DISTRIBUTION OF IMPACT INDUCED PHENOMENA IN COMPLEX TERRESTRIAL IMPACT STRUCTURES: IMPLICATIONS FOR TRANSIENT CAVITY DIMENSIONS; Lakomy, R., Institut für Planetologie, Wilh.-Klemm-Str. 10, D-4400 Münster, F.R.G.

This paper summerizes results of a research program on complex terrestrial impact craters. It mainly concentrates on the permanent effects resulting from the 3 main phases of crater formation: the compression stage, the excavation stage, and the crater modification. The original transient cavity diameter (D_t) is considered as the most significant constraint entering into crater scaling and into the computation of the rock volumes excavated and displaced from complex craters. Controversial discussions have arisen about changes in the transient crater diameter as a function of the apparent diameter (D_a).

The final transient cavity dimensions are established at the end of the excavation phase (1). As a consequence of gravity-driven collapse of a deep bowl-shaped cavity (1 to 6), this diameter is unamenable to direct observations in final apparent craters. With respect to the basic concepts of impact cratering mechanics (3, 6 to 11), various geometric parameters were used for the determination of the transient cavity diameter of complex structures. These are:

(I) the maximum radial extent of dikes of suevitic breccias and of dikes of impact melt rocks in the uplifted basement rocks;

(II) the innermost margin of the ring depression (megablock zone) peripheral to the central uplift as deduced from reflection seismic data and from remnants of sedimentary covers overlying crystalline basement rocks (3),

(III) the diameter corresponding to the steepest gradient of the gravity anomaly measured at the present surface.

In the present study, the distribution of shock-induced features in subcrater basement rocks is also considered. The maximum radial position of characteristic shock features can be used to estimate both the apparent and transient crater diameters of eroded complex structures (12).

The above-mentioned geometric parameters of the most intensely studied complex structures have been determined. The results are presented in Table 1. In the table D_a was taken from tabulations of the terrestrial cratering record of (13). Fig. 1 shows the correlation between the transient cavity diameter and the apparent diameter of these structures. Linear regression analysis of D_t with respect to D_a yields the empirical relationship $D_t = 0.57\ D_a$. The correlation coefficient of the data defining this regression line is 0.99. On the basis of the available data set, this equation is the best approach for D_t and implies proportional growth of the transient crater diameter for the observed range of D_a (Table 1). The equation of D_t presented here is significantly lower than the upper limit of a previously-held notation of (13), $D_t = 0.5 - 0.65\ D_a$.

The outer diameter (D_s) of the zone of shock deformation structures in quartz in basement megablocks and of the present distribution of shatter cones (formational pressures > 2 - 5 GPa; 14) in 15 complex craters as a function of D_a is shown in Fig. 2. Apparent shock pressure of less than about 30 GPa, which are confined to the central basement uplift (15), attenuates to about 7.5 GPa at a radial range $R_{sq} = 0.35 - 0.45\ D_t$. The outer extent of shatter cones (R_{sc}) is limited to $R_{sc} = 0.4 - 0.5\ D_t$. Assuming only small inward displacement of the shock contours near the transient crater rim during transient cavity modification, this result indicates that shock pressures at the cavity rim are in the 1 to 2 GPa range (15).

Consequently, the following constraints on the dimension of the transient cavity in the formation of complex impact structures have been found:

(I) the relation between the transient and the apparent crater diameter is best described by $D_t = 0.57\ D_a$.

(II) Shatter cones extend radially beyond the range of shock deformation structures of quartz.

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(III) The shock pressures at the transient crater rim is near 1 to 2 GPa.

(IV) The geometric parameters of Table 1 apply to complex craters with apparent diameters up to at least 100 km.

