Preliminary Scaling Results for Crater Rim-Crest Diameter

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This work is a continuation of an ongoing experimental program with the objective to perform experiments and to develop scaling relationships for large-body impacts onto planetary surfaces. With both powder and gas guns mounted on the rotor arm of a geotechnical centrifuge, it is possible to match various dimensionless similarity parameters, which have been shown to govern the behavior of large-scale impacts. Current work (Schmidt and Housen, 1986a,b) is directed toward the determination of scaling estimates for both porous and nonporous targets. The results are presented here in summary form. The table below lists our scaling estimates in two forms. The upper part of the table gives the results in the nondimensional form. Note that the equation for time of formation, expressed in terms of crater volume and gravity, is independent of material type. As can be shown with the coupling parameter theory given by Holsapple and Schmidt (1986), the crater volume "accounts" for variations in target and impactor properties. The lower part of the table shows the same scaling laws in a dimensional form (with cgs units) in terms of the impactor energy and velocity, and gravity. In constructing these scaling laws, the density ratio was assumed to be constant, because in most cases there were insufficient data to determine the dependence on density. The lower part of the table was calculated with the target density appropriate for each material and a nominal impactor density (δ) of 3 gm/cm^3. Crater dimensions in all cases refer to the apparent crater.

	Dry Sand	Wet Sand	Water
Crater Volume	$\Pi_V = 0.24\Pi_2^{-0.51}$	$\Pi_V = 0.2\Pi_2^{-0.65}$	$\Pi_V = 2.1\ \Pi_2^{-0.65}$
Crater Radius	$\Pi_R = 0.84\ \Pi_2^{-0.17}$	$\Pi_R = 0.8\Pi_2^{-0.22}$	$\Pi_R = 0.94\Pi_2^{-0.22}$
Volume vs Time	$\Pi_V = 0.16\ \Pi_t^{0.86}$	$\Pi_V = 0.25\ \Pi_t^{1.07}$	$\Pi_V = 1.1\ \Pi_t^{1.07}$
Time of Formation	$\Pi_T = 1.9\Pi_2^{-0.58}$	$\Pi_T = 1.6\Pi_2^{-0.61}$	$\Pi_T = 2.3\Pi_2^{-0.61}$
	$T = 0.8V^{1/6}\ g^{1/2}$		

$\Pi_V = \rho V/m$
$\Pi_R = R\,(\rho/m)^{1/3}$
$\Pi_2 = 3.22ga/U^2$
$\Pi_t = Ut/a$
$\Pi_T = UT/a$

	Dry Sand	Wet Sand	Water
Volume	$V=0.20E^{0.83}U^{-0.64}g^{-0.51}$	$V=0.13E^{0.78}U^{-0.27}g^{-0.65}$	$V=2.9E^{0.78}U^{-0.27}g^{-0.65}$
Radius	$R=0.77E^{0.28}U^{-0.21}g^{-0.17}$	$R=0.70E^{0.26}U^{-0.09}g^{-0.22}$	$R=1.1E^{0.26}U^{-0.09}g^{-0.22}$
Vol vs t	$V=0.29E^{0.71}U^{-0.57}t^{0.86}$	$V=0.21E^{0.64}U^{-0.22}t^{1.07}$	$V=1.9E^{0.64}U^{-0.22}t^{1.07}$
Form. Time	$T=0.74E^{0.14}U^{-0.12}g^{-0.58}$	$T=0.62E^{0.13}U^{-0.04}g^{-0.61}$	$T=0.89E^{0.13}U^{-0.04}g^{-0.61}$

V=crater volume
R=crater radius
T=crater formation time
ρ =target density
Y=target strength
g=gravity
a=impactor radius
U=impactor velocity
E=impactor energy
t=time

In many scaling applications, the rim-crest diameter is of more interest than the apparent diameter, since it can be determined directly from photographs without needing to determine the height of the pre-impact surface. Housen et al. (1983) have shown that the rim-crest diameter is geometrically similar in the gravity regime and is approximately 25% greater than the apparent diameter for dry sand targets. The upper figure gives a fit to the nondimensional rim diameter versus the the gravity-scaled size π_2. The slope is in agreement with a value of the gravity exponent alpha equal to 0.51. There is still some uncertainty in the coefficent, but it is in the range of 1.94 to 2.18.

The second figure compares rim-crest geometry from centrifuge experiments with lunar data give by Pike (1977). The centrifuge data is plotted in its lunar prototype dimensions, that is, it is multiplied by the ratio of gravity between the test environment and that of the moon. These results are considered preliminary and a current best estimate for the coefficient is 2.06.

