THE COSMIC DUST SUCKER: SAMPLING COSMIC DUST PARTICLES FROM ANTARCTIC AIR. A. Bardyn[1], C. M. O'D. Alexander[1], L. R. Nittler[1], R. M. Stroud[2], K. Burgess[2], J. H. Lever[3] and S. Taylor[3], [1]Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, Washington, DC 20015, abardyn@carnegiescience.edu, calexander@carnegiescience.edu, lnittler@carnegiescience.edu, [2]Materials Science and Technology Division, Naval Research Laboratory, 4555 Overlook Ave., Washington, DC 20375, stroud@nrl.navy.mil, kate.burgess@nrl.navy.mil, [3]Cold Regions Research and Engineering Laboratory, 72 Lyme Rd., Hanover, NH 03755, james.lever@erdc.dren.mil, susan.taylor@erdc.dren.mil.

Introduction: Extraterrestrial (ET) materials that are collected on Earth include interplanetary dust particles (IDPs) collected in the stratosphere and micrometeorites collected at the Earth's surface [1]. Among them, the chondritic porous anhydrous particles (CP-IDPs) are thought to originate from comets [2]. They are characterized by the presence of anhydrous crystalline phases, amorphous phases such as GEMS (glass with embedded metal and sulfides [3]), high abundances of presolar grains [4], high organic C contents [5] and H, C, or N isotopic anomalies in the organics [6]. CP-IDPs were also recently collected in Antarctic snow and ice [7]. The particular conditions in Antarctica – low human activity, low accretion rate of terrestrial dust, cold and dry weather – make this area favorable to retrieve preserved micrometeorites from melted snow [8]. Among these micrometeorites are the rare ultracarbonaceous Antarctica micrometeorites (UCAMMs) with very high C contents, as well as large D enrichments in some, which could be a sign of a cometary origin [9]. The presence of highly primitive ET materials in Antarctic snow indicates that they may also be collected directly from the air, thus allowing laboratory analysis of potentially cometary particles with minimal terrestrial alteration.

Sampling cosmic dust particles: A joint project of NASA and NSF was initiated to collect cosmic dust particles from large volumes of clean Antarctic air [10]. The collector is located on the border of the Clean Air Sector near the South Pole station. It filters the air stream continuously at ~5 m s^{-1}, through a 20-cm-diameter polycarbonate filter with 3-µm holes. The filters can be changed anytime but are generally swapped out monthly. A broad range of ET materials should be sampled, such as IDPs, CP-IDPs and some rare UCAMMs. Sampling was started in Dec. 2016 and will continue at least until Dec. 2018.

Contaminants and their seasonal variation: Although the filters appear optically clean, they contain many Al grains in the 10 µm size range and numerous sub-micron aerosols. The Al grains are from the collector fabrication and to minimize that source we cleaned the intake pipe in Dec. 2017, using a CO_2 abrasive jet. The aerosols are primarily sulfur-based condensation droplets that coat the filter as well as filling some of the filter pores. These aerosols decrease by an order of magnitude during the austral winter relative to their summer peak [11]. Interestingly, the meteoric flux measured by radar is also seasonal, it increases during the austral summer when Antarctica has a forward facing orientation relative to the ecliptic and decreases in the winter when meteors arrive from non-ecliptic directions [12]. These winter filters may, therefore, have a larger fraction of cometary material. We have just started to examine the 2017 winter filters. They appear to have fewer Al grains, consistent with depletion of this contaminant source.

Searching for cosmic dust particles: The work presented here focuses on the search for cosmic dust on the filter SPA-4 (exposed 28 days to Antarctic air Dec. 2016 – Jan. 2017). Two small sections of the filter (~ 1 cm^2 each) were cut and placed on a C sticky tab and coated with Ir. We used a SEM/EDS to acquire electron images and element maps at high magnification (200 µm by 300 µm frames). To avoid particulate contamination (dominated by Al-rich grains), we used the Mg and Fe maps to find candidate ET particles. Fig. 1 shows a higher magnification electron image and Fig. 2 an EDS spectrum of a likely ET Fe sulfide particle. To date, we have found 1 ET and 8 possible ET particles from the 53 particles we have examined from the 2 cm^2. Approximately 10,000 Al grains were found in 1 cm^2 of SPA-4.

Cosmic dust analysis: These ET and ET candidate particles will be analyzed by a complementary suite of micro-analytical techniques, such as FIB/SEM, electron microprobe, NanoSIMS, Raman microscopy, C-N-O XANES and STEM. Coordinated NanoSIMS / STEM analyses have been performed on a CP-IDP (Fig. 3) found on an early filter [10]. The IDP consists of multiple phases, including a ~2-µm Fe-sulfide and smaller silicates, including a ~500-nm Al, Na-rich grain (likely a feldspar). We performed Al-Mg analysis of the IDP by NanoSIMS, but the Mg contents of the Al-rich grain were too high to allow detection of extinct ^{26}Al. STEM analysis of the Fe-sulfide grain, prepared by FIB, contains several 100-400 nm Fe-Ni metal inclusions. The edge of the grain, which was attached to the carbon tape substrate and thus protected from ion beam alteration during preparation, shows a damaged rim, likely from exposure to the space environment (Fig. 4). Detailed examination using Electron Energy Loss Spectroscopy (EELS) reveals a signature related to the presence of hydrogen in vesicles in the rim and oxidized iron, possibly from alteration during atmospheric entry heating.

