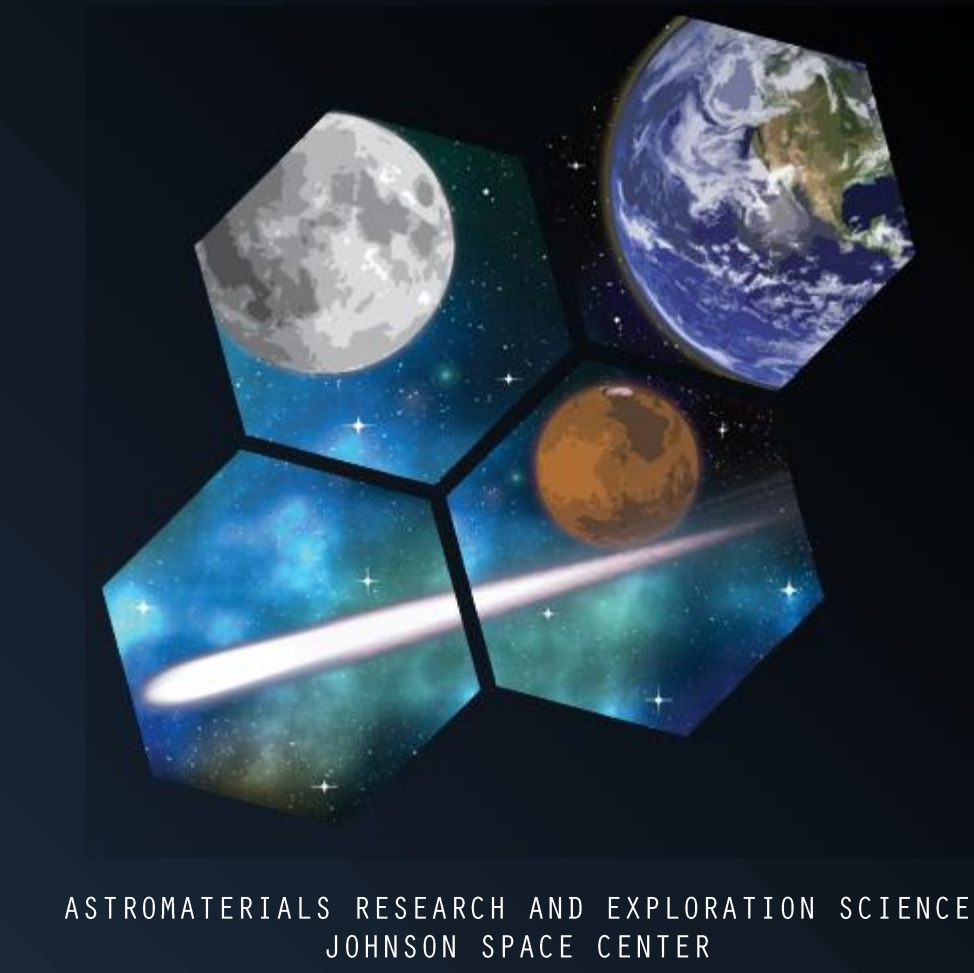
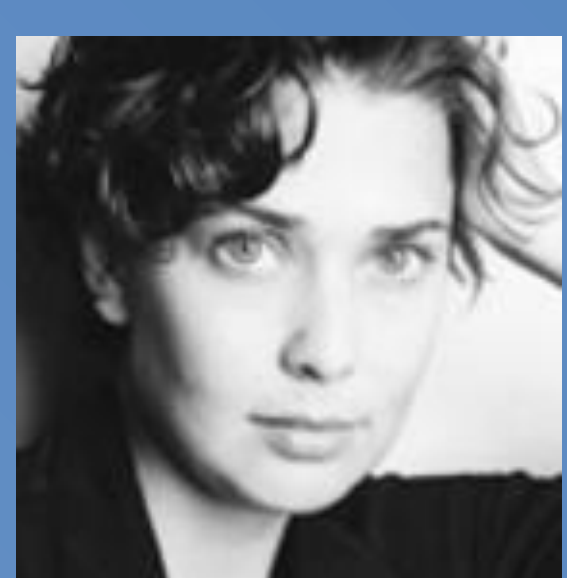


