MORPHOLOGIC VARIATIONS OF MARTIAN RAMPART CRATER EJECTA AND THEIR DEPENDENCIES AND IMPLICATIONS; J.S. Kargel, Dept. of Planetary Sciences, Univ. of Arizona, Tucson, Arizona 85721

Johansen[1] reports observations indicating that the morphology of Martian rampart crater ejecta varies considerably with latitude. She finds that Martian rampart craters can generally be classified into two major descriptive types. The predominantly low latitude "water-type" ejecta morphology typically includes a sharp ejecta flow-front ridge and a highly crenulated, lobate flow-front perimeter; the higher latitude "icy-type" ejecta morphology lacks a sharp distal ridge and has a more circular perimeter. On the other hand, Mouginis-Mark[2] concludes that no correlation of rampart ejecta morphology with latitude exists if one excludes his "type 6" pedestal craters[3]. These contrary conclusions are each based on global surveys of Martian rampart craters using two different qualitative ejecta morphology classifications. This study is intended to approach this controversy in a more quantitative way.

The presence or absence of a distal ridge on an ejecta flow is the most distinguishing feature of the "icy" and "water" types of rampart ejecta, but this feature is difficult to quantify. The lobateness of the perimeter is more easily quantified. Here, lobateness is defined as Γ = (ejecta flow front perimeter $)/(4\pi(\text{flow area}))^{\frac{1}{2}}$. Note that Γ is similar to the H employed by Woronow and Mutch[4]. $\Gamma = 1$ for a circular ejecta flow front, with no upper limit for more circular ejecta. Few craters have Γ greater than 1.6. Similarly shaped ejecta blankets of different sizes have identical values of Γ.

In this study, Γ, crater size, latitude, longitude, elevation[5], and geologic unit[6] were determined for 538 rampart craters using 1:2 million scale USGS photomosaics. The geographic distribution of analyzed craters is shown in Figure 1. The chief selection criterion required a minimum of about 90% of an ejecta perimeter to be well delineated and uneroded; this criterion was relaxed somewhat at high latitudes, where poor image quality and extensive erosion and mantling reduce the sample size. This rigid criterion automatically introduces a sharp bias against the cratered highlands. No craters were rejected on the basis of circumstances such as oblique impact, diversion of the flow around obstacles, or local inclination of the surface. For multi-lobed craters, only the most complete and visually prominent lobe was analyzed.

Figure 2 shows that for low latitudes Γ depends strongly on crater size. High latitude craters show a similar though less clear size dependency. The size dependency of Γ for all craters taken together is about 0.025 per kilometer of crater diameter. This size dependence could be due entirely to a sensitively stress-dependent (and therefore scale-dependent) rheology of the flows, or to the dynamics of the excavation process; but perhaps also involved is the possibility that larger craters penetrate deeper into a water-rich layer that may underly an ice-rich permafrost[8]. Large craters may tap into abundant water, yielding highly fluid ejecta, whereas small craters may tap only into permafrost; these small impacts may melt and vaporize only a small fraction of the cold ice, yielding more viscous ejecta.

Figures 3a, b, and c quantitatively confirm Johansen's[1], and Blasius' et al.[7] observations that ejecta morphology varies with latitude, with the apparently lower viscosity, highly lobate "water-type" flows occuring generally at low latitudes, and the apparently higher viscosity, more nearly circular "icy-type" ejecta occurring at mid and high latitudes; the transition from more lobate to less lobate is gradational in the vicinity of ± 20° to ± 35°, consistent with Johansen's[1] findings. Narrow crater size bins are employed in Figure 3 and Table 1; then crater size is eliminated entirely as a free parameter by normalizing each data point to a common crater diameter using the 0.25/km size dependence. This latitudinal dependence can best be interpreted as indicating an ice-bearing permafrost layer that thickens towards high latitudes, underlain by a water-bearing layer that is more accessible to impacting objects at low latitudes. This observation also argues against long-term deviations from the present rotational axis[9] during Amazonian or Hesperian times, unless these deviations were smaller than about 20°.

