Advances in astromaterials curation: Supporting future sample return missions. C. A. Evans[1], R. A. Zeigler[1], M. D. Fries[1], K.Righter[1], J. H. Allton[1], M. E. Zolensky[1], M. J. Calaway[2], and M. S. Bell[2], [1]NASA Johnson Space Center, 2101 NASA Pkway, Houston TX 77058, cindy.evans-1@nasa.gov, [2]Jacobs Engineering, NASA Johnson Space Center, 2101 NASA Pkway, Houston TX 77058.

Introduction: NASA's Astromaterials, curated at the Johnson Space Center in Houston, are the most extensive, best-documented, and least-contaminated extraterrestrial samples that are provided to the worldwide research community. These samples include lunar samples from the Apollo missions, meteorites collected over nearly 40 years of expeditions to Antarctica (providing samples of dozens of asteroid bodies, the Moon, and Mars), Genesis solar wind samples, cosmic dust collected by NASA's high altitude airplanes, Comet Wild 2 and interstellar dust samples from the Stardust mission, and asteroid samples from JAXA's Hayabusa mission. A full account of NASA's curation efforts for these collections is provided by Allen, et al [1]. On average, we annually allocate about 1500 individual samples from NASA's astromaterials collections to hundreds of researchers from around the world, including graduate students and post-doctoral scientists; our allocation rate has roughly doubled over the past 10 years.

The curation protocols developed for the lunar samples returned from the Apollo missions remain relevant and are adapted to new and future missions. Several lessons from the Apollo missions, including the need for early involvement of curation scientists in mission planning [1], have been applied to all subsequent sample return campaigns. From the 2013 National Academy of Sciences report [2]: "Curation is the critical interface between sample return missions and laboratory research. Proper curation has maintained the scientific integrity and utility of the Apollo, Antarctic meteorite, and cosmic dust collections for decades. Each of these collections continues to yield important new science. In the past decade, new state-of-the-art curatorial facilities for the Genesis and Stardust missions were key to the scientific breakthroughs provided by these missions."

The results speak for themselves: research on NASA's astromaterials result in hundreds of papers annually, yield fundamental discoveries about the evolution of the solar system (e.g. [3] and references contained therein), and serve the global scientific community as ground truth for current and planned missions such as NASA's Dawn mission to Vesta and Ceres, and the future OSIRIS REx mission to asteroid Bennu [1,3].

New advances in astromaterials curation: Our current and developing advanced curation initiatives build on our experience base that includes over 50 years of astromaterials curation planning and execution for multiple collections – each with unique requirements. Key areas of research include: 1) achieving and maintaining increasingly high levels of cleanliness – both inorganic and organic [4]. Our goal is to enable methods of analyses for all elements and relevant organic species. 2) Collaborate with mission teams on new high precision cleaning and validation techniques for sampling materials and witness plates, and continually document levels that we can achieve in our operating laboratories [5]. 3) Continue research on sample handling and containment technologies by participating in studies related to cross contamination and robotic sample handling solutions. 4) Design requirements for cold curation and conduct research that will enable preservation and handling of samples collected at extremely low temperatures. This is especially relevant to future lunar campaigns to permanently shadowed regions and comet sample return. On other fronts, we are enhancing database access and end-to-end documentation of data derived from NASA's astromaterials samples [6], planning for data restoration of legacy data sets, collecting and serving high resolution imagery, developing 3D imaging techniques (Fig. 1) [7,8], establishing an X-ray CT laboratory [9] and upgrading labs with web-based communication enabling remote access to our processing labs for investigators from around the world [10].

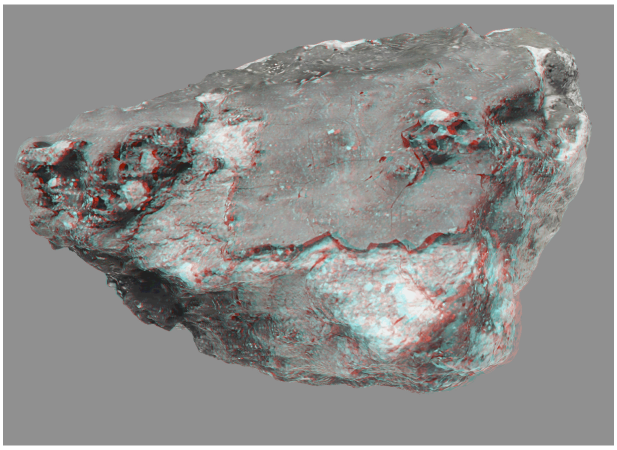

Figure 1. Blumenfeld et al. [7] Anaglyph Structure-From-Motion (SFM) 3D reconstruction of Apollo Lunar Sample 60639 produced from the high-resolution precision images (3D glasses required).

The above areas of advanced curation research are supporting initiatives for both existing collections, but also future missions like NASA's OSIRIS-REx mission (2016) to Bennu, a primitive and carbon-rich asteroid and JAXA's Hayabusa-2 mission. In the future, our evolving curation protocols will be applied to the curation and handling of samples from challenging exploration destinations such as the surface of Mars, a comet nucleus, south pole region of the Moon, or icy moons of the outer planets.

References: [1] Allen C. A. et al. (2011) *Chemie de Erde, 71,* 1-20, [2] NRC Decadal Survey (2013) http://solarsystem.nasa.gov/2013decadal/,
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