VISUALIZATION OF FUSED STRUCTURE FROM MOTION AND MICRO X-RAY COMPUTED TOMOGRAPHY DATA SETS FOR NOVEL 3D VIRTUAL ASTROMATERIALS SAMPLES COLLECTION OF NASA'S APOLLO LUNAR AND METEORITE SAMPLES



Kevin Beaulieu



Erika Blumenfeld

K.R. Beaulieu¹, E.H. Blumenfeld², A.B. Thomas³, D.A. Liddle³, E.R. Oshel⁴, C.A. Evans⁵, R.A. Zeigler⁵, K. Righter⁵, R.D. Hanna⁶, R.A. Ketcham⁶. ¹Barrios Technology—JETS Contract, NASA Johnson Space Center, Houston TX 77058 (kevin.r.beaulieu@nasa.gov), ²LZ Technology—JETS Contract, NASA Johnson Space Center, Houston TX 77058, ³HX5 LLC—JETS Contract, NASA Johnson Space Center, Houston TX 77058, ⁴Jacobs, NASA Johnson Space Center, Houston TX 77058 ⁵NASA Johnson Space Center, Houston TX 77058, ⁶UTCT Facility, Jackson School of Geosciences, University of Texas at Austin, Austin TX, 78712.

INTRODUCTION

Our team continues to develop streamlined processes to collect, process and visualize new high-resolution precision photography (HRPP) and X-ray computed tomography (XCT) data of NASA's Apollo Lunar and Antarctic Meteorite samples for the 3D Virtual Astromaterials Samples (3DVAS) Collection project. The goal of the 3DVAS project is to create a digital database of research-grade 3D models of combined HRPP and XCT datasets for 60 of NASA's Apollo Lunar and Antarctic Meteorites, which will be available to researchers and the public via NASA's Curation website [1, 2, 3, 4, 5, 6, 8, 9].

OBJECTIVE

The main objective is accurate fusion and subsequent visualization of two unique data sets - 3-dimensional Micro X-Ray Computed Tomography (XCT) internal composition data and a Structure-From-Motion (SFM) high-fidelity, textured external polygonal model of Apollo Lunar Sample 79115,0. The developed process utilizes innovative all-in-one functionality now available in off-the-shelf software VG Studio Max (VGS-MAX), providing a platform to "slice through" a photo-realistic rendering of a sample to analyze both its external visual and internal composition simultaneously.

Apollo Lunar Sample 79115,0



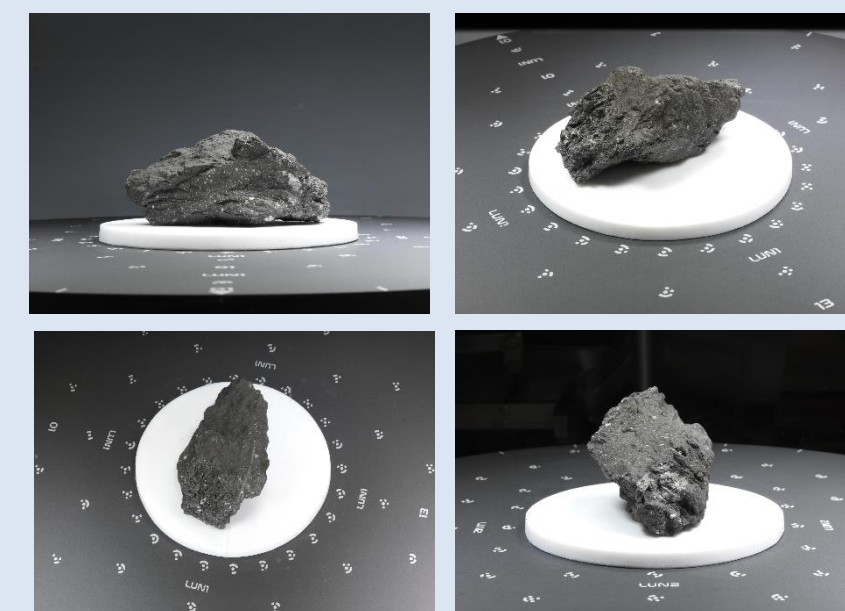
HRPP Image: HRPP_79115-0_2017-08-02_0001-HighPass5.tif
79115,0 is classified as a medium gray soil regolith breccia, was collected during Apollo 17 on the rim of the Van Serg Crater [2] and is currently stored at NASA Johnson Space Center's Lunar Sample Laboratory Facility in the Astromaterials Acquisition & Curation Office [7].

