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The Transitions from Complex Craters to Multi-Ring Basins on Mercury: New Insights from MESSENGER Data

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The transition from simple bowl-shaped craters to complex craters with increasing crater diameter involves the formation of wall terraces, flat floors, and central peaks. At larger diameters, the transition from complex craters to peak-ring basins involves the initial suppression and widening of the central peaks, a transition through "protobasins" (central peak and peak ring), and then replacement of the central peaks by the development of a ring of peaks and massifs (peak-ring basins, PRBs) that progressively increases in diameter with basin size (the diameter ratio of peak ring to basin also increases with basin size). Multi-ring basins (MRBs, with three or more rings) form at still larger diameters. The transitions from complex craters to peak-ring basins to multi-ring basins follow generally similar morphological changes with increasing feature size on different planetary bodies; however, the onset diameters for these transitions, the detailed morphologies at each stage, and the density of basins of different types show differences from body to body. For example, Mercury displays the highest density of PRBs in the Solar System and a low onset diameter for such structures and is thus an excellent laboratory for the analysis of crater and basin transitions. Using image data from Mariner 10 and the first three MESSENGER flybys of Mercury, we document and characterize 1) the transition from complex crater to peak-ring basin, 2) the population of peak-ring basins, and 3) the transition from peak-ring basin to multi-ring basin. Detailed mapping of several large complex craters and "protobasins" newly imaged by MESSENGER (e.g., Eminescu and Raditladi) provides insight into the transition between these forms. We have found 33 additional peak-ring basins in the MESSENGER data, which together with the 27 previously identified brings the total to 60; two of the additional basins (105 and 121 km in diameter) are smaller than the previous onset diameter, whereas the largest peak-ring basin diameter increases the transition diameter to multi-ring basins to 320 km. Detailed mapping of several examples of peak-ring basins and the newly discovered 715 km-diameter Rembrandt multi-ring basin (together with comparisons with the lunar Orientale basin) provide insight into the transition from peak-ring to multi-ring basin and permit the testing of models for basin ring formation. The characterization of these new large craters and basins will provide important targets for the assessment of 1) impact depth of sampling, 2) crustal composition, and 3) crustal stratigraphy during the orbital phases of the MESSENGER and BepiColombo missions.