MORPHOMETRY OF FRESH IMPACT CRATERS IN HESPERIA PLANUM, MARS: Joan Hayashi-Smith and Peter J. Mouginis-Mark, Planetary Geosciences Division, SOEST, University of Hawaii, Honolulu, HI 96822.

INTRODUCTION: We explore a concept originally proposed by Cintala and Mouginis-Mark (1) that martian impact craters display a gradual transition with increasing crater size from larger depth/diameter ratios at small diameters to lower values for larger craters. This correlation was interpreted to be the consequence of a pronounced stratification of volatiles within the target. Recent developments in the ability to use PICS software to make quantitative measurements of crater geometry have enabled us to test the hypothesis using craters located in a single region of Mars on the ridged plains materials of Hesperia Planum (~21 - 34°S, 233 - 248°W).

The origin of the ridged plains materials and their thickness within Hesperia Planum are currently unknown. Because of their similarity to the lunar maria, it is likely, however, that these materials comprise a series of flood lavas that partially infilled topographic depressions within the martian highlands. Measurements of crater diameter and the preserved heights of partially buried crater rims, provide estimates that these lava flows within Hesperia Planum are between 200 - 400 meters thick (2). What is not clear is the spatial distribution of flow thickness or the physical characteristics of the buried terrain.

SHADOW MEASUREMENTS: Our sample contains 61 craters in the diameter range 2.00 - 48.72 km. Of these craters, 26 are morphologically very fresh, possessing complete rims, well preserved ejecta blankets with radial striations or sharp distal ramparts, and have no superposed impact craters. These freshest craters are 2.44 - 14.28 km in diameter, and are used here to investigate the possible role of volatiles in influencing impact crater geometry. Crater depth/diameter measurements were made using digital versions of the Viking Orbiter images and the PICS image processing software (Fig. 1). The resolution of each frame (~95 m/pixel) and the lighting geometry (incidence angle = 64 - 72°) of the crater center were used to convert measurements, in the number of pixels, into distances and shadow lengths and, hence, rim heights. Visual analysis of these images identified that some of the SEDR solar azimuth angle files are incorrect, so that we estimated the solar azimuth (i.e., the perpendicular to rim shadows for near-circular impact craters) for each frame. The average of three crater diameters was used for each crater, one diameter being measured in the same direction as the sun angle and two at about ± 45° to the solar azimuth. In all cases, the rim crest of the crater was taken to be the point where there was a rapid variation in the data number (DN) values (in PICS this typically corresponded to a change of 3 - 5 times the variation observed for illuminated terrains). The rapid increase in DN values was also used to determine the edge of the shadow and, from simple trigonometry, the height of the crater rim. For a few of the craters larger than ~4 km diameter, it was also possible to obtain measurements of the height of the far rim above the surrounding terrain (Fig. 2).

DISCUSSION: The original premise (1) was that sub-surface volatiles had a variable distribution with depth beneath the surface, but that either water or ice was distributed in fixed proportions over the age of the exposed surface. Clearly, as it is likely that volatiles were driven towards the poles over martian history (3), this concept of a constant volatile concentration with depth is unlikely to be valid. Our preliminary analysis of the Hesperia Planum craters fails to identify the gradual transition from small craters formed within a shallow (top 100 m?) permafrost layer within the target to larger craters formed with deeper, volatile-poor, strata below the permafrost (perhaps at depths of a few hundred meters). Based on our estimates of depth and rim height, several of the freshest craters would penetrate the entire 400 m thickness of the ridged plains materials (Fig. 3), excavating the crater floor within the basement materials. Although ejecta deposits are likely to originate from within the near-surface layers (based on analogy with the ejecta deposits associated with Ries Crater in West Germany; ref. 4), the slumping of the inner wall of the crater and the degree of floor rebound may be significantly affected by this strong stratification of the target materials. Although we cannot at this time identify the reason for this disparity between our results and earlier ideas (1), we offer two possible explanations:

1) Cintala and Mouginis-Mark (1980) measured craters on a variety of geological units, some of which may have contained fewer volatiles than did other units.

2) Our analysis has concentrated on the youngest, best-preserved craters within Hesperia Planum, specifically to avoid complications in crater geometry that may have been caused by erosion or subsequent infilling. Our criteria for recognizing these craters will thus bias our sample to preferentially include only the most recent craters, which may have formed at a time when the ridged plains materials of Hesperia Planum had become dessicated. By studying craters of different degradation states, it may still be possible to investigate the temporal evolution of the hypothesized volatile layer provided that subaerial modification processes can be accounted for.

