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CRATER SIZE ESTIMATES FOR LARGE-BODY TERRESTRIAL IMPACT

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Calculating the effects of impacts leading to global catastrophes requires knowledge of the impact process at very large size scales. This information cannot be obtained directly but must be inferred from subscale physical simulations, numerical simulations, and scaling laws. In support of the first symposium on "Large Body Impacts and Terrestrial Evolution; Geological, Climatological and Biological Implications," Schmidt and Holsapple (1982) presented scaling laws based upon laboratory-scale impact experiments performed on a centrifuge (Schmidt, 1980 and Schmidt and Holsapple, 1980). These experiments were used to develop scaling laws which were among the first to include gravity dependence associated with increasing event size. At that time using the results of experiments in dry sand and in water to provide bounds on crater size, they recognized that more precise bounds on large-body impact crater formation could be obtained with additional centrifuge experiments conducted in other geological media. In that previous work, simple power-law formulae were developed to relate final crater diameter to impactor size and velocity. In addition, Schmidt (1980) and Holsapple and Schmidt (1982) recognized that the energy scaling exponent is not a universal constant but depends upon the target media. Recently, Holsapple and Schmidt (1987) have shown that the experimentally-obtained power laws can be explained in terms of point-source similitude solutions and give rise to the concept of a coupling parameter relating the influence of impactor size and velocity. Our most recent work (Schmidt and Housen, 1987) includes results for non-porous materials and provides a basis for estimating crater formation kinematics and final crater size.

For terrestrial impact at 20 km/sec, a crater radius of 31 km is estimated from the following relationship:

$$R = 0.825\ \rho^{-0.33}\ \delta^{0.07}\ g^{-0.22}\ E^{0.26}\ U^{-0.09}$$

which for 1-G and 20 km/sec conditions reduces to:

$$R = 5.11 \times 10^{-2}\ \rho^{-0.33}\ \delta^{0.07}\ E^{0.26}$$

where ρ = target density (gm/cc)

δ = impactor density (gm/cc)

g = gravity (cm/sec^2)

E = energy (ergs)

U = velocity (cm/sec)

Likewise, a crater volume is estimated to be 1.56×10^{13} cubic meters based on the expression

$$V = 0.219\ \rho^{-1}\ \delta^{0.22}\ g^{-0.65}\ E^{0.78}\ U^{-0.27}$$

which for 1-G and 20 km/sec conditions reduces to:

$$V = 5.11 \times 10^{-2}\ \rho^{-1}\ \delta^{0.22}\ E^{0.78}$$

Final crater depth cannot exceed that for stability in the target media. This predicted value is based upon experimental results given by Schmidt and Housen (1987) and more detailed analysis must be done to validate the stability or to find the stability limit for generic terrestrial rock geology. These predicted values are somewhat less than those calculated by Roddy, et al. (1987) in a numerical simulation. A more detailed comparison of his results will be made by looking at the formation dynamics which also can be evaluated by coupling parameter scaling theory for crater growth. Rate of growth of crater depth will also be compared with numerical results by O'Keefe and Ahrens (1987). These results will be presented along with comparisons of ejected masses and velocities calculated by Roddy et al. (1987) and by O'Keefe and Ahrens (1982) and the scaling of ejection parameters as given by Housen, et al. (1983)

A revised set of scaling relationships for all crater parameters of interest will be presented. These will include results for various target media and will include the kinematics of formation. Particular attention is being given to possible limits brought about by very large impactors.

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