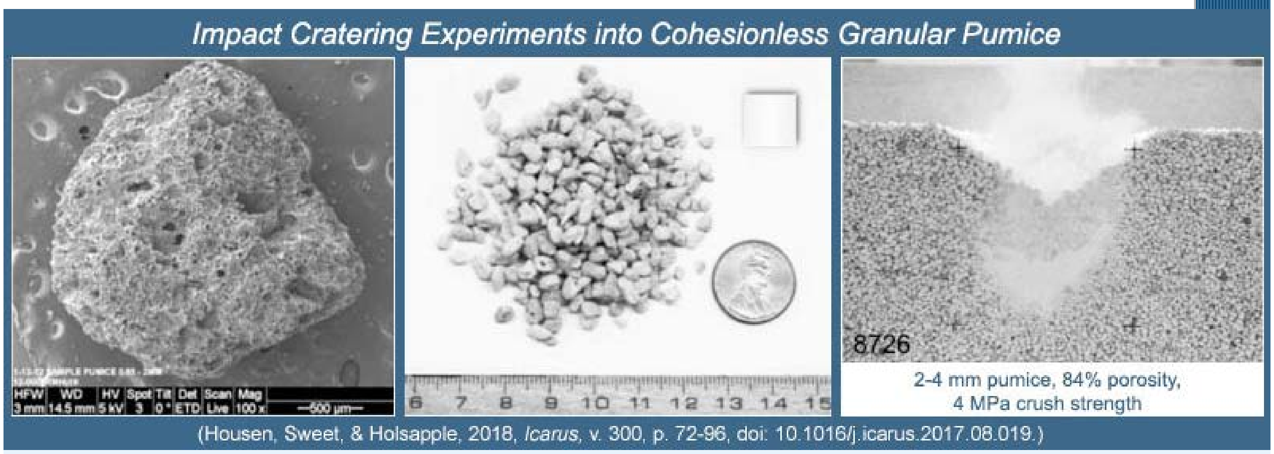
Impact Cratering on Porous Asteroids

Impact bombardment shapes the surfaces of planetary bodies, forming craters and ejecta, and affecting the regolith and environment on the target bodies, as well as adding to their exotic materials.

What happens to the impact crater, projectile, and ejecta when the target is a highly porous asteroid as opposed to a nonporous asteroid, moon, or planet? This question is addressed in detail by new laboratory experiments and analytical modeling by Kevin Housen and Keith Holsapple (University of Washington, Seattle) and William Sweet (The Boeing Co., Seattle). Making the distinction of target porosity is critically important to impact analyses (see PSRD articles: ***Honeycombed Asteroids*** and ***Using Chondrites to Understand the Inside of Asteroid 433 Eros***), as more space missions discover low-density asteroids (heavily cratered rubble piles) with large impact craters lacking ejecta blankets.



[LEFT] Scanning electron microscope image of a typical, highly porous pumice particle used in the centrifuge and high-G experiments. [CENTER] Pumice target materials, sieved to 2-4 mm sizes, used in experiments. [RIGHT] Photo of the result of an impact experiment into pumice target at 150G. The impact crater was formed by compaction and the ejecta landed mostly inside the crater. The bright lens within the pumice beneath the crater floor is a region of highly crushed material. Housen and coauthors observed that the bottom of this region corresponds roughly to the bottom of the initial, ***transient crater*** that formed.

Housen and Holsapple showed in previous work that large impact craters in highly porous targets form by compaction. Porous target materials with sufficient void space crush under their own weight causing permanent compaction and preservation of a crater cavity even though most, if not all, of the ejected materials fall back into the crater. They attribute a lack of ejecta blankets around large impact craters observed on asteroid Mathilde to compaction cratering.

Housen and coauthors' new analyses utilize the NASA Ames Vertical Gun facility and a geotechnical centrifuge for high-gravity experiments. The acceleration in the centrifuge provides a way to scale up the laboratory impact experiment to simulate formation of large craters on asteroid targets several tens of kilometes in diameter, by replicating the higher confining pressures produced by the large craters on asteroids. (Confining pressure is proportional to the product of gravity and crater depth.) The team ran impact experiments at 10G, 50G, 150G, and 500G into target materials with porosities ranging from 43% to 96% to explore in detail how impact craters form and the conditions under which compaction cratering occurs.

Their experiments show that during hypervelocity impact into highly porous targets, permanent compaction of the target material forms a transient crater whose growth is limited by the target shear strength. During impact, material from the surface is driven to the bottom of the transient crater, and is buried there as the transient crater collapses (see the bright lens of crushed material beneath the crater in the righthand photo, above). The projectile, as well, is buried beneath the crater floor at a depth corresponding to the crushing strength of the target materials. Very little material, if any, is ejected from the crater.

Housen and coauthors provide a model of impact cratering in highly porous materials and predictions for compaction cratering on Solar System bodies for which estimates of porosity are available. This work brings us another step closer to understanding all the detailed variations of impact cratering, a ubiquitous Solar System process.

See Reference:

· Housen, K. R., Sweet, W. J., and Holsapple, K. A. (2018) Impacts into Porous Asteroids, *Icarus,* v. 300, p. 72-96, doi: 10.1016/j.icarus.2017.08.019. [***abstract***]

See also:
· Housen, K. R. and Holsapple, K. A. (2003) Impact Cratering on Porous Asteroids, *Icarus,* v. 163(1), p. 102-119, doi: 10.1016/S0019-1035(03)00024-1. [**abstract**.]
· Housen, K. R., Holsapple, K. A., and Voss, M. E. (1999) Compaction as the Origin of the Unusual Craters on the Asteroid Mathilde, *Nature,* v. 402, p. 155-157, doi: 10.1038/45985. [**abstract**.]
· **Impact and Explosion Effects** website by Keith A. Holsapple with Javascrtipt applet to better understand the characteristics of craters and ejecta.

Written by Linda M. V. Martel, Hawai'i Institute of Geophysics and Planetology, for **PSRD**.

February 2018
http://www.psrd.hawaii.edu
psrd@higp.hawaii.edu