RESULTS FROM EARLY RESOLVED IMAGES OF ASTEROID BENNU. B. Rizk[1*], D. N. DellaGiustina[1], D. R Golish[1], C. A. Bennett[1], C. Drouet d'Aubigny, K. J. Becker[1], P. H. Smith[1], L. Le Corre[2], K. N. Burke, C. Hergenrother[1], R. Ballouz[1], B. E. Clark[3], M. C. Nolan[1], H. L. Enos[1], D. S. Lauretta[1], and the OSIRIS-REx Team, [1]Lunar and Planetary Laboratory, University of Arizona (1415 N. 6th Ave., Tucson, AZ 85705, *corresponding author: bashar@lpl.arizona.edu), [2]Planetary Science Institute (1700 E Ft. Lowell Rd, Tucson, AZ), [3]Department of Physics and Astronomy, Ithaca College (953 Danby Road, Ithaca, NY 14850).

Introduction: In late 2018 the OSIRIS-REx spacecraft approached asteroid (101955) Bennu and acquired the first ever resolved images of a B-type asteroid. These data reveal the shape, geometric albedo, surface features, and visible spectrum of Bennu in four bands. Images confirm the results of many ground-based studies, the current understanding of small-body rubble-pile physics, and also illustrate the spectrophotometric and geomorphological diversity of Bennu's surface (Figure 1a–c).

Data from the OSIRIS-REx Camera Suite: The OSIRIS-REx Camera Suite (OCAMS) PolyCam and MapCam imagers [1] acquired the highest-resolution images of Bennu to date. During approach PolyCam acquired broadband images of Bennu at scales down to 0.33 m/pixel at phase angles between ~5° and 55°. From the Approach through Preliminary Survey phases of the mission, MapCam obtained images at scales ranging from 1.1 to 10 m/pixel and at phase angles from ~0.7–90° in four narrow band filters (*b´*, *v*, *w*, *x*) and the panchromatic filter. The color filters are based on similar bands from Eight Color Asteroid Survey.

Global Description of Bennu from PolyCam Data: As was noticed in ground-based radar data [2], Bennu exhibits a spinning top shape similar to asteroid (162173) Ryugu ([3] and other near-Earth asteroids, such as 2008 EV5 [4]. Several craters $\geq$ 50 m wide are apparent along its equatorial ridge, and high-phase-angle PolyCam data show that many equatorial craters exhibit raised rims. The largest boulders ($\geq$ 30 m) exist predominately at high latitudes (>~40°), many of which appear "perched" on the surface; the largest of these was also apparent in the ground-based radar shape model of Bennu [2]. A large (> 80 m) dark and partially exhumed outcrop is visible in the southern hemisphere; the scale of this object relative to the size of Bennu may indicate it as a constituent component of the asteroid.

We estimated the boulder size-frequency distribution by measuring the lateral dimension of some 3000 boulders with diameters between 6 and 23 m. We found this population to possess a cumulative power law index of -3.1 ± 0.2 to be compared to Ryugu's index of -2.5 to -3.0 for the global distribution of large boulders (>~10 m) ([3].

Preliminary photometric analysis: Observing Bennu at a broad range of phase angles has enabled us to develop a preliminary photometric model of its surface using an exponential phase function and the Lommel-Seeliger disk function [5]. Using this model, we estimate a geometric global albedo of 0.0435 ± 0.0015, which is consistent with previous ground-based measurements [6] and in line with the 0.55 µm reflectance of CI and CM chondrites [7]. Bennu exhibits slight reddening in observations that exceed 70° phase angle. For low-albedo single-scattering surfaces, researchers have attributed phase reddening to the presence of micron-scale particles [8].

Preliminary albedo and color analysis: One of Bennu's most striking aspects is its range of surface reflectance, especially among the population of boulders > 1 m. Although the largest boulders ($\geq$ 30 m) have geometric albedos near the average terrain, a population of bright decameter-scale boulders also exists with albedos ranging from 7 to 10%. We have detected a small number of very bright features in PolyCam data that are not yet fully resolved. These features have albedos near 17%; we expect that their peak albedo will increase as they become more resolved in later OCAMS data.

