

from the crater will make chains of craterlets outside the crater rim, like those around the big lunar craters. Quite often you will reproduce central peaks within the craters, and, if you sprinkle a layer of limestone dust or some other distinctive powder over the target, you will now and again make replicas of the rays round the lunar craters.

2. The material of the crater floor is broken. This "breccia" grades from rock-flour at the surface to boulder-size at depth.

3. This disturbance is detectable under large craters even when all surface traces have been eroded, or covered by loess or by sedimentary rock. Gravimetric surveys show anomalously low densities beneath the crater floor.

4. Minute spherules of iron, 0.1 mm. or so across, which condense from vapors produced by the impact flare, may be distributed around the crater.

5. The unusual minerals, coesite and stishkovite, first identified near meteorite craters, are found only at these places. They are dense silicates created by the pressure of the explosion.

6. Rocks surrounding the crater are likely to be shattered in a unique fashion. Compression waves originating from the strike diffract on small irregularities within the rock. This then breaks into *shatter cones* pointing to the center of impact. This piece of evidence also outlives complete deletion of surface traces.

7. When the diameters of various types of explosion crater are graphed against their depths, the incidents group upon a quite remarkably smooth curve. This includes craters from small chemical explosions, from nuclear charges, from the terrestrial meteorite strikes, and finally the lunar craters. The curve *excludes* most volcanic craters—both the conical types, such as Vesuvius, and the Hawaiian shield craters such as Mauna Loa.

The Barringer Crater is very far from being the largest known on Earth. It could have been caused by a body weighing 10,000 tons, striking at nearly 40 kilometers per second.

The meteor which occasioned the Vredevort Ring in South Africa was much bigger. Its volume has been estimated at a cubic mile. Blasting out the sedimentary strata, it exposed naked magma at the base of a pit scores of miles wide. At the tip of the ring, the strata were turned over to show the strati-

graphic sequence in horizontal, concentric rings. The hell-pit then refilled with magma from the depths.

Larger events still have been claimed. For example, Hudson's Bay and the Japan and Weddell seas have been said to have originated in the same way. Mr. Rene Gallant, puts forward strikes by Junoesque bodies, at energies totaling more than  $10^{33}$  ergs. This, by the way, is a quarter of the Sun's entire output of energy for an entire second! It equals the *complete* conversion to energy of a million tons of matter or the explosion of a hundred thousand million million tons—yes, seventeen zeros after the figure one—of TNT.

Very circumstantial proof should be given before these are accepted. If as little as one per cent of the energy of such an impact transferred as heat to the world's atmosphere, the air temperature everywhere would rise by about 200°C. My cal-

#### TEN CANADIAN CRATERS

(Not all of these are situated on the Shield)

Name	Diameter of circular feature as seen now	Estimated diameter of the original rim of crater	Upper limit of age of strike
HOLLEFORD .....	2.35 km.....	2.35 km.....	5 megacenturies
NEW QUEBEC .....	3.7 km.....	3.7 km.....	1-2 megayears
BRENT .....	3.0 km.....	3.7 km.....	5 megacenturies
WEST HAWK .....	3.3 km.....	3.9 km.....	5½ megacenturies
DEEP BAY .....	10 .....	10.5 km.....	2½ megacenturies
LAC COUTURE .....	14 km.....	10 km.....	6 megacenturies
CLEARWATER EAST .....	21 km.....	18 km.....	4 megacenturies
			(Twin strike)
CLEARWATER WEST .....	32 km.....	32 km.....	4 megacenturies
CARSWELL LAKE .....	32 km.....	30 km.....	5 megacenturies
MANICOUAGAN .....	60 km.....	65 km.....	3 megacenturies

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ulation here is approximate, since it ignores the work which the heat would do in expanding the atmosphere; but my one per cent heat allowance is obviously niggardly. Strikes by major asteroids seem to be the instant recipe for pasteurized planet. They also violate the law of parsimony. Nonetheless, you must notice that even the Vredevort event yielded *more than a million megatons of TNT*.

It is calculated that meteorites as heavy as 1,000 tons and