SEARCH FOR PRESOLAR MATERIALS AND ISOTOPICALLY ANOMALOUS DIFFUSE INSOLUBLE ORGANIC MATTER IN SAMPLES FROM ASTEROID 101955 BENNU.

P. Haenecour[1], J. J. Barnes[1], L. R. Smith[1], D. Hills[1], E. Bloch[1], T. J. Zega[1], T. J. McCoy[2], M. S. Thompson[3], L. P. Keller[4], A. J. King[5], D. P. Glavin[6], J. P. Dworkin[6], A. N. Nguyen[4], H. C. Connolly Jr.[1,7,8], and D. S. Lauretta[1]. [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ (haenecour@arizona.edu). [2]National Museum of Natural History, Smithsonian Institution, Washington, DC. [3]Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, IN. [4]NASA Johnson Space Center, Houston, TX. [5]Natural History Museum, London, UK. [6]NASA Goddard Space Flight Center, Greenbelt, MD. [7]Department of Geology, Rowan University, Glassboro, NJ. [8]Department of Earth and Planetary Science, American Museum of Natural History, New York, NY.

Introduction: Carbonaceous asteroids allow us to study the original materials that formed the planets in the protoplanetary disk. They contain organic matter and (sub-)micrometer-size dust grains, called presolar grains, that condensed in the circumstellar envelopes of evolved stars and the ejecta of stellar explosions, such as novae and supernovae, before the formation of our Solar System. The isotopically anomalous organics are thought to have formed in the interstellar medium and the early Solar System [1]. Whereas presolar grains provide insight into the building blocks of our Solar System, studying organics can help us understand the origin of life on Earth [1, 2]. These organics might have contributed to ingredients that helped life emerge [2].

The return of samples from asteroid 101955 Bennu by NASA's Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) mission gives us a new opportunity to elucidate the formation mechanism(s) and evolution of organics, as well as the abundance and distribution presolar grains in carbonaceous asteroids. Here, we report on our ongoing work to characterize the isotopic and chemical compositions, microstructure, distribution, and abundance of insoluble organic matter (IOM) and presolar grains in Bennu samples. This work supports hypotheses 2 and 3 of the OSIRIS-REx Sample Analysis Plan [3].

Sample: The materials included in this work were collected from the exterior of the Touch-and-Go Sample Acquisition Mechanism (TAGSAM) on the avionics deck of the return capsule as part of the "quick-look" analyses [4]. We analyzed a polished mount with one 2-mm-sized particle (OREX-501062-100) and three aggregate samples prepared by pressing particles into high-purity gold mounted on an aluminum stub: OREX-501045-0, OREX-501049-0, and OREX-501057-0.

Analytical Methods: We conducted all the analyses in the Kuiper-Arizona Laboratory for Astromaterials Analysis (K-ALFAA) at the University of Arizona. Each sample was first characterized using a Keyence VHX-7000 digital 4K optical microscope and a Hitachi TM4000Plus tabletop scanning electron microscope (SEM). We first acquired overview reflected-light optical images and 3D topographical images of each sample. Using tabletop SEM, we collected back-scattered electron (BSE) images and energy-dispersive X-ray (EDX) spectroscopy elemental maps.

The samples are currently being analyzed in the CAMECA Next-Generation Nanoscale Secondary Ion Mass Spectrometer High-Resolution (NanoSIMS-HR) at the University of Arizona to search for isotopically anomalous diffuse IOM and presolar materials (e.g., silicate, oxide, SiC, graphite). Using chain analysis, we carry out raster ion imaging of $^{12,13}C^-$, $^{16,17,18}O^-$, and $^{12}C^{14,15}N^-$ secondary ions and secondary electrons in multi-collection mode. After presuttering at each location to remove the C-coating, raster images (10×10 μm^2) were acquired within the same area. The data is being processed using the L'Image© software.

Results and Discussion: As shown in Fig. 1, the particles pressed into high-purity gold are mainly composed of magnetite, hexagonal Fe-sulfide grains, carbonaceous matter, Mg-phosphates, and carbonate grains in a groundmass of Mg-rich phyllosilicate. We observed magnetite in several morphologies, including framboids, spherulitic/rosettes, plaquettes, and cubic. Carbonaceous matter is present both as nanoglobules [5] and more diffuse C-rich areas (Fig. 1). Mg-phosphate was also observed throughout the particles as larger (10-100s microns) and smaller (a few microns in size; Fig. 1s) white grains [6]. We also identified a pseudomorph melt spherule composed mainly of phyllosilicate, Fe-sulfide, chromite, and trace phosphides (Fig. 1) [7].

At the meeting, we will report on our ongoing search for isotopically anomalous IOM and presolar grains in Bennu samples.

Acknowledgments: Supported by NASA under award NNH09ZDA007O and contract NNM10AA11C.