DATA & METHODS

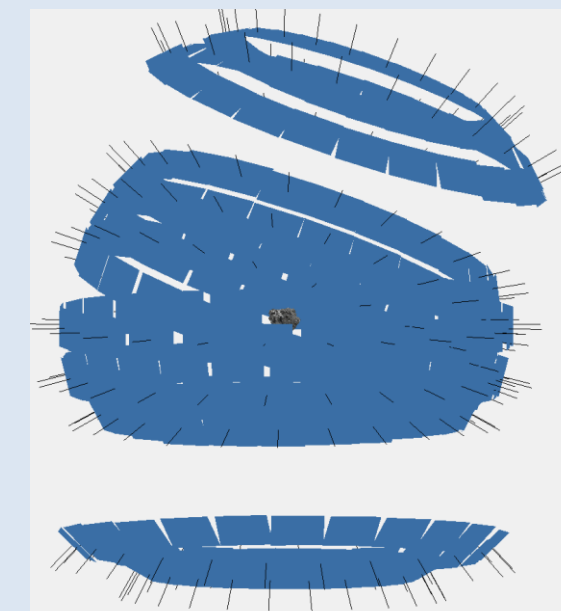
High-Resolution Precision Photography (HRPP) & Structure From Motion (SFM) Data Products



HRPP Data Acquisition



HRPP 240 60-Megapixel TIFF images
Hasselblad H4D-60
NASA Lunar Sample Laboratory



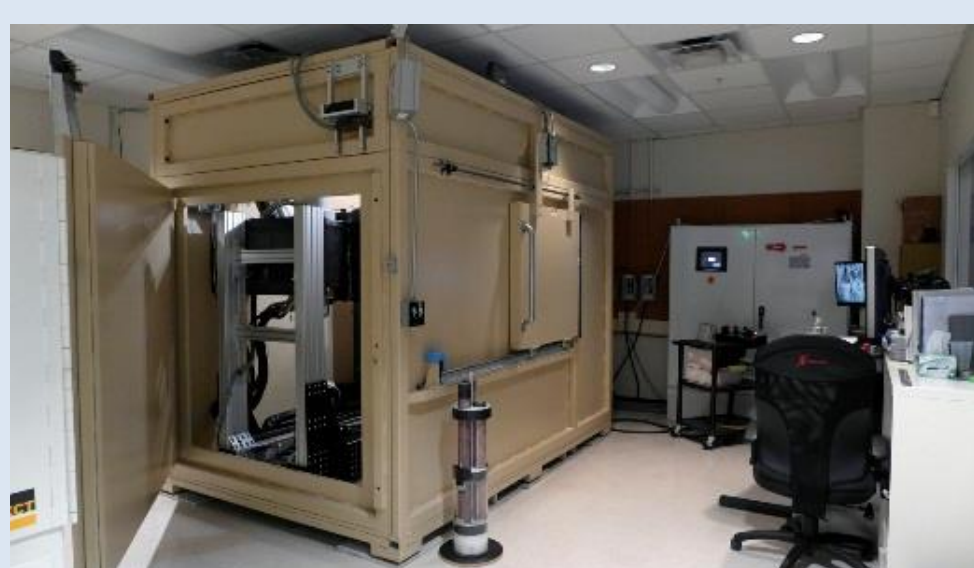
SFM Photogrammetric Triangulation
Agisoft PhotoScan



