CENTRAL PEAKS IN MARTIAN CRATERS: COMPARISONS TO THE MOON AND MERCURY, Wendy Hale and James W. Head, Dept. of Geological Sciences, Brown University, Providence, R.I. 02912

Central peaks are prominent morphologic features of fresh martian craters. Their occurrence as a function of crater diameter and type (1), general substrate type (2) and as a function of specific substrate type, crater altitude (above mean Mars datum), lat/long and ejecta type (3) have been established by earlier workers.

In at least one aspect, the central regions of fresh martian craters display features unique among the terrestrial planets - the presence of pits at the summit of central peaks, or central pits replacing central peaks (2,4,5,6). These pits have been suggested to result from the explosive decompression of a volatile-rich substrate layer during crater formation (2, 7). The distribution of pits has been suggested as a tool to map the areal extent of subsurface volatiles. Recent studies indicate that pits occur over a wide range of substrate types (6). However, no attempt has yet been made to correlate the number of pitted craters to the total number of central peak craters as a function of crater diameter, substrate or altitude.

Studies of central peaks in lunar and mercurian craters have demonstrated that a linear relationship exists between rim diameter and central peak diameter (9,10). This relationship does not vary significantly from the Moon to Mercury despite differences in gravitational field strengths and modal impact velocities (10). A similar, approximately constant relationship has been defined between rim diameter and peak height (11). Also, central peaks in lunar and mercurian crater display a similar range of morphologic types and may be classified under the same scheme (10). These data suggest that analogous studies of central peaks and pits in martian craters may yield important data on the relative contributions of gravity, modal impact velocity and terrain type to the formation of central structures in impact craters. The purposes of this study are to 1) characterize the morphology and morphometry of central peaks and pits in martian craters; 2) determine relationships between these features and terrain type; 3) to compare these to similar data derived for the Moon and Mercury. Preliminary results, presented here, consist of data from 145 fresh craters (as defined by Arthur, 1963 (8)) in the western half of Memnonia quad, a region south and west of the Tharsis plateau. This region consists of rolling plains and ancient terrain cut by a few channels (12). Additional data for 300 craters in eastern Memnonia, Tharsis, Phoenicus Lacus, Coprates and Thaumasia quads is currently being analyzed. All data is derived from Viking Orbiter images and U.S.G.S. Topographic and Geologic map series.

Central Peak and Pit Morphometry - Central peaks, with or without summit pits, occur in 137 of the 145 fresh craters so far analyzed. The 8 remaining craters include 6 with central pits only and 2 indeterminents. Craters developed on ancient terrains make up 91.1% of this data set, 7.4% occur on rolling plains and 1.5% occur in channel deposits. Central peaks in 134 craters (97.8%) display a consistent linear relationship between central peak diameter (D_{cp}) and rim diameter (Drc), expressed as $Dcp = 0.27\ Drc - 0.14$ ($r = 0.90$) over a 5 - 80 km diameter range (Figure 1). A similar relationship is defined for Dcp and floor diameter (D_f). $Dcp = 0.45\ D_f + 0.25$ ($r = 0.92$). The three craters which diverge markedly from

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System

Central Peaks in Martian Craters

Hale, W. and Head, J.W.

these relationships (Nicholson, MC16-Sn, MC16-Rt) display unusual morphologies. Nicholson has a very large central mound with incised channels, while MC16-Sn and MC16-Rt both have small linear peaks partially embayed by unusually wide, draped floors.

Pits, either central or summit, occur in 39 craters. A linear relationship may also be defined between pit diameter (Dp) and Drc, Dp = 0.11 Drc + 0.22 (r = 0.67) (Figure 2). The poor correlation coefficient (r) here is due to one crater with an unusually large, non-circular summit pit.

Morphology of Central Peaks and Pits - Martian central peaks may be classified by complexity (simple, complex) and geometry (linear, symmetric, or arcuate) under a scheme developed for lunar and mercurian craters (9,10). Additional categories are required to characterize pits. Pits may occur as depressions in the top of central peaks (summit pit craters) which are either circular or elongate, open or closed. Closed, circular pits fit the classic picture of a summit crater, and 75% of all pits are of this type. Open pits, where a section of the peak is missing, make up 12.8% of all pits, and may be either circular (5.1%) or elongate (7.7%). Pits may also completely replace peaks (central pit), and 6 such craters (15.4%) occur in west Memnonia.

The distributions of central morphologies as a function of substrate may be seen in Tables 1 and 2. Pits (summit or central) are more common on rolling plains, 85-90% of all peaks are simple and 62% are symmetric regardless of terrains, and arcuate peaks are more common on rolling plains.

Comparisons to the Moon and Mercury - The Dcp/Drc relations for the Moon and Mercury are plotted for comparison in Figure 1. While the slopes of these two relations are statistically indistinguishable, they are markedly different from the Dcp/Drc relation for martian craters. Thus, for a restricted region of predominently ancient terrains and high altitudes (1 km above mean datum), central peaks in martian craters are larger than their lunar and mercurian counterparts for the same crater diameter. In addition, simple symmetric central peaks are more common on Mars, and geometry appears somewhat responsive to substrate type on all three planets.

