Ice or Snow in the Tempel 1 Comet?

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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 $\sigma_c$ 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., $h \approx r$) 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

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

This value is in between that of terrestrial snows (~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