Equatorial features on asteroid (101955) Bennu support mass loss by fission

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Introduction: Asteroid (101955) Bennu's bicone shape is widely ascribed to deformation during periods of critical spin rate [e.g., 1]. Finding geological evidence that can constrain material flow mechanisms and deformation regions is a goal of the OSIRIS-REx mission [e.g., 2]. Two topographic features found near Bennu's equator on high parts of its equatorial ridge - a cone-shaped hill and a deep crater-like cavity - are consistent with formation by fission at critical spin rates. The cavity floor contains evidence of internal flow as thin vertical sheets of rubble.

Bennu Equatorial Features: At ~8° E, centred on the equator, is a unique Bennu landform, a remarkably symmetric ~12 m-tall, ~40 m-diameter cone composed of fine-grained rubble (relative to its immediate surroundings) with some large boulders on its east side. Bennu's equatorial cross section is slightly square in shape [3] with four high points; this cone is located at one of these high points. Although the cone is slightly spectrally distinct from the remainder of the equatorial ridge, and thus may be younger, it has at least 8 small craters 2 to 4 m diameter preserved in its non-boulder-covered area.

At ~4° S, 126° E is a relatively fresh impact crater-like cavity ~10 m-deep and ~45 m-wide formed on the southeast side of a high equatorial hill. Its floor and walls are composed of relatively fine-grained rubble and no large boulders occur within it. Larger crater-like cavities occur both east and west of this feature; the adjacent hills constitute another of the four high spots on Bennu's equatorial ridge. Parts of the floor and walls show a unique banded albedo pattern (of variable distinctness) with rubble bands ~3 to 7 m width. The bands show no obvious topographic expression and a near-vertical dip is indicated by consistent orientation across slope changes. The rubble bands are almost parallel to Bennu's equator (~5° WNW-ESE). A distinct spectral signature suggests that the cavity is relatively young, but the interior has 10 small craters of ~2 to 4 m diameter; this post-formation crater population is comparable to that found on the cone described above.

Possible fission and interior flow scenarios: Equatorial mass loss through fission has been modelled for other NEA's [e.g., 4] to explain equatorial cavities; Bennu's cone and cavity could both be remnants of fission. The described cavity could not have formed by impact or the banded floor structure would not be preserved; the cavity also lacks an ejecta blanket as is found around other young Bennu impact craters. The crater and cone both occur on the highest Bennu equatorial topography, so are logical fission candidates resulting from Bennu's last YORP spin up. The cone may represent an interrupted fission event. For example, Bennu may have been oscillating slightly, allowing the fission flow to start before declining oscillation magnitude lowered the high point always below the loss radius. Modelling of the similarly sized NEA 2008 EV5 equatorial fission required rubble cohesion of <2 Pa [4]. Modelling of Bennu

interior deformation by [1] produces equatorial upwelling with cohesion of 1.25 - 2.5 Pa; given the uncertainties of 2008 EV5 modelling, a common rubble cohesion value may result in both phenomena. The banding would then represent the tops of thin sheets of rising rubble from Bennu’s interior in response to interior deformation and equatorial mass loss.

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