Distribution of Boulders on Asteroid 25143 Itokawa. S. Mazrouei[1], M. Daly[1], O. Barnouin[2], M. Ilnicki[1], E. Kahn[2]. [1]Dept. Earth and Space Science-York University (mazrouei@yorku.ca, dalym@yorku.ca, ilnicki@yorku.ca), [2]Applied Physics Laboratory-Johns Hopkins University (Olivier.Barnouin@jhuapl.edu, Eliezer.Kahn@jhuapl.edu).

Introduction: The distribution of boulders on an asteroid can give insight into the origin and evolution of small bodies (e.g., [1]). This study reviews and updates prior work by Michikami et al., [2] using improvements in the geolocation of images from the Hayabusa spacecraft of 25143 Itokawa [3] – a small Apollo asteroid that is a ruble pile whose surface is densely populated by boulders and craters. The objective of this work is to confirm and update any previously identified trends in the global and regional distributions of boulders on Itokawa. Trends found should provide new insights to how Itokawa's current appearance formed following the disruption of its parent body, and how its surface might have changed since then. In particular, boulder distribution over the surface of the asteroid might provide a means to test the hypothesis of whether or not Itokawa is a contact binary.

Methodology: The mapping of boulders on Itokawa involved using improvements in the geo-location of the AMICA images obtained while producing the Itokawa shape model [4], and ameliorating the Hayabusa LIDAR dataset [5,6]. These images were then injested into an asteroid GIS called the Small Body Mapping Tool (SBMT) provided by the Johns Hopkins University Applied Physics Laboratory [7].

The SBMT facilitates the mapping of any structure including boulders on the surface of an asteroid by providing a convenient interface that allows the user to overlap correctly geo-located Hayabusa's Asteroid Multi-band Imaging Camera (AMICA) [3] images onto the Itokawa shape model [4]. Ellipses used to outline boulders can then be mapped from the images onto the asteroid, automatically providing the correct scale of the features outlined. Multiple images can be viewed, to handle any biases that might occur as a result of the lighting and viewing geometry.

In this way, the SBMT was used to map all boulders greater than 5 meters in major-axis. To ensure the entire surface of Itokawa was covered, we used over a hundred AMICA images [3], providing us with more than one chance to verify boulder sizes and locations. A total of 820 boulders were measured. We also outlined the location of 37 craters or potential craters [8] over the entire surface area of 0.4011 km^2 in order to evaluate any correlation between these craters and boulders This total boulder count is about 60% higher than a similar previous study [2]. Figure 1 illustrates the identified boulders and craters.

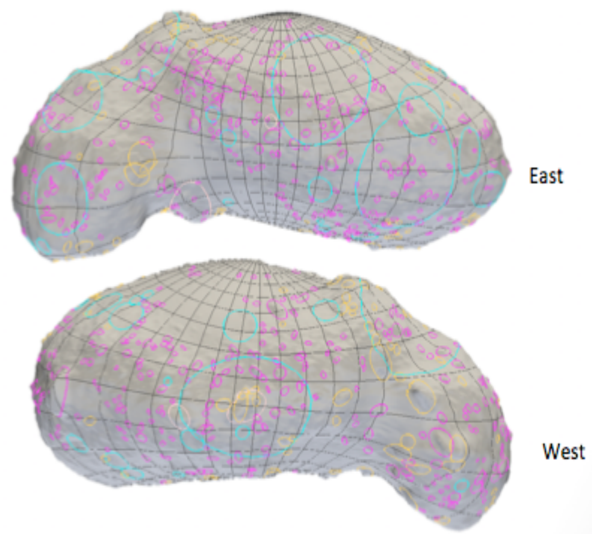

Figure 1 - Mapped Boulders and Craters on Asteroid Itokawa (blue: craters, purple: boulders from high resolution images, orange: boulders from low resolution images)

For the purpose of this study, the root-sum-square average of the major and minor-axes was used as a measure of boulder size for analysis.

Results and Analysis: There are about 820 boulders identified with a major-axis of over 5 meters. The plot of the boulder size versus cumulative number of boulders per km^2 is shown in Figure 2.