References: [1] Glavin D. P. et al. (2018) doi: 10.1016/B978-0-12-813325-5.00003-3. [2] Floss C. & Haenecour P. (2016) doi: 10.2343/geochemj.2.0377. [3] Lauretta, D. S. et al. (2023) arXiv:2308.11794v1. [4] Zega et al. (2024) this meeting. [5] Nguyen A. N. et al. (2024) this meeting. [6] Barnes J. J. et al. (2024) this meeting. [7] Smith L. R. et al. (2024) this meeting.

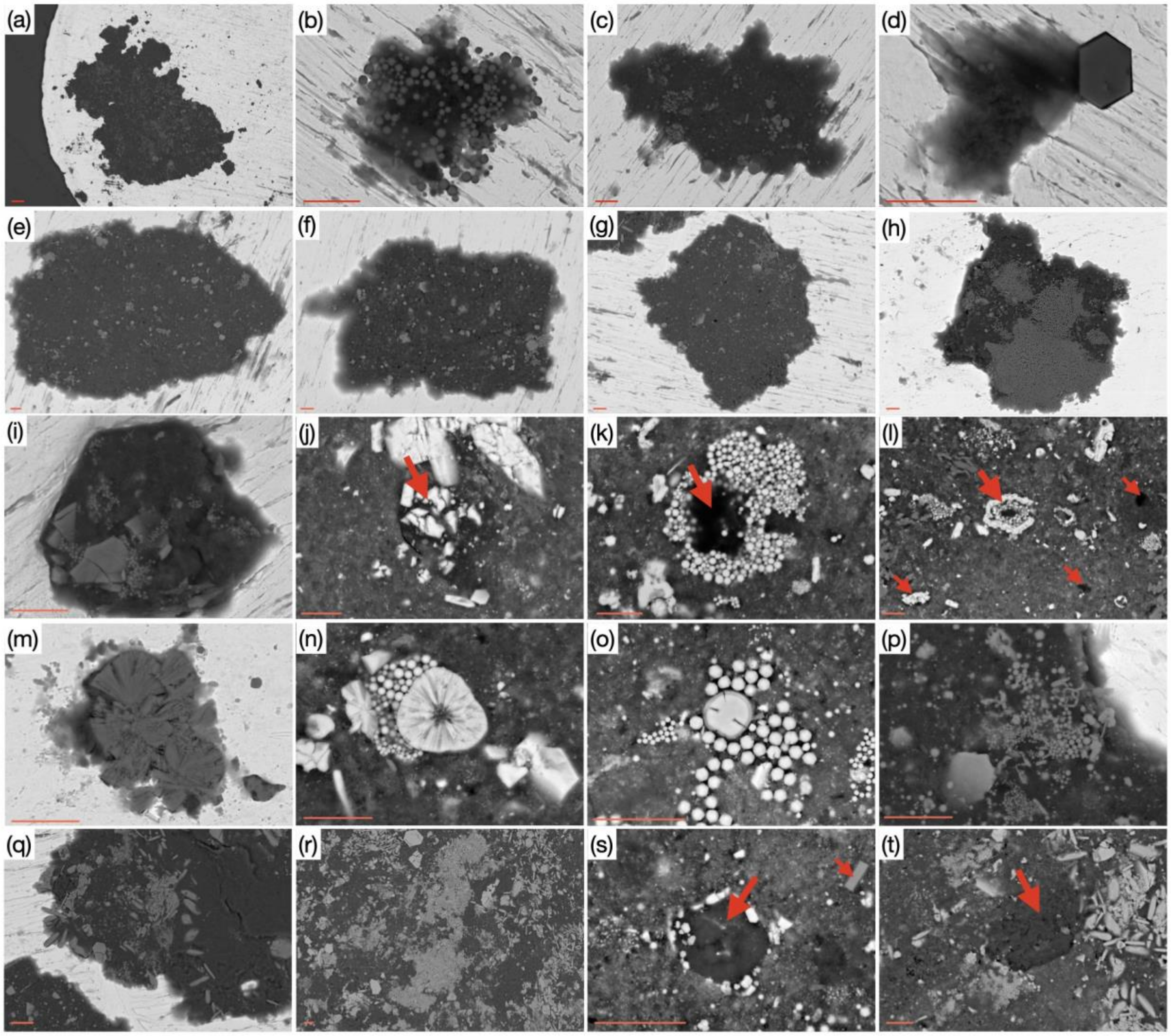

Fig. 1. BSE images of particles pressed into high-purity gold in samples OREX-501049-0 and OREX-501045-0. (a-i) Examples of particles pressed into gold in sample OREX-501049-0. (j-l) Diffuse IOM associated with sulfides, magnetite, and a mix of magnetite/sulfide, respectively. Panel (l) also shows circular C-rich domains resembling nanoglobules. (m-p) Example of magnetite morphologies (*e.g.*, framboids, spherulitic/rosettes and plaquettes). (q, r) Fe sulfides associated with magnetite framboids; (s) 10-µm pseudomorph melt spherule and a small Mg-phosphate plaquette; (t) Mg-phosphate. All red scale bars are 10 µm, except for panel (a), which is 100 µm.