POROSITY AND INTERNAL COMPOSITION OF ASTEROIDS

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A fundamental physical property of an asteroid is its density. One might naively expect asteroid density to be related to its composition, and thus it might be expected to be similar to the densities of meteorites thought to be derived from those asteroids. However, all but the largest asteroids whose densities have been measured appear to be significantly under-dense, with densities in some cases less than half the density of their suggested meteorite analogues. These meteorite analogues have only only about 10 percent microporosity, expressed primarily in microcracks resulting from shock events. Thus, if the proposed analogues are correct, asteroids commonly have very large macroporosity.

The observed power law of asteroid sizes, and studies of the collisional dynamics of the asteroid belt, have suggested a history of intense collisional evolution such that only the largest asteroids retain their primordial masses and surfaces. Asteroids below 300 kilometers in diameter should have been shattered by energetic collisions. After such events, some objects would reaccrete to form gravitationally-bound rubble piles, while the rest would be broken into smaller fragments, to be further shattered or fragmented.

Evidence from the densities are available only for a few dozen asteroids to date. However, the images of 253 Mathilde (whose density is only half the density of typical meteorite material) show six identified impact craters that are larger than the size necessary to shatter the asteroid. The only way that Mathilde could have survived these repeated huge impacts is if it were already a shattered rubble pile that dissipates much of the energy of large impacts in the friction of the pieces of rubble grinding against each other.

In terrestrial experience, significant porosity is possible only if the rubble is size-sorted, preventing smaller particles from filling the voids between larger particles. During the reaccretion, one might expect that the largest pieces, which would travel the least distance from the center of mass of the orbiting fragments, would be the first to re-accrete; smaller fragments would reaccrete later. Jostling within the rubble pile during the reaccretion might also provide such size-sorting. Given the very low gravity driving the collapse of these rubble piles, and the significant friction between between the fragments, this size sorting could be maintained.

Thus most asteroids may be shattered heaps of perhaps loosely bound rubble with significant porosity in the form of large fractures, vast internal voids, and loose fitting joints between major fragments. Thus it is not surprising that the average asteroid would have a very large porosity.

Finally, we note that the shock compression of very porous material during impacts should result in significant heating of that material. This could be an important source of the metamporphism seen in meteorites classes.