IMPACT CRATERS AS INDICATORS OF SUBSURFACE H_2O ON MARS.

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Impact craters provide remotely sensed information about the third dimension (depth) of a planetary surface. Changes in the morphologies of Martian impact craters and their ejecta blankets have been attributed to changes in subsurface properties (1) or to interaction with the atmosphere (2). A combination of crater studies conducted by the author and colleagues, including studies of ejecta blanket morphologies, rampart ejecta blanket sinuosity, and regional crater depth variations, strongly suggest that subsurface volatiles dominate in influencing the observed features.

Ejecta Studies: Barlow and Bradley (3) conducted a study of 3819 craters surrounded by an ejecta blanket distributed across the entire Martian surface. Ejecta morphologies were subdivided into seven classes: single lobe rampart, double lobe rampart, multiple lobe rampart, radial, diverse, pancake, and amorphous. Of these seven classes, the diverse and pancake morphologies are found within specific diameter ranges in localized regions of the planet. The radial morphology is associated with small craters (generally <6-km-diameter in the equatorial region), craters on the flanks of volcanoes, and very large craters (generally >60-km-diameter). Amorphous morphologies are found around large craters as well but appear to represent highly weathered ejecta blankets. Double lobe rampart craters dominate in the 40°-65°N latitude range, with a lower concentration in the 40°-65°S latitude range. Double lobe craters exhibit diameters primarily in the 8-50 km range. Single lobe craters occur primarily in the 8-20 km diameter range within the equatorial region of Mars, giving way to multiple lobe rampart craters at larger crater diameters (16-45 km). However, at higher latitudes, single lobe craters extend over a larger diameter range (up to 60 km diameter) and multiple lobe craters are rare to non-existent.

Ejecta Sinuosity Studies: Barlow (4) and Bridges and Barlow (5) computed the degree of sinuosity exhibited by 1582 single lobe, 251 double lobe and 380 multiple lobe craters across Mars. These studies found that the single lobe morphology displays lower degrees of sinuosity than the multiple lobe morphology. The outer lobe of the double lobe morphology is similar in sinuosity to single lobe. Inner lobe(s) of double lobe and multiple lobe craters are less sinuous than the outer lobe(s). Resolution does play some role in the actual sinuosity values, but the above relationships are seen to hold when resolution effects are taken into consideration. The only statistical variation of sinuosity is seen among the rampart ejecta classes--no significant variation in sinuosity with latitude, longitude, diameter, or terrain is seen for craters within a particular ejecta class.

Crater Depth Studies: Pike and Davis (6) derived a globally averaged depth-diameter relationship for fresh Martian impact craters. Recent photoclinometric studies of crater depths (7, 8) reveal that depth-diameter ratios can vary considerably across the Martian surface, probably as the result of changes in target properties. In areas of thick, friable deposits such as the Medusae Fossae formation, craters are deeper than in the equatorial plains or highlands. At high northern latitudes, preliminary studies suggest that fresh craters are shallower than similarly sized craters at lower latitudes. The lower depth-diameter ratio of craters at high latitudes has been suggested by previous morphologic studies to be the result of relaxation (9) and is consistent with theoretical models of near-surface ice deposits in these regions of the planet (10, 11).

Summary and Discussion: The diameter-latitude variation of single lobe and multiple lobe rampart morphologies is consistent with the theoretical distribution of subsurface ice and water on Mars (10, 11), but is difficult to explain using the theory of atmospheric entrainment of ejecta (2). Barlow and Bradley (3) therefore prefer the theory that the rampart crater ejecta morphologies on Mars result from impact and vaporization of subsurface volatiles. The results from the sinuosity and crater depth studies also are consistent with subsurface volatiles. Combining the results of these studies, we propose that single lobe craters are formed from impact into predominantly ice-

rich targets, multiple lobe craters excavate to depths containing liquid-water/brines, double lobe craters result from impact into layered targets where the upper layer has a higher volatile-to-clast ratio than the lower layer, and radial craters result from excavation of material with an overall low volatile-to-clast ratio (i.e., dry materials). If multiple lobe craters result from excavation into liquid reservoirs, larger sinuosity values than those resulting from impact into ice-rich terrain would be expected. Observation of lower depth-to-diameter ratios and rampart morphologies around smaller craters at high latitudes supports the proposal of theoretical models and other geologic evidence that ice occurs at or very near the surface at high latitudes (>35°-40° latitude).

References:

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