Goldstein Scholar Travel Award – Trip Summary

Awardee: Brendan Haas

The Goldstein Scholar travel award allowed me to travel to Washington DC to collaborate with Dr. Rhonda Stroud, the head of the Nanoscale Materials Section at the U.S. Naval Research Laboratory (NRL). The collaboration allowed us to combine my unique samples (FIB-thinned aluminum foils containing cometary residue from the NASA Stardust mission) with her state of the art electron microscopes and her expertise in operating them.

NASA's Stardust mission flew through the coma of comet 81P/Wild 2, collecting cometary material and successfully returning it to Earth in 2006. Cometary dust impacted aluminum foils on the spacecraft's ample collector, but it underwent extensive alteration due to the high collection velocity (6.1 km/s). The collected material is significant as it remains our only source of unambiguous cometary material, but has proven difficult to study due to the small sizes of the collected grains (often on the scale of microns) and the collection method.

Four craters were initially found at my home institution of Washington University in St. Louis and were elementally characterized using scanning electron microscopy (SEM) and energy dispersive electron spectroscopy (EDS) on a Mira Tescan SEM. These craters ranged in diameter from 1.5 to 4.8 μm and were then thinned to electron transparency (100-150 nm) with a FEI Quanta 3D Focused Ion Beam (FIB).

The Goldstein Scholar travel award allowed me to take my samples to NRL to work with Dr. Stroud on a Nion UltraSTEM 200 aberration-corrected scanning transmission electron microscope (STEM) and a JEOL 2200 FS STEM. The Nion STEM provided high-resolution annular dark field and bright field images of the narrow bands (10-100 nm) of cometary residue present in our FIB thin sections. Z-contrast in the images revealed an aggregate impactor with heterogeneities remaining post-impact on the scale of 10-30 nm. The JEOL STEM provided high-resolution EDS maps of the craters and the cometary residues.

STEM-EDS results showed a mixture of Mg-, Si-, Fe-, and S-rich components consistent with Mg-rich pyroxene and olivine combined with troilite and pyrrhotite. STEM imaging showed a lack of clear crystalline material. These results are consistent with glass embedded with metal and sulfides (GEMS) that are typically found in interplanetary dust particles. While proving the material was amorphous prior to impact is difficult, these results were consistent with our previous Stardust investigations and suggest that the cometary material contains a significant amorphous component.

These results and conclusions could not have been reached without the Goldstein Scholar travel award allowing me to travel to NRL and use their high-resolution instruments. I was able to learn how to use these STEM instruments are operated and to see the high level of detail they can reveal even in some of the smallest extraterrestrial materials ever collected. These results will be presented at the Microscopy and Microanalysis 2017 meeting in St. Louis.