References: (1) Schultz PH & Merill RB (eds.), Multi-ring Basins (1981) (2) Croft SK in (1) (1981) (3) Grieve et al., in (1) (1981) (4) Croft SK, J Geophy Res 90 (1985) (5) Holsapple KA & Schmidt RM, J Geophy Res 92(1987) (6) Melosh HJ Impact Cratering - A Geologic Process (1989) (7) Melosh HJ in (6) (1977) (8) Gault DE, et al., in: French B & Short NM (eds.): Shock Metamorpohism of Natural Materials (1968) (9) Roddy DJ et al.(eds.), Impact and Explosion Cratering (1977) (10) Dence MR et al., in (9)(1977) (11) Melosh HJ, Ann Rev Earth Planet Sci 8 (1980) (12) Stöffler D et al., in: Boden A. & Eriksson KG (eds.) (1988) (13) Grieve RAF, Ann Rev Earth Planet Sci 15(1987) (14) Milton DJ, in (9) (1977) (15) Robertson PB & Grieve RAF in (6) (1977)

Table 1: Characteristic geometric parameters for the determination of D_t of complex craters (km); values in parantheses are maximum estimates of D_t.

Crater	D_a	D_{db}	D_{rd}	D_{gr}
Decaturville	6	-	3.5	-
Sierra Madera	13	7.5	(10.5)	-
Haughton	24	-	13.5	-
Ries	24	-	13.0	12.5
Rochechouart	25	13.0	-	13.5
Clearwater W.	32	-	19	-
Carswell	38	21	(27)	-
Charlevoix	46	-	27	-
Siljan	52	-	28	-
Manicouagan	100	-	55-60	-

D_a = apparent diameter
D_{db} = diameter of zone of breccia dikes
D_{rd} = inner diameter of ring depression
D_{gr} = diameter of the steepest gradient of surface gravity anomaly

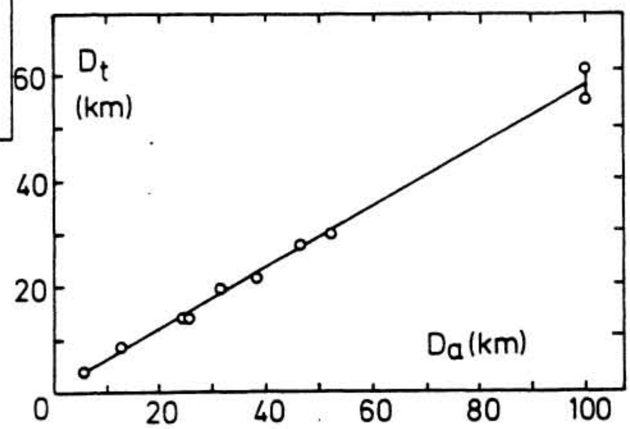

Fig.1 : Transient cavity diameter (D_t) versus the apparent crater diameter (D_a) for the craters listed in Table 1.

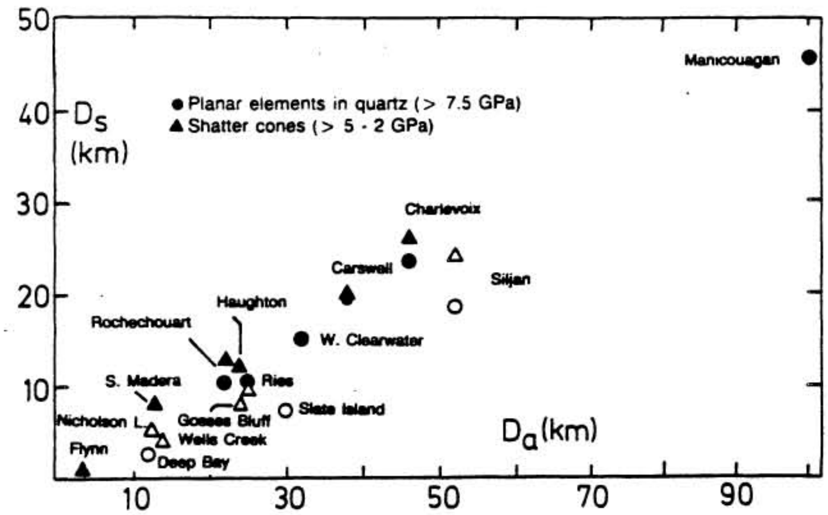

Fig. 2: Maximum radial extend of quartz with shock features (D_s) in the basement rocks of complex impact craters; open symbols represent minimum estimates resulting from insufficient exposures.