ANALYTICAL STUDIES OF IMPACT EXPERIMENTS SIMULATING CAPTURE OF COSMIC DUST IN SILICA AEROGEL, R.A. Barrett[1] and M.E. Zolensky[2], [1]Lockheed Engineering and Sciences Co., Houston, TX 77058; [2]Planetary Sciences Branch, NASA Johnson Space Center, Houston, TX 77058.

INTRODUCTION: The Space Station Cosmic Dust Collection Facility and other space-based dust collection facilities depend upon the development of a chemically and structurally suitable collection medium. The development of suitable collection media is proceeding through laboratory studies involving the capture of projectiles simulating cosmic dust particles. To be successful, these experiments must properly mimic the velocity of impacting projectiles, structure and chemistry of impactors, and physical conditions of the capture process itself [1,2,3]. We report here recent progress in cosmic dust impact simulation experiments, techniques for the extraction of impactor residues from silica aerogel, and characterization of the physical state of impactor residues.

EXPERIMENTS: The projectile material we employed consisted of approximately 150, 100 um-sized, grains of olivine, pyrrhotite and calcite (either alone or mixed) loaded into sabots. The projectiles were launched into targets using a two-stage light gas gun, as previously described (1,3). Nineteen experiments were successfully performed, with shots being made into silica aerogel targets at velocities ranging from 5.06 to 7.18 km/sec. The targets were constructed of monoliths of silica aerogel with densities of 120 mg/cc, 40 mg/cc, and 20 mg/cc. These silica aerogels were fabricated by L. Hrubesh [3]. The impacting projectile material produced many small, gently curving, penetration "tracks" in the silica aerogel as described previously [2,3]. Measures were taken to clean up the experimental shots in an effort to eliminate contamination particulates from the gun (e.g. gun powder). These actions included 1) reduction of the gun hydrogen pressure from 90 to 60 psi to reduce the amount of hydrogen in the chamber, 2) reduction of the amount of gun powder from 16.5 to 14.5 grams per shot, 3) use of a smaller, 11/16 inch orifice at the sabot catcher, 4) insertion of a second sabot-catcher tube, and 5) placement of a 3/8 inch-thick shield with a 1 inch hole in front of the target.

SAMPLE PREPARATION: The silica aerogel targets were carefully observed to determine areas of tracks with particles. A better description of particulate track appearance and length is given in [3]. The silica aerogel was carefully cut away around a particle using an exacto-blade under a binocular microscope. Each residue grain (still encased within a small block of aerogel) was then impregnated by the low-viscosity epoxy EMBED 812, and placed in an oven to cure at 75° C. It was found that vacuum impregnation of silica aerogel using the epoxy rendered the aerogel clear as water. This action served to guide removal of the smallest residue grains in some cases. The particles were microtomed into 90 nm-thick sections, and examined using a JEOL 2000FX STEM equipped with a LINK eXL EDX analysis system.

RESULTS OF ANALYTICAL ELECTRON MICROSCOPY: We describe here the analytical results from two of the shots at the highest gun velocities attained, and into low density aerogels, i.e. nearest to the expected conditions for the actual Cosmic Dust Collection Facility. Shots 467 and 468 were at velocities of 6.29 and 7.18 km/sec, respectively. The aerogel targets for these shots had densities of 40 and 20 mg/cc, respectively. The projectile residue material recovered from the aerogel from both of these shots was similar. All recovered projectile residue grains were encased within melted aerogel, as described previously [3]. No calcite, and only a few grains of pyrrhotite were recovered from the enclosing aerogel. In place of most pyrrhotite, blebs of iron were noted. We conjecture that sulfur was lost from pyrrhotite grains through volatilization upon impact. Crystalline olivine was the principal phase noted in the recovered residues. As is the case with most terrestrial olivine, the projectile olivine grains originally contained small pockets of serpentine (an alteration product of the olivine) before the experiment. Within the projectile residue olivine grains, we noted fibrous, flaky material with a bulk composition near that of olivine. This material is shown in Figure 1. Composition and diffraction data from this material is identical, however, with a so-called "intermediate" phase produced by the heating of serpentine to temperatures between 400 and 600^{o}C [4, M. Zolensky, unpublished data]. This material is pseudomorphous after flaky serpentine, and is characterized by electron diffraction patterns intermediate between those of serpentine and anhydrous ferro-magnesian silicates. At temperatures of ~600^{o}C and higher, this intermediate phase transforms to olivine and/or pyroxene [M. Zolensky, unpublished data].

These results indicate that under the capture conditions simulated in these experiments, which are believed to simulate critical aspects of the Cosmic Dust Collection Facility, component minerals of cosmic dust can be expected to behave differentially. Some minerals will be partially or completely vaporized, some merely dehydrated and structurally reordered, while only the most resistant phases can be expected to survive "intact". Final experiments are now in progress using silica aerogels with densities of 3 mg/cc. We note that track-lengths increase in length roughly with decreasing silica aerogel density, and may therefore ultimately determine the minimum feasible aerogel density that can be employed on the Cosmic Dust Collection Facility.

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REFERENCES: [1] Zolensky et al. (1989) Lunar Planet. Sci. 20, 1251-1252; [2] Tsou et al. (1989), Lunar Planet. Sci. 20, 1132-1133; [3] Zolensky et al. (1990) Lunar Planet. Sci. 21, 1381-1382; [4] Akai (1989) Fourteenth Symposium on Antarctic Meteorites, 22-23.

FIGURE 1. TEM Image of "intermediate" phase (pseudomorphous after serpentine) among olivine in the residue of Shot 468.