# SHEAR STRENGTH AND SEISMIC VELOCITIES OF THE MURCHISON METEORITE.

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**Introduction:** As geologic understanding of asteroids improves and spacecraft interactions with asteroids increase, the physical properites of asteroid lithologies are becoming more useful in constraining modelling of asteroids' geologic history. We have begun measuring static strengths (compression and shear), seismic velocities (compression and shear), and related static and dynamic elastic constants for carbonaceous chondrites. To minimize terrestrial weathering produced perturbations measurements are prioritized on relatively recent falls.

**Murchison Meteorite:** The Murchison meteorite is a CM2 chondrite which fell Sept. 28, 1969, and many specimens were collected near Murchison, Australia before long local exposure. The studied individual is a sawn slab, sample ME2640, from the Field Museum collection. The slab is relatively uniform in lithology with bulk density of 2.4 g/cm$^3$; grain density and microporosity were determined by He pycnometry as 2.94 g/cm$^3$ and 18.3%, respectively. These densities and microporosity fall in the range previously measured for Murchison individuals [1], but the microporosity is at the low end of those previously measured (18.7 – 24.9%) although the grain density is typical.

**Seismic Velocities:** Seismic velocities were measured using a supporting jig with ultrasonic transducers; samples were measured dry using only contact pressure for wave coupling (applied pressure was monitored using a force meter and never exceeded ~200 N). Slightly polishing the slab may have improved coupling slightly; measurements were repeated several different days with three different operators to explore reproducibility. Compression wave velocities ranged from 3,118 to 3,309 m/s with a mean of 3,246 m/s. Shear wave velocities ranged from 1,756 to 1,885 m/s with a mean of 1,834 m/s (mean Vp/Vs ratio of 0.57). Some of the velocity variation reflects measurement uncertainty, but Murchison is known to be brecciated [e.g. 2] (brecciation was also seen in this slab with visible angular clasts up to ~1 cm in size), and part of the variation is also likely due to variation between the matrix and clasts. In particular the slightly darker clasts seemed to have Vp ~100 m/s faster than the meteorite matrix.

**Shear Strength:** Shear strengths were measured on four 2.5 cm-square cubes (subdivided from a single 2.5 mm thick wafer as shown in Fig.1) using a guillotine-style fixture and Test Resources electromechanical press; the cubes were stressed to failure. Measured stresses were 7.1, 7.3, 13.9, and 16.6 MPa. Some stress-strain curves were multipeaked indicating multiple failures and the two lower values probably indicate that inclusions governed mechanical failure in those two cases; as shown in Figure 1 Murchison has abundant inclusions up to ~0.5 mm in size. For this lithology measuring cubes as small as 2.5 mm probably violates the consideration of testing samples roughly an order of magnitude larger than the grain size, and larger cubes will be measured to check this. The dynamic elastic properties are Poisson's ratio, 0.27; Shear modulus, 8.1 GPa; Bulk modulus, 14.5 GPa; Young's modulus, 20.4 GPa.

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**References:**

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**Figure 1:** A sawn and smoothed Murchison wafer ~ 5.2 mm square.