COMPRESSIONAL AND SHEAR WAVE VELOCITIES IN METEORITES. M. S. Hons[1] and A. R. Hildebrand[1], [1]Department of Geology and Geophysics, University of Calgary, 2500 University Drive NW, Calgary, AB Canada T2N 1N4 (yakatak@shaw.ca;ahildebr@ucalgary.ca).

Introduction: Elastic properties of asteroids govern much of their response to impact events, and are germane to mitigation and exploitation strategies. From pioneering efforts dating to a half century ago [e.g. 1] density, porosity, elastic wave velocities, thermal conductivity, specific heat, and magnetic susceptibility have been increasingly studied during the last decade. Of these quantities the elastic wave velocities have been one of the least explored quantities probably due to the slightly more specialized equipment required. To date we are aware of only ~30 determinations of elastic wave velocities in meteorites [2]. Velocities measured to date show a range of several for both compression and shear wave velocities, possible anisotropies, and a strong dependence upon porosity [2]. The latter apparently enables model determination of thermal properties from seismic response. We have measured compressional and shear wave velocities in 72 additional meteorites.

Techniques: Meteorites were measured in the form of slabs as commonly found in collections. Pieces with two roughly parallel flat sides are required to accommodate the velocity transducers' shape. The degree of surface roughness on the typical sawn surface was not a problem for the apparatus. Velocity measurements were made by clamping two disc shaped ultrasonic transducers (one source, one receiver) onto opposite sides of the slab. Lightly clamping the transducers to the slabs resulted in adequate coupling. Yomogida and Matsui [2] reported similar improvement in coupling with light pressure. Each measurement was made three time at different positions on a slab to improve statistics and to test for variation. Compression (p) and shear (s) wave velocities were measured with two different sets of transducers. A pulse generator and oscilliscope monitor completed the experimental equipment. Slab thicknesses were measured with a high precision caliper. One disadvantage of measuring slabs vs. cubes as done by [2] is that potential directional anisotropies couldn't be explored. Bulk densities were measured with a modified Archimedean method using ~1 mm diameter glass beads as used by [3], excepting that the much larger bead size allows minimal chance of contamination and reduces settling effects (although the geometrical "wall effect" is a greater potential problem with larger beads). Porosities were measured for some specimens in a commercial He pycnometer. Porosities for other meteorites measured were taken from literature sources including [3, 4, 5, 6, 7, 8, 9].

Results: Bulk and grain densities and porosities were generally found to be consistent with previous work, although rare large discrepanicies were found. Seismic velocities were also found to be similar to previously obtained values, although slightly greater variations were obtained from surveying a larger population. Seismic velocities and the ratio of P to S wave velocities were found to be independent of the thickness of the meteorite slab measured. However, a correlation exists between seismic velocity or porosity and date of fall (see Fig. 1). Also, falls from the last 50 years show a smaller range of velocities indicating variable weathering effects (probably crack propagation vs. filling pores by secondary minerals).

Various relationships have been quantified; here are presented velocity vs. fall date (Fig. 1), class (Fig 2a &b), petrologic grade (Fig 3), porosity (Fig. 4), bulk density (Fig. 5), and darkness (Fig. 6). The data presented here are generally restricted to only the data obtained for ordinary chondrites. Results are generally consistent with those of [2], however a velocity dependence on petrologic grade was found that probably reflects microscale changes in pore shape as porosity doesn't show such a dependence. Also, a possible relationship to the darkness of a meteorite (presumed to be related to shock history) was found although darkening from weathering effects complicates interpretation.

Conclusions: Velocities in chondritic meteorites are strongly influenced by pores' abundance with second order effects (possibly related to pore shape or grain contacts) from metamorphic history possibly including shock history. Meteorite seismic velocites are strongly influenced by even minor weathering of short duration in the terrestrial environment; any effort to infer asteroidal physical properties should be confined to study of recent falls. At least some meteorites should be curated in inert gas environments, or their usefulness as physical property indicators will degrade.

Acknowledgements: Invaluable assistance from E. Gallant, M. Bertram and the CREWES Project at the U. of Calgary; M. Grady, D. Jones and the Natural History Museum for assistance working with the NHM collection and loaning specimens; and L. Madden and Core Laboratories Canada Ltd. is gratefully noted. M. Hons gratefully acknowledges financial support from the Paneth Trust, and M. Hons and A. Hildebrand both acknowledge financial support from NSERC; M. Hons through an USRA.

References: [1] Alexeyeva, K.N. (1958) *Meteoritika*, *16*, 67–77. [2] Yomogida, K. and Matsui, T. (1983) *JGR.*, *88*, 9513-9533. [3] Consomagno, G.J. et al. (1998) *MAPS*, *33*, 1221–1229. [4] Stacey. et al. (1961) *JGR,66*, 1523-1534. [5] Matsui, T. et al. (1980) *Mem. Natl. Isnst. Polar Res. Spec. Issue 17*, 268-275. [6] Kukkonen, I. and Pesonen, L.J. (1983) *Bull. Geol. Soc. Finland 55*, 157-177 [7] Flynn, G.J. et al. (1999) *Icarus 142*, 97-105. [8] Corrigan, C.M., et al. (1997) *MAPS 32*, 509-516. [9] Britt, D.T. and Consolmagno, G.J. (2000) *Icarus 146*, 1,213-1,219.