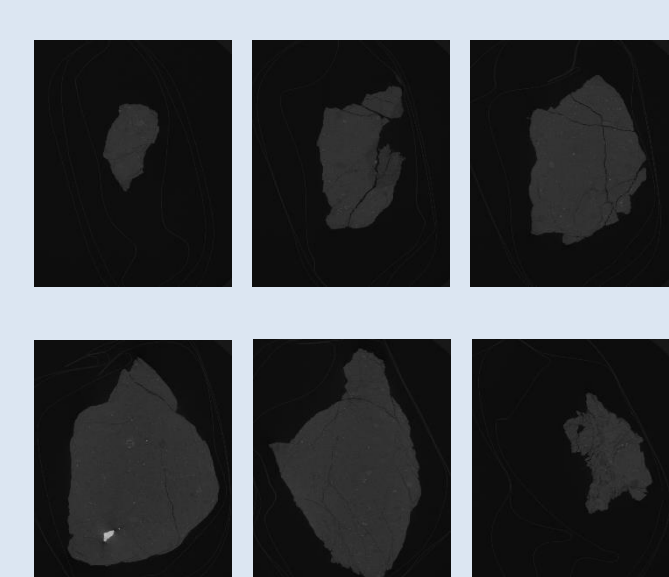
High-Fidelity, Textured Polygonal Model
Agisoft PhotoScan

Registration

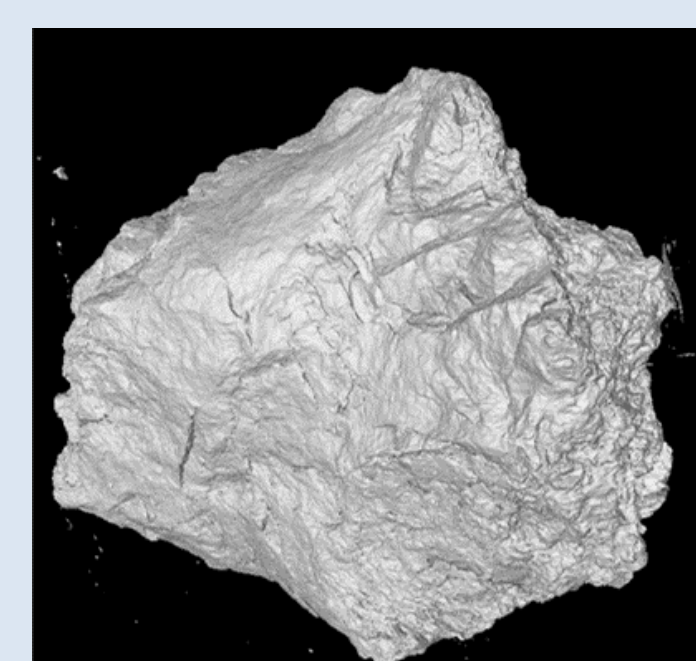
Micro X-Ray CT (XCT) Data Products



XCT Data Acquisition



XCT Data:
1,929 16-bit TIFF
imagery "slices"



