CRATERS ON THE MOON, MARS, AND MERCURY: A COMPARISON OF DEPTH/DIAMETER CHARACTERISTICS, Mark J. Cintala, James W. Head, Thomas A. Mutch, Brown University, Providence, RI 02912

Analysis of the relationships of crater depths and crater diameters can provide important information on crater formation and modification on specific planetary bodies. In addition, a comparison of depth/diameter characteristics between planets may provide clues to the important variables in both cratering processes and modification processes (e.g. surface gravity, atmospheric effects, substrate variations). This paper examines the depth/diameter characteristics of lunar and mercurian craters and compares them with new information for martian craters.

Moon-The depth/diameter characteristics of fresh lunar craters[1] are shown in Fig. 1. The distribution of craters smaller than about 10-15 km diameter[1] is described by the expression $R_i=0.196D_r^{1.010}$, where R_i is interior relief or depth, measured from rim crest to floor, and D_r is crater diameter measured from rim crest to rim crest. Craters over about 15 km diameter[1] are described by the expression $R_i=1.044D_r^{0.301}$. The change in slope at about 15 km also corresponds to diameters at which changes in crater morphology are noted[2,3,4,5]. This marks the approximate boundary between simple and complex craters[6]. Changes in fresh crater morphology and morphometry between simple and complex craters have been attributed to 1) increased significance of modification stage above about 15 km with essentially no change in the cratering process[2,7,8] (in this case, the depth/diameter ratio for small craters would scale up to larger diameters, but modification in the terminal stages of the event would produce the observed depth/diameter relationship); 2) changes in the characteristics of the cratering process, followed by modification in the terminal stages of the event[9,10,5] (in this case, the depth of the initial cavity does not grow at the same rate as smaller craters, causing the initial crater to be shallower; modification processes in the terminal stages of the event also add to the present configuration).

Degraded lunar craters show different depth/diameter characteristics (Fig. 1). Eratosthanian and Imbrian craters appear slightly shallower than Copernican craters but pre-Imbrian craters are significantly shallower[2]. Pre-Imbrian craters are preferentially degraded by higher flux rates and multi-ringed basin erosion, both of which tend to decrease R_i by decreasing rim height and raising the floor by impact erosion and deposition[11].

Mercury-Data for depth/diameter relationships for 130 fresh mercurian craters greater than 1 km are shown in Fig. 1. Distinctive differences and similarities are seen with the lunar plot[12] including a distinctive kink in the curve, at 7-8 km.

The curve at lower diameters is essentially the same as the lunar depth/diameter curve, while, above the kink, the line is parallel, but at depths approximately a factor of 2 shallower than lunar craters.[12]

Mars-Depth/diameter data for martian craters comes from photoclinometric processing of Mariner IV data [13,14] and from analysis of Mariner 9 UVS data[15] (Fig. 1). Although the sample of 155 craters presented here includes degraded as well as fresh martian craters, the population lies at depths systematically shallower than either lunar or mercurian craters. Although an inflection point appears to exist at about 10-30 km diameter[14], its exact placement is difficult because of the small mixed population. However, evidence from fresh crater morphology supports a change in this range and suggests that it lies at about 13-15 km diameter[16].

Discussion-Differences in the depth/diameter relationships between fresh lunar and mercurian craters have been attributed to differences in surface gravity[12] (Moon=0.16 Earth's; Mercury=0.37). If surface gravity were the dominant factor in the determination of depth/diameter for fresh craters, the martian data would be expected to closely parallel the mercurian data (Mercury=0.37; Mars=0.38). Fig. 1 shows considerable differences at all diameters. Although degraded craters are included in this sample, over 14 percent are fresh or only slightly modified. Therefore, shallowness of martian craters does not appear to be due to surface gravity or long-term modification processes alone. Possible additional factors include substrate differences, atmospheric effects, and impact velocity variations.

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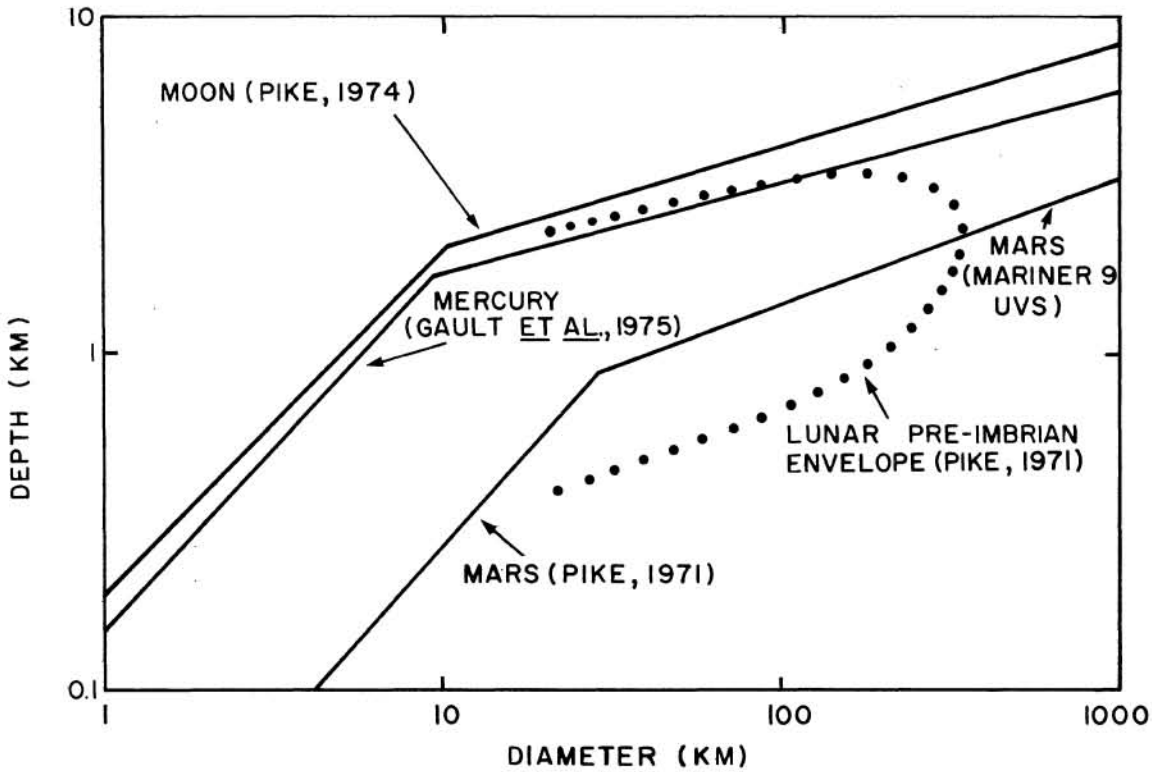

Figure 1. Depth/diameter relationships for craters on the Moon, Mars, and Mercury.