Contrary to the observations of Mouginis-Mark[2], Γ is not dependent on elevation. That observation was probably due to the inclusion of generally low-elevation pedestal craters in the data set[3].

Table 1 suggests that there is little or no geologic control on Γ. When high latitude and low latitude craters are considered separately, terrains of greatly varying age and characteristics possess craters with similar values of Γ. This tentative result suggests a roughly constant Martian climate through Amazonian and into Hesperian times, and roughly uniform volatile contents of diverse geological materials. However, initial indications are that modest excursions of the climate might be revealed by more detailed geologic and morphologic analysis.

NOTES AND REFERENCES

1. Johansen, L.A. (1979) NASA TM 80339, Reports of Planetary Geology Program, 1978-1979, p. 123. 2. Mouginis-Mark, P. (1979) Jour. Geophys. Res., 84, B14, 8011-8022. 3. No correlation was found except for the mid-to-high-latitude pedestal "Type 6" craters whose "pedestals" are probably inappropriately considered by Mouginis-Mark to be fluidized ejecta flows; pedestals are more likely to be ejecta-armored eolian erosional remnants[10]. 4. Woronow, A., and Mutch, T. (1980) Lun. Plan. Sci 11, 1282. 5. USGS (1976) Topographic Map of Mars. 6. Scott, D.H., and Carr, M.H. (1978) USGS Geologic Map of Mars. 7. Blasius, K.R., et al. (1981) Report of Planetary Geology Program - 1981, p. 93. 8. Boyce, J.M. (1979) NASA TM 80339, Reports of Planetary Geology Program, 1978-1979, p. 114. 9. Schultz, P.H. (1985) Scientific American, December issue, p. 94. 10. Arvidson, R., et al. (1979) Nature 278, p. 533.

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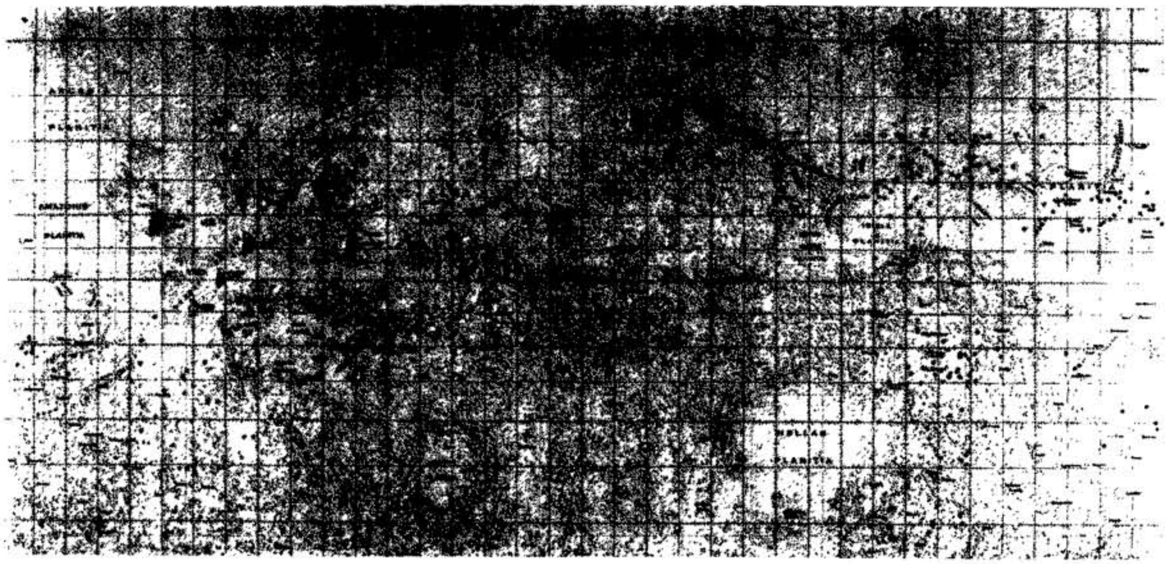

Figure 1. Locations of analyzed craters, except for those at latitudes >± 65°.