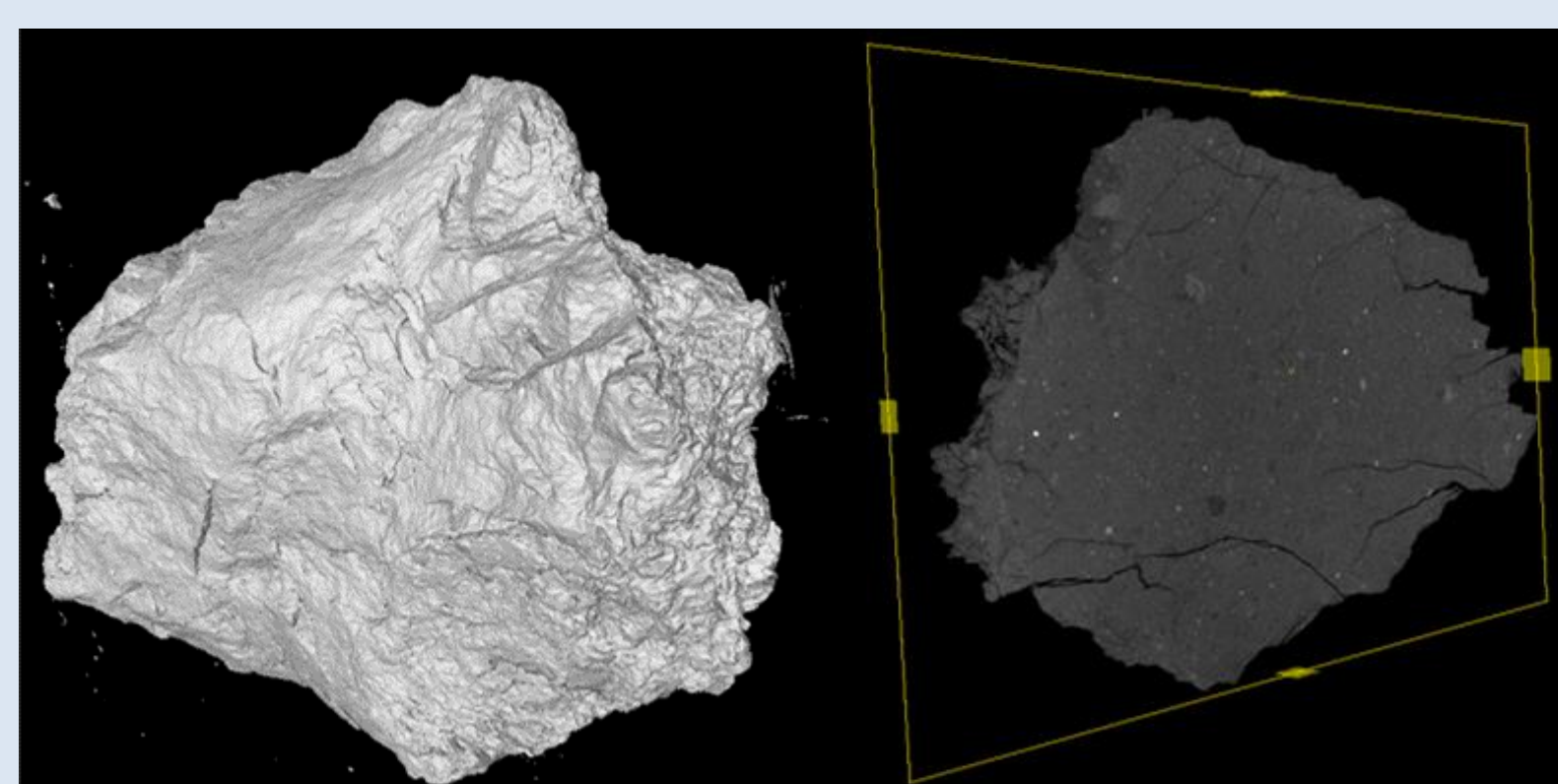
Isosurface Model
Volume Graphics VG STUDIO MAX

