Geometric Measurements of Martian Impact Craters: Comparison of Measurement Techniques

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We have developed an interactive computer program (called "IMPACT") 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 1/128th 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.

IMPACT allows for the automated collection of the following parameters: (1) Crater latitude and longitude; (2) Crater diameter; (3) Maximum crater depth; (4) Mean crater depth; (5) Cavity volume; (6) Rim height; (7) Rim volume; (8) Inner and outer ejecta lobe thicknesses and volumes; and (9) Mean floor fill thickness. This last parameter is calculated for all craters, but is relevant only where the floor is above the level of the pre-existing terrain. It 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.

One of the issues that we has arisen in the measurement of the crater dimensions is the approach taken in the production of the digital elevation model that is used as input data. This issue arises because the raw MOLA data are not uniformly distributed across Mars, so that at the kilometer-scale it is possible to find areas in the DEM that contain only interpolated data. This is particularly relevant for craters less than a few kilometers in diameter, as either the deepest part of the crater floor, or the rim crest, may not be measured by MOLA.

In our studies, we are using the 1/128th degree MOLA DEM, which is readily available to the science community. In making our measurements, we also pay attention to the distribution of the MOLA data by using the MOLA "Hit Map", which shows the number of data points in a particular cell. But there are other methods for using MOLA data, and it is relevant for the Mars Crater Consortium to investigate the strengths and limitations of each method. For example, some methods use only center-line MOLA profiles and derive crater parameters from the individual MOLA shots. This has the advantage that all data are free from interpolation and it is clear where there is no data coverage. This approach also makes the assumption that craters are azimuthally symmetric, with the along-track (approximately north-south) MOLA ground-track being representative of the entire crater. We also know of other approaches, such as the one under development by at the Smithsonian Institution, which again uses the raw MOLA data. Here the geometry of the crater is determined in several azimuths from the user-

selected low point on the crater floor, using program-defined inflection points in the profiles radiating away from this center. In this way, the boundary between the floor and the inner wall, the rim crest, and the boundary between the outer rim and the ejecta layers can all be determined automatically.

Each of the three approaches has its merits and strengths. There are also several different ways in which an interpolated DEM could be generated which might influence the parameters derived for the smaller craters (i.e., those that are less than about 5 km in diameter). What we feel is needed is a systematic comparison of the different approaches to measuring the geometry of Martian craters. We advocate the selection of a few dozen craters of different degradation states and sizes so that the results from each method can be inter-compared. It is expected that the greatest variation may come from smaller craters, where the number of MOLA shots is relatively small. Some parameters, such as crater depth may be easier to determine for any given size crater than, for example, rim height, since the larger craters may have flat floors but sharp rim crests. An important role for the Mars Crater Consortium could be the selection of these craters, and the compilation of geometric data for this sample using the different measurement techniques that are under development at this time.

We are currently beta-testing the IMPACT program with members of the Mars Cratering Community. If you would like to test the program, it is available from the following web site along with a technical discussion of how to use it:

http://www.higp.hawaii.edu/~harold/Impact_Program/Impact.html