Discussion - For central peak craters in a restricted region of predominently ancient terrain in western Memnonia quad on Mars, a linear relationship exists between Dcp and Drc analogous to that defined previously for lunar and mercurian craters (9,10). However, the slope of the martian relationship is much steeper (Figure 1) indicating central peaks are larger on Mars for similar crater diameters. Since Mars and Mercury have similar gravitational field strengths, this would suggest some unique terrain effects for martian craters. The existence of pits has been proposed to result from a subsurface volatile layer (2, 7). Volatiles dispersed more generally through the target result in a decrease in mechanical strength (13) and could result in proportionally larger central peaks. Pit distributions have been suggested as a method of mapping a subsurface volatile layer (2). Although pits occur globally on Mars (6) the distribution of central or summit pits as a function of unpitted peaks appears to vary as a function of terrain type (Table 1). Further, pit diameter appears to vary linearly as a function of crater diameter. These results indicate the importance of extending this study to include a wider range of substrate types, and such additional studies are currently underway. References:

1) Cordell, B.M. et al (1974) Icarus 21 p. 448-456. 2) Wood C.A. et al (1978) PLSC 9 p. 3691-3709. 3) Mouginis - Mark, P.J. (1979) JGR 84 p. 8011-8022. 4) Smith, E.I. (1976) Icarus 28 p. 543-550. 5) Hodges, C.A. (1978) LPSXI

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System

Hale, W. and Head, J. W.

p. 521-523. 6) Hodges, C.A. et al (1979) LPS XI p. 450-452. 7) Smith E.I. and Hartnell, J.A. (1977) NASA TMS-3511 p. 91-93. 8) Arthur, D.W. et al (1963) Comm. LPL 2 p. 71-78. 9) Hale, W. and Head, J.W. (1979) LPSC 10 p. 2623-2633. 10) Hale, W. and Head J.W. (1980) LPSC 11, in press. 11) Malin, M. and Dzurisin, D. (1978) JGR 83 p. 233-243. 12) Scott, D.H. and Carr, M.H. (1978) U.S.G.S. Map I - 1083. 13) Kieffer, S.W. (1977) LS VIII p. 543-545.

Figure 1

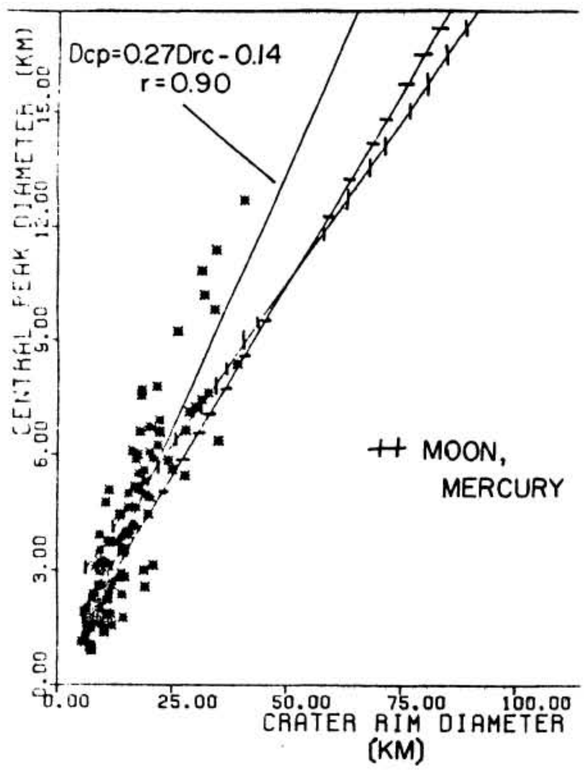

Figure 2

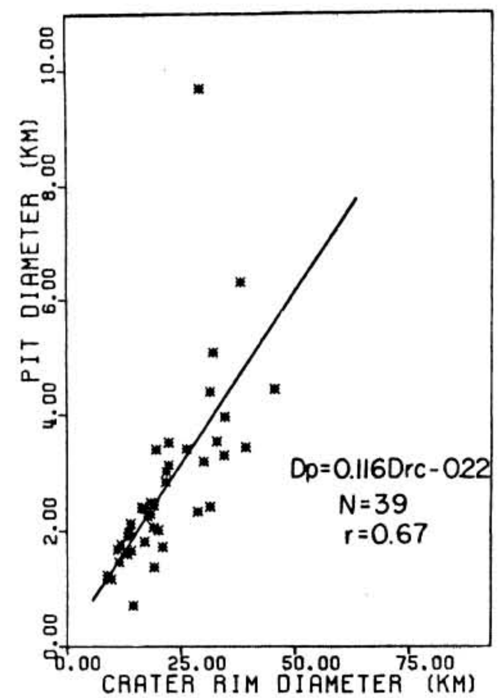

TABLE 1

TERRAIN	PEAK	PEAK & PIT	PIT	IND	% PEAKS ALONE	% PITS
Ancient terrain	99	28	5	0	75%	25%
Rolling plains	7	3	1	0	64%	36%
Channels	0	0	0	2	--	--

TABLE [illegible]

	ANCIENT TERRAIN	ROLLING PLAINS	CHANNELS
Complexity			
Simple	(116) 87.8%	(10) 90.9%	(0) 0
Complex	(11) 8.4%	(0) 0%	(0) 0
IND	(5) 3.8%	(1) 9.1%	(2) 100%
Geometry			
Symmetric	(83) 63%	(7) 63.6%	(0) 0
Linear	(40) 30%	(2) 18.2%	(0) 0
Arcuate	(4) 3.8%	(1) 9.1%	(0) 0
IND	(5) 3.8%	(1) 9.1%	(2) 100%

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System