CRATERS ON ASTEROID DINKINESH: IMPLICATIONS FOR SURFACE AGE AND COLLISIONAL EVOLUTION.

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Introduction: The NASA Discovery-class *Lucy* mission [1] performed its first asteroid flyby on November 1st, 2023. The target was the small Main Belt asteroid (MBA) (152830) Dinkinesh, with a semi-major axis of 2.19 AU, eccentricity of 0.11, inclination of 2.1 deg. Pre-encounter ground-based spectroscopy revealed that Dinkinesh has a S-type composition [2], and a mean diameter of 0.66-1.36 km [3].

The reconstructed *Lucy* trajectory indicates a close approach distance of 431 km, and a relative velocity of 4.5 km/s. All instruments successfully acquired scientific data, including the high-resolution camera L'LORRI (5 microrad/px [4]), revealing that Dinkinesh is a binary system. The primary has a top-like shape, analogous to recently visited asteroids like Bennu, Ryugu, and Didymos, with an average diameter of ~720 m. Its satellite, named Selam, has two lobes, each are ~220 m in diameter.

Dinkinesh is the smallest MBA visited by spacecraft, and therefore provides an opportunity to study small asteroids in the Main Belt before they possibly become near-Earth asteroids (NEAs). Several NEAs with sizes similar to Dinkinesh have been visited (e.g., Bennu, Ryugu, Didymos), allowing for a direct comparison in terms of cratering histories. Of particular interest is the comparison with the Didymos binary system [e.g., 5] for its similar size and spectral type, and the presence of a satellite. In this work, we present Dinkinesh crater mapping based on a sequence of L'LORRI images near close approach. We also present a similar analysis for one of Selam's lobe.

Crater identification and surface ages: Dinkinesh exhibits a few craters that are readily visible in the close-approach image (see Fig. 1). A total of 28 candidate impact craters have been identified on roughly 50% of the asteroid surface. The mapped craters have been classified with confidence levels (ranging from most likely '1', to less likely '3'). We note, however, that the ability to detect small craters is not uniform across the imaged surface due to varying illumination and camera geometries.

Dinkinesh's uneven shape is sculpted by several large concavities, and we used a preliminary shape model to assess their nature. Some of them are readily identified as craters based on overall morphology, while others could instead be shapes produced by mass wasting. Similar analyses are also conducted for one of the lobes of the satellite Selam.

The identified craters are used to constrain surface ages using a model production function for MBA cratering and a range of cratering scaling laws including terrain properties, such as strength [6].

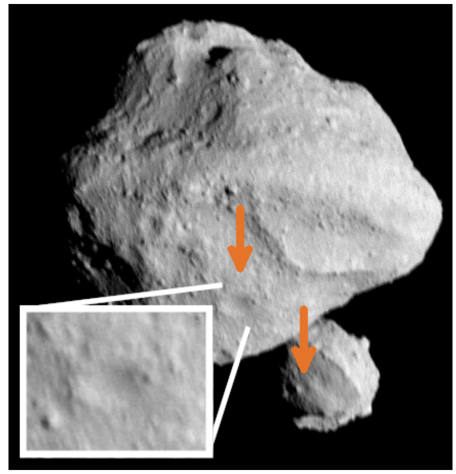

Figure 1: *This image shows the "moonrise" of the satellite, Selam (lower, right), as it emerges from behind asteroid Dinkinesh as seen by the L'LORRI imager. This image was taken at 12:55 EDT (16:55 UTC) Nov. 1, 2023, within a minute of closest approach. Arrows indicate two well visible craters on Dinkinesh and Selam, respectively.*

Collisional evolution and relevant timescales: We then performed numerical simulations [e.g, 7] to constrain the overall lifetime of the Dinkinesh-Selam binary system against impacts. This timescale can be compared with predictions for how long satellite formation should take by YORP thermal torques (i.e., spin up of the primary that eventually becomes fast enough that it sheds mass). Finally, our cratering results are compared to similar studies for the Didymos binary system [8].

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References: [1] Levison, H.F., et al. (2021) PSJ, 2:171 (13pp). [2] Bolin, B. et al. (2023) Icarus, 400, 115562. [3] Mottola, S. et al. (2023) MNRAS 524, L1-L4. [4] Weaver, H.A. et al., (2023) SSRv, 219, 82. [5] Daly, T.R., et al. (2023) Nature 616, 443. [6] Marchi S., et al. (2015) in Asteroids IV, ed. P. Michel, F. E. DeMeo, & W. F. Bottke (Tucson, AZ: Univ. Arizona Press). [7] Marschall, R., Nesvorný, D., Deienno, R., et al. 2022, AJ, 164, 167. [8] Barnouin, O. et al. Submitted Sept 29, 2023.