A COMPARISON OF SCALING LAWS FOR PLANETARY IMPACT CRATERING: EXPERIMENTS, CALCULATIONS, AND THEORY

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The literature is filled with a wide variety of scaling laws that define crater characteristics that result from an impactor with a given energy, size and composition into a given target at a given gravity strength and atmospheric pressure. Many such laws are special, intended for a limited range of variables, or for given materials only. In many cases these special laws do not even address the effects of all the pertinent variables. Such scaling laws have been obtained in several ways; these include experiments, code calculations, and theoretical arguments at various levels of sophistication. The variety of scaling laws, when applied over the wide range of variables of interest can give answers that differ by orders of magnitude for the same problem.

A comparison and critique of these scaling laws is appropriate. Recent results of the author (1) have led to a better understanding of the general form and limits of scaling laws for impact cratering, and have shown that the wide variety of results from the literature all fold into a common framework. However, even within this framework there still exist significant differences when these different approaches are applied to extremely large impact events such as a 10-km diameter body terrestrial impact (2).

A number of approaches to scaling have been studied. The attached figure presents some representative results on the basis of the crater mass normalized by impactor mass as a function of impactor radius. Experimental results are represented by the two curves labeled "Centrifuge Impact Result" (3). Results based upon 1/3.4 Scaling laws applied to the nuclear explosive crater Teapot ESS are represented by the estimates for Meteor Crater by Shoemaker, the Brent crater estimate by Grieve and Cintala, and the curve labeled "Grieve and Cintala."

The lines labeled "Melt Mass" and "Vapor Mass" are representative of those mass ratios respectively and are based upon a simple criteria for melt and vaporization (4) and compare well to code calculations (5).

REFERENCES


(3) Schmidt and Holsapple (1982) Submitted to Proceedings of Conf. on Large Body Impacts and Terrestrial Evolution, Snowbird, Utah.


SCALING COMPARISONS
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Impactor Radius

10^-1 cm 1 cm 10 cm 1 m 10 m 100 m 1 km 10 km 100 km

Crater Mass / Impactor Mass

0.1 km 1 km 10 km 100 km

Melt Mass, 30 km/s

Meteor Crater Estimate
(Shoemaker & Kieffer, 1974)

Grieve & Cintala,
30 km/s

Centrifuge Impact Results

Meteor Crater Estimate
(Schoemaker, 1963)

Equivalent Teapot ESS

Brent Crater Estimate
(Grieve & Cintala, 1981)

Meteor Crater
(Schmidt, 1980)

Ries Estimate
(Taylor et al., 1980)

Vapor Mass, 30 km/s

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