The darkest material on Bennu appears to possess ~3.4% geometric albedo. Aside from the dark outcrop in the southern hemisphere, dark boulders and diffuse units of dark material are well distributed across the asteroid. Some dark material also appears to show an absorption at 0.55 µm and is redder than the global average terrain. The source of this absorption band remains unclear; however, the detection of magnetite made by the OSIRIS-REx Thermal Emission Spectrometer (OTES) data may provide an explanation for the observed spectral feature [9].

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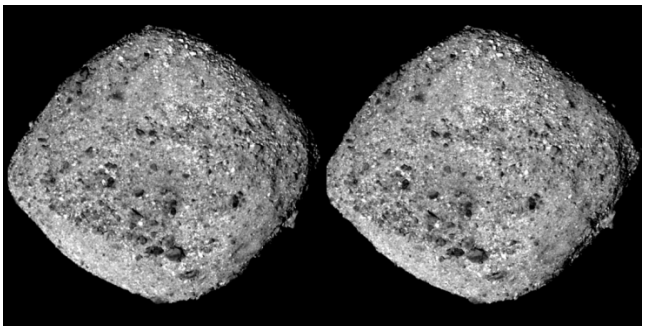
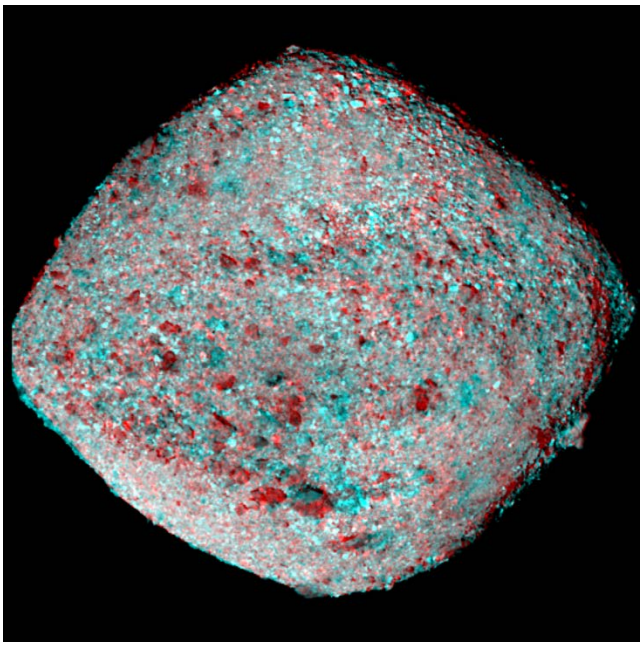
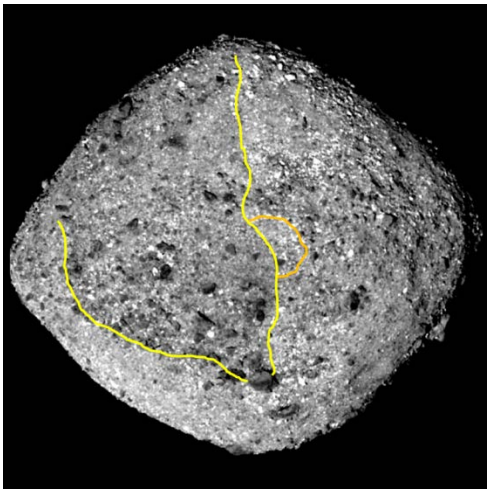
References: [1] Rizk, B., et al. Space Sci Rev 214:26 (2018). [2] Nolan, M. C., et al. Icarus 226.1 (2013): 629-640. [3] Sugita et al. Science (2019) [4] Busch, Michael W., et al., Icarus 212.2 (2011): 649-660. [5] Golish et al., LPSC 50. [6] Lauretta, D. S., et al. Meteoritics & Planetary Science 50.4 (2015): 834-849. [7] Clark, B. E. et al. Icarus 216.2 (2011): 462-475. [8] Li, J. Y. et al. preprint arXiv:1812.08361 [astro-ph.EP]. [9] Hamilton et al., LPSC 50.

Figure 1a,b,c These PolyCam stereo pairs: free-view (a) and anaglyph (b) show a triangular lower-albedo area, regional in scale, acquired in a sequence at 4.8° phase angle on November 25, 2018 at approximately 240° E longitude at a range of around 80 km from the asteroid at a plate scale of ~ 1 m/pixel. It extends outwardly from the dark southern boulder and breaches the boundary of one circular feature at the equator in an apparent flow (c).

a)



b)



c)