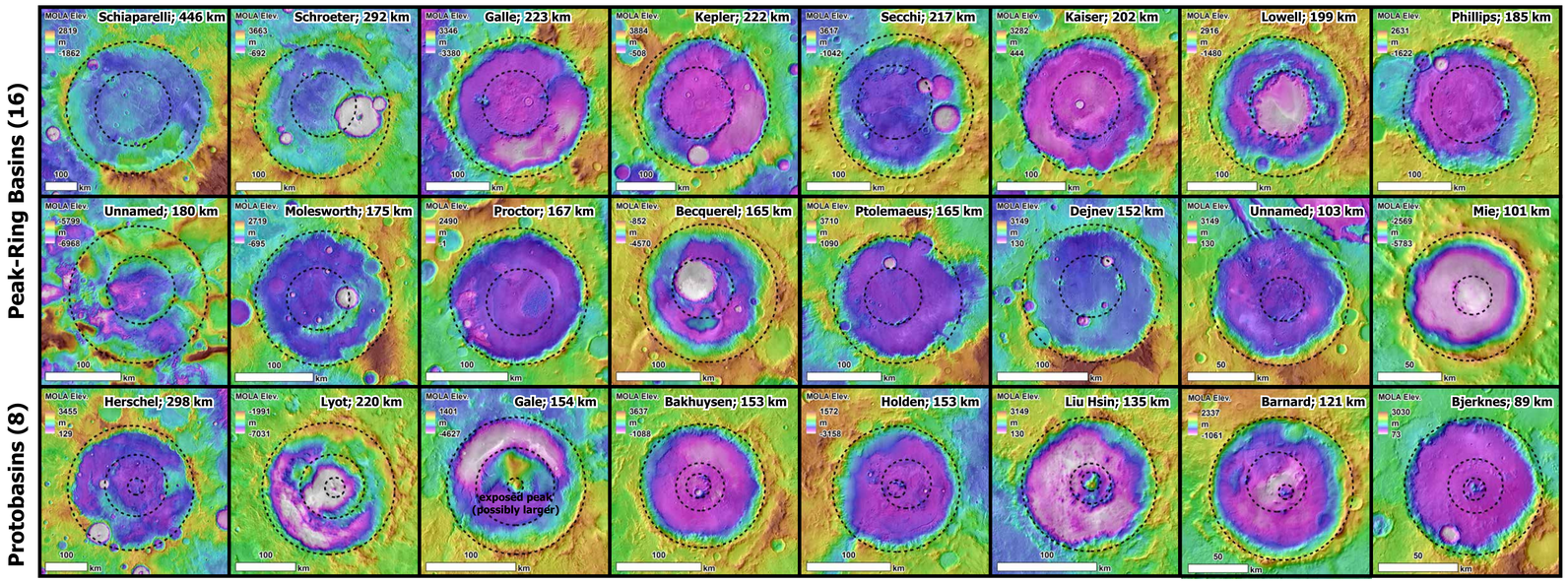


◯ Peak-ring basins and protobasins

● Complex craters >50 km with central peaks

II. Basin Images

A catalog of craters ≥1 km on Mars from Robbins et al. [2] was used to survey all craters >50 km on the planet (N=2,070) in a manner similar to [5,6] for the Moon and Mercury. Datasets used included MOLA gridded topography and a global THEMIS daytime IR mosaic [7]. During the survey, each crater was identified as having a rim crest in addition to a single interior ring of peaks (peak-ring basin), an interior ring of peaks plus a central peak (protobasin), a central peak only (complex crater), or no interior structure (unclassified).



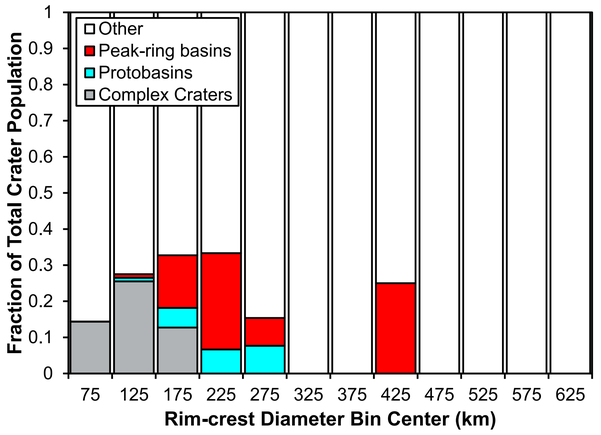
III. The Updated Basin Catalogs for Mars

Updated basin catalogs.

