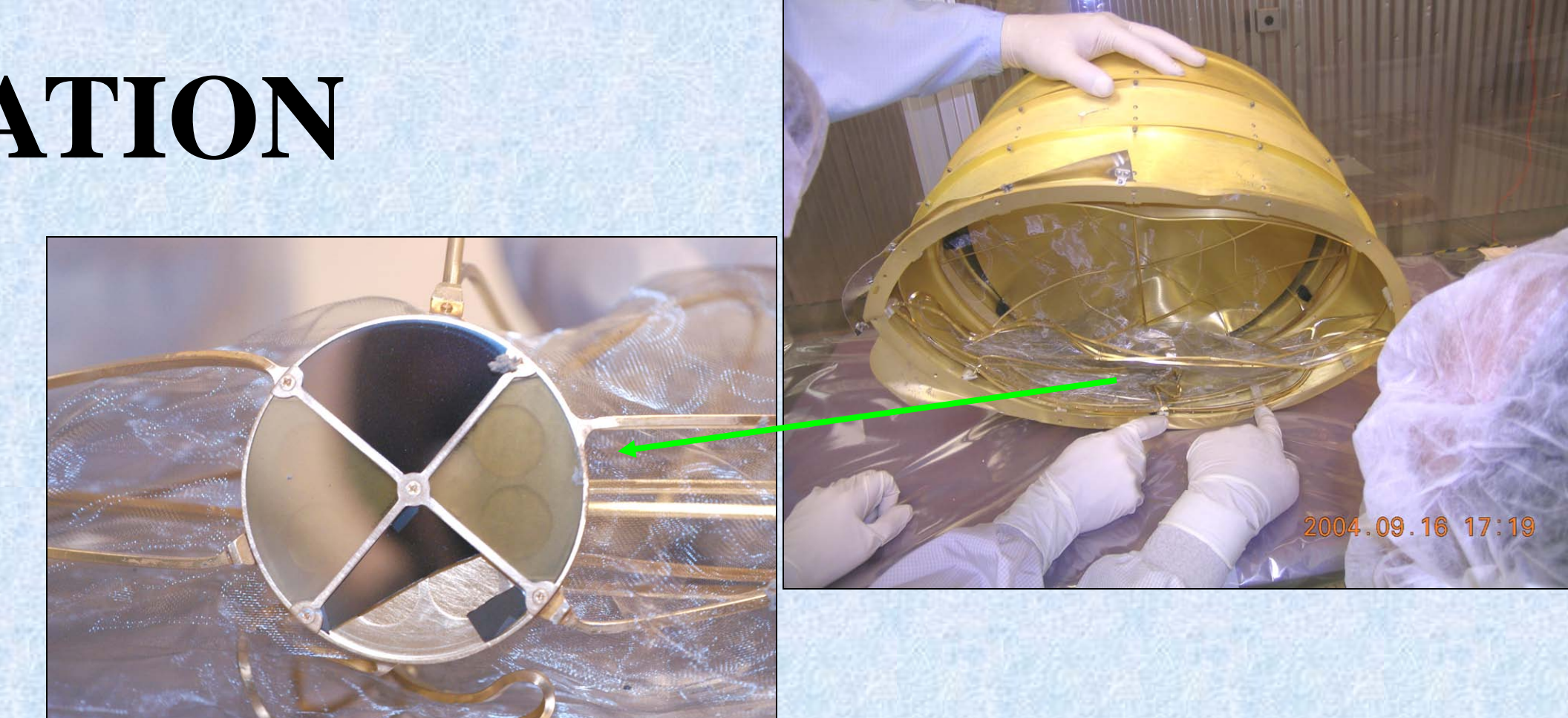
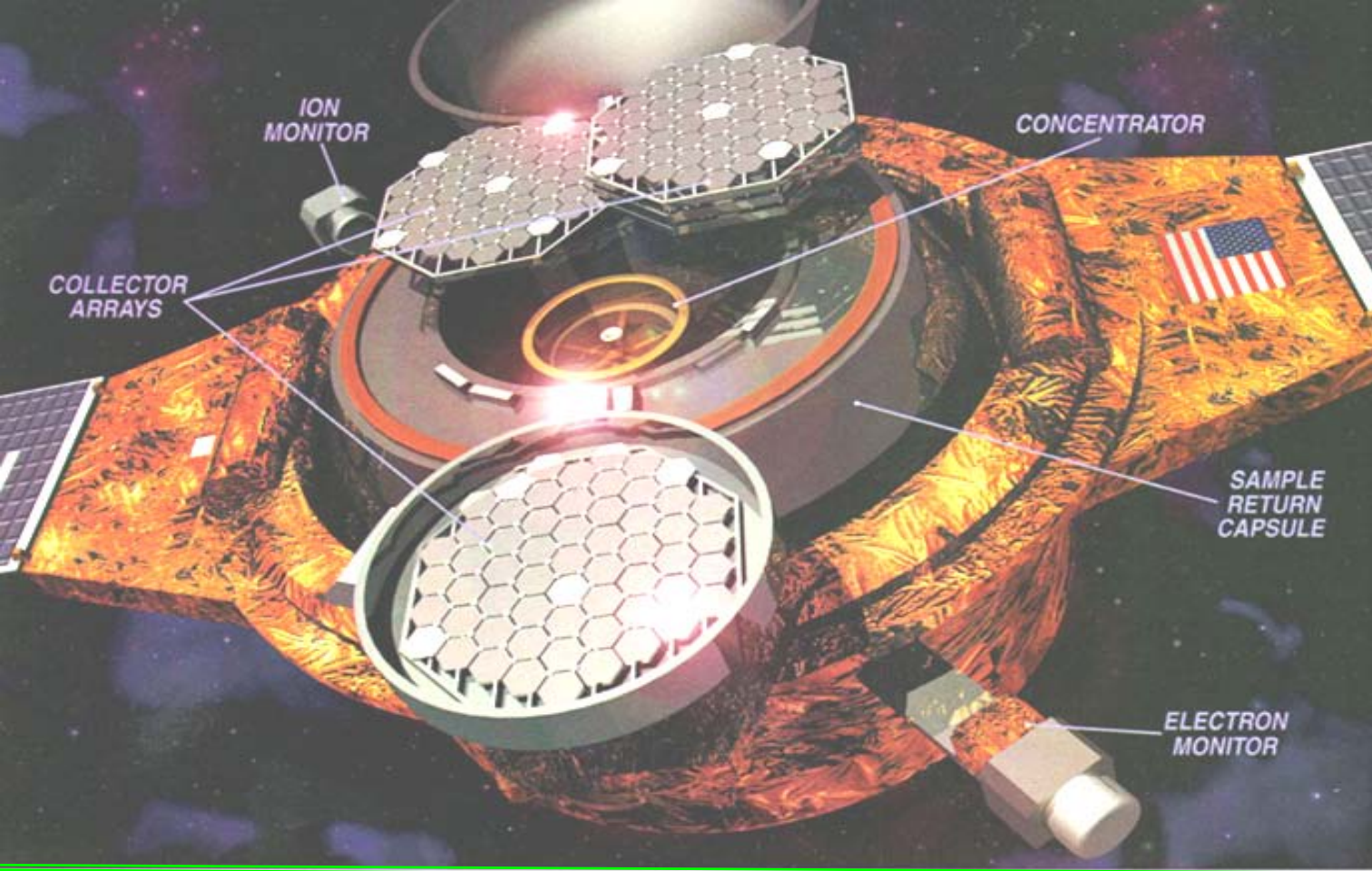