The Cosmic Dust Sucker allows continuous filtration of the air to collect cosmic dust, while avoiding any contact with snow or liquid water, and thus preserving the collected particles in a pristine state. It may also be possible to collect particles from specific comet dust streams, as has been done for some stratospheric IDP collections (e.g., comet 26P/Grigg-Skjellerup [4] and comet 21P/Giacobini-Zinner [13]). To make its potential a reality, we need to refine our techniques to efficiently identify ET particles relative to background contaminants.

References: [1] Taylor S. et al. (2016) *Elements, 12,* 171-176. [2] Ishii H. A. et al. (2008) *Science, 319,* 447-450. [3] Bradley J. P. (1994) *Science, 265,* 925-929. [4] Busemann H. et al. (2009) *Earth Planet. Sci. Lett., 288,* 44-57. [5] Thomas K. L. et al. (1993) *Geochim. Cosmochim. Acta, 57,* 1551-1566. [6] Messenger S. (2000) *Nature, 404,* 968-971. [7] Noguchi T. et al. (2015) *Earth Planet. Sci. Lett., 410,* 1-11. [8] Duprat J. et al. (2007) *Adv. Space Res., 39,* 605-611. [9] Duprat J. et al. (2010) *Science, 328,* 742-745. [10] Taylor S. et al. (2017) *LPS XLVIII,* Abstract #2024. [11] Bodhaine B. A. and Murphy M. E. (1980) *Journal of Aerosol Science, 11,* 305-312. [12] Janches D. et al. (2004) *Geophysical Research Letters, 31.* [13] Nakamura-Messenger K. et al. (2015) *78th Annual meeting of the Meteoritical Society,* Abstract #5322.

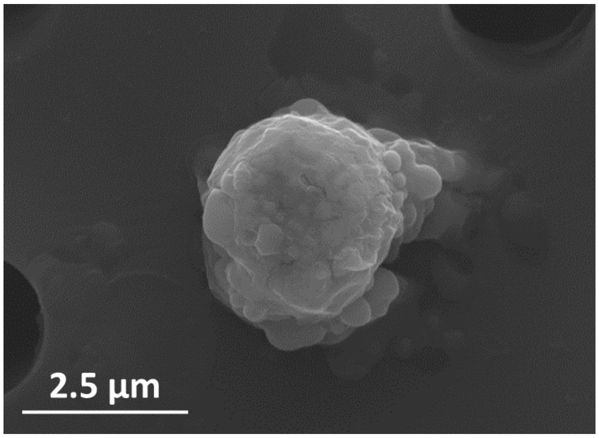

Fig. 1. Electron image of a likely ET particle from the filter SPA-4.

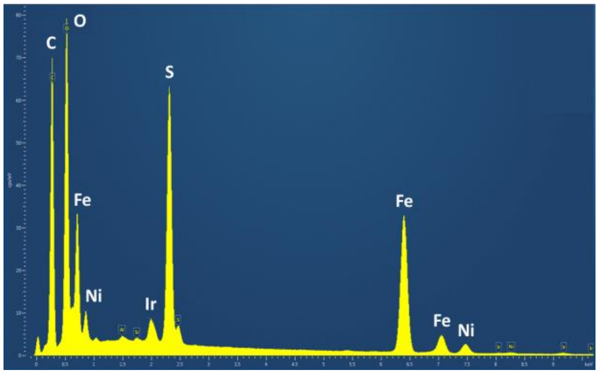

Fig. 2. EDS spectrum of a likely ET particle (Fig. 1). Ir comes from the coating.

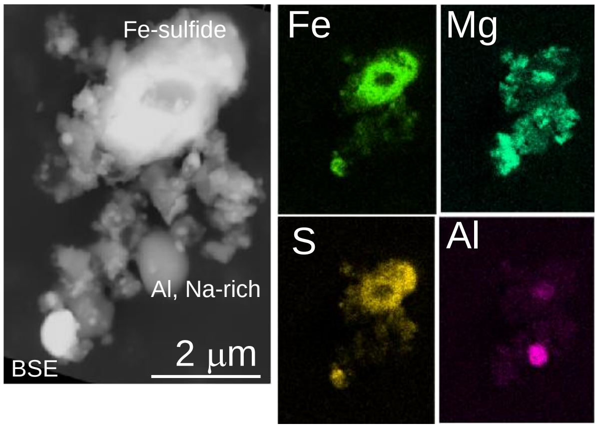

Fig. 3. Backscattered electron (BSE) image and select X-ray maps of the CP-IDP analyzed by NanoSIMS and STEM.

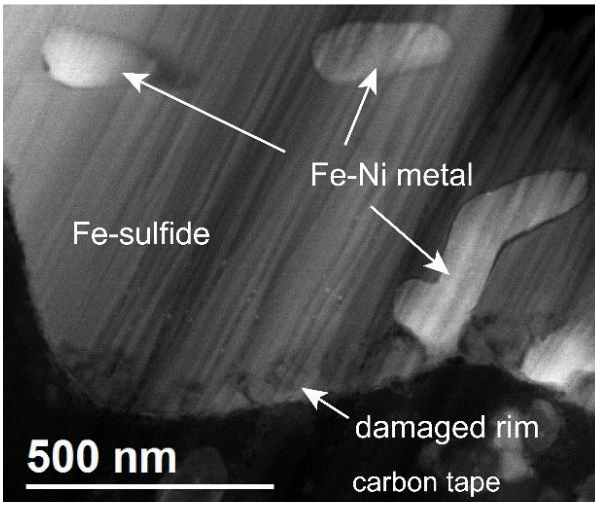

Fig. 4. HAADF image of a FIB cross-section of sulfide grain (Fig. 3) with Fe-Ni metal inclusions and alteration rim. The sub-vertical lines are a FIB preparation artifact.