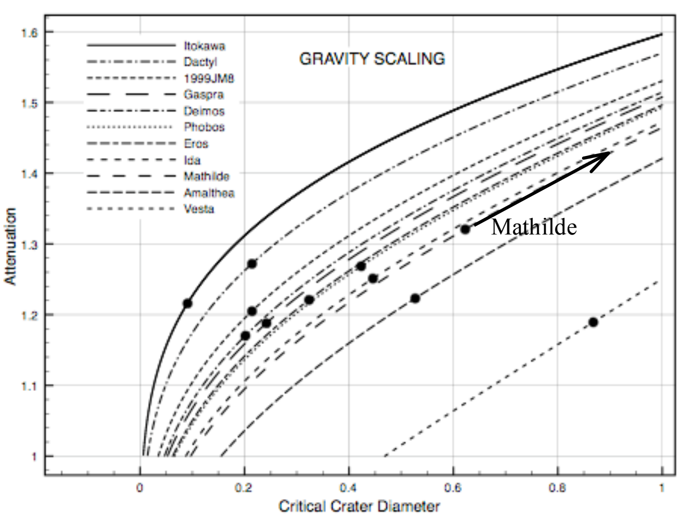
CRITICAL CRATER DIAMETER OF MINOR BODIES. E. Asphaug, Department of Earth and Planetary Sciences, University of California, 1156 High St., Santa Cruz, CA, USA, easphaug@ucsc.edu

Introduction: Asteroid seismic degradation [1,2] combined with crater formation models can explain why large asteroids appear to have hemisphere-spanning craters, whereas small asteroids lack undegraded craters larger than a fraction of the global radius. This is quantified [3] using crater scaling relations and power-law approximations for stress wave particle velocity attenuation with radial distance.

The *critical crater diameter* is the threshold at which cratering "goes global": D_{crit} is the smallest crater which degrades all prior topography to a scale $<D_{crit}$; it is computed by balancing crater formation models with stress wave attenuation models. Because it is a function of seismic attenuation, an asteroid's largest undegraded crater bears a quantitative record of its global-scale attenuation of impact energy (Fig 1).

New Results: An extension of [3] is to consider the two or three largest undegraded craters, to assess whether critical crater equilibrium has been attained. As an example we compare Phobos (D~22 km) and Mathilde (D~53 km), both with craters about equal to their global diameter. Phobos has a single largest crater (D_L=9.4 km) with no rivals, whereas Mathilde has five of six craters around 30 km diameter [4]. In this context, Phobos has achieved its critical crater, which has degraded previous topography of that size, whereas Mathilde has not (arrow in Fig. 1). If so then Phobos is a competent propagator of stress energy (lower attenuation, smaller D_{crit}) compared to Mathilde. Mathilde's D_{crit} is probably larger than Mathilde.

Fig. 1 plots seismic attenuation α as a function of $\chi=D_{crit}/D$, derived from gravity crater scaling relations. The assumptions are that (1) gravity scaling applies to the largest craters, (2) stress wave attenuation is represented by a power law, and (3) that the evolution of an asteroid's largest-scale topography is governed by impacts. Variations on (1) will be presented.



The attenuation α is the exponent at which peak particle velocity decays with radial distance $v_p(r)=v_i(r/r_i)^{-\alpha}$,. In shocks this exponent α is near 2, a value adopted by some analytical models of asteroid disruption. But *for global studies* a much smaller attenuation applies. Because asteroids can undergo ground upheaval and disassembly at cm/s to m/s particle velocities, seismic rather than shock attenuation is expected to apply, typically α~1.2. If χ is equated to $\chi_{obs}=D_L/D$ (black dots) this gives an attenuation close to seismic values for most asteroids.

If the above assumptions apply, then the following can be deduced: (1) For a given value of attenuation, the normalized critical crater diameter $\chi=D_{crit}/D$ increases with asteroid diameter D, providing a simple explanation for why small asteroids have no global craters, unlike large asteroids. (2) Stress wave particle velocities attenuate globally with about the 1.2-1.3 power of distance for most asteroids; attenuation appears to be greater (α>~1.3-1.4) for porous asteroids. (3) For Mathilde-sized (~50 km) asteroids with attenuation α=1.45 or higher, D_{crit} exceeds the diameter of the target, and all craters are "local"; if impact governs their large-scale topography, such bodies become saturated with hemisphere-spanning craters.

It is probable that $\chi\sim\chi_{obs}$ for asteroids with one solitary large crater, while $\chi>\chi_{obs}$ for asteroids with several craters that are almost equally large, so that Mathilde's attenuation derived by setting $\chi=\chi_{obs}$ is a lower limit (arrow in Fig. 1). Note that Itokawa is globally reset by an impact crater only ~30 m diameter (χ~0.1) – reset, that is, to scales of 30 m. Also note that asteroids of lower density, or otherwise suspected of being highly porous (e.g. Mathilde, Phobos, Dactyl) appear to have the highest seismic attenuation.

References:

[1] Richardson et al. (*Science* 2004), Impact-induced seismic activity on asteroid 433 Eros. [2] Thomas & Robinson (*Nature* 2005), Seismic resurfacing by a single impact on the asteroid 433 Eros. [3] Asphaug (*MAPS* 2008, in press), Critical crater diameter and asteroid impact seismology. [4] Thomas (*Icarus* 1999), Large craters on small objects: Occurrence, morphology, and effects.