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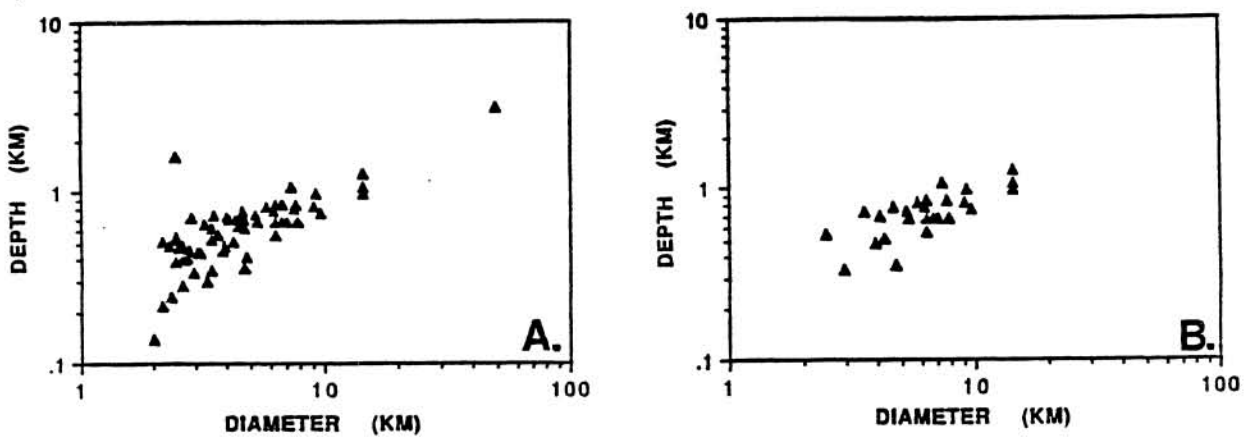

Fig. 1 A) Depth - diameter plot of all craters measured in this analysis. B) Depth - diameter plot of only those craters considered to be "pristine" in this analysis.

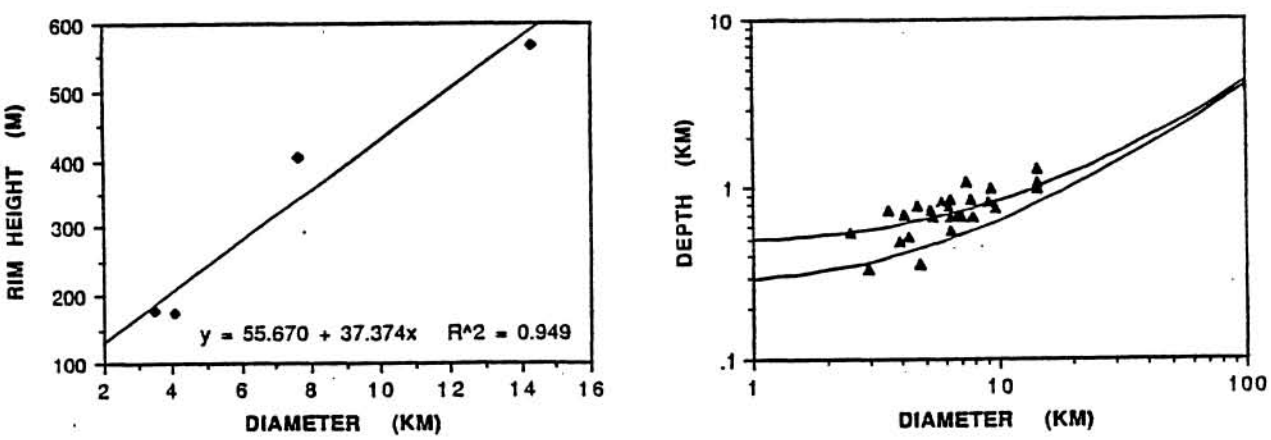

Fig. 2 (Left) Four of the studied craters possess measurable rim heights, permitting a linear least squares fit and, hence, the rim height to crater diameter relationship to be obtained. Fig. 3 (Right) Using the relationships between depth (Fig. 1) and rim height (Fig. 2) to crater diameter, the minimum depth of a crater that is required to penetrate the average thicknesses of the ridged plains materials can be inferred (2). Bottom curve - 200 m; top curve - 400 m plains thickness.