# GENESIS CONCENTRATOR TARGET PARTICLE CONTAMINATION MAPPING AND MATERIAL IDENTIFICATION

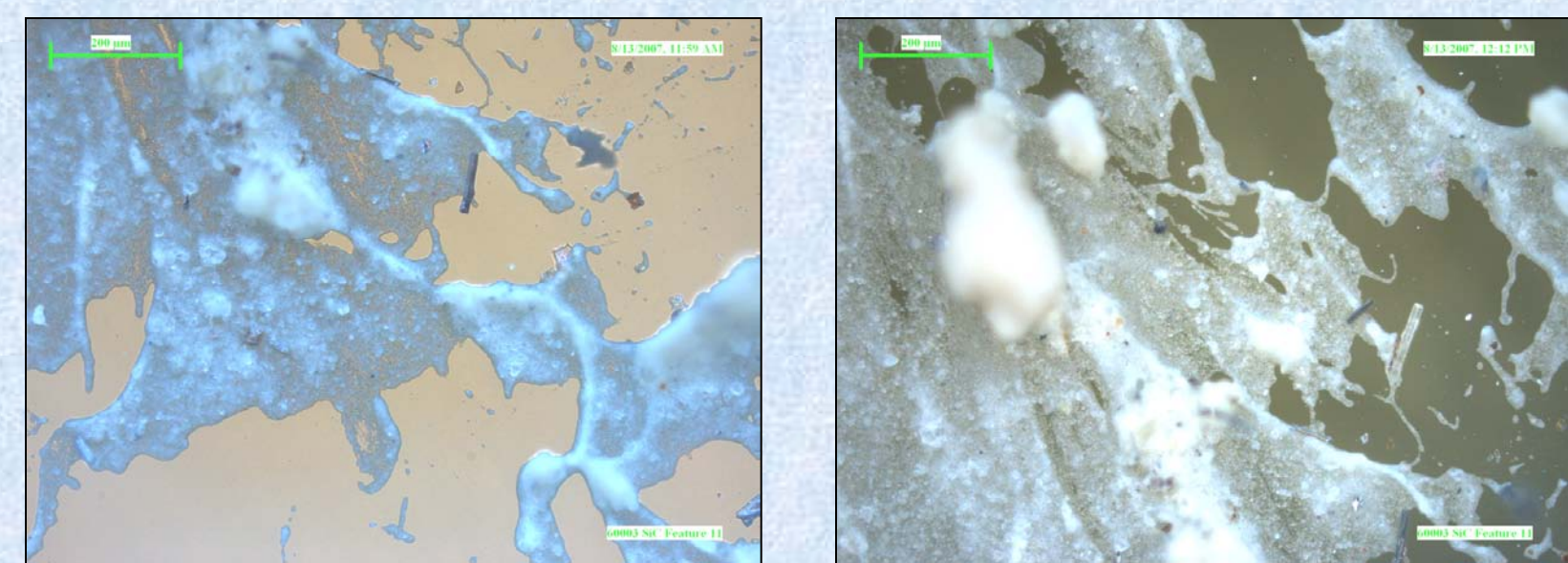
Michael J. Calaway<sup>1</sup>, Melissa C. Rodriguez<sup>2</sup>, and Judith H. Allton<sup>3</sup>

(1) Jacobs (ESCG) at NASA Johnson Space Center, Houston, TX  
 (2) Geocontrol Systems (ESCG) at NASA Johnson Space Center, Houston, TX  
 (3) NASA, Johnson Space Center, Houston, TX  
 michael.calaway-1@nasa.gov

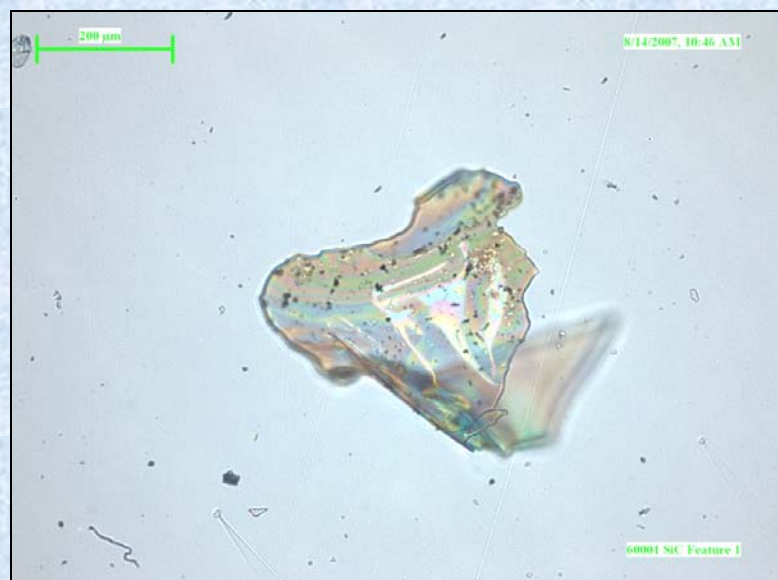


## Particle Contamination Features

Surface particle contamination on three Genesis concentrator targets [1, 2] was closely examined to evaluate cleaning strategies. Two silicon carbide (Genesis sample # 60001 and 60003) and one chemical vapor deposited (CVD) <sup>13</sup>C concentrator target (60002) were imaged with optical microscopes. The targets were first imaged with a Leica MZ9.5 stereoscope. This produced a good overview of the larger particles and impact features. Individual contamination features originating from the crash environment were also imaged with a Leica DM6000M automated microscope using 5X, 10X, and 50X objective lens. This resulted in particle feature maps encompassing the entire target area. Particle morphologies were subsequently compared with non-flight, but flight-like, concentrator targets and sample return capsule (SRC) materials.

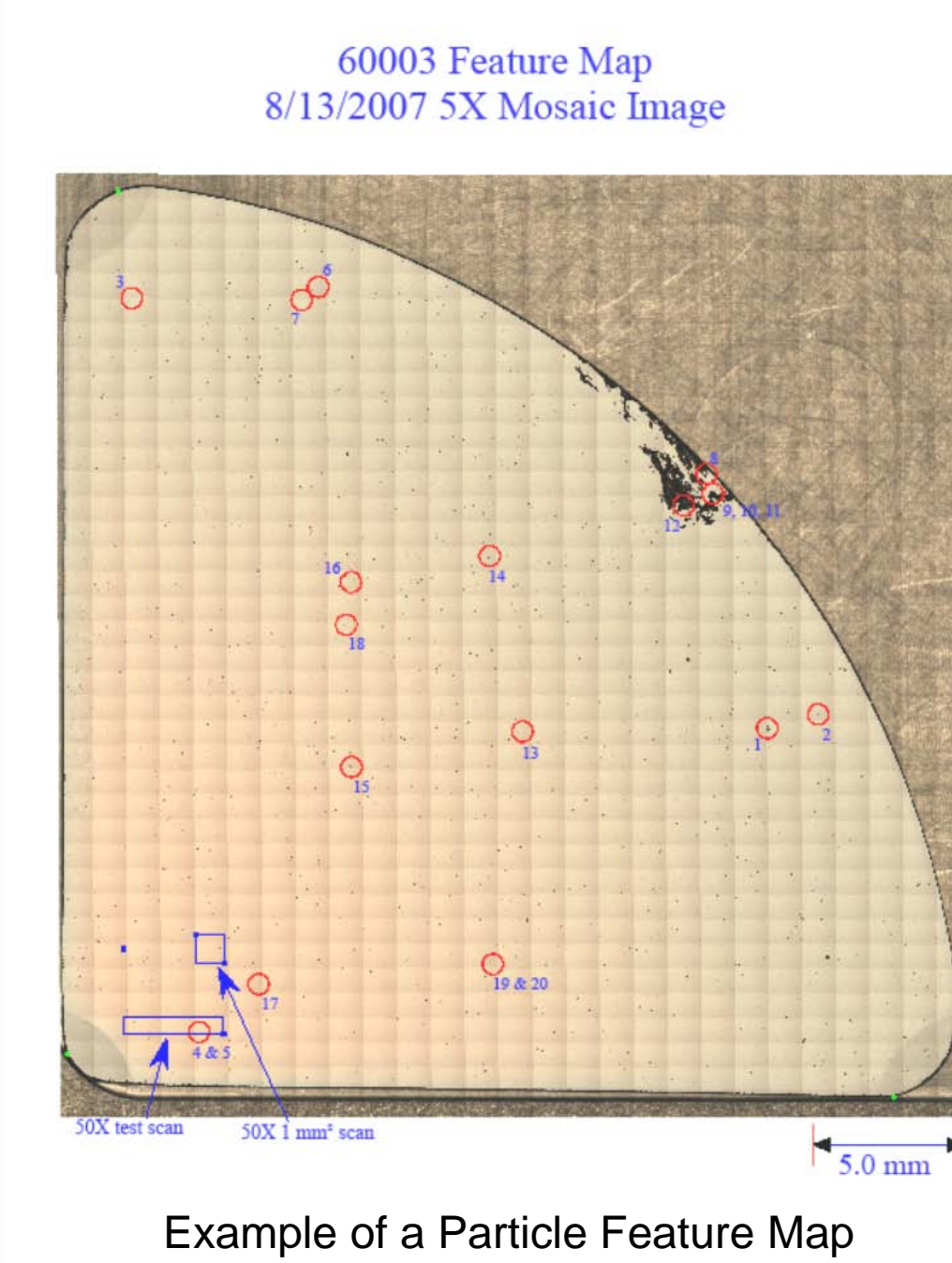


The above images show an example of a salt deposit on SiC target 60003. The salt deposit is probably a dried mixture of halite and other sediments from the lacustrine environment at the Utah Test and Training Range. Black carbon-carbon fibers, Al fragments, and other SRC materials can be visibly identified mixed within the salt matrix. (Scale bar ~200 µm).

