THE BOULDER POPULATION ON ASTEROID (152830) DINKINESH AND DINKINESH 1 SELAM BASED ON THE 2023 LUCY FLYBY. S.J. Robbins1,2, E.B. Bierhaus3, J.M. Sunshine3, W.F. Bottke1, S. Marchi3, J.R. Spencer1, K. Noll1, H. Levison1, and the Lucy Science Team. 1stuart@boulder.swri.edu, 2Southwest Research Institute, 1050 Walnut Street, Suite 300, Boulder, CO 80302. 3Lockheed Martin, Space Support Building, MS 811012257, S. Wadsworth Blvd., Littleton, CO 80125. 3University of Maryland, Departments of Astronomy and Geology, College Park, MD 20742.

Introduction: NASA's Lucy mission to the Trojan asteroids [1, 2] successfully completed its first deep space object encounter on November 01, 2023, with the asteroid (152830) Dinkinesh and its contact binary satellite Selam. Dinkinesh is approximately 720 m across, while each component of Selam is approximately 200 m across. The flyby provided a successful test of Lucy's instruments and permitted narrow-angle imaging of much of Dinkinesh's surface.

The closest approach imagery provided well-resolved images of both bodies numerous geologic features. Found across the surfaces of both bodies – and other small, rocky bodies observed by spacecraft – are boulders. Boulders can reveal information about the fragmentation history of a body, informed by their size-frequency distributions. In this work, we present initial results of characterizing the boulder populations of Dinkinesh and Selam, and we place those populations in context with boulder populations measured on other small asteroids.

Available Data: Lucy's L'ORRI camera [3] provided the highest resolution views of both bodies. L'ORRI imaged at up to ≈2 m/pix. L'ORRI's point-spread function (PSF) is almost 3 pixels across [3]. The best images of Dinkinesh and Selam are effectively ≈130 and ≈35 resolution elements, respectively. Deconvolution processes may improve this. Because L'ORRI is still the highest effective resolution camera on Lucy, and both Dinkinesh and Selam were fully captured in its field of view, we restrict this analysis to L'ORRI images only.

At the time of this abstract, mosaics, shape models, and other derived data products are still being developed [see abstract by Preusker et al., this conference]. Therefore, we have restricted our initial work to pixel space and mapping features on individual images. These data are then preliminarily scaled to physical units (meters) using plate scales from the current version of the reconstructed spacecraft trajectory.

Approach: We have mapped boulders on Dinkinesh and on Selam. At the time of this writing, multiple people have mapped boulders on the closest approach image, while one mapped boulders on both the closest approach image and an image from 27 seconds earlier, which provided slightly poorer pixel scales but included some different terrain and more favorable phase angle for observing features.

Mapping small features (≤15 pix [4]) in L'ORRI images requires mitigation strategies to account for L'ORRI's elongated PSF [3]. [4] demonstrated that using the minor axis of ellipse fits to otherwise circular features can provide a generally reliable estimate of their diameter to smaller sizes than a circle fit. However, because we are using unprojected images in the mapping effort at this stage, one must also be cognizant of emission angle foreshortening effects as one approaches the limb of either body.

SJR's approach used ArcMap software to display images without a georeference and use simple lines to draw a cord along the short axis of each visible boulder, with units recorded in pixel space. EBB's approach used SAOImage to record two points along the long axis of each boulder, and then a third point between them to measure the minor axis.

Analysis Methods: At this stage, we are using two basic analysis methods. One is the SFD$_{LF}$ method [5] to generate size-frequency distributions using an empirical density function to display the results and visually examine them. The other analysis method is to fit slopes using a power-law fit based on a truncated Pareto distribution using a maximum-likelihood estimator (MLE) [5, 6].

Results: Figure 1 shows the boulders that two authors identified on the closest approach image. They identified very similar features, though there are some differences indicating different thresholds for what someone will consider to be a boulder. The largest boulders observed are just slightly larger than 25 m across; completeness is currently estimated at 10–13 m, depending on the person and depending on the body.

Identifiable boulders on Selam during the closest approach number approximately 4, which makes any analysis subject to substantial uncertainty. However, their presence at all provides some constraints. Boulders visible number ~100–200 on images used.

Discussion—Fitting Slopes: At this stage, we have found that the slopes fit to the SFDs are sensitive to the minimum and maximum diameters used. Such a finding is indicative of significant uncertainty, which in this case is due to the relatively small numbers of boulders.

We also explore using the absence of larger boulders as information within the truncated fits. What this means is that the lack of larger features, when they could have existed, is real information that can be incorporated into the fit. E.g., the largest boulders identified are slightly larger than 25 m across; if $D_{max}$ in the MLE is set to 30 m instead of 26 m, our preliminary slopes steepened by up to ≈1 (this is independent of cumulative or differential slopes, since the slope on a cumulative is equal to the slope on a differential +1).

In the other direction, decreasing the completeness...
estimate from 13 to 12 m shallows fits by up to $\approx 1$.

While the changes are technically within each others' 1σ uncertainties, the sensitivity to the exact diameter range used – including an accurate estimate of completeness diameter of the counts – is critical to deriving a reliable fit value. The exact range over which to fit is an active area of work.

**Brief Comparison with Other Bodies:** Using the above-described preliminary data, fits, and estimates of completion, our power-law slopes match best with data from Itokawa [7] and Eros [8]; Toutatis [9] is steeper, while Bennu [10], preliminary work on Dimorphos [11], and Ryugu [12] are shallower. Refinement of our slopes and comparison with past work is ongoing.


**Acknowledgements:** The Lucy mission is funded through the NASA Discovery program on contract No. NNM16AA08C.

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**Figure 1:** The closest approach image showing Dinkinesh and Selam. Only boulders on Dinkinesh are included so as to highlight similarities and differences. SJR's boulders are in red and plotted as simple circles, while EBB's are shown in blue and plotted as ellipses (note: the elongated L'ORRI PSF in this orientation is oriented diagonally, from the roughly 1:30 to 7:30 positions on a clockface.)