MINERALOGY OF DUST COLLECTED BY THE COSMIC DUST SUCKER IN ANTARCTICA. K. D. Burgess[1], D. Bour[2], R. M. Stroud[1], A. Bardyn[3], C. M. O'D. Alexander[3], L. R. Nittler[3], J. H. Lever[4], S. Taylor[4]; [1]U.S. Naval Research Laboratory, Washington, DC 20375 (kate.burgess@nrl.navy.mil); [2]ASEE, 1818 N St. NW, Washington, DC; [3] Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, Washington DC, 20015; [4] CRREL, 72 Lyme Road, Hanover NH 03755.

Introduction: Collections of interplanetary dust particles (IDPs) and micrometeorites (MMs) provide a valuable resource for laboratory studies of Solar System materials from reservoirs that may not be sampled by meteorites. The primitive chondritic-porous IDPs collected in the stratosphere and ultra-carbonaceous Antarctic MMs (UCAMMs) from melted snow in particular are thought to be cometary in origin and show affinities to Wild2 grains returned by the Stardust mission [1,2]. Filtering of clean Antarctic air provides a potential way of obtaining these extraterrestrial (ET) particles, complementary to the existing collections [3].

The examination of filters returned from Antarctica and the locating of candidate extraterrestrial particles has proven time-consuming, although bulk ^{3}He measurements provide evidence of ET particles on each cm^2 of filter analyzed [4]. Initial characterization using scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDS) has been used to select candidate grains for further analyses by (scanning) transmission electron microscopy (S/TEM) and NanoSIMS. Previously, we have shown results from several grains, including an Fe-Ni-sulfide [5]. In order to increase the efficiency of our particle search, we need a better understanding of the range of materials trapped by the filters and how they compare to stratospheric and snow-melt collections. Here we present details from a systematic search for particles >5 µm on small regions of two filters and the detailed analysis of several particles of interest.

Methods: We examined filters returned from Antarctica after being exposed for six days and one month in summer and winter, respectively. Small (~10 cm^2) sections were cut from the larger filters and carbon coated for the SEM. We imaged a portion of the filter sections and collected EDS spectra from each particle >~5 µm within the field of view, covering in total ~1 cm^2 of each filter and collecting 353 spectra. We classified the particles based loosely on categories determined for stratospheric collections [6]. Here, chondritic particles are those within a factor of 6 of chondritic ratios for Mg/Si, Fe/Si, and Ca/Si, and a factor of 10 for S/Si. Low-Z particles are those with atomic number less than 11 (with an exception for S, which is present in aerosols and coats some particles).

Several particles were of particular interest and were prepared for examination in the STEM with focused ion beam (FIB) or ultramicrotomy techniques depending on the specific particle. The internal structure and composition can be analyzed using STEM with EDS and electron energy loss spectroscopy (EELS). The EELS and EDS data were collected with the NION UltraSTEM200-X at the U.S. Naval Research Laboratory, which is equipped with a Gatan Enfinium ER EEL spectrometer and a Bruker SDD-EDS detector.

Results and Discussion: Of the hundreds of particles analyzed here, ~3% fall within the constraints of "chondritic" bulk composition (Fig. 1). Similar to stratospheric IDP collections, we also observed a significant fraction of "low-Z" carbonaceous particles. While a small proportion of these may be from our carbon coating process, many contain N and O in addition to C. Al metal contamination is a known issue associated with the intake pipe. Sulfate from aerosols is ubiquitous and present both as particles and as coatings of Al metal and silicate grains. The addition of Na, Al, and Ca with the sulfate coatings may also mean that some "non-chondritic silicates" would be chondritic without this contamination and further manual sorting to identify candidate ET particles is necessary. NaCl is also present on the winter filter.

Comparisons with particle populations from other filters show basic similarities. We did not locate any Fe-Ni metal or sulfide particles, which have been found on other filters. It is possible that differences in search methods, such as particle size ranges of interest or using carbon tape to remove particles from the filter then searching the tape may highlight different populations of particles.

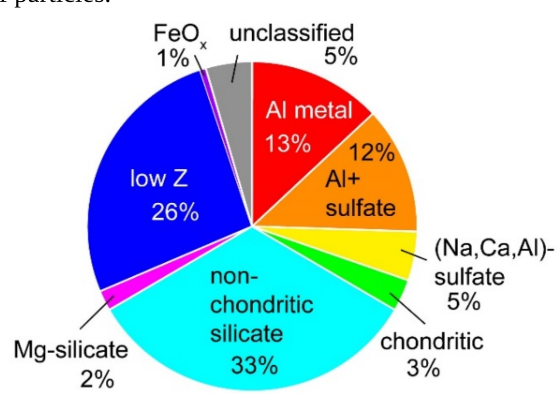

Figure 1. Distribution of systematically classified particles (>5 µm) in ~1 cm^2 regions of two filters, a total of 353 particles. About 3% of particles fall within the "chondritic" category for bulk composition; non-chondritic silicates and low-Z particles dominate the measured particles.

One class of particles of great interest for further analyses are monomineralic Mg-rich silicates with very little Fe or other elements (Fig. 2). These particles were identified on several different filters in addition to those discussed here and range in size from a few microns to >50 µm across. A FIB section from a large grain shows layers of vesicular sulfate within the silicate, which has Mg:Si close to that of talc and is easily damaged by the beam. Na and Fe are the dominant cations (with possibly Mg) in the sulfate with trace amounts of many other elements, including Ni. While these grains may be terrestrial seafloor alteration of basalt or similar, these phases are seen in meteorites as well.

