Research-Grade 3D Virtual Astromaterials Samples: Novel Visualization of NASA's Apollo Lunar Samples and Antarctic Meteorite Samples to Benefit Curation, Research and Education

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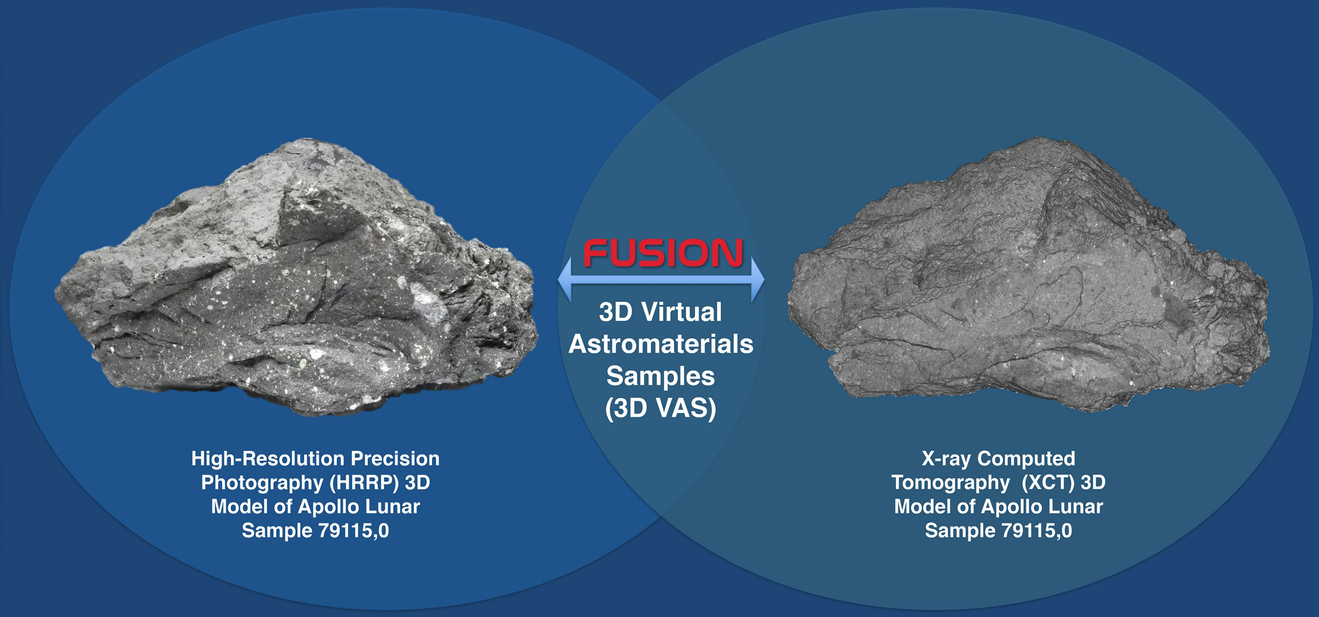
Introduction

NASA's vast and growing collections of astromaterials are both scientifically and culturally significant, requiring unique preservation strategies that need to be recurrently updated to contemporary technological capabilities and increasing accessibility demands. New technologies have made it possible to advance documentation and visualization practices that can enhance conservation and curation protocols for NASA's Astromaterials Collections.

Objectives

Our objective is to create virtual 3D Virtual Astromaterials Samples (3D VAS) reconstructions of Apollo Lunar and Antarctic Meteorite samples that are a fusion of two state-of-the-art data sets: the interior view of the sample by collecting Micro X-ray Computed Tomography (XCT) data and the exterior view of the sample by collecting High-Resolution Precision Photography (HRPP) data. These new data offer the research community an information-rich visualization of both compositional and textural information prior to any physical sub-sampling.



