BLOCK DISTRIBUTION ON ITOKAWA: IMPLICATIONS FOR ASTEROID SURFACE EVOLUTION.

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Introduction: Asteroid 25143 Itokawa is an S-type irregular asteroid 535 by 294 by 209 meters in size [1]. Past studies suggest that Itokawa is a rubble pile [e.g., 1] that aggregated from a parent body [2, 3]. The global population of blocks ≥ 6 m in diameter follows a power law with slope -3.5 ± 0.1, which may be unchanged since the asteroid accreted [3]. The overall distribution of blocks ≥ 6 m on the "head" and the "body" are statistically indistinguishable from one another and from the global distribution [2, 3]. However, there is evidence for a preferred local accumulation of these blocks at mid-latitudes on the body.

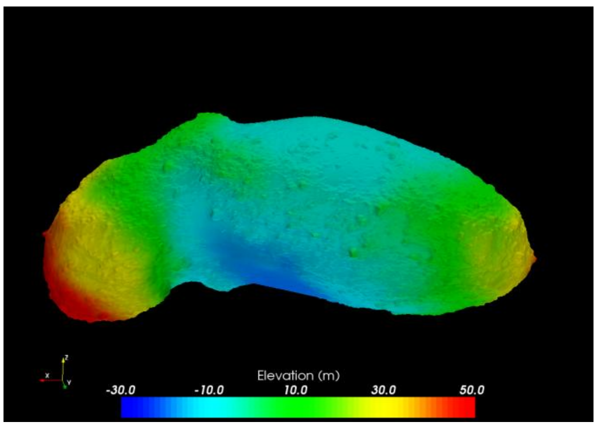

Figure 1. Elevation distribution on Itokawa. Lowlands are those regions shown in blue.

Despite this lack of large-scale (head vs. body) differences in the large block population, Itokawa does show two distinct geologic regions, referred to as the highlands and the lowlands (Fig. 1) [1]. The highlands are characterized by a high density of large, angular blocks. The lowlands of Itokawa are characterized by a noted absence of large (> 1 m) blocks and an increased presence of regolith (< 0.1 m). Loose material, if mobilized, is expected to move "downhill," from the highlands to lowlands.

This study examines quantitatively the differences between the block cumulative size-frequency distributions (CSFD) of local highland and lowland units, with an emphasis on the < 6 m blocks. The purpose is to test whether or not the movement of regolith from highlands to lowlands suffices to explain the notable differences in block population observed while still preserving the indistinguishable large-scale block populations of the head and body. Differences in block distribution

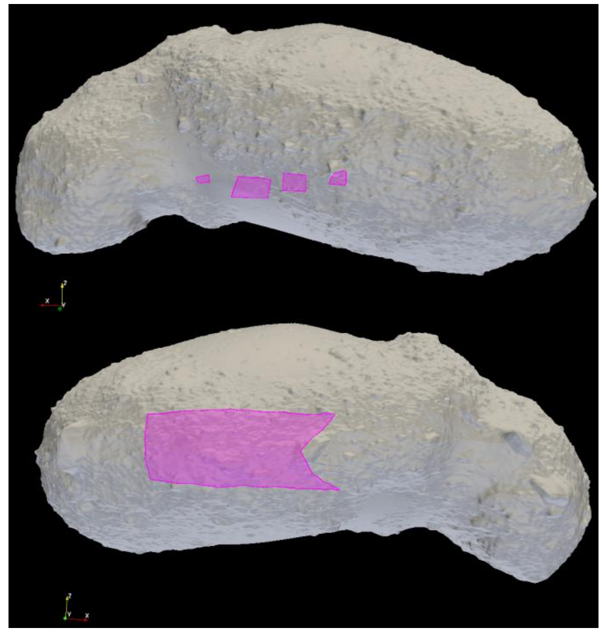

Figure 2. Study areas projected onto the Itokawa shape model [4].

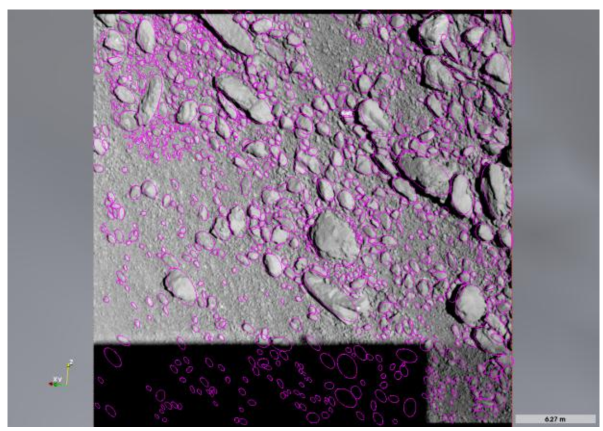

Figure 3. Projected image of the ST2539423137 AMICA image on the Itokawa model using the SBMT showing the study area on the Muses-C region of Itokawa with ellipses surrounding the visible blocks.

regionally across Itokawa could provide insights into the surface evolution of the asteroid.

