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Title: The Geology and Geophysics of Kuiper Belt Object (486958) 2014 Arrokoth

J.R. Spencer* et al.

1-page print summary

*Corresponding author: spencer@boulder.swri.edu.

Introduction

On 2019 January 1, the New Horizons spacecraft passed 3538 km from Kuiper Belt object (KBO) (486958) Arrokoth. Arrokoth is a contact binary consisting of two distinct lobes, connected by a narrow neck. Its orbital parameters, albedo and color, make Arrokoth a typical cold classical KBO (CCKBO). CCKBOs are the most dynamically and physically primitive population of small Solar System bodies known.

Rationale

Since the publication of initial results from the flyby, additional data have been downlinked and analyzed. This paper describes the resulting analysis of Arrokoth's shape, geological evolution, and satellite and ring constraints.

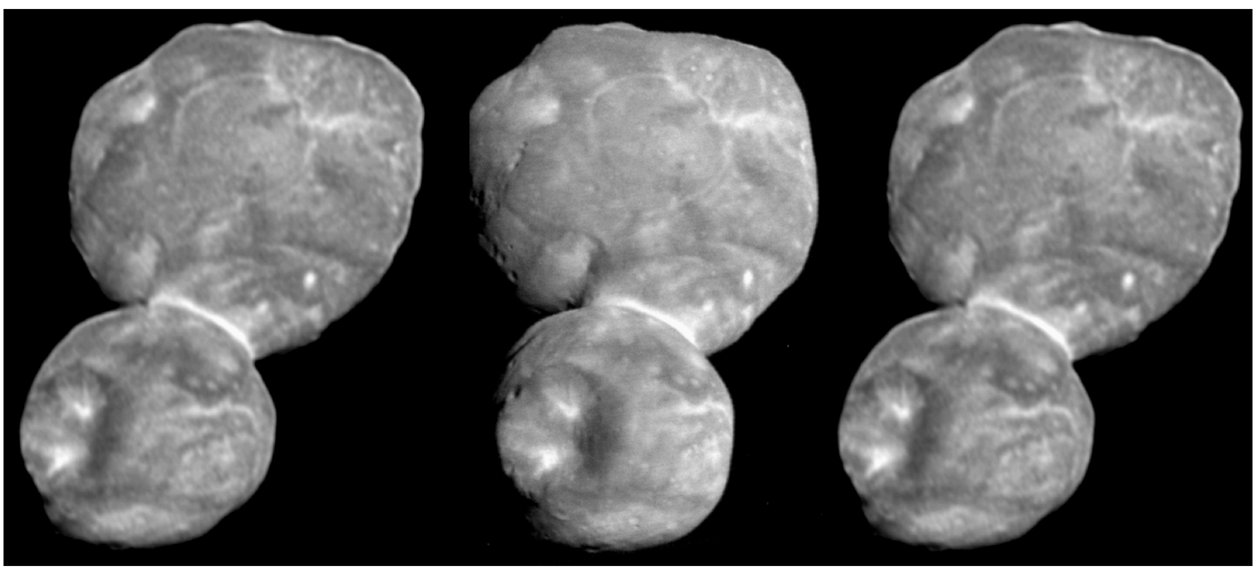

Figure. Stereo image pair of Arrokoth. *The left and center images can be viewed cross-eyed, or the right and center by direct viewing.*

Results

Improved stereo imaging constrains the object's shape and topography and allows us to generate a stereographic terrain model. Typical relief on both lobes (away from the neck region) is ~0.5 km or smaller.

Arrokoth's rotational period is 15.92 ± 0.02 hours, with its rotational pole pointing to Right Ascension = 317.5 ± 1°, Declination = -24.9 ± 1° , J2000 equinox. The object consists of two roughly ellipsoidal lobes with overall dimensions of 36 × 20 × 10 km. The maximum dimensions of the two lobes are 20.6 × 19.9 × 9.4 km and 15.4 × 13.8 × 9.8 km, with uncertainties of 0.5 × 0.5 × 2.0 km. The total volume is equal to a sphere of diameter 18.3 ± 1.2 km, and the volume ratio of the two lobes is 1.9 ± 0.5. Global bulk density must be >290 kg m^{-3} if the neck is not in tension. Assuming a bulk density of 500 kg m^{-3}, as measured for comets, the mean surface gravity is ~1 mm s^{-2}, and the compressive strength of the neck must be > 2.3 kPa. The axes and equators of the two lobes are closely aligned.

The small lobe's surface is marked by complex albedo patterns, often with sinuous margins and no detectable topographic signature, while the large lobe's surface is dominated by clusters of low dark hills superposed on brighter, smoother, terrain. The large lobe's surface is divided into distinct sub-units which may represent smaller bodies that accreted to form it, though the overall smoothness of the surface, and the youthful appearance of many boundaries, which are sometimes undetectable or cross-cut by clusters of hills, suggest a more complex post-formation history. If the sub-units did accrete first, the smoothness of their mutual boundaries suggests subsequent accretion of additional material and later reactivation of the boundaries.

We identify ~40 possible impact craters on Arrokoth, though only about 10 with high confidence. The largest crater, nicknamed Maryland, is about 7 km in diameter, while the rest are smaller than 1 km. Their size-frequency distribution is consistent with a single power law. Crater densities are lower than on many other small bodies, but are consistent with a surface age of >4 Gyr. No satellites or rings are detected: satellite diameter upper limit is 180 meters out to 8000 km radius from Arrokoth.

Conclusions

Arrokoth's smooth, lightly-cratered surface is unlike other Solar System bodies and appears to date from the period of planetary accretion. The alignment of its two lobes constrains the processes that formed this contact binary. Because its orbit, albedo, color, and rotation are typical of other CCKBOs, Arrokoth can likely be used to understand the cold classical belt as a whole.