Methods

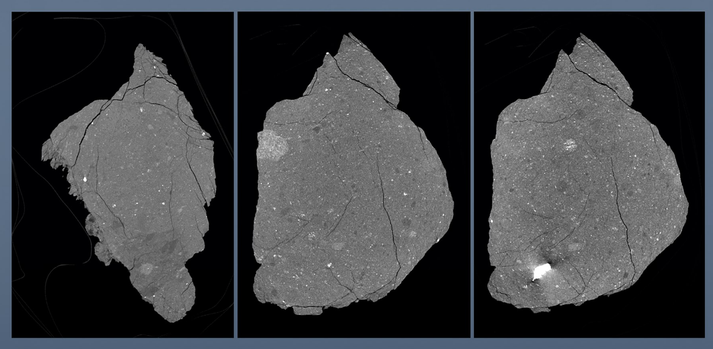
We are an interdisciplinary team with expertise in the fields of professional photography, heritage conservation practices, geoscience, astromaterials curation, photogrammetry, imaging science, x-ray computed tomography, application engineering, and data curation. Since 2013 we have been working to establish new curation protocols to create 3D VAS. Initial results demonstrated the successful creation of the first image-based 3D reconstruction of an Apollo Lunar Sample (60639) correlated to a 3D reconstruction of the same sample's XCT data. In May of 2016 we began a 3-year NASA-funded project to produce 3D VAS for 60 high-priority Apollo Lunar and Antarctic Meteorite samples and serve them on NASA's Astromaterials Acquisition and Curation website.

- Our method uses three primary existing technologies: High-Resolution Precision Photography (HRPP), Structure-From-Motion Photogrammetry (SFM) and Micro X-Ray Computed Tomography (XCT).
- HRPP provides exceptional detail and reliable fidelity of the sample being photographed, and allows for calibration of the equipment to eliminate distortion.
- SFM provides off-the-shelf software to produce 3D reconstructions of the HRPP images using photogrammetric principles.
- XCT provides a complete volume data set of the sample, where brightness of textural features is related to its density and composition.
- Initial efforts in aligning the coordinate system to combine these two data sets and achieve the 3D VAS have been successful. The process computes and applies the six degrees-of-freedom transformation of a sample's SFM-derived data into the XCT data coordinate system of the same sample, resulting in simultaneous visualization of the sample's exterior texture and internal composition.

Results

Our research continues to demonstrate that research-grade 3D Virtual Astromaterials Samples (3D VAS) are beneficial in preserving for posterity a precise 3D reconstruction of the sample prior to sub-sampling. This protocol greatly improves documentation practices by providing unique and novel visualization of the sample's interior and exterior features. As we continue to improve the fidelity and resolution of our system in advance of the creation of the final models, we are assured that we will be offering scientists an unprecedented research tool for preliminary investigation and targeted sub-sample requests. Additionally, this project yields 3D models that are a visually engaging and interactive tool for bringing astromaterials science to the public. With new sample return missions on the horizon, it is of primary importance to develop advanced curation standards for documentation and visualization methodologies. All 3D VAS models and original data will be served on NASA's Astromaterials Acquisition and Curation website (https://curator.jsc.nasa.gov) and is set to launch in 2019.

Views of JSC Lunar Lab setup with Apollo Sample 79115,0 being imaged. Astromaterials curation protocol requires samples to be stored in a multi-clean room facility and kept in nitrogen cabinets during the photographic process. We have designed and built new hardware and developed methods to achieve a singular coordinate system to fuse the resulting two data sets into one 3D VAS. Camera remains outside the cabinet and images are taken through the optical glass of the Scientific Observation Port. Sample is imaged at 15-degree intervals at several elevations



Three XCT scans of Apollo Lunar Sample 79115,0. XCT provides a complete volume data set of the sample, where brightness of textural features is related to the sample's density and composition. Research Year 1 sample selections, including 9115,0, were scanned at UTCT Facility at UT Austin's Jackson School of Geosciences. Research Year 2 & 3 sample selections will be scanned on the new in-house state-of-the-art Micro-XCT scanner at NASA's Astromaterials Acquisition & Curation Office at Johnson Space Center (JSC).

References

[1] Blumenfeld E. H. et al. (2014) *Metsoc 77*, Abstract #5391. [2] Blumenfeld E. H. et al. (2015) *46th LPSC*, Abstract #2740. [3] Blumenfeld E. H. et al. (2016) *AGU Fall Meeting*, Abstract #190585. [4] Allen C. et al. (2011) *Chemie der Erde, 71*, 1-20. [5] Ketcham R. A. et al. (2001) *Computers and Geosciences, 27,* 381-400. [6] Beaulieu K. R. et al. *48th LPSC*, Abstract #2649.