The shape of Bennu: Implications for internal structure.

*Olivier S Barnouin[1], Micheal G. Daly[2], Eric E Palmer[3], Robert W Gaskell[3], John R. Weirich[3], Catherine L Johnson[4], Manar Al Asad[4], James H Roberts[1], Mark E. Perry[1], Hannah C.M. Sursorney [4], R. Terik Daly[1], Edward B. Bierhaus[5], Jeff A Seabrook[2], Raymond C. Espiritu[1], A. Hari Nair[1], Lilian Nguyen[1], Gregory A Neumann[6], Carolyn M Ernst[1], William V Boynton[7], Micheal C. Nolan[7], Coralie D. Adams[9], Micheal C. Moreau[6], Bashar Rizk[7], Christian Drouet D'Aubigny[7], Erica R. Jawin[8], Kevin J Walsh[10], Patrick Michel[11], Stephen R. Schwartz[7], Ronald L. Ballouz[7], Erwan M Mazarico[6], Daniel J. Scheeres[12], Jay W. McMahon[12], W Bottke[10], Seiji Sugita[13], Naru Hirata[14], Noayuki Hirata[15], Sei-ichiro Watanbe[16], Keara N. Burke[7], Daniella N. DellaGuistina[7], Carinna A. Bennet[7], Dante Lauretta[7]

1. Johns Hopkins University Applied Physics Laboratory, 2. The Centre for Research in Earth and Space Science, York University, Toronto, Ontario, Canada., 3. Planetary Science Institute, Tucson, AZ, USA, 4. Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, Canada., 5. Lockheed Martin Space Systems Company, Denver, CO, USA., 6. NASA Goddard Space Flight Center, Greenbelt, MD, USA., 7. Lunar Planetary Laboratory, University of Arizona, Tucson, AZ, USA., 8. Smithsonian Institution National Museum of Natural History, Washington, DC, USA., 9. KinetX Aerospace, Inc. Simi Valley, CA, USA, 10. Southwest Research Institute, Boulder, CO, USA., 11. Université Côte d' Azur, Observatoire de la Côte d' Azur, CNRS, Laboratoire Lagrange, Nice, France., 12. Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA., 13. University of Tokyo, Tokyo, Japan., 14. Aizu University, Aizu-Wakamatsu, Japan., 15. Kobe University, Kobe, Japan., 16. Nagoya University, Nagoya, Japan.

Introduction: We used data collected by the Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) spacecraft since November 1, 2018 to develop a global digital terrain model (DTM) of Bennu. The DTM is developed from images collected by the OSIRIS-REx Camera Suite using stereophotoclinometry (SPC). We validated the DTM independently using limb data and by the identification of keypoints between actual images and synthetic images rendered from the DTM. The results are also compared to an independent model derived from range measurements collected by the OSIRIS-REx Laser Altimeter (OLA). While developing the global model, we also refine the pole orientation and rotational state of the asteroid. The characteristics of the resulting global digital terrain model provide constraints on the factors responsible for the origin and evolution of Bennu' s shape and surface.

Digital Terrain Model Construction from Imaging: About 1500 OCAMS images with ground sample distance ranging from 30 to 200 m were used to develop the global DTM of Bennu. We used distant limb data of Bennu to construct an initial DTM of Bennu. Then a combination of geometric stereo data and surface lighting conditions (or photoclinometry) modeled small patches (or maplets) of terrain across the asteroid. Geometric stereo typically defines the location of the center of each maplet, while the surface tilts across the maplet are estimated by best fitting the brightness variations of images that contain some portion of the maplet. These maplets are then combined to build a global model. The model increases in detail, accuracy, and precision as higher-resolution images and images with different viewing conditions are incorporated.

Digital Terrain Model Construction from Laser Altimetry: We collated several six-hour linear scans obtained by OLA during orbit around Bennu to make an independent shape model of Bennu at a resolution equivalent to the one derived from imaging. This DTM is improved relative to the SPC-derived model because OLA better resolves the heights, and extent of 1 to 3m boulders across the surface of the asteroid.

Bennu's Geomorphological and Structural Properties: The evaluation of the both models shows that the average size of the asteroid is 490.06 ±0.16 m.

The model shows the presence of several features:
-An equatorial ridge that is muted, and is diamond-shaped when viewed from the pole;
-Topographic north-south ridges that extend in some instances from pole to pole. The ridges influence the distribution of boulders, which are frequently concentrated between the ridges;
-Large craters that influence some of the attributes of the shape, primarily along the equator;
-A few large protruding boulders >40 m in diameter and >10 m high, mostly in the southern hemisphere;
-Grooves, scarps, and troughs that in some instances extend several 10s to 100s of meters, with depths ranging from 2–10 m.

Conclusion: The initial shape characteristics suggest that Bennu has some interior stiffness. Considering past modeling efforts investigating deformation due to spin-up, the lack of a circular equatorial ridge with a pronounced bulge, and the presence of high standing north-south ridges indicate that in spite of an abundance of evidence for material moving towards the equator, Bennu has interior structure that resists deformation.

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