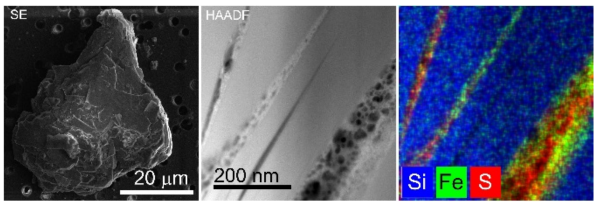

Figure 2. Monomineralic Mg-silicate grains have been found on several different filters and were of interest for further analyses. The grain shown here is likely talc with vesicular sulfate layers of varying composition.

We have also performed detailed analyses on a carbonaceous particle with elevated Ni and N in its bulk composition (Fig. 3). The excess S is possibly related to contamination from aerosols. TEM samples were prepared using both FIB and ultramicrotome; all samples show Fe-phosphate and Ni-sulfate material in a carbonaceous matrix with variable N, O and S (Fig. 4). Mg-silicate grains are present but rare. NanoSIMS measurements show that D/H and $^{15}N/^{14}N$ ratios are homogeneous and consistent with terrestrial origin or alteration. This result does not support, but also does not preclude an extraterrestrial source.

Conclusion: The Cosmic Dust Sucker has demonstrated that extraterrestrial particles can be captured from air at ground level. However, significant work is still needed to optimize SEM-based search algorithms to locate candidate cosmic grains and distinguish them from background contamination. Bulk methods have shown that ET particles are present, and a large amount of filter area remains to be searched. STEM and NanoSIMS analyses are able to confirm in some cases the extraterrestrial origin of particles, but some remain enigmatic. They may be highly altered or reflect new types of samples that we have not observed previously in our dust collections and thus are a potentially unique suite of samples.

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References: [1] Dobrică, E., et al. (2009) *M&PS*, *44*, 1643. [2] Duprat, J., et al. (2010) *Science*, *328*, 742. [3] Taylor, S., et al. (2017), *LPSC*, 2024. [4] Taylor, S., et al. (2018), *AGU Fall Meeting*. [5] Bardyn, A., et al. (2018), *LPSC*, 1547. [6] Zolensky, M.E., et al. (1989) *JGR*, *94*, 1047.

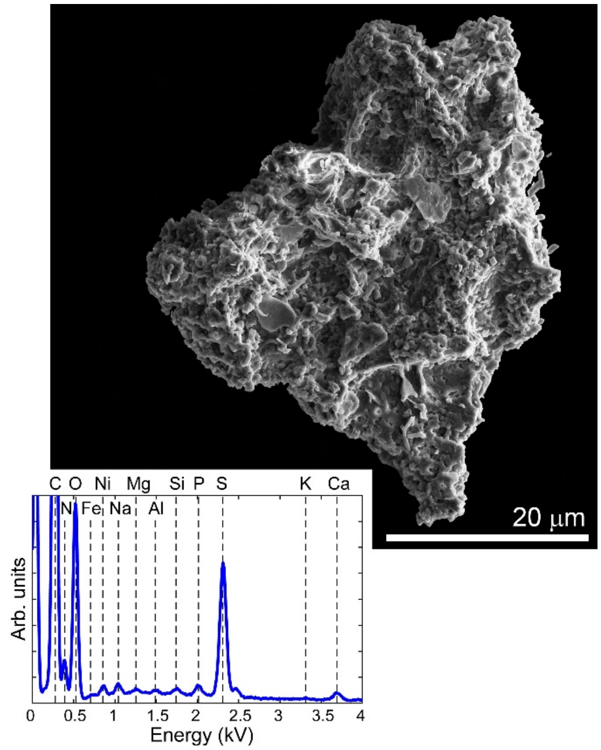

Figure 3. A carbonaceous particle was chosen for further analyses because of its high bulk Ni and N content in the SEM.

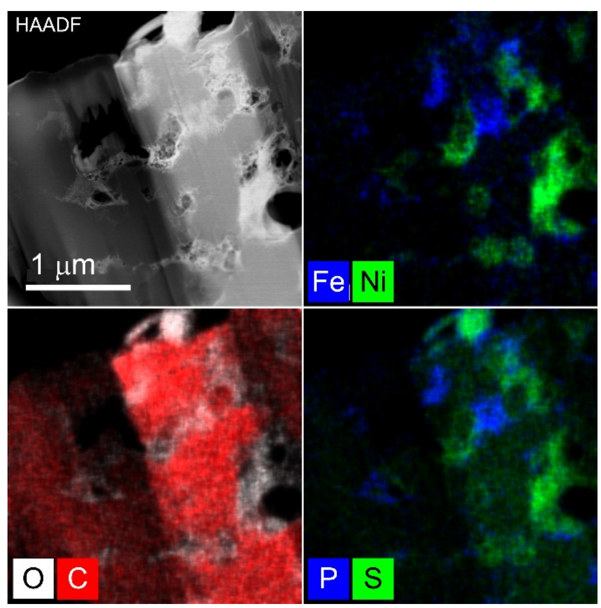

Figure 4. STEM-EDS analyses of a FIB section from the carbonaceous particle in Fig. 3 show that Fe is in phosphate and Ni is in sulfate. The carbonaceous material has high but variable N.