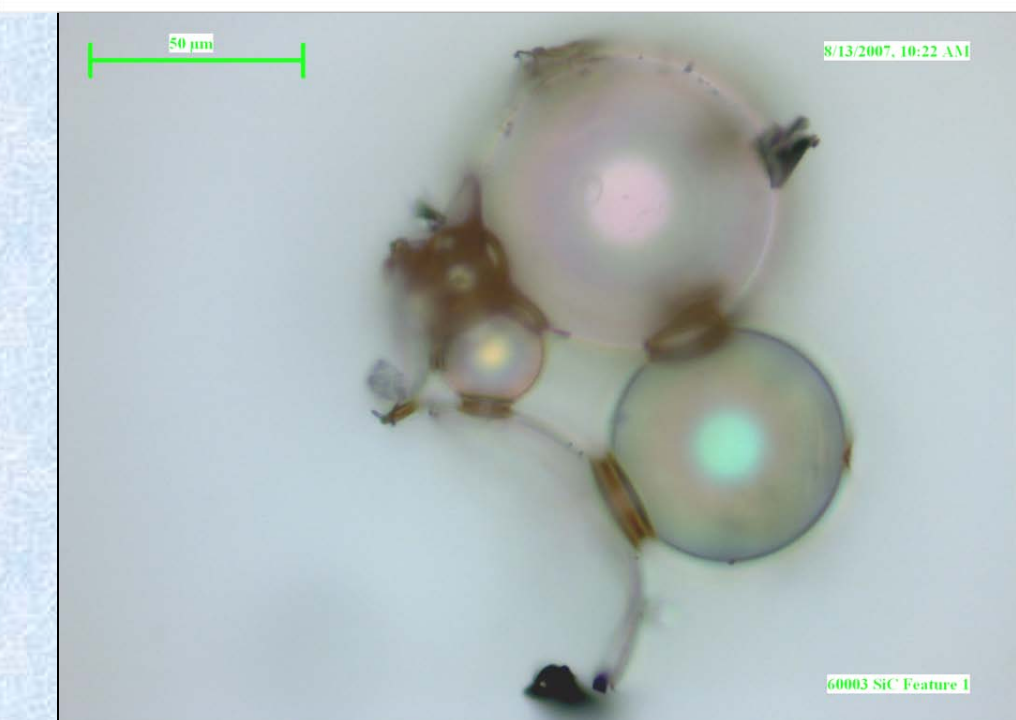


The image on the left is a possible piece of Kapton from the SRC on SiC 60001. (Scale bar ~ 200 µm).

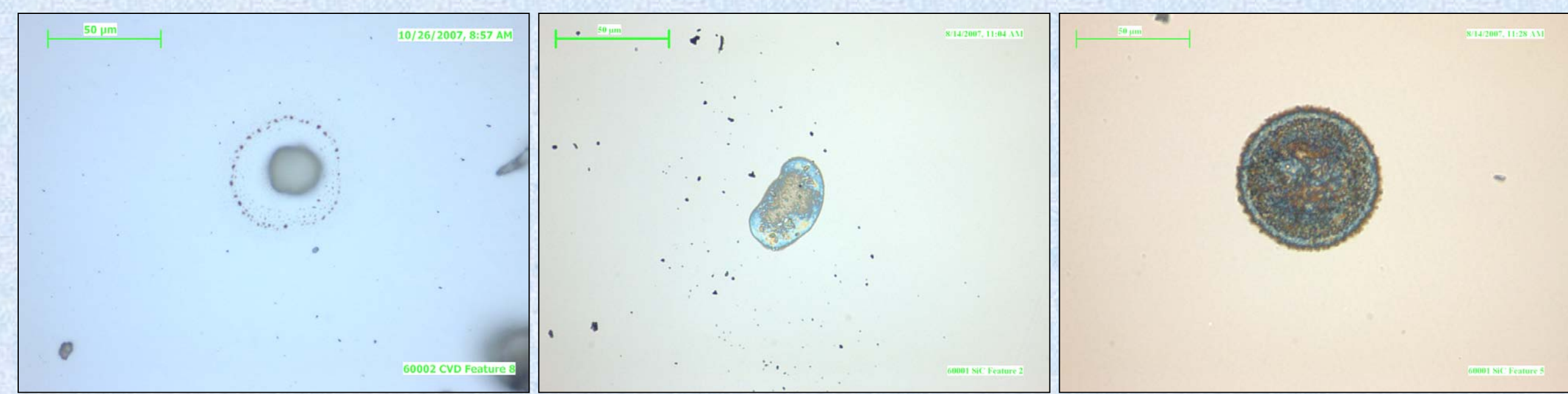
The image on the right shows the boundary between solar exposure (right) and an area covered by the gold cross (left) on CVD target at the focal point. (Scale bar ~ 500 µm). [3, 4]



