PRODUCTION OF COSMIC DUST BY HYDROUS AND ANHYDROUS ASTEROIDS: IMPLICATIONS FOR THE PRODUCTION OF INTERPLANETARY DUST PARTICLES AND MICROMETEORITES. G. J. Flynn[1], D. D. Durda[2], M. A. Minnick[3], 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 300, Boulder, CO, 80302. [3]Department of Chemistry, Alma College, Alma, MI 48801

Introduction: In our Solar System the asteroid belt is compositionally zoned, with the asteroids similar in reflection spectrum to the carbonaceopus meteorites dominating the outer-half of the main belt. In the outer-half of the main belt about one-half of the carbonaceous asteroids are hydrous, based on their infrared spectra [1]. The asteroids in the inner-half of the main belt are predominantly anhydrous. Thus, about one-quarter of the main belt asteroids are hydrous.

Because dust particles from the main-belt asteroids generally encounter the Earth with lower relative velocities than dust from comets [2], asteroidal dust experiences much less severe atmospheric entry heating and much greater gravitational focusing. Both factors contribute to a significant overabundance of asteroidal over cometary dust in Earth collections [2]. Thus, much of the cosmic dust collected at Earth is expected to be from asteroids rather than comets. With about one-forth of the main belt asteroids being hydrous, we would expect about one-forth of the cosmic dust from the asteroids to be hydrous if the production mechanism were unbiased.

There has been a long-standing puzzle in understanding the relationship between the interplanetary dust particles (IDPs), typically 5 μm to 50 μm cosmic dust particles collected from the Earth's stratosphere, and the micrometeorites, typically 50 μm to millimeter-size cosmic dust collected from the polar ices. A majority of the IDPs are anhydrous, consistent with the composition of the main belt. However, most of the polar micrometeorites are reported to be hydrous [3].

The dominant mechanism for the production of cosmic dust by asteroids is believed to be hypervelocity impact, either by cratering or catastrophic disruption. Tomeoka et al. [4] compared results from shock-recovery experiments on the hydrous CM meteorite Murchison and the anhydrous CV meteorite Allende. They determined that the onset of fracturing occurred at a significantly lower shock pressure in Murchison than in Allende, and suggested hydrous asteroids might contribute far more dust to the interplanetary medium then would be produced by anhydrous asteroids impacted under the same conditions. We have followed up on this work by disrupting samples of anhydrous [5] and hydrous meteorites using the NASA Ames Vertical Gun Range (AVGR).

Measurements: We have performed disruption experiments on four hydrous meteorite targets, Murchison and three CM2 meteorites recovered from the Antarctic. The projectiles in these experiments were 1/8th inch diameter aluminum spheres fired at the meteorite targets at speeds comparable to the collision velocities in the main-belt.

Each meteorite target was surrounded by "passive detectors" that included three thicknesses of aluminum foil to monitor the size of the small debris from the distrption. The foil hole diameters were measured, and converted to impacting particle diameters using the calibration data of Hörz et al. [6]. In addition, the fragments from the disruption were recovered from the floor of the AVGR chamber, and particles down to 0.01 gm were individually weighed. Combining the foil and weighing data produced a size-frequency distribution spanning the size-range from about 8 μm up, the smallest size we could measure using the scanner employed for the hole diameter measurements, to the size of the largest fragment from the disruption. Typically our measurements covered about a nine order-of-magnitude mass range [7].

We compared the mass-frequency distributions of the fragments produced by these disruptions with those from anhydrous meteorites we disrupted in earlier experiments. Figure 1 compares the mass-frequency distribution for an anhydrous ordinary chondrite meteorite, Saratov, with the data obtained on the disruption of the hydrous Murchison meteorite [7]. Saratov was disrupted by an Al projectile with a specific energy of ~ 4000 J/kg, about one-third the specific energy (projectile energy per unit target mass) of the Murchison shot. The Saratov results are generally representative of our results on the 10 anhydrous meteorite targets.

