

EXTRAPOLATING LABORATORY EXPERIMENTS TO THE 'REAL WORLD'

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Laboratory impact experiments provide the only way to witness the complexities of the impact process through all temporal and spatial scales. As informative and compelling as such experiments might seem, they cannot be used to simulate directly the terrestrial and planetary record. Rather, laboratory-scale experiments can be used to isolate processes and control independent variables. Theory or full-scale examples then allow assessing and testing extrapolations. For example, loose particulate targets (e.g., sand) to simulate the post-shock conditions and the role of gravity in limiting growth. But the early-time transfer of energy and momentum will be very different from impacts at much higher velocities and larger scales.

Oblique impacts, however, map time into space by exposing successive stages of the cratering process that are preserved in the planetary impact record. Such stages are successively overprinted during near-vertical impacts. This strategy reveals that the impactor trajectory may not be lost in the geologic record. It is expressed by: (1) multiple stages of ejection (jetting, downrange-moving vapor, uprange plume, excavation flow); (2) shock asymmetries (crater shape, structural elements, and ejecta distributions); and (3) even impactor size and direction (central uplift, offset, and shape of central peak complex). With increasing crater size and decreasing impact angle, the impactor becomes more evident as the coupling stage comprises an increasing fraction of the crater excavation. The "basin-scaling paradox" for oblique impacts underscores this point: the impactor diameter may be only 1/3 to 1/5 of the transient basin diameter if current scaling relations are applied. This contrasts with laboratory-scale impacts into sand where the impactor is only 1/20 to 1/50 the size of the final crater. Since peak pressures are also reduced during oblique impacts, expressions of early-stage processes (e.g., impactor failure and structural asymmetries) may be preserved.

New experimental strategies and diagnostic techniques using the NASA Ames Vertical Gun Range now allow probing time-resolved details in the transfer of energy and momentum. These techniques include high-speed spectroscopy, direct shock measurements, nanosecond photometry, and 3-Dimensional Particle Imaging Velocimetry, and mega-frame imaging. The challenge is not just calibrating computational codes but also to recognize key signatures in the geologic record. But in 2005, the first "live" collision experiment will allow probing below a comet (NASA's Deep Impact Mission) and exploring the consequences of increasing velocities by 40%, increasing mass by three-orders-of-magnitude, and decreasing gravity by four-orders-of-magnitude.