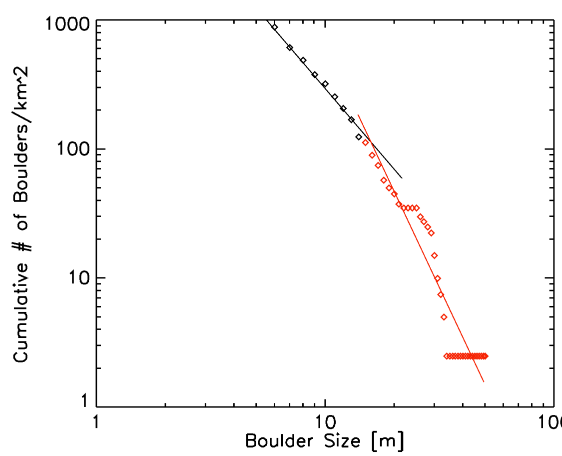

Figure 2 - Cumulative boulder size distribution per unit area on the entire surface of asteroid Itokawa

The cumulative boulder size distribution per unit area on the entire surface of asteroid Itokawa has a slope, or power-index, of -3.0 ± 0.1. This agrees with the smaller sampling from [6]. The power-index can exhibit minor variance due to histogram bin sizes or the definition of the boulder size.

The break in slope in Figure 2 at boulder size ~ 15 meters, suggests that there might be two boulder populations with unique origins. Boulders smaller than ~15 meters have a power-index of -2.1 ± 0.1 and boulders greater than ~ 15 meters have a power-index of -3.8 ± 0.1.

For further studies, Itokawa was divided into two parts; the head and the body. Figure 3 shows the cumulative boulder size distribution per unit area on the head (red) and body (black) of asteroid Itokawa, with slopes of -2.1 ± 0.1 and -3.0 ± 0.1 respectively.

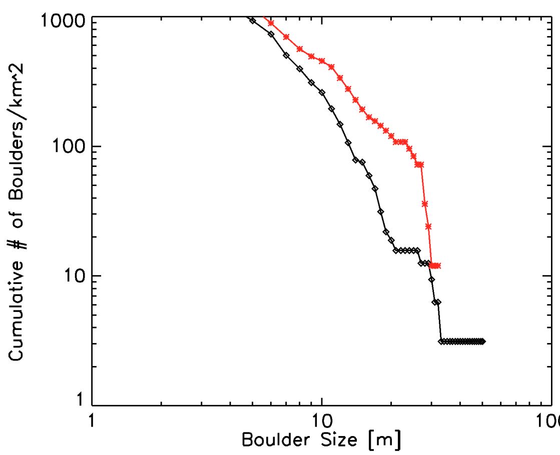

Figure 3 - Cumulative number of boulders per unit area on the head (red) and body (black) of Itokawa

It is evident that the cumulative number of boulders per unit area on the body has a steeper slope than the head. Steeper slopes imply greater variation in size of the boulders, which implies the body has boulders that are closer in size, whereas the sizes of the boulders on the head have a larger variation. The difference in the slopes could also support the hypothesis that Itokawa is a contact binary asteroid, by providing two different histories and possibly a difference in the material that make up the head and body of Itokawa.

Further analysis where the measured boulder population is separated into two equal degrees of longitude that align with the east and the west sides of Itokawa show additional differences. The cumulative number of boulders per unit area on the east side has a power-index of -3.1 ± 0.1 which is steeper than the west side's power-index of -2.7 ± 0.1. This difference can be accounted for by the higher number of large boulders at high surface elevations where no regolith coverage exists, thereby resulting in a steeper slope. The east side of Itokawa contains the majority of the Muses-C lowland and the west side includes most of Sagamihara lowland, where the regolith dominates and has probably submerged the boulders [5,9].

Conclusion: The surface of asteroid Itokawa is covered with at least 820 boulders greater than 5 meters in the long-axis and 37 craters or potential craters. The break in slope of boulder sizes versus the cumulative number of boulders suggests two different boulder populations with different origins.

The power-index of plotted boulders varies on different regions of Itokawa. The difference in the power-index of the head and body of this asteroid could support the hypothesis that the current state of Itokawa is a result of the collision of two different bodies (contact binary asteroid).

When comparing the west and east regions of Itokawa, the power-index difference appears to reflect differences that can be associated with surface elevation. Larger boulders at high elevations are not affected by the presence of fine-grained regolith that might cover these boulders up. At low elevations, the boulders are hidden by this regolith, which dominates these low regions.

In our future work we will assess the distribution of the major to minor axes around the asteroid to better understand the asteroid re-accretion process. Furthermore, we will establish any connection between the observed distribution, size and aspect-ratio of boulders with any of the possible cratering processes that might have occurred on Itokawa in order to gain more insight into surface evolution of this asteroid.

References:

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