Disruption of Carbonaceous Chondrite Analogs

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Introduction:

Understanding the fragmentation of asteroids is important for investigating the origins of meteorites and interplanetary dust. Research into asteroid impacts uses meteorites as analogs for asteroids. Previous work found that anhydrous ordinary chondrites disrupt differently than hydrous carbonaceous chondrites [1, 2]. Carbonaceous chondrites and other hydrous meteorites are rare and limited access greatly impedes further research into these samples. Ongoing work attempts to hydrate ordinary chondrites to produce the mineralogy and structure of carbonaceous chondrites [3].

Analyzing the mass distribution of particles after disruption events has proven to be a good technique for comparing these events [5].

Figure 1. The Ames Vertical Gun Range is used to impact meteorites at supersonic speeds in a vacuum. All impacts are conducted here. High speed cameras record every shot from various angles.

Figure 2. The first image shows an overhead view of a meteorite hung in the chamber of the Ames Vertical Gun Range. The second image is an overhead view a meteorite immediately after being impacted by an aluminum projectile at approximately 5 km/s. The third image shows a side view of an impacted meteorite shortly after impact. Four foam core detectors mounted with three different foil thicknesses are placed in strategic locations around the target to capture the sizes of ejecta.

Experimental:

For hydration, Northwest Africa 869, a relatively abundant L3-6 ordinary chondrite, was used. Samples were crushed to less than 2 mm using a hydraulic press, sorted in an eight-layer sieve, and weighed. Crushed material was mixed, slightly oversaturated with pH 13 water, and placed in a Parr pressure bomb at 150^{0} C for 12 weeks. Hydration levels were monitored using FTIR analysis [3]. After hydration, material was removed from the pressure bomb and placed into 2-inch PVC molds with a cut down the side that is zip-tied shut. The material is again oversaturated with pH 13 water and allowed to settle and dry.

Figure 3. The left image is a carbonaceous chondrite analog drying in its PVC pipe mold. The right image shows the resulting roughly cylindrical analog after having its zip ties cut and the PVC peeled away.

Each of the samples were hung in the gun chamber of the NASA Ames Vertical Gun with fishing line attached by a small amount of epoxy. The samples were shot with 1/16-inch aluminum projectiles at approximately 5 km/sec as seen in Figure 2. The resulting particles were then collected from the chamber, the largest of which were individually weighed. The smaller particles were sorted with an eight-layer sieve and weighed according to their size range including a sampling of individual particles to obtain an average mass.

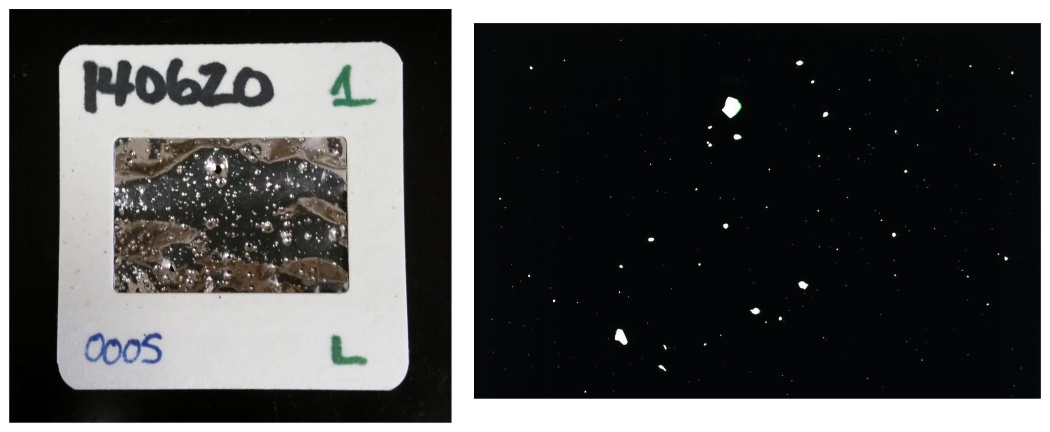

Figure 4. An example of one of the foil detectors that surrounds the target upon impact and its corresponding scanned image. All of the foils are scanned on a PrimeFilm 7250 Pro3 scanner at 7200 dpi using the program CyberViewX. The scanned images are then analyzed using the program ImageJ to estimate the mass of the particle that created each hole.

