Critical observations that constrain hypervelocity impact models

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Mapping and interpreting the structures left by terrestrial hypervelocity impacts is analogous to archaeology. Since erosion, cover and degradation hamper and obscure data collection identifying key features is essential. As a result a few clear observations may be adopted as universally applicable regardless of differences in size or target properties. Among the most important are those that identify or aid reconstruction of the following features:

1. crater morphology and regional topography at the time of impact;
2. contours of equal shock metamorphism, including melt rocks;
3. transient crater form;
4. interface between the lining of the transient crater and the underlying parautochthone;
5. volume involved in rim collapse and central uplift.

Craters in the crystalline rocks of the Canadian Shield range over two orders of magnitude in size and display many of the morphologies recognized in craters elsewhere in the Solar System. Critical data come from several complementary groups including the 3-4km Brent-Pingualuit (New Quebec) simple craters, the 10-20km Deep Bay-Nicholson Lake-East Clearwater Lake central peak group that resemble the Bosumtwi and El'gygytgyn craters and the larger West Clearwater, Charlevoix and Manicouagan peak-ring structures.

At Brent crater the lining of the centre of the transient cavity is preserved under collapse debris and the boundary of the parauthochthone (the fragmentation limit) seen in closely space deep holes demonstrates that the profile of the transient crater was hyperbolic with an eccentricity e ~1.6 and resembles experimental craters formed in loose sand. The down-axis fragmentation limit occurs at apparent shock levels that increase with size and are much higher than laboratory measurements of dynamic tensile strength; this suggests gravitational attenuation of tensile rarefaction waves during excavation. The approximate relationship between the transient depth (d) and final diameter (D) for crystalline rock craters is $d = 0.4D^{0.75}$ and for the height of the central uplift (h) is $h = 0.17D$ both significantly different from relationships derived from craters formed in stratified targets. The two relationships converge at D ~30km where central peaks collapse to form peak rings such as at West Clearwater Lake crater.

Rim collapse resembles landslides in mountains due to large earthquakes. It occurs along spheroidal surfaces that are beyond the limits of visible shock metamorphism and migrate further from the transient cavity rim with increasing size. The combination of seismic vibrations with duration and other possible controlling factors may generate ruptures where shock pressures exceed the dynamic tensile fracture strength of the target modulated by gravity at depth. There is a need for additional measurements of target properties including dynamic tensile strength for fracturing and fragmentation and further evaluation of interplay between gravity and energy in crater development.

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