Ice or Snow in the Tempel 1 Comet?

Nicola M. Pugno

Department of Structural Engineering,
Politecnico di Torino, Corso Duca degli Abruzzi 24,
10129 Torino, Italy
e-mail: nicola.pugno@polito.it

An estimation of the Tempel 1 comet strength is deduced as intermediate between that of snow and ice. [DOI: 10.1115/1.2127958]

On July 4, 2005 NASA celebrated the success of the mission *Deep Impact*, culminated with the impact of a ballistic projectile on the *Tempel 1* comet. The projectile, with a mass of $m \sim 370$ Kg, hit the target at a (relative) velocity of $v \sim 37\,000$ Km/h creating a crater of $r \sim 100$ m in radius and $h \sim 40$ m in height.

Material scientists would be happy to measure the mechanical strength σ_C of the comet material, as well as the other solid heavenly bodies. The extraction of specimens for such a purpose has not been realized until now. In spite of this, an estimation of the comet strength can be easily deduced by the following procedure. The kinetic energy K available in the collision is proportional to a power of the crater volume V with a fractional exponent [1]. For example, according to the Gault's scaling [2], assuming geometrical self-similarity (i.e., $h \propto r$) we deduce 1.19 from the lunar crater data. In particular, for large-sized fragmentations the exponent is close to the unity and the constant of proportionality to the mechanical strength of the comminuted material [3]. Thus, from the previous reported experimental observations we can estimate the mechanical strength of the *Tempel 1* comet, to be around

$$\sigma_C \approx \frac{K}{V} = \frac{1/2 m v^2}{\pi h/2(r^2 + h^2/3)} \approx 30 \text{ kPa} \tag{1}$$

This value is in between that of terrestrial snows ($\sim 1 - 10$ kPa) and ice (~ 1000 kPa).

To have an idea of such strengths, note that the last value corresponds to the fracture of an ice cubelet just under the weight of a middle-sized man, as can be easily verified in our own home.

References

[1] Carpinteri, A., and Pugno, N., 2002, "One-, two- and Three-Dimensional Universal Laws for Fragmentation due to Impact and Explosion," ASME J. Appl. Mech., **69**, pp. 854–856.
[2] Gault, D., 1974, "Impact Cratering," *Primer of Lunar Geology*, R. Greeley and P. Schultz, eds., NASA Ames Report, pp. 137–175.
[3] Carpinteri, A., and Pugno, N., 2002, "A Fractal Comminution Approach to Evaluate the Drilling Energy Dissipation," Int. J. Numer. Analyt. Meth. Geomech., **26**, pp. 499–513.