THE PHYSICAL PROPERTIES OF METEORITES AND INTERPLANETARY DUST PARTICLES: IMPLICATIONS FOR THE PROPERTIES OF STONE ASTEROIDS. G. J. Flynn, Department of Physics, SUNY-Plattsburgh, 101 Broad St., Plattsburgh, NY 12901 (george.flynn@plattsburgh.edu).

Introduction: Most asteroids for which porosities have been inferred have porosities ranging from 20% to >50%, with a mean of ~30% porosity [1]. Porosity significantly affects the physical properties of rocks, including the strength, thermal conductivity, seismic velocity, and dielectric permeability. Some asteroids have high enough porosities to affect their internal structure, gravitational field, response to impacts, and collisional lifetimes. This suggests modeling the behavior of asteroids using the physical properties of low- to moderate-porosity terrestrial rocks is not appropriate. Most/all stone meteorites and a significant fraction of interplanetary dust particles (IDPs) are believed to be fragments of asteroids, with some IDPs sampling comets. Thus, the physical properties of meteorites and IDPs provide indications of the properties of their parent asteroids [2]. Thermal evolution modeling indicates that, within each group (H, L, or LL) of ordinary chondrite meteorites, increasing thermal metamorphism correlates with increasing formation depth in ~100 km diameter parent asteroids [3], so these meteorites permit determination of properties of asteroids at depths ranging from the near surface to the deep interior.

Effects of Porosity: Meteorites generally exhibit significant porosity, with three distinctly different types of porosity, cracks, gaps, and vugs, identified by computed microtomography and examination of thin sections. Specific classes of meteorites are associated with different types of asteroids based on similarity of visible and near-infrared reflection spectra. However, the mean porosity of ordinary chondrite meteorites is lower than that of the associated S-type asteroids and the mean porosity of carbonaceous chondrite meteorites is lower than that of the C-type asteroids. This indicates meteorites do not sample the entire range of porosity observed in asteroids – in particular, the highest porosity material is missing in the meteorite population.

Strength. Porosity reduces the compressive, tensile and sheer strengths of rocks. While the compressive strengths of the strongest ordinary chondrite meteorites are comparable to low-porosity terrestrial basalt (100 - 300 MPa), meteorite measurements span a much wider range. Some highly metamorphosed ordinary chondrites, potentially sampling deep interiors of asteroids, have very low compressive strengths – 20 MPa for the L5 Elenovka [4] and 6 MPa for the L6 Holbrook [5].

An alternative measure of strength is the response to hypervelocity impact, characterized by the parameter Q* and the impactor energy per unit target mass producing a disruption with the largest fragment being one-half the target mass. Energy that goes to compressing voids is not available for disruption, so porous targets require more energy per unit mass for disruption than non-porous ones. Q* for 9 ordinary chondrites is ~1400 J/kg [6], about twice that of non-porous basalt.

Speed of Sound and Shock Attenuation. As expected, the speed-of-sound decreases with increasing meteorite porosity [7]. However the speed-of-sound is also affected by the type and distribution of porosity, particularly cracks. Two samples of the Saratov L4 ordinary chondrite gave significantly different sound speeds ~ 2357 m/s for a normal sample and 1320 m/s for a sample exhibiting a well-developed crack [2].

Shock is attenuated over a much shorter distance in porous rocks [8, 9] and x-ray tomography after hypervelocity cratering of pumice showed no detectable alteration of texture outside the crater [9]. Rapid attenuation of shock waves and variation of sound speed with local crack density will hamper efforts to characterize interiors of highly porous asteroids by seismic studies.

Thermal Properties: Modeling thermal evolution requires the thermal conductivity and heat capacity. Thermal conductivity and porosity of stone meteorites are strongly correlated [10], while the heat capacity of ordinary chondrites is similar to quartz [11].

Conclusions: Meteorites and IDPs constrain the physical properties of asteroids. However, meteorites likely sample only part of the range, with IDPs sampling higher porosity. Atmospheric deceleration fragments the weakest meteors, since strengths of stone meteorites, inferred from breakup dynamics, are only 1/10th to 1/100th the strengths measured on stone meteorites of the same class [12]. This may explain why the mean porosity is lower for meteorites of a given class than for asteroids having a similar reflection spectra.