Example of a Particle Feature Map

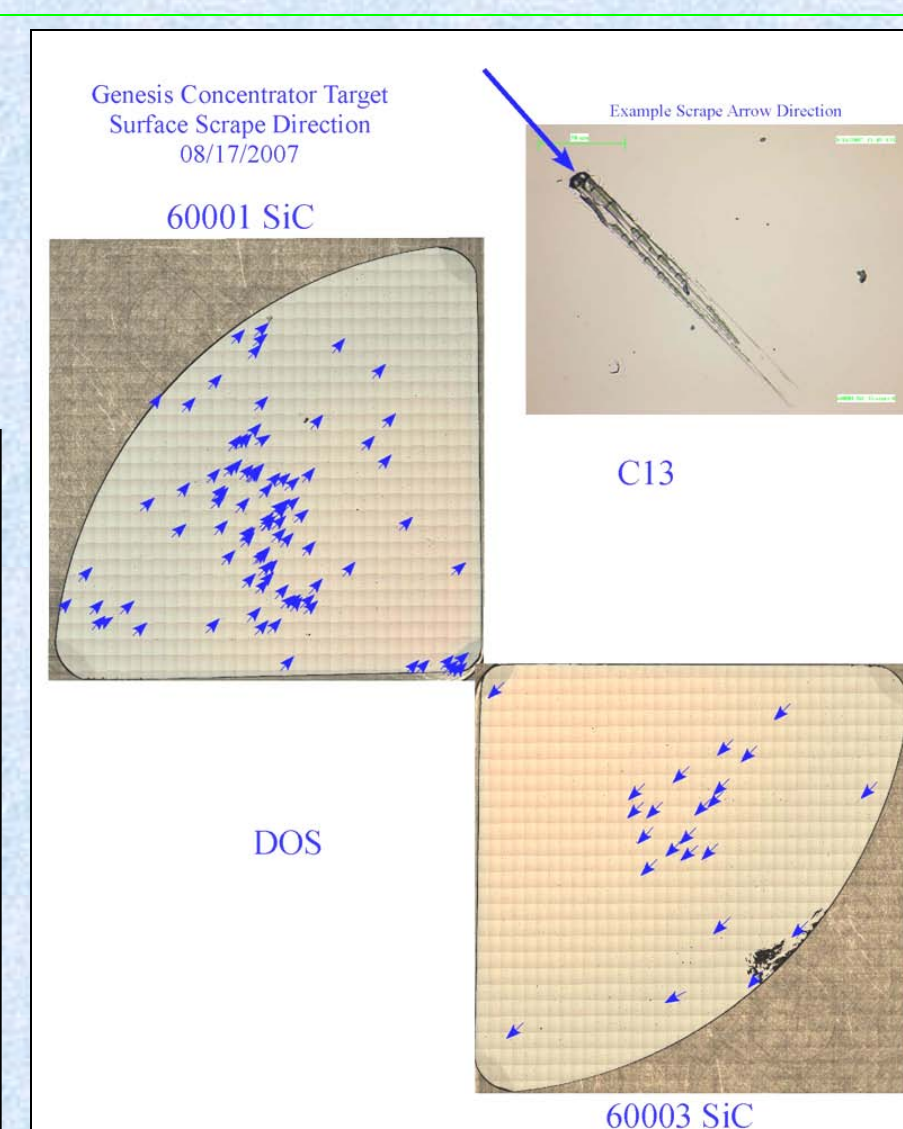
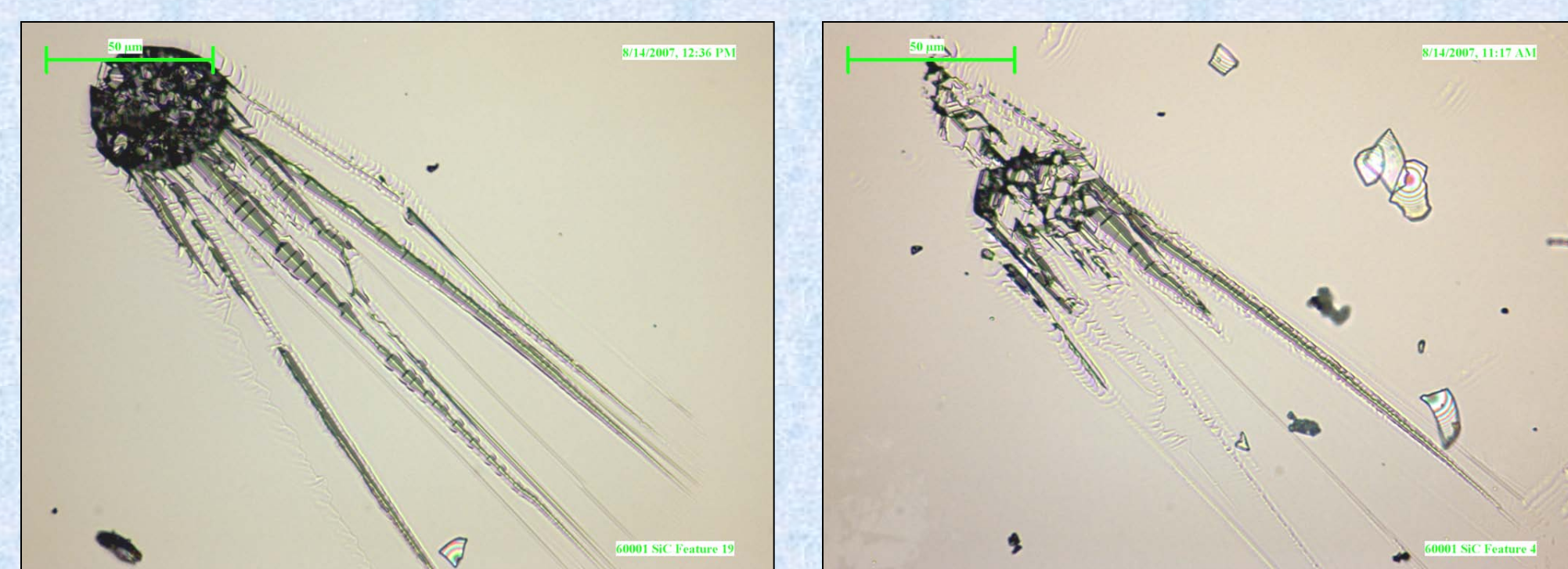


Above images show examples of microsphere contamination, most likely from the super-light ablator (SLA) material from the SRC. (Scale bar ~50 µm).



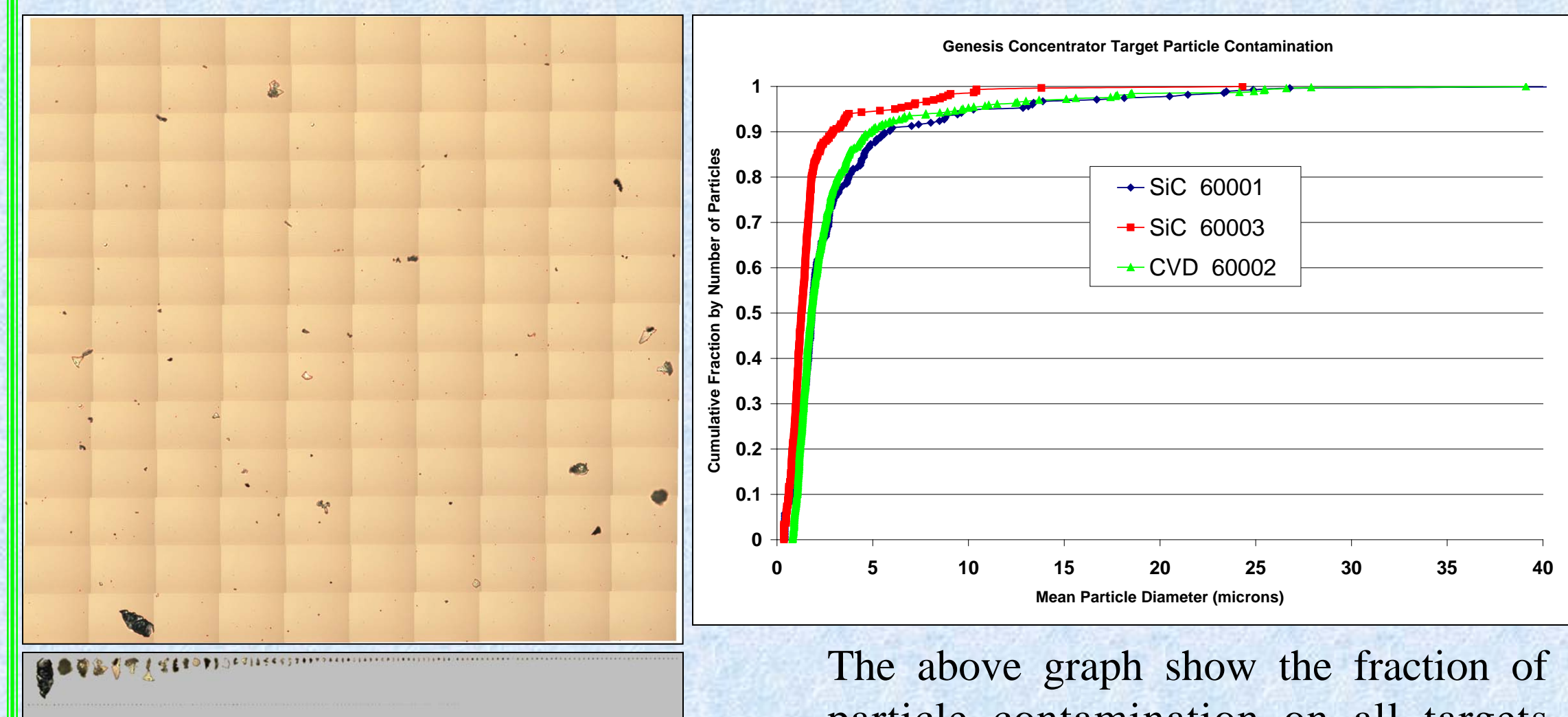
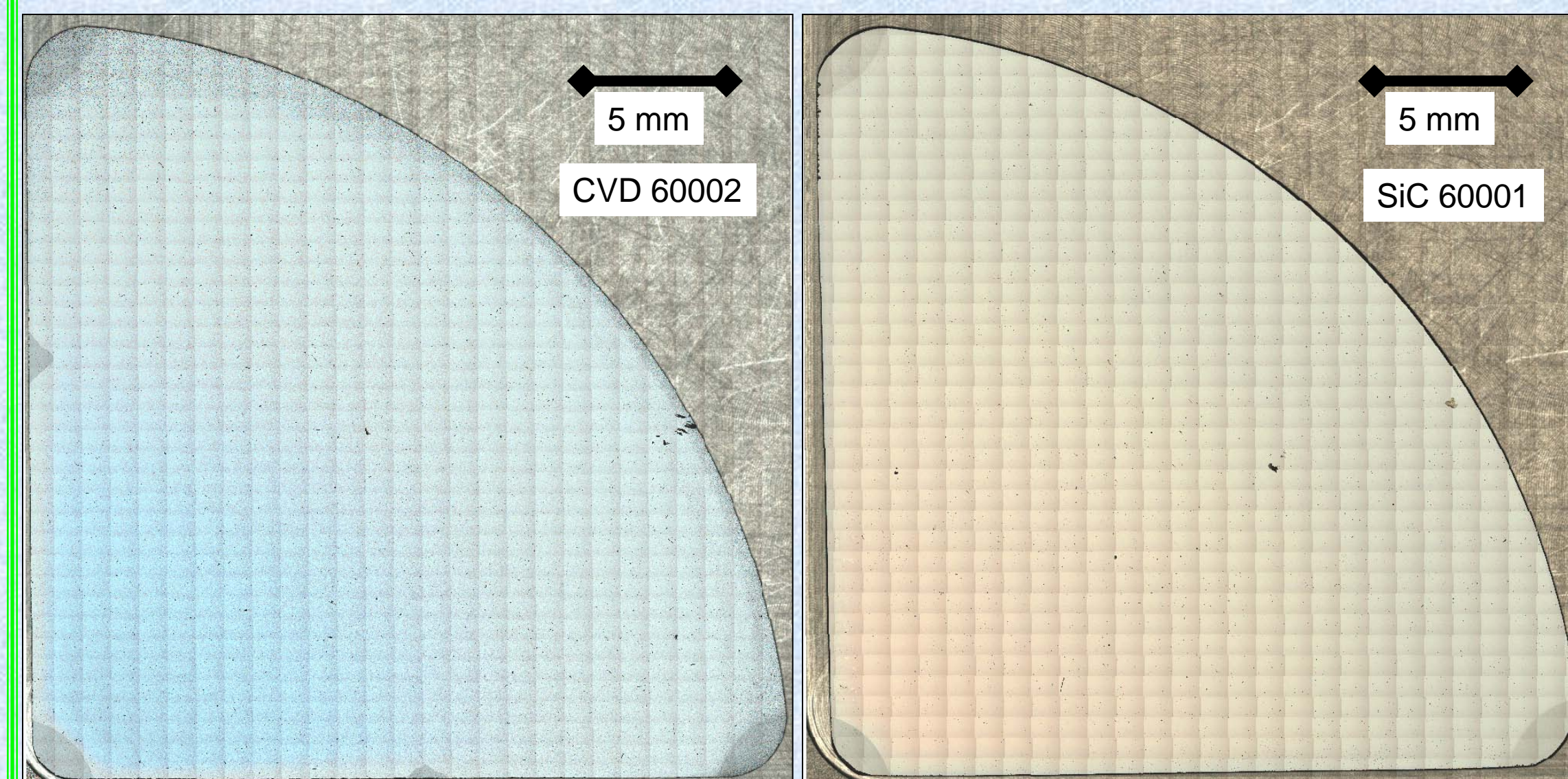
These five images show the various stains on the targets from either the moist sediment or SRC from the crash site. (Scale bar ~ 50 µm).

