MEASUREMENTS OF MARTIAN IMPACT CRATER GEOMETRY VIA A NEW INTERACTIVE COMPUTER PROGRAM. P. J. Mouginis-Mark[1], H. Garbeil[1], J. M. Boyce[1], S. M. Baloga[2], and C. Ui[3], [1]Hawaii Institute Geophysics & Planetology, University of Hawaii, Honolulu, HI 96822 <pmm@higp.hawaii.edu> [2]Proxemy Research, Laytonsville, MD 20882; [3]Univ. Washington, Seattle, WA.

Introduction: We have developed an interactive computer program to investigate the geometry of Martian impact craters. The program is written in C++ for MS Windows based personal computers, so that it will run on any moderately powerful PC running Windows 98/NT/XP/2000. As input data, we use the 1/64th degree digital elevation model (DEM) of Mars obtained from the Mars Orbiter Laser Altimeter (MOLA). Our objective is to search for spatial variations in crater geometry (e.g., depth/diameter, rim volume/rim height, or ejecta volume/crater volume) that might indicate variations in target properties or the resurfacing history of Mars. Here we describe the measurement technique, and in a companion abstract [1] present our preliminary assessment of 1,430 craters within Utopia Planitia (25.1° - 66.8°N, 88.4° - 149.6°E).

Measurement Method: Our method differs from that previously used by Garvin et al. [2], who took single MOLA profiles that run through the crater centerline to derive parabolic fits to the crater rim and exterior deposits to estimate cavity volume and shape, depth versus diameter correlations, rim heights, and ejecta thicknesses. In our approach, the extraction of heights, volumes, and other quantities that rely on vertical measurements from the MOLA DEM uses a systematic method for estimating the shape of the pre-existing surface prior to the impact. The user selecting at least 8 points beyond the ejecta deposits defines this surface. The surface then serves as a reference base for the extraction of heights and volumes from the DEM derived from the MOLA data.

In the most general case, the pre-existing surface is modeled as a section of a hyperbolic or elliptic bowl or dome-like surface [3 - 5]. The values of the parameters and estimates of their statistical confidence limits are available in the output for the inspection of the user. The quality of the overall fit of the pre-existing surface and the values of the each of the individual parameters can therefore be evaluated statistically. Based on the user-selected points, a second degree polynomial is generated using a least squares fitting routine.

Once this reference surface has been determined, all quantities involving crater depth or vertical relief are computed on a pixel-by-pixel basis with respect to this surface. In cases such as the ejecta lobe thickness, pixels that lie below this surface are flagged on the user display. Typically, on the N. Plains, a few (>~5%) of the pixels are below this surface. Our preliminary work on Highlands craters shows that as many as 20% of ejecta pixels may be below the reference surface. Future efforts will incorporate the propagation of errors into averages of variables (e.g., average rim height), that require repeated use of this estimated pre-existing surface at multiple locations along the feature.

Because it is much easier for the user to select features off of a shaded relief image rather than a DEM display, the program has the provision to display a shaded relief file generated from or coregistered to the MOLA DEM. There is also a provision to toggle between that shaded relief file and a second shaded relief generated with a different illumination direction. This is intended to assist the user in highlighting breaks in slope (at, for instance, the outer edge of the crater rim) around the perimeter of the entire crater. The third image file used by the program is a "Hits" file. This file has been produced by the MOLA Science Team and represents the number of shots that were aquired within each cell or pixel of the DEM. This function enables the user to see where actual MOLA data are in the DEM, rather than relying on interpolated values. The user can therefore see where the MOLA shots are located so that it is possible to avoid placing critical data points (such as measurements of the crater rim crest) in areas of interpolated data. One can also evaluate MOLA coverage of the crater floor to ensure that the floor depth is indeed measured.

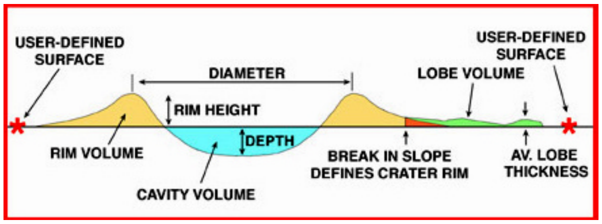

Fig. 1: Skematic of parameters measured

Derived Parameters: Figure 1 shows the parameters that are measured for each crater using our program. These parameters are:

1) <u>Crater latitude and longitude</u>: Computed as the center of figure of the crater rim crest. The crater rim crest is user-defined from at least 3 points selected around the topographic high-point of the rim as identified in the shaded relief images. These points define a polygon, with the rim crest being the points lying upon on the polygon.

2) <u>Crater diameter</u>: Calculated (from the data in #1) as the diameter of a circle that has the same area as the area contained within the rim crest.

3) <u>Maximum crater depth</u>: Measured as the height difference between the mean rim crest height and the lowest point on the crater floor. It uses data from #1.

4) <u>Mean crater depth</u>: Measured from the mean rim crest height, and includes all points on the crater between within the area defined by the rim crest.

5) <u>Cavity volume</u>: Calculated by taking each pixel within the DEM that lies below the pre-existing surface and within the crater rim crest. These points are extended upwards until they intersect the pre-existing surface. All of these individual pixel volumes are then summed to give the cavity volume.

6) <u>Rim height</u>: This is the mean height of the profile drawn around the rim crest (data from #1) compared to the pre-existing surface. It is the mean height of a single line running around the absolute crest of the rim.

7) <u>Rim volume</u>: Calculated by the user first delineating at least 3 points that interpreted to mark the boundary between the rim and the inner ejecta lobe. The rim volume is derived using all the points within this perimeter and the place where the inner crater wall intersects the pre-existing surface.

8) <u>Inner and outer ejecta lobe volumes</u>: The user digitizes as many points as necessary to mark the edge of the inner and outer ejecta lobes. The volume of material within the inner and outer lobes that lie above the pre-existing surface are calculated from this perimeter and either the edge of the rim (for the inner lobe) and the edge of the inner lobe (for the outer ejecta lobe).

9) <u>Inner and outer ejecta lobe mean thicknesses</u>: Uses the same boundaries as defined in #8. Calculated as the mean height between the pre-existing surface and the surface of the inner and outer ejecta lobes. Any points within the inner lobe below the pre-existing surface are flagged and discounted.

10) <u>Floor fill, mean thickness</u>: Calculated for all craters, but is relevant only where the floor is above the level of the pre-existing terrain. This is computed as the difference between the mean floor height (itself determined as the mean of all points within the rim crest) and the surrounding surface.

Output: The program generates a tabulated output file that is continually appended as crater selection and analysis progresses. This file is easily imported into other statistical and plotting software. A second file is also created so that GIS shape files can be created from the digitized points, or statistical studies can be conducted on the topographic variability along a measured line.

Summary: To date, we have measured 1,430 craters in the diameter range 1.8 - 66.8 km in Utopia Planitia. Preliminary results for these craters are presented in [1]. Once fully tested, this program will be made available to other users via the Mars Crater Consortium and the U.S. Geological Survey [6].

References: [1] Boyce, J. M. et al., this volume. [2] Garvin J. B. et al. (2000) *Icarus 144*: 329 - 352. [3] Draper, N., & H. Smith, 1981, Applied regression analysis, 2nd ed., Wiley, New York, New York. [4] Sheskin, DJ, 1997, Handbook of parametric and nonparametric statistical procedures, CRC Press, New York, 719pp. [5] CRC Standard Mathematical Tables 21st ed., 1973, CRC Press, Cleveland OH, 714 p. [6] Barlow N. et al. *J. Geophys. Res. 105*: 26,733 - 26,738.