QUANTIFYING THE DEGRADATION STATE OF MARTIAN IMPACT CRATERS. N. G. Barlow, SN21, NASA/Johnson Space Center, Houston, TX 77058.

Mariner 9 and Viking imagery revealed martian impact craters in various stages of degradation. Attempts at understanding the obliteration history of Mars have relied primarily on qualitative descriptions of impact crater morphology (1, 2, 3), although a few studies have used photoclinometric techniques to quantify a general relationship between morphology and global location (4). A variety of studies from the past few years now allow a re-evaluation of the martian obliteration history using more quantitative techniques.

Davis and Soderblom (5) developed a photoclinometric technique which permits determination of topographic information from a single planetary image. Two profiles are chosen across the feature of interest, each along a path assumed to have identical topographic and albedo variations. This method eliminates many of the problems existing with previous photoclinometric techniques. This technique is useful for determining the present profile of impact craters on Mars, but in order to understand the obliteration history of particular regions we need to determine how the crater shape has changed since the crater formed. Pike and Davis (6) used a photoclinometric algorithm to derive relationships between diameter, crater depth, rim height, floor width, etc., for pristine impact craters on Mars. By comparing the actual crater form obtained using the photoclinometric technique of Davis and Soderblom with that expected for a pristine crater of the same size from the relationships of Pike and Davis, we can estimate the amount of obliteration experienced by the crater. Similar analyses of other craters in the surrounding region can then provide information about the overall amounts of obliteration acting in that region of the planet.

The current project utilizes the two techniques described above to determine the crater depth and rim height of impact craters in areas surrounding the proposed Mars landing sites (7). We limited the study to the ±40° latitude range to avoid the possible complication of terrain softening (4). We selected 788 images (based on quality of image, number of impact craters, and sun angle) representing 25 of the proposed landing sites. Profiles for craters of ≥2 km in diameter are determined using the photoclinometry program of Davis and Soderblom. Profiles are initiated at the geometric center of the crater and are chosen in opposite directions along the direction of illumination to provide the most accurate solution. The program produces a representation of the crater shape, from which the crater depth and the rim height (both relative to the surrounding surface level) are determined. Results for crater depths from the photoclinometric technique are within 5% of the values obtained from shadow estimates, the same accuracy as found by Davis and Soderblom. The corresponding crater depth and rim height values for pristine craters of identical diameter are calculated using the following equations from Pike and Davis:

$$\text{depth} = 0.212\pm0.049 \times (\text{diameter})^{0.544\pm0.094} \quad \text{for diameter}>6\text{ km}$$
$$\text{depth} = 0.158\pm0.011 \times (\text{diameter})^{1.013\pm0.092} \quad \text{for diameter}\leq6\text{ km}$$

$$\text{height} = 0.076\pm0.007 \times (\text{diameter})^{0.474\pm0.091} \quad \text{for diameter}>6\text{ km}$$
$$\text{height} = 0.038\pm0.003 \times (\text{diameter})^{0.969\pm0.108} \quad \text{for diameter}\leq6\text{ km}$$

The current values are then compared to the pristine crater values to get the percentage change from the original crater shape.

DEGRADATION OF MARTIAN CRATERS: Barlow, N.G.

Table I gives results of this procedure for part of Mars landing site 61, a proposed penetrator site centered at 30°N 327°W in the Arabia region, an area of heavily cratered intercrater plains. Rim heights vary considerably within the area immediately surrounding the proposed landing site and little correlation between rim height and location is seen. Crater depths, however, suggest that obliterative processes systematically affected specific regions of this area (Fig. 1). Much of the region displays current crater depths which are 25-50% of the expected pristine depths, indicating that obliterative processes have destroyed a substantial proportion of these craters. Localized areas show much higher (current/pristine depths <25%) and much lower (current/pristine depths >55%) degrees of obliteration. No correlation of these areas with specific regions on published geologic maps is seen. The exact location of the proposed landing site is in an area where this analysis suggests high degrees of obliteration--thus, a penetrator/lander in this region could expect to find fairly weathered surroundings.

Results of this technique will be combined with thermal inertia data and crater size-frequency distribution analyses to better constrain the surface properties and obliteration history of the selected regions. Until the thermal inertia data are applied, information about the relative importance of lithology versus climate on current crater morphology cannot be addressed. Because the initial emphasis is on the proposed Mars landing sites, this project will produce predictions of the surface geologic conditions that such missions may encounter at these particular sites. The results of this project, therefore, should be of interest to final site selection of future Mars surface missions.

References: (1) Chapman, C.R. (1974), *Icarus*, **22**, 272-291. (2) Jones, K.L. (1974), *J. Geophys. Res.*, **79**, 3917-3931. (3) Chapman, C.R. and Jones, K.L. (1977), *Ann. Rev. Earth Planet. Sci.*, **5**, 515-540. (4) Squyres, S.W. and Carr, M.H. (1986), *Science*, **231**, 249-252. (5) Davis, P.A. and Soderblom, L.A. (1984), *J. Geophys. Res.*, **89**, 9449-9457. (6) Pike, R.J. and Davis, P.A. (1984), *Lunar Planet. Sci. XV*, 645-646. (7) Greeley, R. (1990), *NASA Ref. Publ. 1238*.

TABLE I

EXAMPLES OF COMPARISON
BETWEEN THEORETICAL AND MEASURED CRATER VALUES

Crater Diameter (km)	Height (m) Meas.	Height (m) Theo.	Height (m) %	Depth (m) Meas.	Depth (m) Theo.	Depth (m) %
6.8	15	189	7.9	273	601	45.4
7.2	48	194	24.7	294	621	47.3
4.8	68	173	39.3	312	774	40.3
3.7	43	135	31.9	252	595	42.3
2.6	76	96	79.2	355	416	85.3
2.4	24	89	27.0	159	384	41.4
2.0	17	74	23.0	159	319	21.6
2.0	6	74	8.1	61	319	19.1

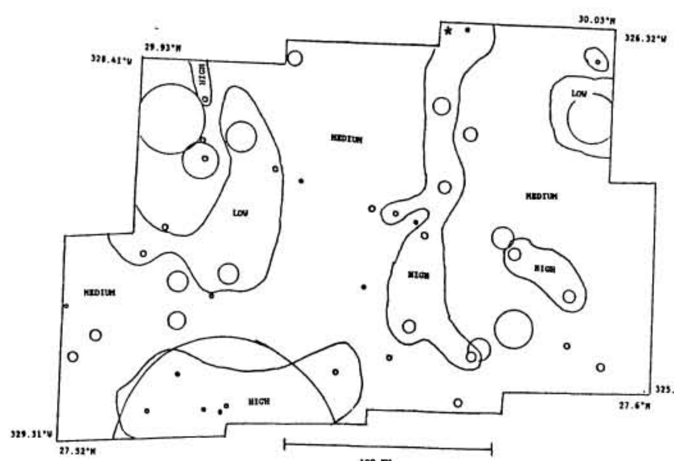

Figure 1: Map of the region near proposed Mars landing site 61 in Arabia. Circles represent craters measured in the analysis discussed in text. "High" refers to areas which have experienced high amounts of obliteration (current/pristine crater depth ratio between 0 and .25). "Medium" areas have crater depth ratios between .25 and .55, and "Low" areas have experienced little obliteration (crater depth ratios between .55 and 1.00). The proposed penetrator landing site is indicated by the star.