The images below show uniform surface scrapes that were found on both SiC targets (Scale bar ~ 50 µm). Further investigations showed that this feature were possibly a preflight feature caused by surface polishing as indicated by the map on the right.



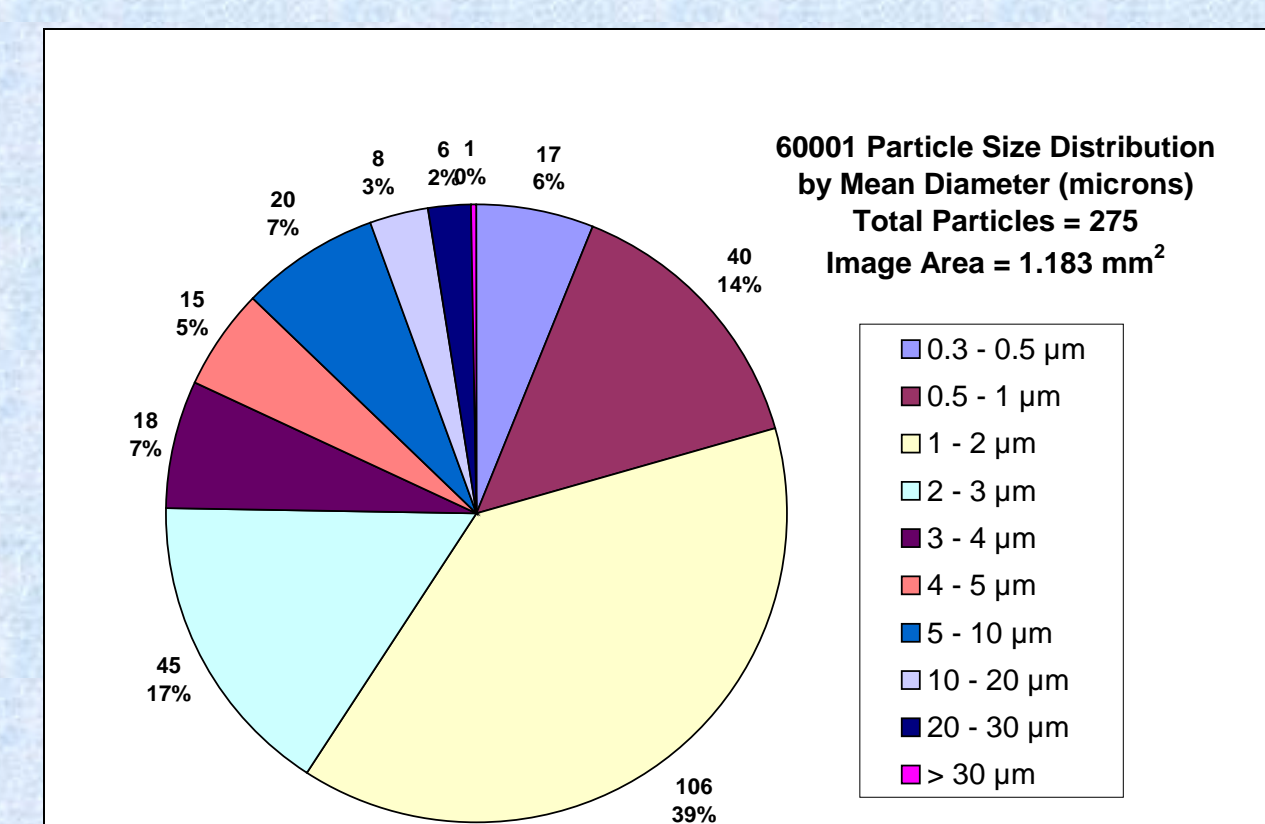
## Mosaic Mapping and Particle Counts

Full mosaic images were constructed for each target using Surveyor software interfaced with ImageProPlus software on the Leica DM6000M microscope using a 5X objective lens (see images below). In addition ~ 1 mm<sup>2</sup> areas were mosaic mapped with the 50X objective lens. ImageProPlus software was used to identify and count all particles > 0.3 µm in diameter within the ~ 1 mm<sup>2</sup> area. The following graphs show the particle distribution in the scanned area for each target material.