Methodology Block CSFDs were made following the methodology of Mazrouei et al. [3]. High-resolution Hayabusa AMICA images were projected onto the Itokawa shape model [4] using the Small Body Mapping Tool (SBMT) [5]. Several highland sites, two boundary sites that transition from the highlands to the lowlands, and one lowland site were investigated (Fig. 2). The SBMT was then used to map and measure all resolvable blocks within each image. The resulting diameter assigned to each block was set equal to the diameter of a sphere with equivalent volume to the measured ellipsoid. A CSFD for each area was generated and a least-squares method was used to calculate a linear regression slope to the distribution. The fit was only applied to block diameters larger than the resolution rollover.

Due to the small areas of the images analyzed, the largest blocks measured were typically between 2 and 3 m, with some outliers as large as 5 m. In contrast, the global surveys measured blocks ≥ 6 m [2, 3]. To examine the distribution of blocks in the intermediate size range (between 2 and 6 m), we also selected some lower-resolution AMICA images covering larger regions of the asteroid to understand how the distribution from global to local scales might transition.

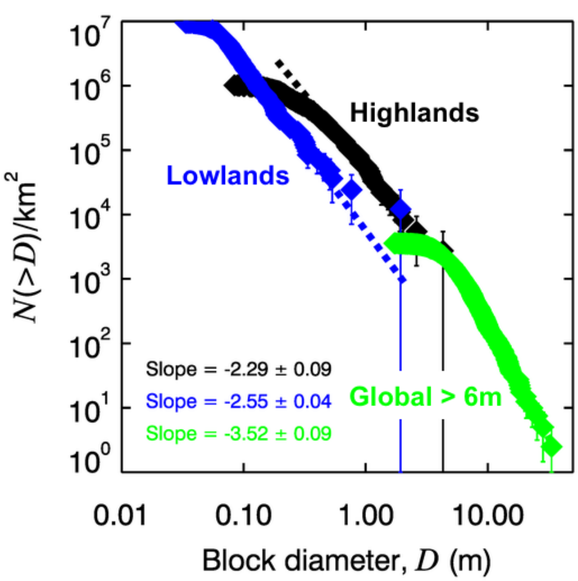

Figure 4. Block cumulative size-frequency distributions from lowlands (blue - AMICA images ST2563511720, ST2563537820 and ST2563607030), highlands (black - ST2539437177), and globally on Itokawa [3]. The fits are for blocks ≥ 0.1 m in the lowlands, ≥ 0.9 m in the highlands, and ≥ 6 m for the global population.

Results: Preliminary results (Fig. 3) reveal that the CSFDs from local regions (10 to 100 m^2) possess lower slopes than those for global studies, although it is important to note that the local analyses cover a smaller block diameter range. These observations indicate that small blocks are potentially affected by differing accretionary or geological processes relative to the large ones.

Besides the observed slope difference between the smaller-diameter blocks in local areas and larger-diameter blocks on a global scale, we identify clear differences in the distribution of blocks of equivalent size range (< 5 m) mapped in the lowland unit relative to the highland unit: the total number of blocks in the lowland unit is smaller than that in the highland unit; and the lowland unit possesses a CSFD slope that is statistically steeper than that of the highland unit.

Discussion and Conclusions: The cause of the CSFD differences between the local terrains analyzed and the global population [2, 3] requires further analysis, as does the relationship between blocks in the different size ranges. However, preliminary analyses suggest that a process may have caused a decrease in the slope of the distributions when moving from large to small blocks. Furthermore, there appears to be a small increase in the fit to the slopes for small block CSFDs in the lowlands relative to the highlands, possibly indicating the presence of fewer large blocks and an abundance of fines in the lowlands.

A possible explanation for these observations could be linked to the mobilization of smaller blocks and fines across the surface of Itokawa, as proposed in [7, 8]. Itokawa's regolith and smaller blocks may move to lower elevation via seismic shaking, thus altering the size distribution of blocks in an area. To test this possibility, CSFDs will be examined as a function of elevation. Additionally, some simple laboratory experiments will be conducted to see how accumulation or removal of fines in an area affects the resulting block CSFD distribution and slope.

References: [1] Fujiwara, A. et al. (2006) *Science*, 312, 1330-1334. [2] Michikami, T. et al. (2008) *Earth Planets Space*, 60, 13–20. [3] Mazrouei, S. et al. (2014) *Icarus*, 229, 181-189. [4] Gaskell, R. et al., 2008. Gaskell Itokawa Shape Model V1.0. *NASA Planetary Data System*, 92. [5] Crater Analysis Techniques Working Group (1979) *Icarus*, 37, 467-474. [5] Kahn, E.G. et al. (2011) *LPS XLII*, Abstract #1618, (http://sbmt.jhuapl.edu). [6] Miyamoto et al., (2007) Science, 316, 1011-1014. [7] Barnouin-Jha et al., (2008) *Icarus*, 198, 108-124.