CRATERING EXPERIMENTS IN SAND

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Many impact experiments in sand have been made by several workers (1, 2, 3, 4, 5). But these are not sufficient enough to be compared in detail with theoretical models. The present study provides additional data base of impact experiments in sand and aims to compare these data with some existing theoretical models (6, 7).

Present experiments consists of impacting aluminum projectiles into sand at velocities in the range of 100 m/s to 1 km/s which are smaller than those of previous studies, whereas the range of the kinetic energies in the present experiments is comparable with previous studies: $E=10^7 \sim 10^{10}$ ergs. Measurements of the crater diameter and depth as a function of projectile velocity and size were carried out.

As Quaide and Oberbeck (5) and Piekutowski (3) observed the crater morphology in the case of two-layered sands changes from a bowl-shaped to a concentric crater, we found the change of the crater morphology also occurs in the case of self-compacted sands. By self-compaction, the sand rearranges itself into the target with continuously varying hardness. Therefore the change of crater morphology as a function of crater diameter does not necessarily indicate the existence of sharp discontinuities in planets. Gradual change of target hardness which may be produced by self-compaction may be sufficient enough to cause a rather systematic change of crater morphology as observed in moon and planets.

The all available data on the diameter versus projectile's velocity relation (1, 2, 4) are reasonably well expressed by

$$D=A(p\cdot d^3)^{\frac{1}{4}} \quad \text{or} \quad D=B\{m(a+bv)v\}^{\frac{1}{4}}$$

where P is the initial shock pressure at impact, d is the projectile size, m is the projectile mass, a is the bulk sound-wave velocity ($=\sqrt{Ko/\rho o}$), $b=(Ko'+1)/8$, and A and B are constants. The above expression is also consistent with the "late-stage equivalence" relation proposed by Dienes and Walsh (8). The empirical relation of the late-stage equivalence is also discussed in terms of the Hugoniot equations and shock-wave propagation.

References:

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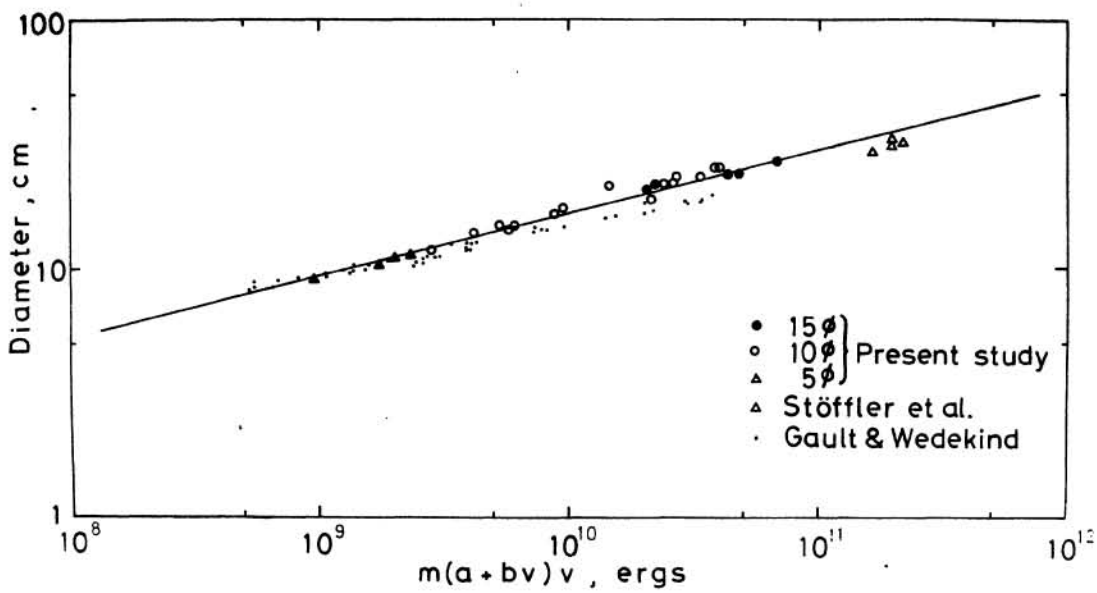

Figure 1. Dependence of crater diamter in sands on m(a+bv)v. Many experimental data obtained by using various projectile sizes and the impact velocities are observed to fall in a single line without using any additional parameters.