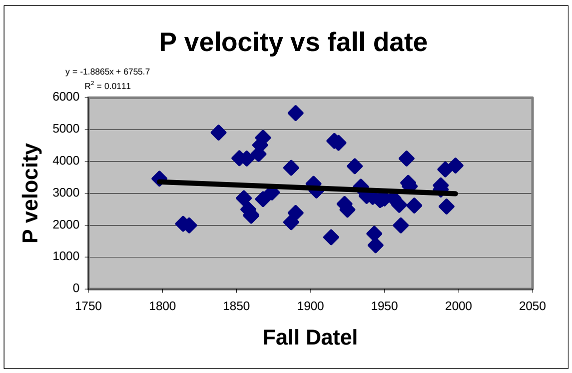

Figure 1: P velocity vs. fall date for O.C.

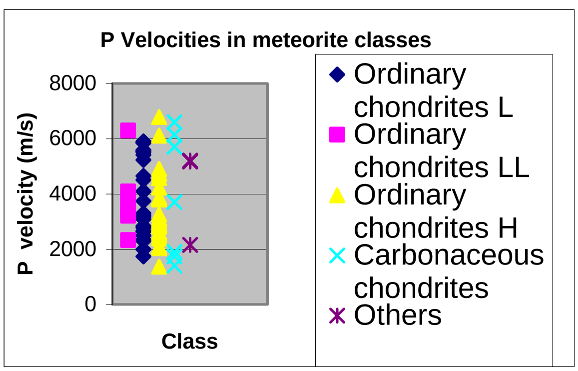

Figure 2a: Compression wave velocity vs. Class; note wide and continuous velocity ranges.

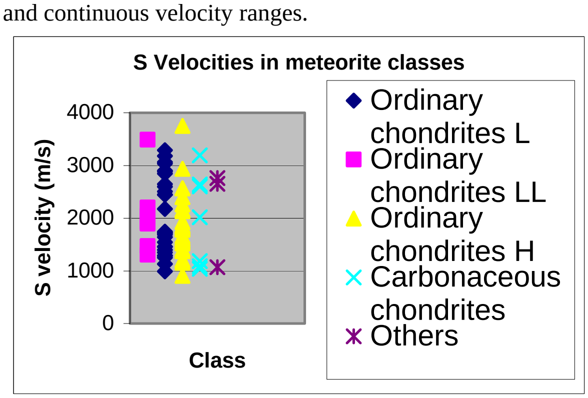

Figure 2b: Shear wave velocity vs. Class.

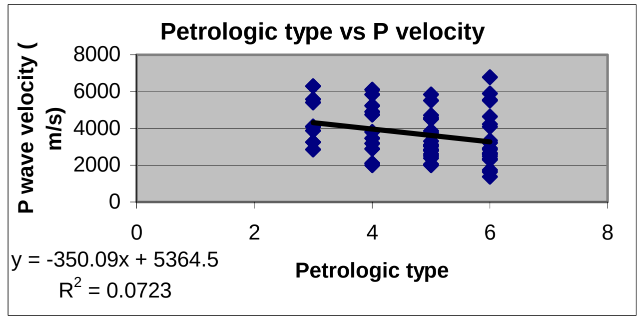

Figure 3: P velocity vs. petrologic type for ordinary chondrites; note counterintuitive inverse correlation.

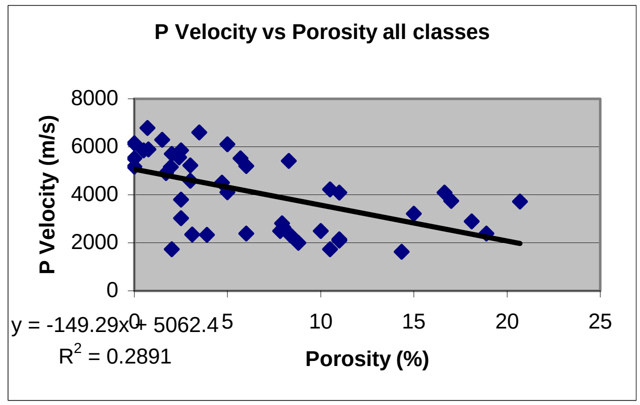

Figure 4: P velocity vs. porosity for all classes.

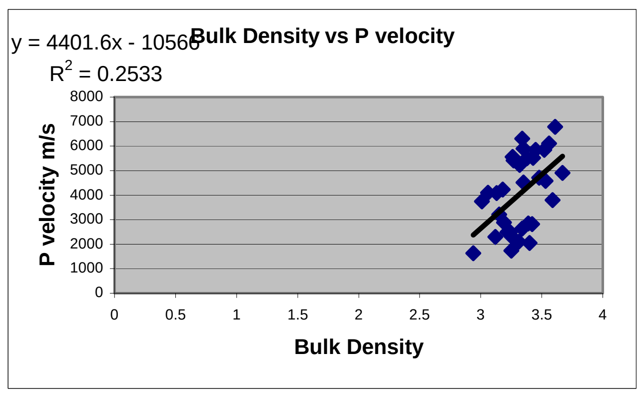

Figure 5: P wave velocity vs. bulk density for OC.

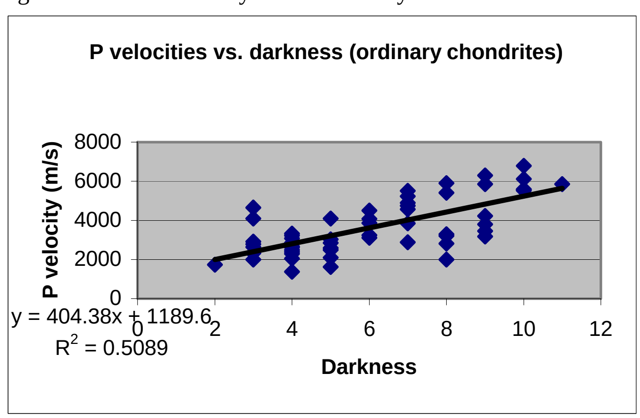

Figure 6: P velocity vs. darkness (grayscale comparison).