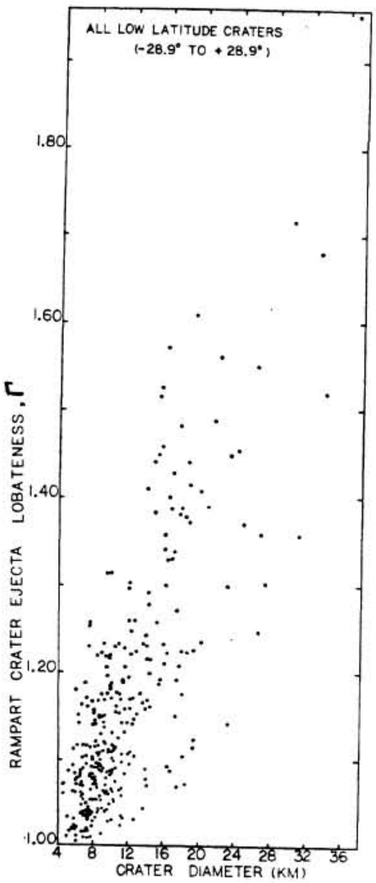

Figure 2. Size dependence of ejecta lobateness. Error in Γ ±.03.

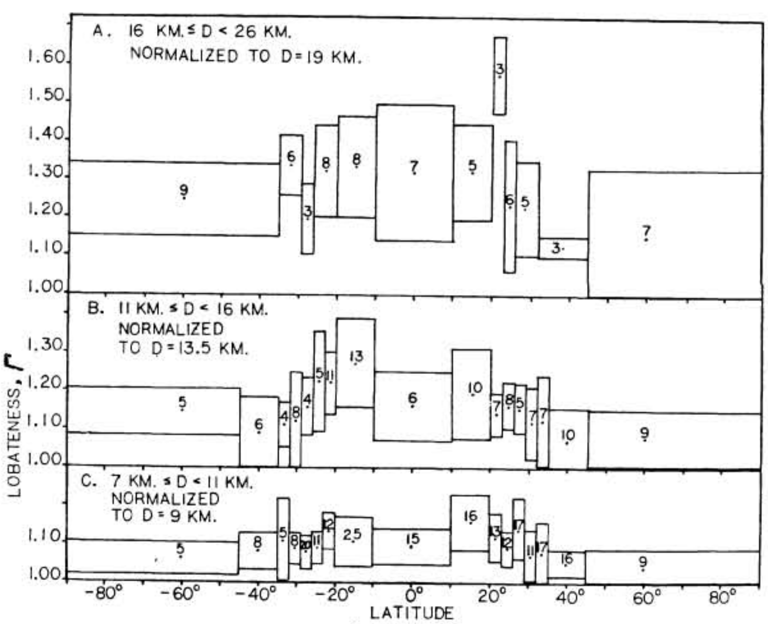

Figure 3. Latitudinal dependence of ejecta lobateness. Boxes give 1σ dispersion (not error) of Γ and width of latitude bins. Also given are numbers of samples and mean Γ (dots). Normalizations discussed in text.

Table 1. A comparison of the lobateness of crater ejecta on various terrains for craters with 10 km ≤ D < 20 km. Also given are numbers of samples and 1σ natural dispersions (not error) of Γ.

	Cratered terrains, Nhc + Nplc	Mottled Plains, Npm	Ridged Plains, Hprg	Rolling Plains, Hpr	Amazonian Plains, Apt, Apc, Aps
High Latitude (≥ ± 30°)	1.130 ± .078 (N=25)	1.118 ± .127 (N=20)	1.121 ± .095 (N=16)	1.102 ± .080 (N=7)	1.132 ± .095 (N=25)
Low Latitude (< ± 30°)	1.174 ± .113 (N=23)	No Npm; not applicable	1.205 ± .094 (N=52)	1.163 ± .100 (N=7)	1.205 ± .111 (N=46)