The vertical axis of this plot corresponds to the number of particles in each mass bin. The mass-frequency distributions produced by the Murchison and Saratov disruptions are quite similar for masses $<10^{-8}$ grams and $>10^{-5}$ grams. However, the results from these two disruptions suggest that Murchison produces an order-of-magnitude more fragments over the 10^{-7} to 10^{-4} gram mass range, about 30 to 300 μm in diameter, than were produced in the Saratov disruption. This 10^{-7} to 10^{-4} gram mass range corresponds to the size range of the micrometeorites collected from the polar ices.

To determine if the Murchison results are representative of the CM meteorites, we have recently disrupted samples from three Antarctic CM2 meteorites, ALH83100, LON94101, and EET96006, at the AVGR. The mass-frequency distributions from these three disruptions are shown in Figure 2. These results are consistent with our prior Murchison results.

Conclusions: Our results from the disruption of these four CM2 meteorites suggest that hypervelocity disruption of hydrous targets significantly overproduces dust particles in the micrometeorite size range compared to the disruption of anhydrous meteorite targets under the same conditions. These results are generally consistent with the shock-recovery results obtained by Tomeoka et al. [3], and appear to explain the long-standing puzzle that polar micrometeorites are mostly hydrous while a majority of the IDPs are anhydrous. For a main belt population of about one-quarter hydrous and three-quarters anhydrous asteroids we would expect a majority of the ~10 µm IDPs to be anhydrous while the ~100 µm micrometeorites would be dominated by hydrous particles.

References: [1] Rivkin et al., in *Asteroids III*, Univ. of Arizona Press, 235-253 (2002). [2] Flynn, G. J. *Icarus,* **77**, 287-310 (1989). [3] Tomeoka, K. et al. *Nature*, **423**, 60-62 (2003). [4] Maurette, M., *Micrometeorites and Mysteries of Our Origins,* Springer (2006).

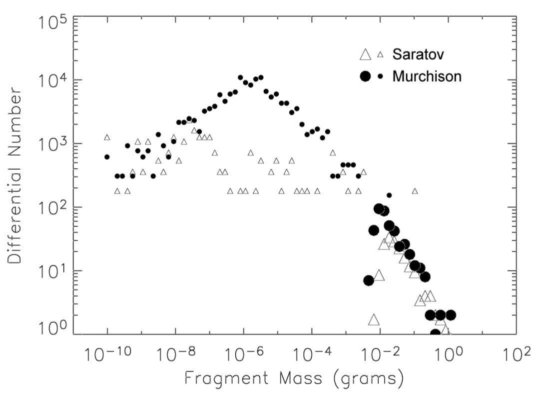

Figure 1: The differential mass-frequency distribution of debris from the disruption of an ~30 gm Murchison sample and a 105 gm sample of the anhydrous ordinary chondrite Saratov, determined by combining penetration data from the 7 and 13 µm thick Al-foils (small symbols) and from weighing all fragments >10^{-2} grams (larger symbols) recovered from the floor of the AVGR chamber. The Saratov data have been scaled to the same total mass as Murchison. The weighing data are incomplete for masses <10^{-2} grams, resulting in the falloff in those data. The Murchison disruption produced an order-of-magnitude more fragments over the 10^{-7} to 10^{-4} gram mass range than Saratov.

[5] Flynn, G.J. and D. Durda, *Planet. & Space Sci.,* **52**, 1129-1140 (2004). [6] Hörz et al. *NASA Technical Memorandum 104813* (1995). [7] Flynn et al., Dust Production from Hypervelocity Disruption of the Murchison CM2 Meteorite *Planet. & Space Sci.* (in press).

Figure 2: The mass-frequency distributions of the debris from the disruptions of ~30 gm samples of the Antarctic CM2 meteorites ALH83100, LON94101, and EET96006 and a 105 gm sample of Saratov, determined by combining penetration data from the 7 and 13 µm thick Al-foils (small symbols) and from weighing all fragments >10^{-2} grams (larger symbols) recovered from the AVGR chamber. The Saratov data have been scaled to the same total mass as the CM2 meteorite.