RESULTS & DISCUSSION

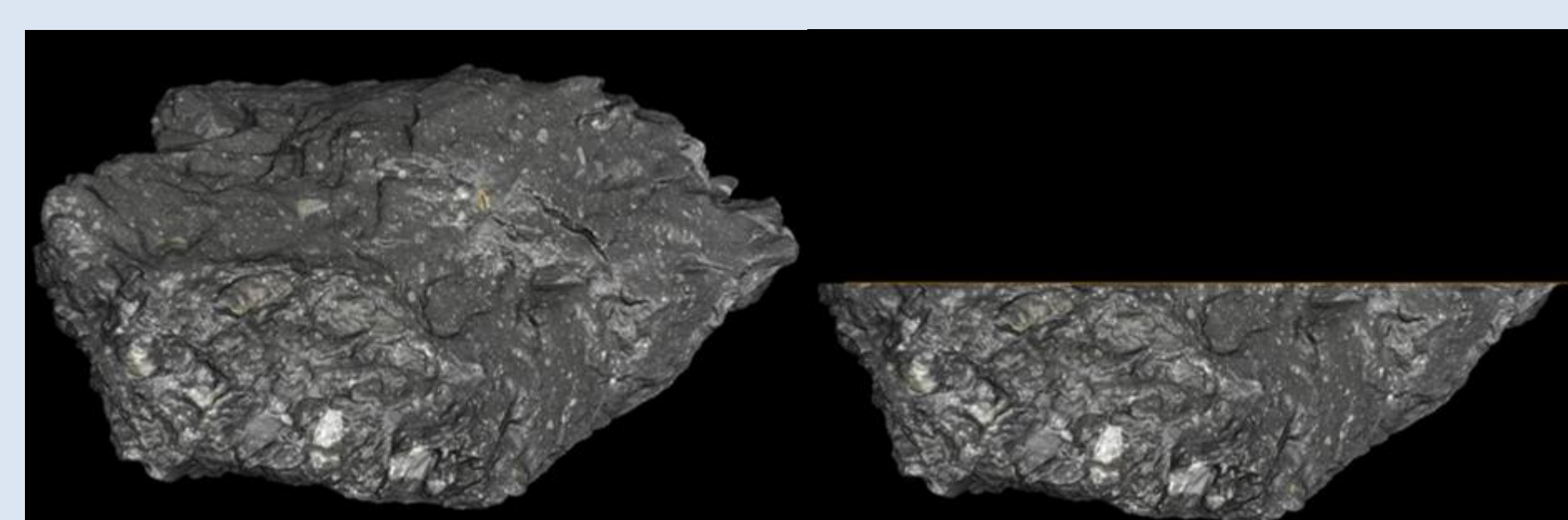
Through this effort, a streamlined process for XCT 3-D reconstruction, XCT/SFM data fusion and slice visualization within a single software package, VGS-MAX, has been developed. We have achieved successful fusion of the two datasets for Apollo Lunar Sample 79115,0 into one coordinate system using an improved technique from our first efforts [4, 8]. We used HRPP and XCT data acquired from Lunar Sample 79115,0 to develop and further our procedure in combining the two datasets. The VGS-MAX best fit registration algorithm has yielded accurate fusion of 79115,0 XCT 3-D reconstruction and SFM model data sets.

The results allow for a novel visualization of 79115,0 and the rest of the 3D VAS Collection using data acquired with high-resolution modern photography and X-ray CT data acquisition systems, to be served on NASA's Astromaterials Acquisition and Curation website: <https://curator.jsc.nasa.gov>.