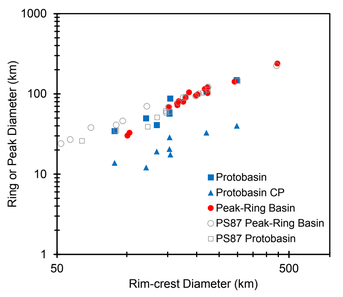
Name	Lat.	Lon.	D_r	D_{pr}	D_{cp}
Peak-Ring Basins					
Schiaparelli	-2.51	16.80	446	239	--
Schroeter	-1.90	55.99	292	142	--
Galle	-50.65	-30.88	223	102	--
Kepler	-46.75	141.16	222	120	--
Secchi	-57.85	101.97	217	115	--
Kaiser	-46.16	19.11	202	98	--
Lowell	-51.95	-81.37	199	96	--
Phillips	-66.33	-44.79	185	104	--
Unnamed	-39.34	76.83	180	90	--
Molesworth	-27.49	149.21	175	80	--
Proctor	-47.57	29.69	167	81	--
Becquerel	21.89	-7.94	165	72	--
Ptolemaeus	-45.89	-157.73	165	76	--
Dejnev	-25.14	-164.64	152	68	--
Unnamed	-9.07	150.51	103	33	--
Mie	48.12	139.69	101	30	--
Protobasins					
Herschel	-14.48	129.89	298	148	40
Lyot	50.46	29.31	220	106	33
Gale	-5.37	137.81	154	87	18
Bakhuysen	-22.97	15.76	153	57	29
Holden	-26.04	-34.02	153	58	21
Liu Hsin	-53.20	-171.51	135	41	19
Barnard	-61.08	61.55	121	50	12
Bjerknes	-43.06	171.48	89	34	14

D_r: rim-crest diameter (km); D_{pr}=peak-ring diameter (km); D_{cp}: central-peak diameter (km).

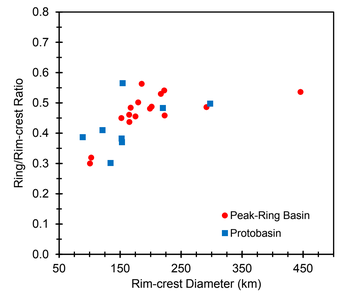
Below: Number of basins and craters with interior structures as a fraction of the total crater populations [2]. Note the low number of craters and basins on Mars with recognizable interior peaks or rings due the higher erosion and resurfacing rates on the planet. This is most evident when compared with the Moon and Mercury (below).



Peak-ring and/or central-peak diameters versus rim-crest diameters for peak-ring basins and protobasins on Mars only. Data from Pike and Spudis [3] (PS87) are shown for comparison.



Ratios of peak-ring diameter to rim-crest diameter for peak-ring basins and protobasins on Mars only. The ratio increases with increasing basin size. The same occurs on the Moon and Mercury (see below).

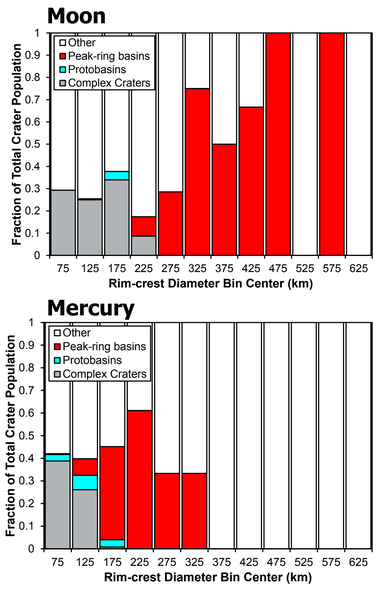


IV. Comparisons with the Moon and Mercury

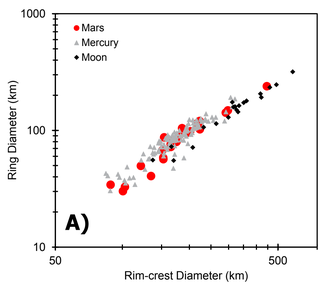
Table of basin summary statistics, comparing the Moon [1,5], Mercury [1,6] and Mars. Mars has the lowest population of preserved peak-ring basins even though it has the greatest surface area. Protobasins also occur at anomalously large diameters on Mars.

	Moon	Mercury	Mars
Gravitational acceleration (m/s^2)	1.62	3.70	3.69
Surface area (km^2)	3.8 x 10^7	7.5 x 10^7	1.4 x 10^8
Mean impact velocity (km/s)	19.4	42.5	10.6
Peak-ring basins (N_{pr})	17	110	16
N_{pr}/km^2	4.5 x 10^{-7}	1.5 x 10^{-6}	1.1 x 10^{-7}
Geometric mean diameter (km)	343	172	188
Minimum diameter (km)	207	84	101
Maximum diameter (km)	582	320	446
Onset diameter, method 1 (km)	206	109 (+23,-19)	132 (+35,-28)
Onset diameter, method 2 (km)	227	103	102
Protobasins (N_{proto})	3	70	8
N_{proto}/km^2	7.9 x 10^{-8}	9.4 x 10^{-7}	5.7 x 10^{-8}
Geometric mean diameter (km)	157	92	155
Minimum diameter (km)	137	50	89
Maximum diameter (km)	170	195	298
Complex Craters ≥ 50 km (N_{cpc})	430	682	311
N_{cpc}/km^2	1.1 x 10^{-5}	9.1 x 10^{-6}	2.2 x 10^{-6}
Geometric mean diameter (km)	75	70	75
Minimum diameter (km)	50	50	50
Maximum diameter (km)	205	168	182

Number of basins and craters as a fraction of total crater populations [1].



A) Peak-ring diameters versus rim-crest diameters for peak-ring basins and protobasins on Mars, the Moon [1,5], and Mercury [1,6]. The data fall along a similar power-law trend.



Ratios of peak-ring diameter to rim-crest diameter for peak-ring basins and protobasins on the Moon (B) and Mercury (C). Note the similarly increasing ratios with basin size, suggesting a continuum in process forming protobasins and peak-ring basins.