AN ESTIMATE OF THE GLOBAL THICKNESS OF IMPACT MELT ON MARS. S. M. Clifford[1], M. J. Cintala[2], and N. G. Barlow[2]. [1]Lunar and Planetary Institute, Houston, TX 77058. [2]Mail Code SN21, NASA Johnson Space Center, Houston, TX 77058.

The quantity of melt generated by an impact has important implications for the composition of the regolith [Newsom, 1980; Allen et al., 1982] and as a potential heat source for driving hydrothermal activity within the crust [Pieri, 1980; Clifford, 1980; Newsom, 1980; Brakenridge et al., 1985]. In this abstract we present an estimate of the cumulative thickness of impact melt generated over the course of martian geologic history based on both the crater size-frequency distribution of the planet's cratered highlands [Barlow, 1990] and a revised scaling relationship for the melt volume produced by impacts [Cintala and Grieve, this volume].

Statistical data on the crater size-frequency distribution of the martian highlands is presented in Table 1. As discussed by Barlow [1990], this data has been binned and analyzed using the relative (R plot) procedure recommended by the *Crater Analysis Techniques Working Group* [1978]. The R plot technique highlights any deviation from a power law distribution function by presenting the crater size-frequency data in differential form (where $\log R$ is plotted against $\log D_m$). The parameter R is given by

$$R = (D_m)^3 N/A(D_b - D_a) \qquad (1)$$

where N is the number of craters within the diameter range D_a to D_b ($D_b = D_a\sqrt{2}$), D_m is the geometric mean diameter of the bin ($= \sqrt{D_a D_b}$), and A is the surface area over which the craters are counted (in Table 1: $A = 8.8 \times 10^6$ km^2 for $D_b < 181$ km and $A = 8.0 \times 10^7$ km^2 for $D_b > 181$ km). Assuming that the differential crater size-frequency distribution preserved in the cratered highlands (i.e., R) is representative of the cratering flux experienced over the entire planet, the *global* number of impacts that have occurred within a particular size range can be calculated from eq. (1) by setting A equal to the surface area of Mars ($= 1.45 \times 10^8$ km^2) and solving for N_g (Table 1).

Cintala and Grieve [this volume] have presented a revised scaling relationship for the volume of melt produced by an impact in an effort to reconcile the large discrepancy between the observed and calculated melt volumes for a given crater diameter. The model is based on the volume-scaling relationship of Schmidt [1980] and assumes a transient cavity depth/diameter ratio of 0.33. Their expression for the volume of melt produced by the vertical impact of a chondritic projectile into a granite target on Mars (impact velocity ~10 km/s, Hartmann [1977]) is

$$V_m\,(\text{km}^3) = 2.14 \times 10^{-5} D_{tc}^{3.83} \qquad (2)$$

where D_{tc} is the transient crater diameter. (Although granite is a questionable analog for the composition of the martian crust, it serves for the purposes of this study because its shock behavior is similar to that of other igneous rocks.)

Figure 1 illustrates the relationship between melt volume and transient diameter for the crater size range appropriate to this study. The transient crater diameters were calculated for the mean diameters of each bin in Table 1 using the scaling relation of Croft [1985], i.e.

$$D_{tc}\,(\text{km}) \cong D_c^{0.15 \pm 0.04} D_m^{0.85 \pm 0.04} \qquad (3)$$

where D_c is the transition diameter between simple and complex craters (~8 km for Mars, Cintala and Mouginis-Mark [1979]; Pike [1980]) and where D_m represents the final crater diameter.

Given the global crater size-frequency distribution extrapolated from the highlands data (Table 1), and the melt volumes calculated from eq. (2), we calculate a minimum global thickness of impact melt on Mars of ~110 m. By far, the greatest contribution to this total (~100 m) is made by the largest basins ($D > 512$ km). This fact is evident in Fig. 2, where the cumulative thickness of impact melt is plotted as function of D_{tc}.

In a similar analysis, Newsom [1980] found that craters up to 256 km in diameter contributed a quantity of melt equivalent to a global layer ~60 m thick. We find the volume of melt produced by craters in this size range to be an order of magnitude smaller. This discrepancy is primarily explained by Newsom's assumption of a lunar crater size-frequency distribution, which yields a higher estimate of the number of small craters, and his use of a melt expression ($V_m = 2 \times 10^{-4} D^{3.4}$) derived by Lange and Ahrens [1979], which predicts melt volumes that are appreciably greater at small crater diameters than those predicted by eq. (2).