Results:

The mass distribution graph in Figure 5 compares particles from three shots: hydrated and anhydrous Northwest Africa 869 (L3-6) and ALH 83100 (CM). The mass distribution graphs include data from the foil detectors as seen in Figure 4 and the particles collected after each shot. The graph in Figure 5 shows that the hydrated Northwest Africa 869 has a different disruption pattern than anhydrous NWA 869, but is still not the same as a carbonaceous chondrite. Anhydrous ordinary chondrites tend to have a central plateau shape as seen in Figure 6. The hydrated material has lost this characteristic shape and appears to be more similar to the distribution pattern of the CM meteorite.

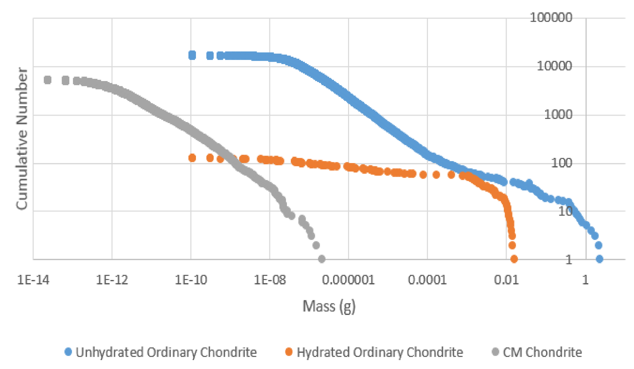

Figure 5. A comparative graph showing the differences in size distribution patterns between carbonaceous chondrites, ordinary chondrites, and hydrated ordinary chondrites.

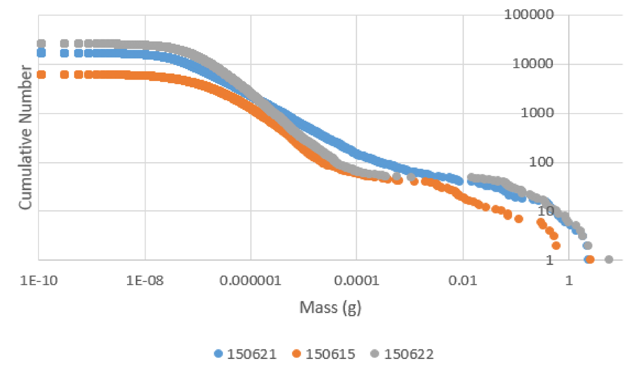

Figure 6. This central plateau shape is characteristic of ordinary chondrites mass distribution patterns post-disruption. Each of the shots shown are of Northwest Africa 869 (L3-6).

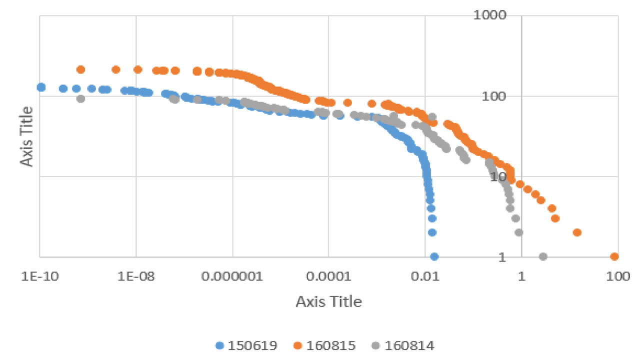

Figure 7. Examples of the mass distribution pattern of three different artificially hydrated carbonaceous chondrite analogs.

Despite the hydrated analogs beginning to trend more toward the shape of a carbonaceous chondrite it is still not the same. Currently experiments are being conducted to see if reducing the density of the analogs to better resemble the density of carbonaceous chondrites will also correct the mass distribution pattern of the analogs [4]. In the future, further analysis will identify other factors that influence the discrepancy in the mass distribution patterns of carbonaceous chondrites and the analogs.

References: [1] Durda D. D. And Flynn G. J. (1999) Icarus, 142, 46-55. [2] Flynn G. J. et al. (2009) Planetary and Space Science, 57, 119-126. [3] Clayton, A. N. et al. (2014) Lunar and Planetary Sci. Conf. XXXXV #2419. [4] Congram S. N. et al. (2017) *Lunar and Planetary Sci. Conf. XLVIII*, #2842

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