LARGE CRATERS OR SMALL BASINS ON THE MOON

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Rings gradually replace central peaks in large impact craters, with increasing crater size [1,2]. New lunar data elucidate this morphologic transition. Analysis (Figure 1) of 54 of the 87 craters larger than 135 km across [3] (no data for the 33 others) from Lunar Orbiter and Apollo images has revealed at least two classes of central features that span the transition from massive peaks in large craters to mature rings in small basins. These are (1) open clusters of central peaks or peak elements that usually are greater in diameter than single peaks or the tight clusters of peaks [4], and (2) central rings that are systematically smaller in diameter than central rings of larger (mature) basins. Despite the gradual character of the crater-to-basin transition, the distinction between craters and basins remains that between presence of peaks and presence of rings: In Figure 1, the gap between centers of distributions, normal to fitted lines, separating small central rings from open peak clusters exceeds the gaps separating peaks from peak clusters and small rings from mature rings.

The size-dependent transition from peaks to rings on the Moon [1] begins at the smallest crater containing both features (Antoniadi, 135 km) and ends at the largest crater whose central ring occupies substantially less than the 0.5 ± 0.05 D_{II}/D_{IV} fraction (Mendeleev, 325 km +) that characterizes mature two-ring and multiring basins [5,6]. The new data suggest that lunar basins begin with Schrödinger (320 km $\pm$ 5 km), not Antoniadi, which with Compton resembles craters more than basins in morphology [4]. Craters with both peaks and rings may include Hipparchus, Campbell, Fermi, and Mendeleev. Central peaks in five of these six craters (Figure 1) are far smaller for the diameter of their host craters than normally (equation in [7]) is the case.

The reduced size of both peaks (allowing for embayment by crater fill) and rings within large transitional craters, which was first established from the more voluminous data on Mercury and Mars [8], may well reflect division of energy between two competing central structures [7,8]. Similarly, single central peaks of the largest fresh craters in the transition zone (e.g. Tsiolkovskiy) are wider than normal [7], probably as compensation for absence of a central ring. Some variant of the oscillating mechanism outlined in [9] may explain these and other observations.

In sum, Antoniadi and Compton (and the other possible, older, examples of peak-and-ring craters on the Moon) are not mature basins, comparable in geometry with typical two-ring basins such as Schrödinger and Korolev, but rather belong to a special class of large transitional craters, immature basins, or "proto-basins", distinguished by central rings whose diameters are only 0.4 ± 0.05 of the rim crest (main ring, or Ring IV) diameter. Like many large craters on Mercury and Mars [8], all lunar craters in the transitional range may have possessed both a central peak and a ring before partial or complete burial by later deposits (e.g., Clavius, Deslandres).

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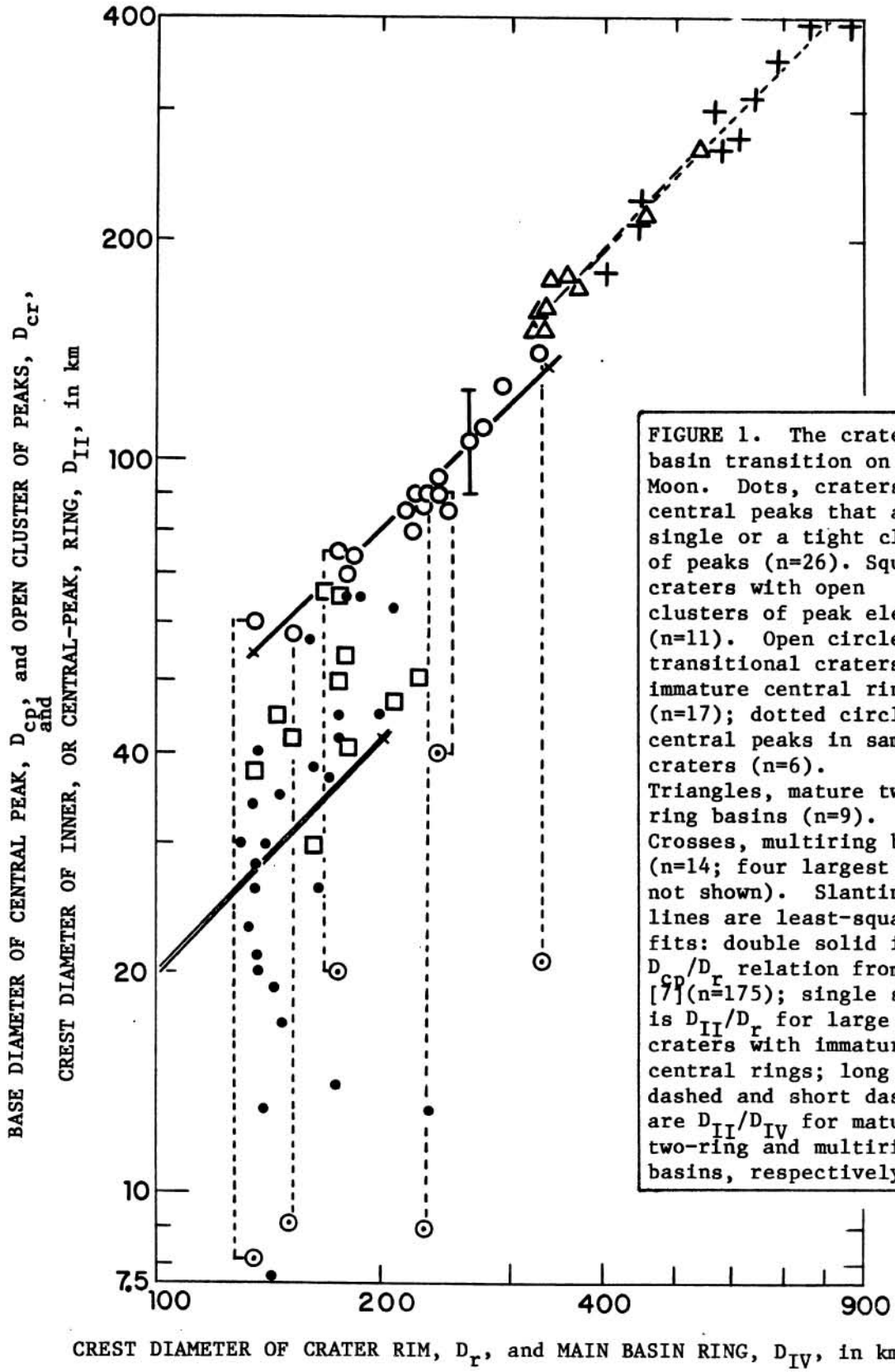

FIGURE 1. The crater-to-basin transition on the Moon. Dots, craters with central peaks that are single or a tight cluster of peaks (n=26). Squares, craters with open clusters of peak elements (n=11). Open circles, transitional craters with immature central rings (n=17); dotted circles, central peaks in same craters (n=6). Triangles, mature two-ring basins (n=9). Crosses, multiring basins (n=14; four largest ones not shown). Slanting lines are least-squares fits: double solid is D_{cp}/D_r relation from [7] (n=175); single solid is D_{II}/D_r for large craters with immature central rings; long dashed and short dashed are D_{II}/D_{IV} for mature two-ring and multiring basins, respectively.