Although we readily acknowledge the large uncertainties associated with our analysis, there are at least two reasons for believing that the estimate of 110 m of impact melt is conservative. First, because the highland

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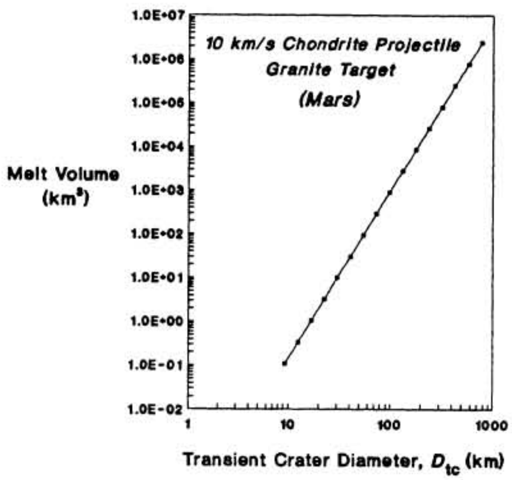

Figure 1. Impact melt volume as a function of transient crater diameter.

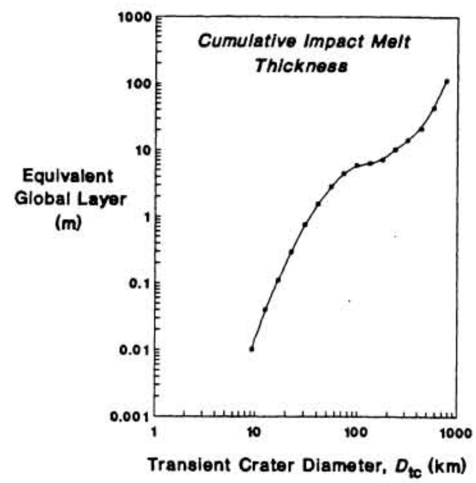

Figure 2. Cumulative thickness of impact melt as a function of transient crater diameter.

Table 1. Crater statistics and impact melt volumes for the crater size-frequency distribution of the martian cratered highlands.

D_a (km)	D_b (km)	D_m (km)	N	log R	N_g	D_{tc} (km)	V_m (km^3)	V_t (= $N_g \cdot V_m$)	Thickness (m)
8.00	11.31	9.51	946	-1.55	15705	9.27	1.08E-01	1.70E+03	0.01
11.31	16.00	13.45	777	-1.34	12735	12.45	3.34E-01	4.26E+03	0.03
16.00	22.63	19.03	582	-1.16	9638	16.71	1.03E+00	9.96E+03	0.07
22.63	32.00	26.91	499	-0.93	8184	22.43	3.19E+00	2.61E+04	0.18
32.00	45.25	38.05	417	-0.71	6791	30.12	9.87E+00	6.70E+04	0.46
45.25	64.00	53.82	227	-0.67	3723	40.43	3.05E+01	1.14E+05	0.78
64.00	90.51	76.11	119	-0.65	1949	54.29	9.42E+01	1.84E+05	1.27
90.51	128.00	107.63	51	-0.72	830	72.88	2.91E+02	2.42E+05	1.67
128.00	181.02	152.22	14	-0.98	228	97.85	9.00E+02	2.05E+05	1.42
181.02	256.00	215.27	11	-1.74	20	131.37	2.78E+03	5.56E+04	0.38
256.00	362.04	304.44	8	-1.57	15	176.37	8.60E+03	1.29E+05	0.89
362.04	512.00	430.54	9	-1.22	16	236.80	2.66E+04	4.25E+05	2.94
512.00	724.08	608.87	4	-1.27	7	317.92	8.21E+04	5.75E+05	3.97
724.08	1024.00	861.08	2	-1.27	4	426.82	2.54E+05	1.01E+06	7.01
1024.00	1448.15	1217.75	2	-0.97	4	573.04	7.84E+05	3.14E+06	21.66
1448.15	2048.00	1722.16	2	-0.67	4	769.35	2.42E+06	9.69E+06	66.92
							Global Totals:	1.59E+07	109.65

statistics include no correction for erosion or obliteration, they likely underestimate the cumulative number of impacts the highlands have experienced. Second, Barlow's [1990] statistics do not include any of the six "megabasins" (i.e., $D >$ Hellas) that have been reported in the literature [Schultz et al., 1982; Schultz, 1984; McGill, 1989; Schultz and Frey, 1990]. This omission reflects both the tentative nature of the identification of these basins, and the clear geometric and scaling difficulties associated with estimating the amount of impact melt produced by basins whose diameters approach and exceed the radius of Mars. The contribution of even the smallest of these basins (Daedalia, D ~2540 km, Schultz and Frey [1990]) would nearly double the melt volume estimate presented here, while inclusion of the largest (Elysium, D ~4970, Schultz [1984]) might increase it by over an order of magnitude.

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