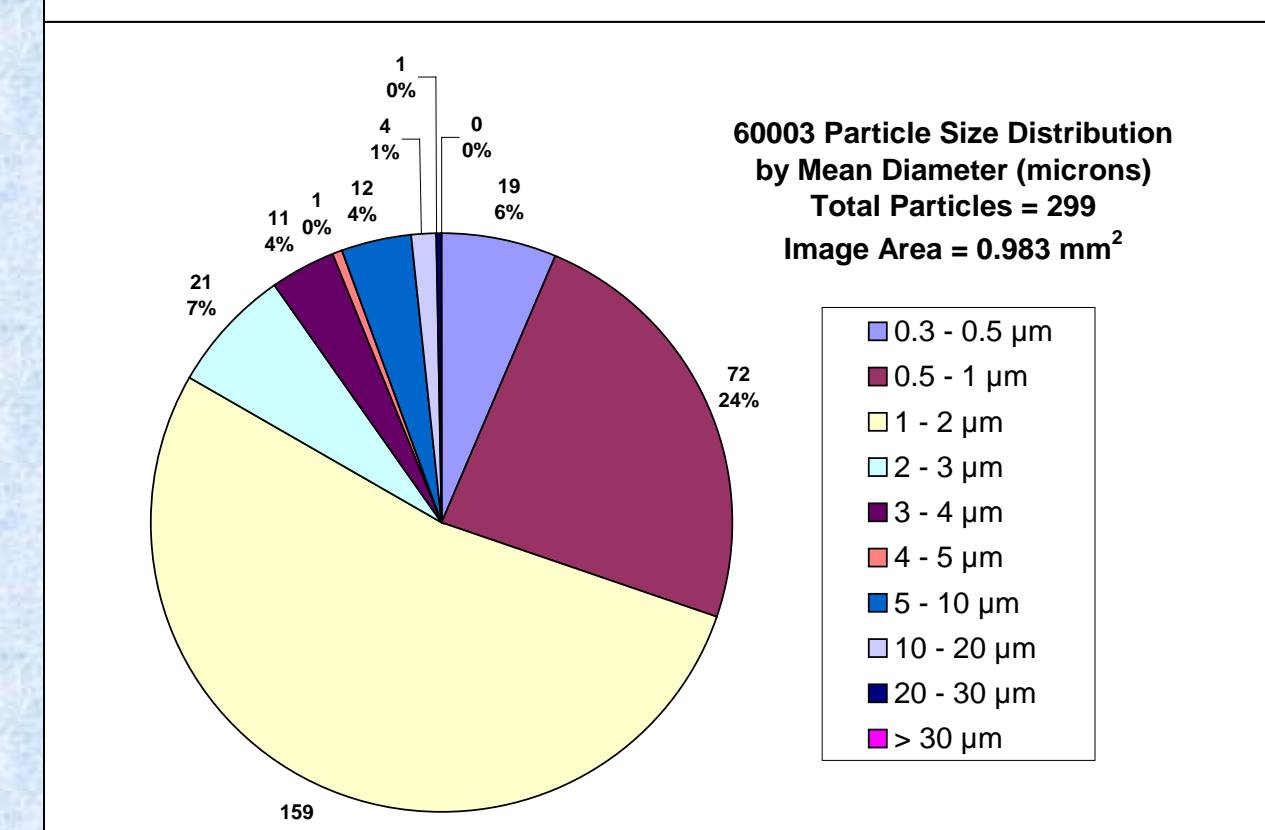


The above graph show the fraction of particle contamination on all targets sorted by mean particle diameter.

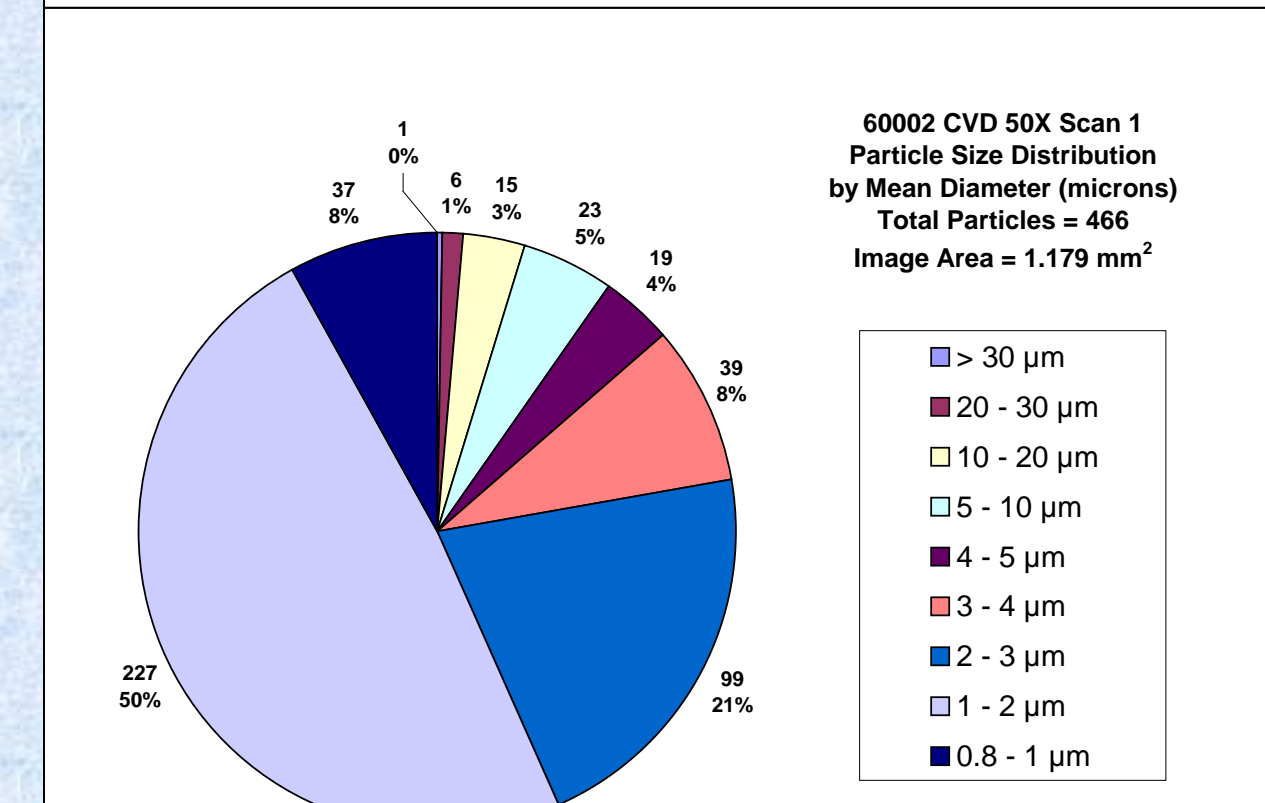
The above image show the 50X mosaic with particle trace and particle sorting. The area represents ~ 1 mm<sup>2</sup>.



SiC 60001 target graph shows that 88% of the particles are < 5 µm in diameter and 59% are < 2 µm in diameter.

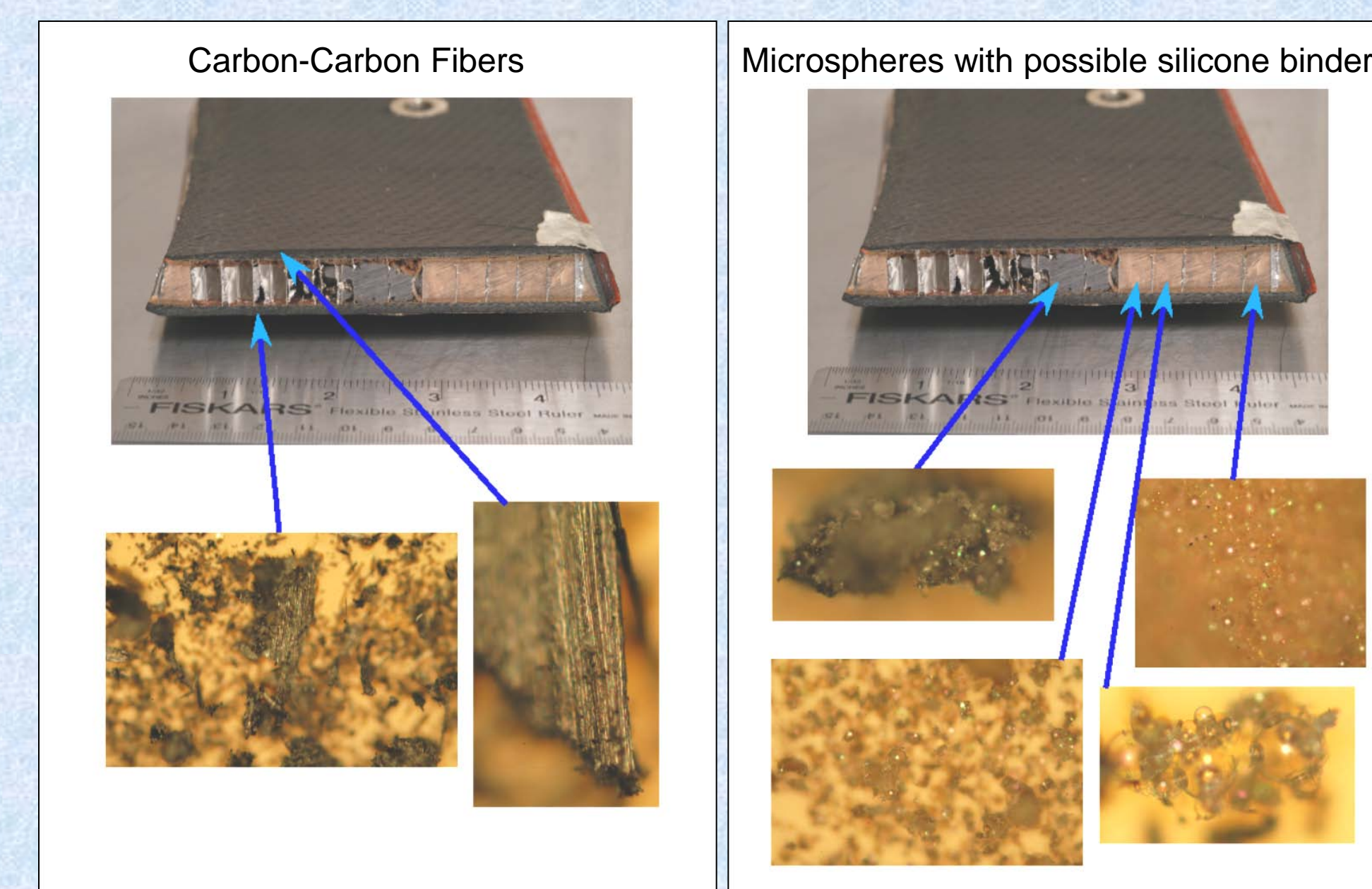


SiC 60003 target graph shows that 95% of the particles are < 5 µm in diameter and 84% are < 2 µm in diameter.

