CATASTROPHIC DISRUPTION EXPERIMENTS ON THE MURCHISON HYDROUS METEORITE. G. J. Flynn[1], D. D. Durda[2], J. W. Kreft[3], I. Sitnitsky[1], and M. Strait[3]. [1]Dept. of Physics, SUNY-Plattsburgh, 101 Broad St., Plattsburgh, NY 12901 (george.flynn@plattsburgh.edu), [2]Southwest Research Institute, 1050 Walnut St., Suite 426, Boulder, CO, 80302. [3]Department of Chemistry, Alma College, Alma, MI 48801

Introduction: The outer half of the main asteroid belt is dominated by asteroids that are classified as C-, P-, or D-type, based on their reflection spectra. These low-albedo asteroids are believed to be the parent bodies of the carbonaceous chondrite meteorites. A significant fraction of the carbonaceous chondrite meteorites are hydrated, and some of the C-, P-, and D-type asteroids show evidence for hydration in their reflection spectra. Thus, a significant fraction of the targets for cratering and collisional disruption in the outer half of the main-belt are likely to be hydrated bodies. Nonetheless, most disruption experiments on natural rock targets have concentrated on anhydrous rocks, such as basalts.

Tomeoka et al. [1] shock disrupted a small target of the hydrated carbonaceous meteorite Murchison and compared the results to the shock disruption of Allende, an anhydrous carbonaceous meteorite. They found that Murchison disrupted far more easily than anhydrous meteorite targets, and suggested that the hydrated asteroids might contribute far more dust to the Zodiacal Cloud than would be expected based on their abundance in the main belt.

We have begun a series of impact experiments on hydrous meteorites. This project has two major objectives:

1) to compare the mass-frequency distribution of the dust produced by hypervelocity impact disruption of hydrous and anhydrous asteroid material, and,
2) to determine if the chemical composition of the primary fragments from these disruptions shows any systematic variation with size of the debris.

In our previous work, the mass-frequency distributions from hypervelocity impacts into anhydrous terrestrial and meteorite targets were best fit by a single power law over a order-of-magnitude mass range. However, the mass-frequency distributions we measured for hypervelocity impacts into hydrous terrestrial targets (greenstone) showed a distinct change in slope near 10^{-2} grams, and an overproduction of particles in the size range from 10^{-4} to 10^{-1} grams compared to the disruption of anhydrous targets of the same size under similar conditions [2].

We measured the mass frequency disruption of the fragments produced by the Murchison disruption and determined the chemical compositions of primary fragments, collected in aerogel capture cells in order to compare the results of the disruption of Murchison with the results we have previously reported on anhydrous terrestrial basalt [3] and anhydrous meteorite [4] targets as well as a hydrous terrestrial material [2].

Samples and Techniques: We disrupted a 30.09 gram sample of the Murchison CM2 meteorite using a ⅛-inch diameter Al-sphere fired at 4.45 km/s using the NASA Ames Vertical Gun Range (AVGR). The Murchison sample was a somewhat elongated and flat whole stone.

Six "passive detectors," each containing two 7-µm- and two 13-µm-thick Al-foils mounted in 35mm slide mounts, a single 51-µm-thick Al-foil stretched over a hole cut in foam core, and two aerogel capture cells were deployed in the AVGR chamber to record/capture debris from the disruption.

Disruption Results: We determined the mass-frequency distribution of the debris over more than a five order-of-magnitude mass range by combining the data from the foil penetrations with the data from the fragments recovered from the floor of the AVGR chamber (as described in detail in Durda et al. [5]).

We recovered all of the debris from the disruption from the floor of the AVGR. Each fragment having a mass >0.01 grams was weighed individually, providing the mass-frequency distribution for the debris $>10^{-2}$ grams.

The 7-µm- and 13-µm-thick foils from all six passive detectors were scanned using a Canon Canonscan FS 4000US slide scanner, producing 4000x5888 pixel images of the penetration holes in each foil. At this scan size, a pixel corresponds to ~6.3 µm. The area of each hole was measured from the scanner images using ImageJ (from NIH), and the diameter of a circular hole having the same area was determined. The foil hole diameters were converted to impacting particle diameters using the calibration data of Hörz et al. [6], assuming a particle speed of 2 km/sec. The mass of each impacting particle was inferred using assumed densities of 3 and 4 gm/cc.

