DINKINESH STRUCTURE AND EVOLUTIONARY CLUES FROM LUCY FLYBY DATA. E. B. Bierhaus¹, S. Marchi², J. Sunshine³, J. Emery⁴, S. J. Robbins⁵, J. F. Bell III⁶, J. Spencer², K. Noll², H. Levison², and the Lucy Science Team. ¹Lockheed Martin Space, ²Southwest Research Institute, ³University of Maryland, ⁴Northern Arizona University, ⁵Arizona State University, ⁶NASA Goddard Spaceflight Center.

Introduction: On November 1, 2023 NASA’s Lucy spacecraft [1-2] had a close approach with the ~720 m main-belt asteroid (152830) Dinkinesh. Data acquired throughout the flyby confirmed the presence of a satellite, now named Selam. Remarkably, Selam itself is a contact binary. The existence of a binary system in which the satellite itself is a contact binary motivates a search for morphological characteristics that can inform the formation and evolution of such a system.

Several small bodies have been observed by spacecraft, providing resolved observations of their shapes and surface features, with implications for structure and strength, and ultimately the histories of these bodies. Spectrally Dinkinesh is consistent with S-type asteroids [3], and thus should be compositionally most similar to (in decreasing size scale) Ida, Gaspra, Eros, Toutatis, Didymos, and Itokawa. In addition, two S-type satellites have been observed by spacecraft: Dactyl, a satellite of Ida [4], and Dimorphos, a satellite of Didymos [5]. Though still a relatively small set, these objects provide valuable context in which to evaluate Dinkinesh and Selam, and collectively the ensemble of these objects provide an increasingly expansive catalogue to assess effects of physical size, and collisional, thermal, and radiation environments.

We use observations and measurements from the L’LORRI instrument [6] to evaluate structural characteristics that constrain formation mechanisms for this system, and enable comparison to other small bodies. The images used have pixel scales between ~2.1 and 10 m/pix, which corresponds to image resolutions between ~6-30 m per resolution element (1 resolution element ~ 3 L’LORRI pixels due to the PSF, e.g. [6]).

Ridges: Among the most prominent features on Dinkinesh is the equatorial ridge, which is visible in both the approach and departure hemispheres. Though the width is variable, a typical value from preliminary measurements is ~100 m, a significant fraction of the overall dimensions. The ridge height also could be variable, and in general is of-order 10’s of meters. The ridge appears to be superimposed over other major features, suggesting it is one of the most recent significant landforms (though a smaller trough may be younger, see below).

The second major ridge is an arcuate feature that appears to have partial symmetry relative to the equatorial ridge – i.e. there is a branch of this ridge on both sides of the equatorial ridge.

Smaller features that may be linear or sub-linear ridges also are present, though further work is needed to assess the morphology and extent of these features.

Linear polar depression(s). One polar region is dominated by a linear depression (Fig. 1A). Both ends of the depression intersect concavities in the body that extend down in latitude to the equatorial ridge. Late-stage departure images reveal a potentially similar depression in the opposite hemisphere that is offset but potentially parallel to the better-observed feature seen in Fig. 1A.

Smooth band: Also associated with the polar depression is a qualitatively smoother band (Fig. 1A) that extends from the polar depression to the opposite hemisphere. This apparently smooth band is superimposed by the equatorial ridge. The texture of the band changes between the hemispheres separated by the equatorial ridge.

Troughs: Several candidate narrow troughs are visible. The longest (Fig. 1B) follows a roughly longitudinal pathway, and extends from the polar depression, through the equatorial ridge, and into the opposite hemisphere. This feature appears to be superimposed on all other features, and thus may be one of the youngest structural features on the asteroid.

Downslope movement / slope failure: There are several possible cases of material failure that appear in the two major ridges and in the polar depression (Fig 1C). These features appear to be quasi-linear, with the present termination front of the material movement approximately parallel to the origin point. Further examination of these features, in the context of the acceleration environment, will provide important constraints on surface and near-surface strength.

Possible clues from profile: The profiles seen on approach and departure contain arcuate segments at several longitudes. The origin of these regional and hemispherical-scale arcuate features is not clear, though potential hypotheses include large impact craters, or large-scale slope failure of the body, perhaps by spin up.
Figure 1. A. L’LORRI image lor_0752129617_03613_cal. Arrowed features are (1) equatorial ridge, (2) polar depression, (3) smooth band, (4) arcuate ridges. B. Slightly zoomed version of image in A. Arrows (5) point to a trough extending from the polar depression. C. L’LORRI image lor_0752129950_03680_cal. Arrows (6) point to mass movement in the polar depression. This image also provides a more clear view of the polar depression itself (arrowed features (2) in panel A).

Discussion: Analysis is ongoing, and we will report a more complete synthesis of these observations at the conference. Impact cratering and YORP spin-up are two mechanisms that have acted on Dinkinesh, and Selam, since their formations. Examining the dimensions, orientations, and spatial relationships (including stratigraphic) between these features will inform the potential formation and evolution pathway(s) of the Dinkinesh/Selam system.

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