Asteroid structure

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Even before the first space missions to asteroids, in the mid-1990s, it was known that asteroids have weird structures. Photometry indicated complicated shapes, and the pioneering radar investigations by Ostro and colleagues followed by adaptive optics campaigns and flybys showed odd binary forms, and confirmed the common presence of satellites, and indications of highly varying surface roughness. Some asteroids turned out to be dominated by a single major cratering event, while others showed no evidence of a major crater, or perhaps for global crater erasure.

The first space mission to orbit an asteroid, NEAR, found a mixture of heavily cratered terrains and geomorphically active 'ponds', and indicated evidence for global seismicity from impact. The next mission to orbit an asteroid, Hayabusa, found what most agree is a rubble pile, with no major craters and an absence of fines. There is to date no direct evidence of asteroid interior geology, other than measurements of bulk density, and inferences made for mass distribution asymmetry based on dynamics, and inferences based on surface lineaments. Interpolating from the surface to the interior is always risky and usually wrong, but of course the answer is important since we are someday destined to require this knowledge in order to divert a hazardous asteroid from impact with the Earth. Even considering the near-subsurface, here we remain as ignorant as we were about the Moon in the early 1960s, whether the surface will swallow us up in dust, or will provide secure landing and anchoring points. Laboratory experimentation in close to zero-G is still in its early stages. Adventures such as mining and colonization will surely have to wait until we better know these things.

How do we get from here to there? I will focus on 3 areas of progress: (1) asteroid cratering seismology, where we use the surface craters to understand what is going on inside; (2) numerical modeling of collisions, which predicts the internal response and fragmentation and mass rearrangement and loss; and (3) upcoming and conceptual space missions ranging from active seismology, to radar tomography, to building a 'patch of regolith' as an experimental playground in near-Earth space.

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