METHODS FOR QUANTIFYING RESULTS OF IMPACT DISRUPTION EXPERIMENTS OF CHONDRITIC METEORITES. L. E. Sandel[1], M. M. Strait[1], D. D. Durda[2], and G. J. Flynn[3]. [1]Alma College Alma MI 48801, [2]Southwest Research Institute, 1050 Walnut Street Suite 400 Boulder CO 80302, [3]SUNY-Plattsburgh Plattsburgh NY 12901.

Introduction: Impact experiments were completed on a series of meteorites and meteorite simulants by Flynn and Durda [1]. These experiments were conducted at the NASA Ames Vertical Gun Range (AVGR). In each experiment the target was suspended in the center of the AVGR chamber, surrounded by two to four passive detectors. Each detector included a series of foils with three different thicknesses, chosen so that high speed particles could penetrate. The holes in the foils provide information about the size distribution of the fragments. Foils 7 μm and 13 μm thick were mounted in slide mounts and were taped to the foam core detector. A large foil, with a thickness of 51 μm, was placed below the two thinner foils and was taped directly to the foam core as shown in Figure 1. The size of this larger foil ranged from 35 mm by 60 mm to 50 mm by 130 mm. The foils in slide mounts were 35 mm by 24 mm. The meteorites and meteorite simulants were impacted with 1/4 or 1/8 inch aluminum projectiles at speeds of roughly 5 km/s [2]. This speed was chosen because it is the average impact speed between asteroids in the main belt [2].

In order to quantify the results of the impact disruption experiments, the foils were scanned and analyzed digitally. In addition, the fragments of the meteorites that were left on the chamber floor after each impact experiment were sieved and weighed.

Methods:

Foil Data from Impact Experiments. To prepare for analysis of the foils impacted during the experiments, the foils had to be removed from the foam core detectors and scanned by a slide scanner. Before the large foils could be scanned they first had to be cut up so that they could fit inside a series of 35 mm slides. Before cutting up the large foils, they were scanned on a flatbed scanner to retain an image of the whole foil before it had been cut up. The large foils were then cut into smaller pieces and placed in slide mounts. This was done very carefully to avoid losing holes. Each piece of the large foil was numbered according to how it was cut up. The large foils were labeled according to shot number, detector, and foil number. The 7 μm and 13 μm foils were labeled in a similar fashion, but also included a reference to their position on the foam core detector and their foil thickness.

All of the foils were placed in slide mounts and scanned using a Canon Canoscan FS 4000US with Photoshop LE. The images were scanned at 8-bit grayscale and 4000 dpi for both output and input resolution.

After the foils were scanned, the images were analyzed using ImageJ, a software package from the NIH [3]. The area, perimeter, centroid, and circularity of each hole was determined. In some cases, the images were too large to be analyzed as is and were digitally cut up into four pieces. For analysis of the images, the color range of the image was inverted to allow ImageJ to make the measurements above. In addition, the image was calibrated to convert pixel readings to millimeters. The scale was derived by scanning an image of a ruler under the same conditions as the films and measuring the distance between millimeter marks in pixels. The scale was calculated to be 157.48 pixels per millimeter for all images because all of the images were scanned at 4000 dpi.

The results from ImageJ were copied and pasted into spreadsheet files that were named by shot and detector number. The data were sorted by decreasing hole area. The hole radius and diameter were then calculated from the area; for irregularly-shaped holes, the derived diameter is that of a circular hole of equivalent area. To create the size-frequency distribution graphs, the diameter in microns versus the cumulative number of holes was plotted in a log-log fashion [4].

Sieve Data of Impact Fragments. Prior to sieving, the total mass of the sample left on the floor of the AVGR chamber was measured using a scale with a sensitivity of 0.0001 grams. Then, using a standard sieve set, the fragments left on the floor of the AVGR chamber were separated by size. The sieves used had mesh sizes of 4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm, and 0.063 mm. All of the fragments in each sieve were weighed. Each particle was weighed in the 4 mm and 2 mm sieves. For the 1 mm and 0.5 mm sieves, a sample of 20 fragments were weighed [5] to get an approximate weight per fragment for that particular sieve. The average of the 20 fragments was calculated and the total weight was divided by this number to get an approximate number of fragments for the particular sieve size. For the remaining sieves a total mass of the sample was taken, since these fragments were too small to measure independently. The percent of the sample recovered after the impact experiments was calculated by dividing the mass of the target recovered from the chamber floor by the original mass of the target.

