X-RAY COMPUTED TOMOGRAPHY OF BENNU PARTICLE OREX-501054-0. N. V. Almeida¹, S. S. Russell¹, A. J. King¹, T. J. Zega², T. J. McCoy³, L. P. Keller⁴, P. Haenecour², M. S. Thompson⁵; K. Thomas-Keptra⁶, L. Le⁷, V. Tu⁷, H. C. Connolly Jr.²,⁸,⁹, and D. S. Lauretta²; ¹Planetary Materials Group, Natural History Museum, London, SW7 5BD (n.almeida@nhm.ac.uk); ²Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ; ³Smithsonian Institution, Washington, D.C.; ⁴NASA JSC, Houston, TX; ⁵Purdue University, West Lafayette, IN; ⁶Barrios Technology/Jacobs, NASA JSC, Houston, TX; ⁷Jacobs, NASA JSC, Houston, TX; ⁸Rowan University, Glassboro, NJ; ⁹American Museum of Natural History, New York, NY.

Introduction: NASA’s Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) mission successfully returned a sample of the near-Earth asteroid (101955) Bennu in September 2023. The spacecraft detected phyllosilicates, carbonates, oxides, and organic species on the surface of Bennu that are directly related to its initial composition and geological processing [1–3]. Analyses of the returned samples aim to test hypotheses on the evolution of Bennu, including how and when it accreted, the extent to which it was modified by hydrothermal alteration, and the role of impacts in the formation and mixing of lithologies [4]. To test these hypotheses, we applied X-ray computed tomography (XCT), a powerful technique for non-destructive characterization of samples [5], to coarse (500–5000 µm) Bennu particles. We report preliminary 3D mineralogy and petrography of particle OREX-501054-0.

Samples: OREX-501054-0 was allocated as part of the quick-look analysis of the fine-grained dust found coating the touch-and-go sample-acquisition mechanism [6]. The sample was later transported to the Natural History Museum (NHM) where it was mounted in a pipette tip which was secured at the top and bottom with Parafilm® to prevent movement during scanning.

Analytical methods: OREX-501054-0 was imaged using the Zeiss Versa 620 XCT scanner at the NHM. A total of 2401 projections were collected at 90 kV and 89 µA, with an exposure time of 32 seconds. An optical magnification of 4.023 resulted in a voxel size of 0.5096 µm. Segmentation, quantification, and visualization was carried out using the Avizo® software.

Results: OREX-501540-0 is ~0.75 mm across in longest dimension, with a volume of 0.0606 mm³. The thresholded porosity is 5%, which provides a minimum value as it does not account for porosity at scales below the resolution of the XCT data. Opaque phases account for 9.4 vol.%, of which approximately half is present in an interconnected vein structure (Fig. 1). The greyscale values of the vein indicate an X-ray attenuation similar to that of sulfides while the morphology suggests it contains a high portion of magnetite blebs. The remaining material, considered matrix, accounts for 85.7 vol.% of the particle. This also includes anhydrous silicates, which are sometimes evident from their morphology but cannot be thresholded from the fine-grained (sub-µm) phyllosilicate-rich groundmass.

Discussion: XCT analysis shows that Bennu particle OREX-501054-0 is a single lithology consisting of an abundant fine-grained phyllosilicate-rich matrix in which magnetite, sulfide, and rare anhydrous silicates are embedded. This secondary mineral assemblage is consistent with Bennu having experienced extensive aqueous alteration similar to petrologic type 1 carbonaceous chondrites [7]. The particle also contains evidence of veins precipitated from fluids. Meter-sized carbonate veins observed on Bennu were interpreted as the products of a large, open hydrothermal system [e.g., 3], whereas in OREX-501054-0, they occur on the mm-scale and appear to consist of an Fe-rich oxide or sulfide phase, suggesting a distinct alteration event. It should also be noted that, owing to the small grain size of magnetite frambooids observed in this material, the lower greyscale value may be a result of voxels sampling both magnetite and pore space. A similar magnetite-bearing vein has been identified in OREX-501062-100, and previously reported in a Ryugu particle [8], hinting that fluid flow was a common process on volatile-rich asteroids.

Further investigation of this sample will continue, confirming mineralogy and compositions with SEM-EDS and EPMA. This will ground-truth our XCT data, allowing better interpretation of the three-dimensional petrographic relationships. We will also present additional XCT data of other particles allocated.

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Figure 1. Top: a single greyscale slice from the XCT scan of OREX-501054-0. Middle: phases assigned by thresholding of the data, where porosity is in purple, the vein in blue (with resolvable magnetite blebs inside colored yellow to illustrate the texture of the vein), and all sulfide and magnetite grains in the matrix are in green. Bottom: a 3D view of the vein inside the sample, illustrating the interconnected curved morphology.