Ideally, the target would be completely surrounded by foil, documenting the size-frequency distribution of the dust over the full 4π geometry. However, this is not practical. So, we collected data from a total of 24 foils, each having an exposed area of 8.05 cm^2. In order to combine the foil data with the weighing data (which was collected over the full 4π geometry) the area of each foil was projected onto a one meter sphere, and the ratio of the surface area of the virtual sphere to the projected surface area of 24 the foils was determined. This was used to scale the foil data to the 4π geometry, providing the mass-frequency distribution for particles smaller than ~10^{-3} grams.

The mass-frequency distribution that results from combining the foil penetration data with the weighing data is shown in Figure 1. For masses >10^{-4} grams, the data is reasonably well fit by a single power-law, consistent with our results from the disruption of anhydrous meteorites including Allende. We see no evidence, in this Murchison shot, for a break in the power-law near 10^{-2} grams, as we saw for the hydrous terrestrial greenstone targets. The difference between the greenstone targets and Murchison may result from the greenstone being more completely altered by aqueous processing than is Murchison. If so, the greenstone may be more analogous to the more completely hydrated CI meteorites like Orgueil.

To address our second objective, we measured the elemental compositions of the particles captured in the aerogel cells using in-situ x-ray fluorescence. Our objective is to determine if the mean chemical composition of the ~10 µm fragments, the typical size of the interplanetary dust particles (IDPs) collected from the Earth's stratosphere, is representative of the composition of the parent body, or if significant chemical segregation occurs in the fragmentation process.

The mean Ni/Fe ratio is distinctly lower in the olivine chondrules than in the matrix of primitive meteorites (see Scott et al. [7] and references therein). We use this characteristic to distinguish matrix material from olivine chondrule fragments. Figure 2 shows the Ni/Fe ratio vs. the fragment size for 210 particles ranging from 6 to 270 µm in size in one aerogel cell deployed on Detector 4 (located upstream from the target at an ~45 degree angle to the incoming projectile), which was hit by a spray of fragments from the Murchison disruption. The results are generally consistent with what we have observed for the disruption of the anhydrous meteorites, that the highest Ni/Fe ratios (characteristic of some of the matrix material) occur for the smallest particles while larger particles generally have lower Ni/Fe (as is seen in the olivine chondrule fragments).

Our preliminary results suggest that this disruption of Murchison was more similar to our previous disruption of Allende than to that of the terrestrial greenstone targets. Further experiments disrupting three Antarctic CM chondrites, ALH84034, LON94101, and EET96006, are planned for the Spring of 2007 at the AVGR.

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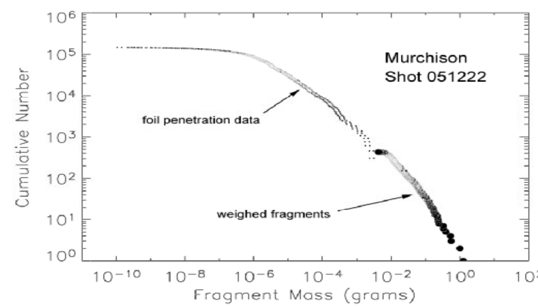

Figure 1. Tbe cumulative mass-frequency distribution combining data from the 7 and 13 µm thick Al-foils and from weighing fragments recovered from AVGR chamber from the disruption of an ~30 gram sample of Murchison.

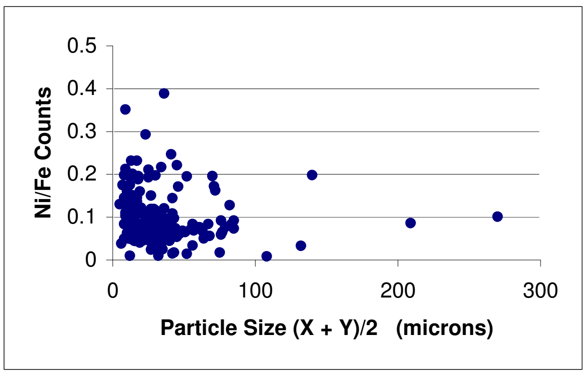

Figure 2. Ni/Fe fluorescence counts versus particle size for 210 particles from the disruption of the Murchison carbonaceous chondrite.