Results: Foil data analysis was completed for 22 different impact experiments. Sieving was done for 6 of these experiments. For all of the impact experiments, it was found that the thinner foils had many more holes than the thicker foils. However, the thicker foils more often had larger holes than the thinner foils. This is due to the speed of the particles and their ability to penetrate the foil. The graphs of most of the impact experiments reflect this. The size-frequency distribution for the large foils often have a noticeable slope change in the graph, which depicts the separation of larger and smaller particles that penetrated it (figure 2). For the 7 μm and 13 μm foils, the graphs usually had a smoother curve, demonstrating the broad range of sizes of the fragments that were able to penetrate the foils. A good example of this phenomenon is shot number 040401, which had very smooth curves for the 1st and 4th detectors in the size-frequency diagrams (figure 3).

Sieve data has helped to determine how destructive a particular impact experiment was. Shot 030802 was done on a clay target weighing 83 grams prior to the experiment. The largest fragment left after the collision was only 2.2444 grams. From this shot there were approximately 53,197 measurable fragments left on the chamber floor. This number does not include any of the dust size particles from the 0.125mm sieve and smaller. For this shot, 95.4 percent of the original target was recovered after the impact experiment and utilized in the sieving process.

Conclusions: The mass-frequency distribution of the debris produced in collisional disruption is important to the understanding of the collisional evolution of asteroids and interplanetary dust and is required in order to accurately model the infrared signature of small particles in our own Solar System and in other planetary systems. By combining the data obtained by weighing the larger fragments, sieving the smaller fragments, and determining the size-frequency distribution of the holes in the foils, we are able to cover more than nine orders-of-magnitude of this mass-frequency distribution, ranging from gram-size fragments down to those weighing a few nano-grams.

References: [1] Durda, D. D.and G. J. Flynn. (1999) *Icarus*, **142**, 46-55. [2] Flynn, G. J. and D. D. Durda (2004) PSS, **52**, 1129-1140. [3] Rasband, W.S., ImageJ, U. S. National Institutes of Health, Bethesda, Maryland, USA, http://rsb.info.nih.gov/ij/, 1997-2005. [4] Van-Veghten, T. W. et al. (2003) LPS XXXIV, Abstract #1264. [5] Durda, D. D. et al. (2005) Dust in Planetary Systems, LPI 2005, p. 41.

Figure 1. This shows one detector of four placed around the target that was suspended from the center of the AVGR chamber. This detector included two 7 μm, two 13 μm, and one 51 μm thick foils.

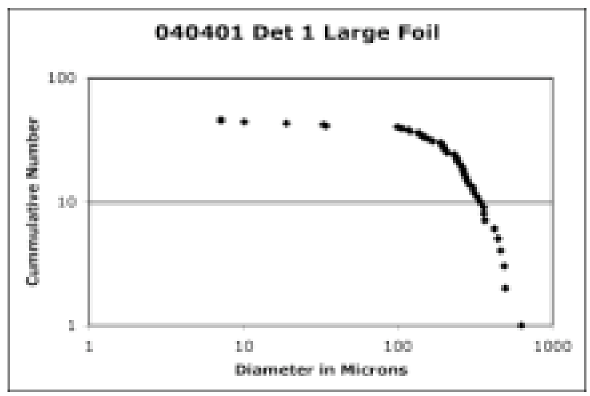

Figure 2. This is a size-frequency distribution of a 51 μm film from shot 040401. A sharp change in slope is noticed around 100 microns, which depicts the separation of larger and smaller particles that penetrated it.

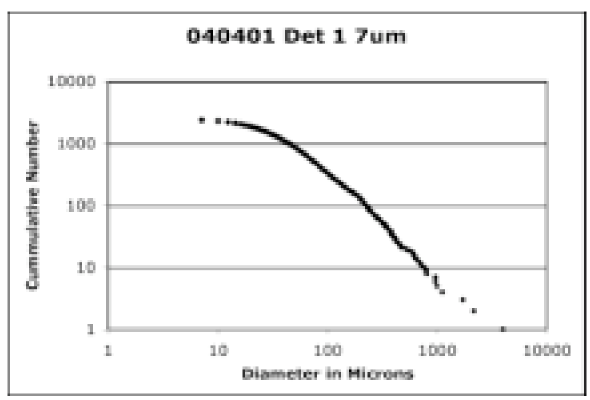

Figure 3. This is a size-frequency distribution of a 7 μm film from shot 040401. The slope is very smooth, which shows that the fragments that penetrated the 7 μm foils were from a wide range of sizes.