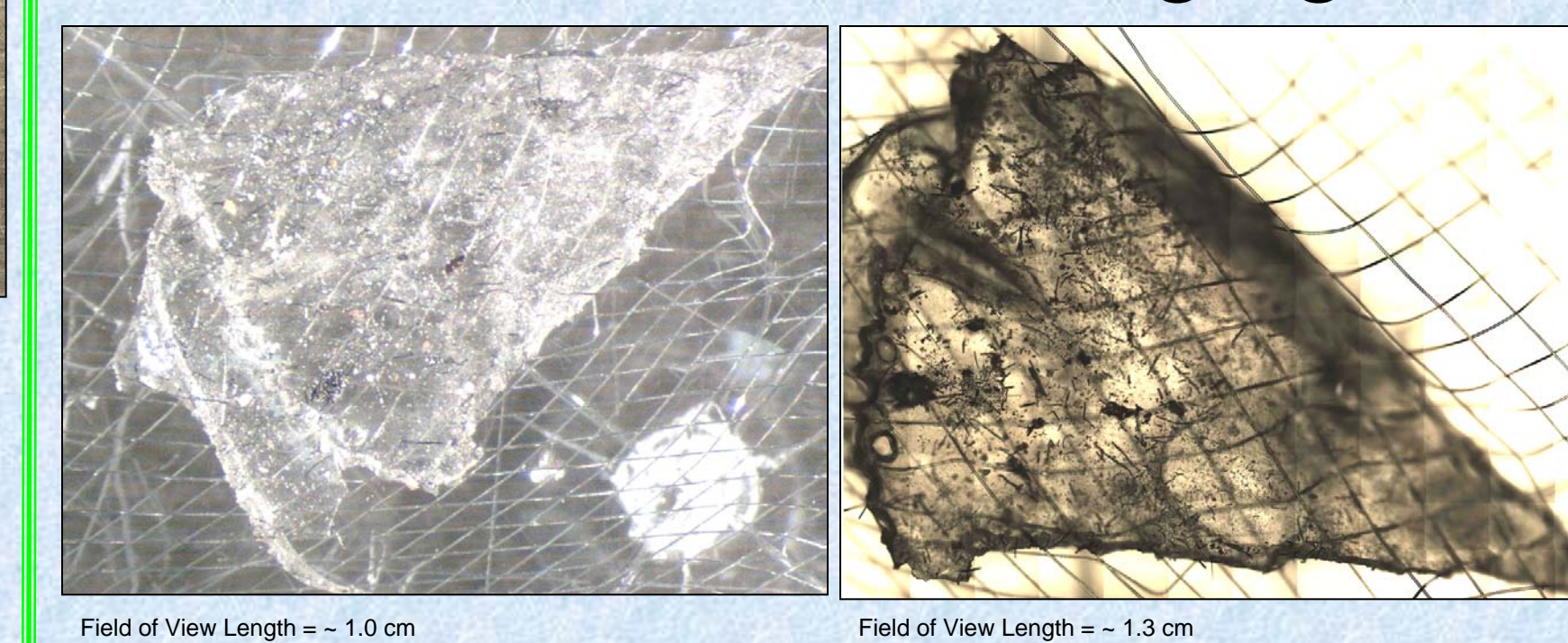


CVD 60002 target graph shows that 91% of the particles are < 5 µm in diameter and 58% are < 2 µm in diameter.

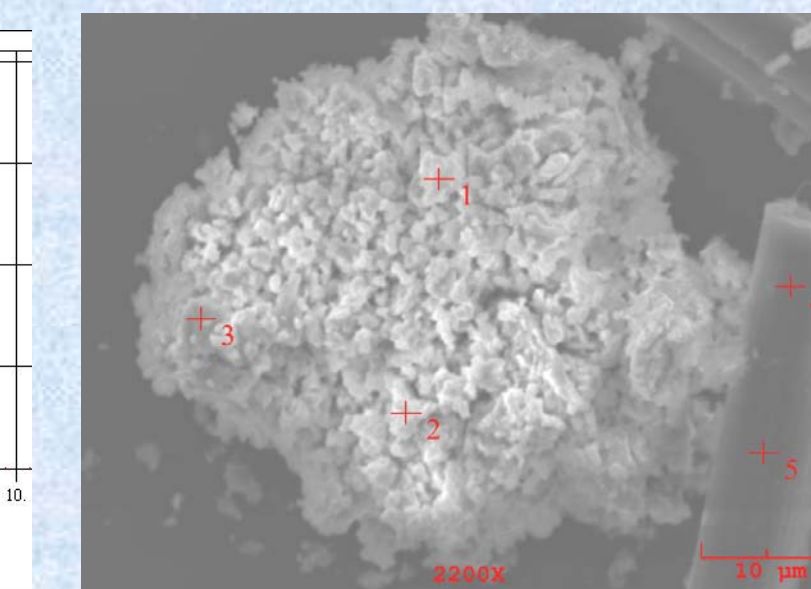
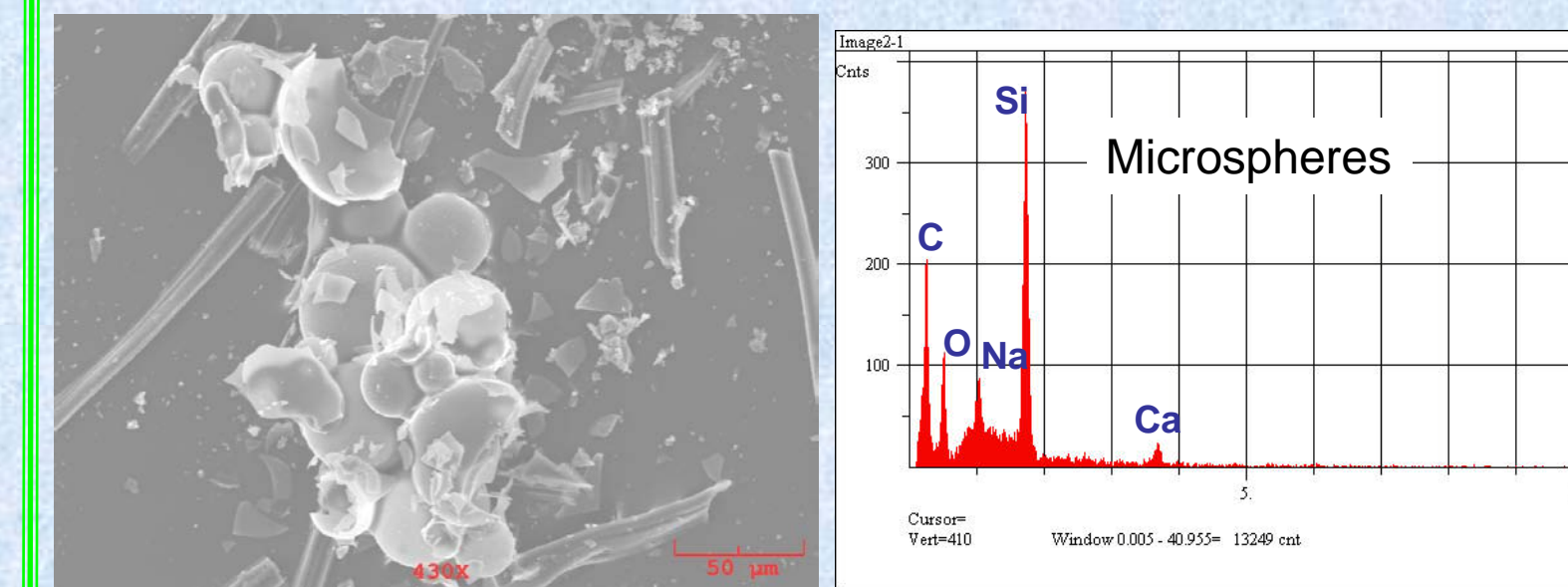
Non-flight reference SRC materials were examined for comparison with contamination found on the flown targets. Microscopic inspection shows that microspheres from the orange insulation foam and carbon-carbon fibers from the heat-shield from the SLA are similar to contamination found on the flown SiC and CVD targets.