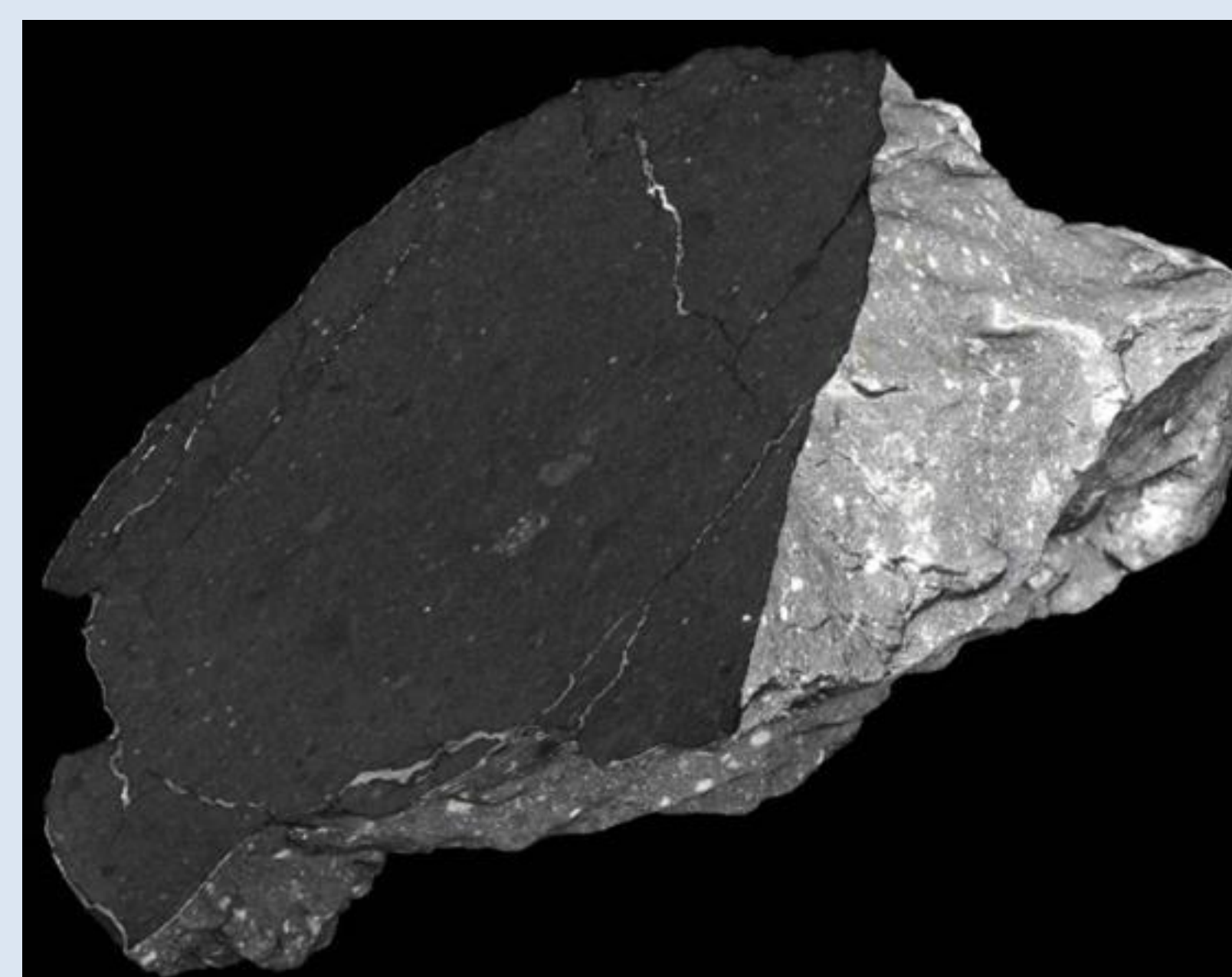
Data Fusion



Before (left) and after (right) application of a clipping box to the XCT 3-D reconstructed data of 79115,0 in VG Studio MAX



Before (left) and after (right) application of a clipping plane to the registered SFM model of 79115,0 in VG Studio MAX



Single slice visualization of 79115,0 fused XCT and SFM data sets in VGS-MAX

References: [1] Blumenfeld E. H. et al. (2014) *Metsoc* 77, Abstract #5391. [2] Blumenfeld E.H. et al. (2015) *LPSC*, Abstract #2740. [3] Blumenfeld E. H. et al. (2016) *AGU Fall Meeting*, Abstract #190585. [4] Blumenfeld E.H. et al (2017), *ToSCA North American Symposium*, [5] Blumenfeld E.H. et al (2017), *LPSC*, Abstract #2874. [6] Blumenfeld E.H. et al (2018) *AGU Fall Meeting*, Abstract #422858. [7] Meyer, C. (2011) NASA's Lunar Sample Compendium: 79115. [8] Beaulieu K.R. et al (2017), *LPSC*, Abstract #2649. [9] Thomas A.B. et al (2018) *AGU Fall Meeting*, Abstract #436923.