MARTIAN IMPACT CRATERS: CONTINUING ANALYSIS OF LOBATE EJECTA SINUOSITY.

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The lobate ejecta morphology surrounding most fresh martian impact craters can be quantitatively analyzed to determine variations in ejecta sinuosity with diameter, latitude, longitude, and terrain. The results of such studies provide another clue to the question of how these morphologies formed: are they the result of vaporization of subsurface volatiles (1) or caused by ejecta entrainment in atmospheric gases (2). Kargel (3) provided a simple expression to determine the degree of non-circularity of an ejecta blanket. This measure of sinuosity, called "lobateness", is given by the ratio of the ejecta perimeter to the perimeter of a circle with the same area as that of the ejecta:

$$\Gamma = \text{perimeter}/(4\pi*\text{area of ejecta})^{1/2}.$$

A circular ejecta has a Γ of 1; more sinuous ejecta display $\Gamma>1$. Kargel's study of 538 rampart in selected areas of Mars led him to suggest that lobateness increased with increasing diameter, decreased at higher latitudes, and showed no dependence on elevation or geologic unit.

Major problems with Kargel's analysis are the limited size and distribution of his data set and the lack of discrimination among the different types of lobate ejecta morphologies (4). Bridges and Barlow (5) undertook a new lobateness study of 1582 single lobe (*SL*) and 251 double lobe (*DL*) craters. Their results are summarized in Tables I and II. These results agree with the finding of Kargel that lobateness increases with increasing diameter, but found no indication of a latitude dependence for *SL* craters. A slight terrain dependence was also detected, contrary to Kargel's results.

The Bridges and Barlow study is now being extended to multiple lobe (*ML*) craters across the entire martian surface. To date, 108 *ML* craters located entirely in the northern hemisphere have been studied. *ML* craters provide more complications to lobateness studies than do *SL* or *DL* craters--in particular, the ejecta lobes surrounding the crater are often incomplete (i.e., do not extend completely around the crater). Since the lobateness formula compares the perimeter of the ejecta lobe to that of a circle, we have restricted our analysis only to the complete lobes. The lobes are defined sequentially starting at the outermost lobe and moving inward: L1 for the outermost lobe, L2, L3, etc. for inner lobes. Generally only two or three complete lobes are recognizable for the *ML* craters studied thus far.

Median lobateness values for the lobes are 1.23 for L1, 1.20 for L2, and 1.13 for L3. The L1 and L2 values are larger than the median *SL* and *DL* lobateness values. L3 lobateness values are comparable to those found for the highland *SL* craters and for the outer lobe (L1) of *DL* craters. Analysis of individual craters show that 73.5% of the L2 lobes display smaller Γ than their accompanying L1, and, in 77.3% of craters with three lobes, L3 has a lower Γ than L2. All craters with three lobes show L3 with less sinuous ejecta (i.e., lower Γ) than L1. This continues the trend seen with *DL* craters. No lobateness dependence on latitude is suggested for L1 but an increase in Γ with diameter is suggested. L2 lobes show a slight increase in Γ in the 30-65°N latitude range and Γ values increase as diameter increases for L2. Extension of this study to the southern hemisphere will determine if these observed trends are global in extent.

Although the *ML* study is incomplete at this point, we can begin to compare the lobateness studies for the three lobate ejecta classes. The

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similarity in lobateness values of plains *SL* craters and the L2 lobe of *DL* craters suggest a similar origin. If the lobate morphologies are created by impact into subsurface volatiles, the smaller crater sizes and relatively low values of Γ (Median = 1.09) may indicate impact into near surface ice, while the larger *ML* craters have larger Γ values because of impact into deeper water reservoirs (as suggested by (6) based on qualitative studies of ejecta lobateness). Changes in lobateness value may therefore reflect the physical state of the volatiles, thus explaining the lack of an apparent lobateness dependence on latitude. A latitudinal dependence of ejecta morphology, reported by Barlow and Bradley (7), may more accurately reflect the distribution of the subsurface volatiles.

References: (1) Carr, M.H. et al. (1977), *JGR*, **82**, 4055. (2) Schultz, P.H. and Gault, D.E. (1979), *JGR*, **84**, 7669. (3) Kargel, J.S. (1986), *LPS XVII* (abs.), 410. (4) Mouginis-Mark, P. (1981), *JGR*, **84**, 8011. (5) Bridges, N.T. and Barlow, N.G. (1989), *LPS XX* (abs.), 105. (6) Johansen, L.A. (1979), NASA TM 80339, Rpts. Planet. Geol. Geophys. Prog. 1978-1979, 123. (7) Barlow, N.G. and Bradley, T.L. (1990), submitted to *Icarus*.

Table I--General Results of Lobateness Studies

	SL		DL		ML		
	P	H	L1	L2	L1	L2	L3
Number	370	1212	251	245	108	102	22
Median Γ	1.09	1.13	1.14	1.09	1.23	1.20	1.13
Max Γ	3.33	3.81	2.27	1.38	1.74	1.47	1.33
Min Γ	1.00	1.01	1.01	1.00	1.05	1.05	1.05
Average Γ	1.13	1.16	1.17	1.10	1.26	1.20	1.15
Latitude Dep?	No	No	*	*	No	Slight	†

P = Northern Plains H = Southern Highlands

**DL* craters are located primarily within the 40-65°N latitude range, thus latitudinal dependence studies are not valid.

†Too few *ML* craters display a L3 lobe to provide adquate statistics for the diameter and latitude dependence analyses.

Table II--Median Γ Values by Diameter Range

Diam (km)	SL		DL		ML		
	P	H	L1	L2	L1	L2	L3
8.0-11.3	1.09	1.11	1.13	1.07	1.10	1.08	1.06
11.3-16.0	1.09	1.14	1.14	1.07	1.10	1.08	1.06
16.0-22.6	1.12	1.16	1.17	1.10	1.19	1.13	1.09
22.6-32.0	1.15	1.18	1.17	1.13	1.28	1.22	1.16
32.0-45.3	1.08	1.17	1.30	1.24	1.32	1.28	1.25
45.3-64.0	--	1.11	1.08	1.17	1.28	1.33	1.25
64.0-90.5	--	--	--	--	1.51	1.36	--