## SEM Imaging and EDS Analysis

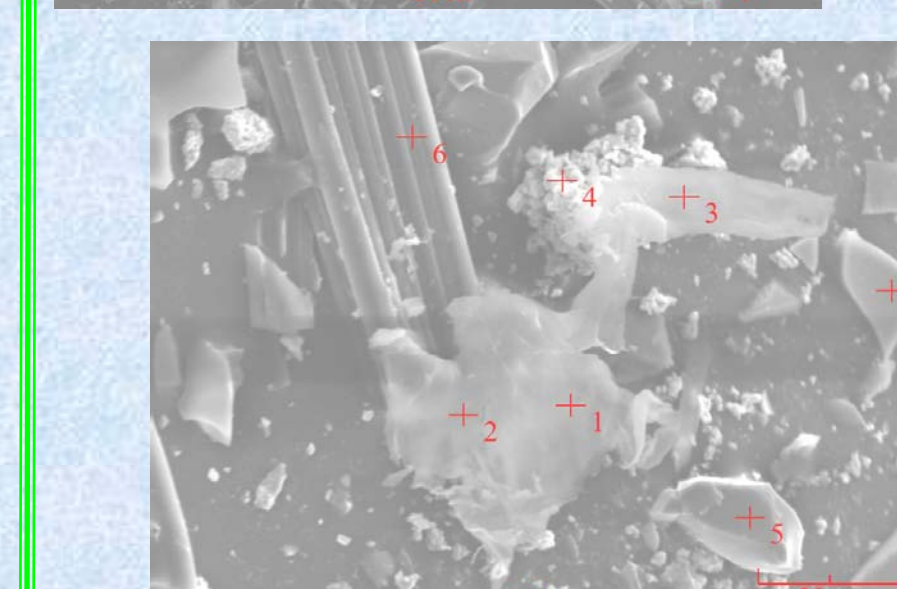


Genesis flown targets could not be examined in a SEM due to the probability of instrument induced contamination. Therefore, EDS analysis of surface particle contamination from the concentrator's flown acceleration grid was studied and compared with particles on the flown targets. The two images on the left show the transparent globular contamination analyzed in the SEM.

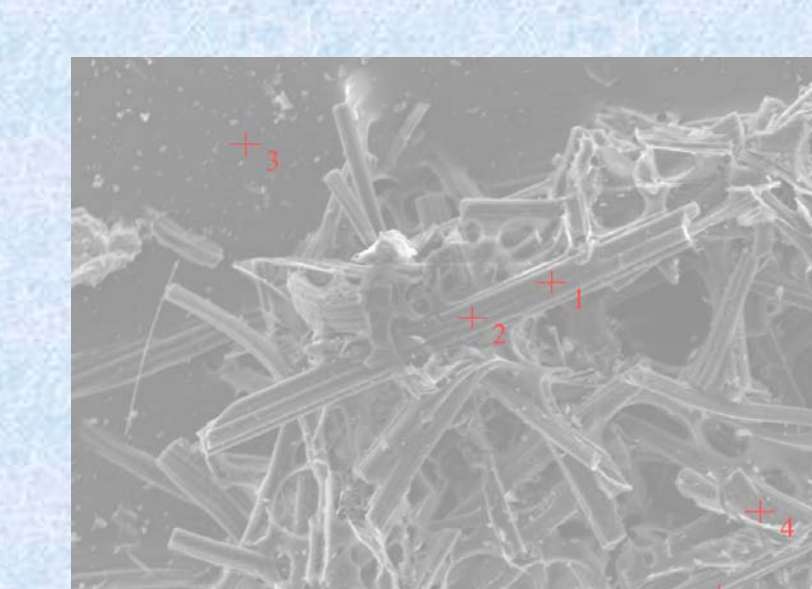


The chemical signature of spots 1-3 are consistent with white paint found on the SRC (see EDS plot). Spot 4 and 5 has a pure carbon signature with a morphology similar to carbon-carbon fibers from the heat shield.

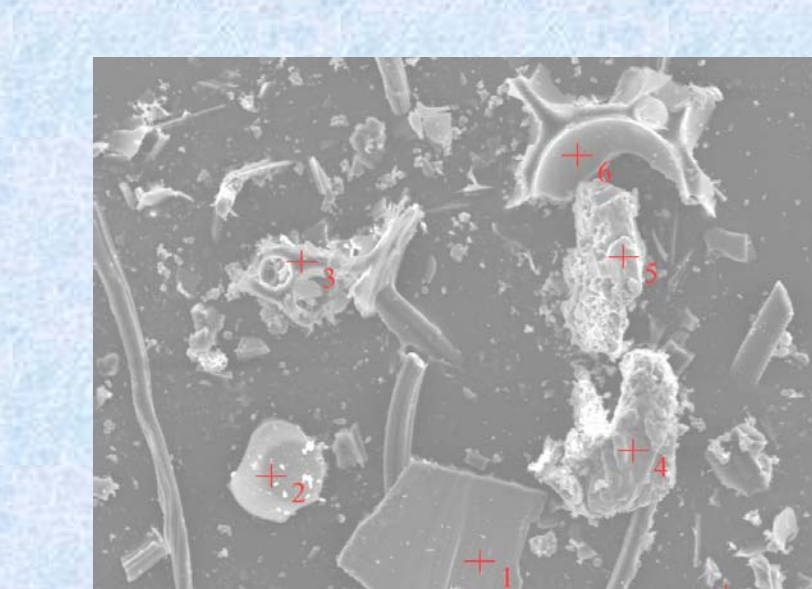
The two images (right) show that the morphology similar to microspheres found in the SLA SRC materials. The above EDS plot show that these microspheres are Si-rich spheres attached with a possible silicone binder.



Spot 1-3: carbon material (possible Kapton)  
 Spot 4: possible white paint  
 Spot 5: pure Al with (Al<sub>2</sub>O<sub>3</sub>)  
 Spot 6: carbon fiber  
 Spot 7: Si-rich with Ca and C



The SEM image above shows black carbon-carbon fibers from the SRC heat shield.



Spot 1 is a Si-array fragment  
 Spot 2, 3, 6 are Si-rich microspheres  
 Spot 4 and 5 are pure NaCl (halite)

**Summary:** The majority of surface particles were found to be < 5 µm in diameter with increasing numbers close to the optical resolution limit of 0.3 µm. Acceleration grid EDS results show that the majority of materials appear to be from the SRC shell and SLA materials which include carbon-carbon fibers and Si-rich microspheres in a possible silicone binder. Other major debris material from the SRC included white paint, kapton, collector array fragments, and Al. Image analysis also revealed that SRC materials were also found mixed with the Utah mud and salt deposits. The EDS analysis of the acceleration grid showed that particles < 1 µm where generally carbon based particles.

These studies were also used to help qualify Xylene cleaning SiC target 60001. In December 2007, the JSC team removed a large amount of particle contamination on SiC 60001 with a 10 minute ultra-pure Xylene sonication treatment under the guidance of Don Burnett and Dimitri Papanastassiou at JPL.

Chemical cleaning techniques with Xylene and HF in an ultrasonic bath are continuing to be investigated for removal of small particles by the Genesis science team as well as ultra-pure water megasonic wafer spin cleaning by the JSC team [5]. Removal of organic contamination from target materials are also being investigated and practiced by the science team with the use of UV-ozone cleaning devices at JSC and Open University [6].

References: [1] Burnett, D.S. et al. (2003) Space Science Reviews 102 (1-2), 1-28; [2] Wiens, R.C et al. (2003) Space Science Reviews 102(1-2), 93-118; [3] Calaway, M.J., et al. (2007) LPSC XXXVIII, Abstract # 1632; [4] Allton, J.H., et al. (2008) LPSC XXXIX; [5] Allton, J.H., et al. (2007) LPSC XXXVIII, Abstract # 2138; [6] Calaway, M.J., et al. (2007) LPSC XXXVIII, Abstract # 1627.