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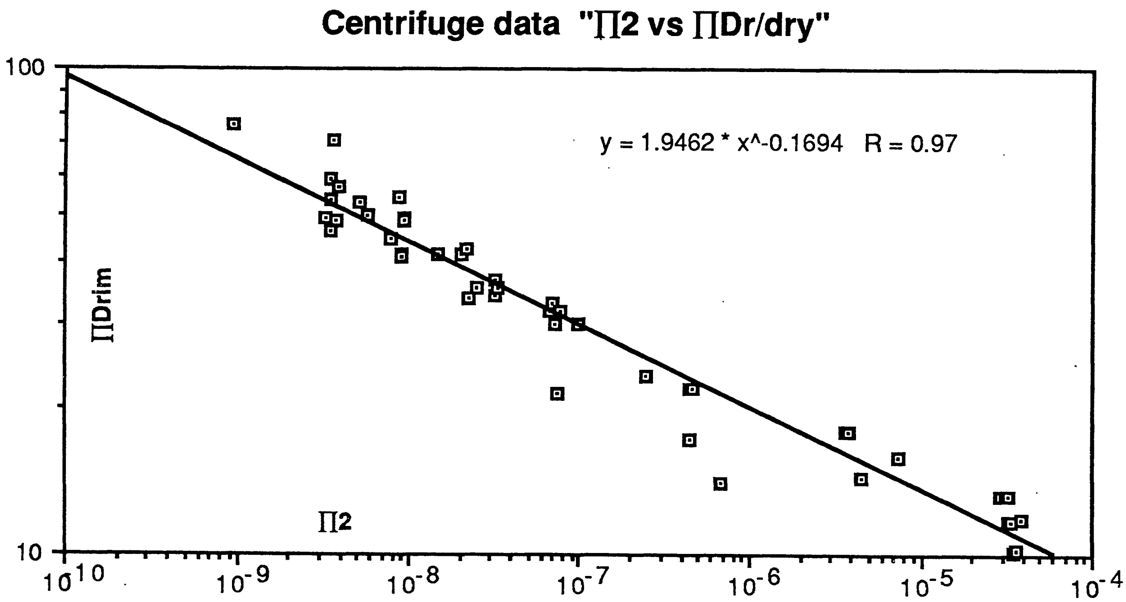

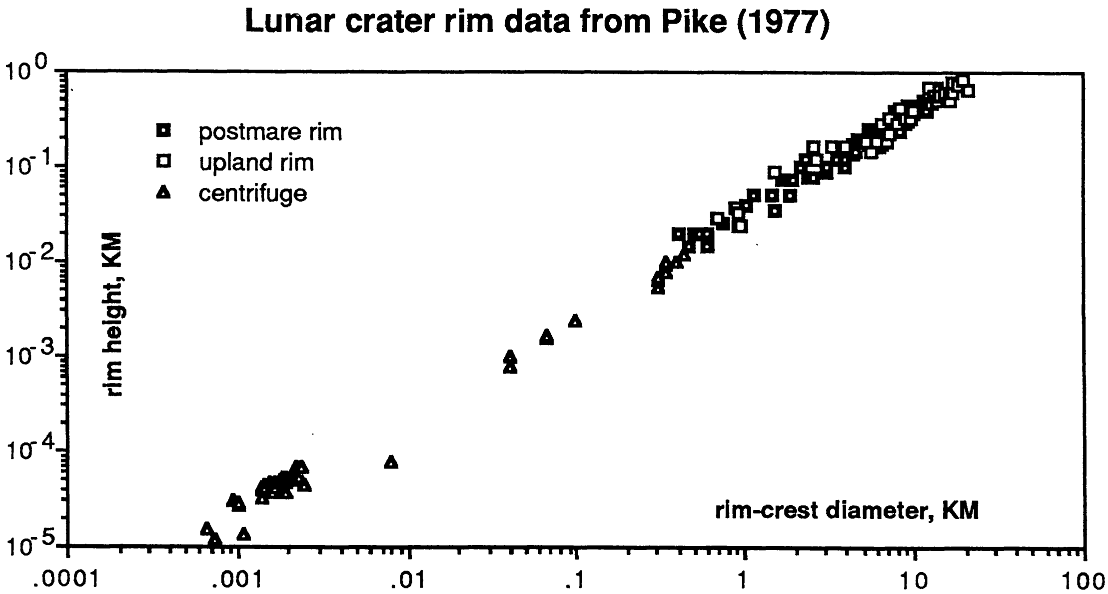

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(2) Holsapple K. A. and Schmidt R. M. (1986) Point-source solutions and coupling parameters in cratering mechanics. *J. Geophys. Res.* (in press).
(3) Pike R. J. (1977) Size-dependence in the shape of fresh impact craters on the moon. In *Impact and Explosion Cratering* (D. J. Roddy, et al. eds) Pergamon Press, 489-509.
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