IDENTIFICATION OF MICROFEATURES ON EUROPA IN LOW-RESOLUTION GALILEO IMAGES: SUCCESSES, LIMITS, AND IMPLICATIONS FOR EUROPA'S EXPLORATION. J. L. Noviello[1] and A. R. Rhoden[1], [1]School of Earth and Space Exploration, Arizona State University, 781 E. Terrace Mall, ISTB4–795, Tempe, AZ 85287–6004.

Introduction: First imaged by the Voyager and the Galileo missions, Europa is a compelling target for understanding the thermo- and geodynamics of icy satellites and their potential for habitability. The upcoming Europa Clipper mission [1] will take the best images of Europa so far (95% of the surface imaged at pixel scales of ≤ 50 m/px [2]); unfortunately, this mission will not reach Europa until at least 2026. It is important to obtain as much information as possible from the currently available images to advance our knowledge of Europa now and ensure the highest level of science return on the Europa Clipper mission.

Roughly 10% of Europa's surface is imaged at scales of ≤ 250 m/px, while the rest is imaged at scales upwards of 1 km/px. In the moderate-resolution (≤ 250 m/px) images used for geologic mapping, a number of small features are identifiable which fall into the morphologic catergories of pits, domes, spots, hybrids (a mix of icy chaos and domes), and icy chaos. These features are collectively called lenticulae or microfeatures [3], and are generally under 10 km in diameter. A previous study [4] looked at the limits of mapping icy chaos in low-resolution images (≥ 1 km/px). They found that qualitative chaos mapping is inconsistent at resolutions coarser than 250 m/px for most images with incidence angles less than 70° [4].

Here, we examine the efficacy of using low-resolution images, in conjunction with a statistical test [5], to *quantitatively* identify and classify microfeatures on Europa's surface. Doing so would greatly increase the amount of information available on microfeatures on Europa's surface, observations which can then be used to test models that pertain to microfeature formation, heat transport, and geophysics of Europa and icy satellites in general. Here we report on the effectiveness of this approach, including the likelihood of failing to identify features and failing to correctly classify features, the measurements needed and imaging requirements for the best identification practices, and potential underlying reasons for these results.

Methods: To identify the metrics that enable identification of microfeature types, we first mapped and analyzed features in moderate-resolutoin imagery. The images used in this analysis are from the Galileo mission. All raw Galileo files were processed with ISIS3 software and imported into ArcGIS, where they were individually aligned with the basemap of Europa [6]. All features were first mapped as polygons in high-resolution images. We focused on the E15RegMap01 (central meridian at 137°) and E15RegMap02 (central meridian at 280°) regions. We used a sinusoidal projection aligning the central meridian of each individual region. We then extracted information about the area, perimeter, maximum length, maximum width, and "darkness" of each feature. To obtain "darkness" we used the zonal statistics tool, which output the mean, median, range, and standard deviation of the normalized reflectance of each feature. We also noted which microfeature group each feature belonged to, though some were difficult to classify even in these images. These unclassified features were not included in the statistical tests.

Statistical test. The statistical test used here is the discriminant function analysis, or DFA [5], included in the software SPSS [7]. It is a test primarily used to sort data points of unknown origin or morphology into one of two or more naturally occurring groups. Using the quantitative measurements of all of the mapped features, we ran the statistical analysis to determine how well the chosen variables sorted between the groups, with the purpose of determining which variables sorted microfeatures most effectively.

Low-resolution testing. After determining the variables that best sorted between the microfeature groups, we began mapping in low-resolution images that overlapped with the regions we mapped in moderate-resolution (Fig. 1). We selected low-resolution images that had the closest incidence angle to the original images used, following the advice of [4]. We included these features as unclassified features in another DFA. This allows the test to sort the unclassified features into one of the established groups, predicting a particular feature's most likely group membership.

Results: In the E15RegMap01 region, at moderate resolution, we identified a total of 457 features: 179 pits, 128 domes, 110 chaos, 26 spots, and 17 hybrid features. In the first low-resolution image we mapped (5139r), which covers a portion of the E15RegMap01 region, we mapped 81 features: 44 chaos, 1 dome, 2 hybrids, 1 pit, and 22 spots. We failed to map roughly 70% of features identified in the moderate-resolution images within the low-resolution image, even though it covered the same area, although 89% of the features missed were simply too small to be identifiable at low-

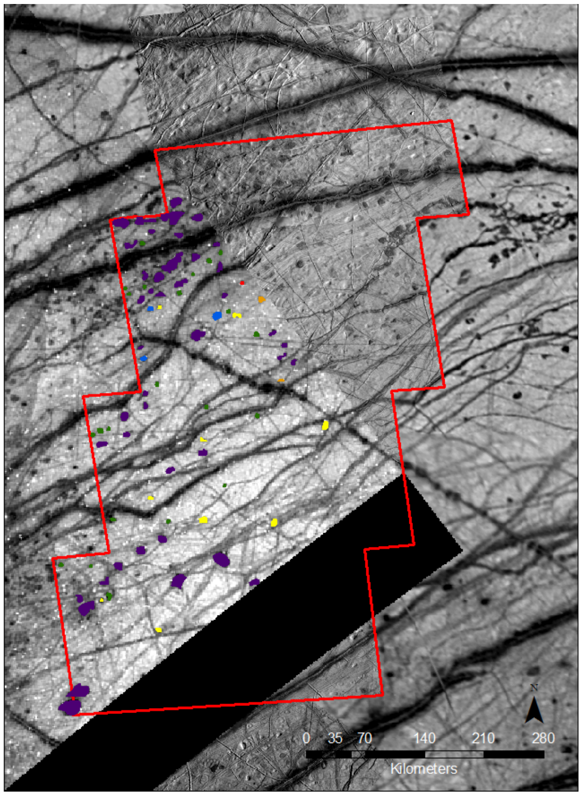

Figure 1: Low-resolution image 5139r superimposed on the E15RegMap01 mosaic. The red outline indicates the limits of the regional mosaic as it relates to mapping in 5139r; the mosaic actually continue farther north. Purple polygons are chaos, blue are hybrids, green are spots, red are pits, orange are domes, and yellow are unclassified.

resolution. However, the number of spots reported in the low-resolution is almost as high as the number of spots in the entire E15RegMap01 region, indicating a tendency to over-report spots when mapping in low-resolution. Out of the total of 81 features, 31 were mapped and classified consistently with the high-resolution mapping.

The features that were most often missed were domes and pits; only 16.4% of domes and 1.4% of pits were identified in low-resolution images. 75% of both chaos features and spots were able to be identified in the low-resolution image, and 80% of hybrid features were identified.

Since there were only 4 spots identified in the moderate-resolution images for this same area and 22 in the low-resolution mapping, 18 features were misclassified as spots. Of those 18 features, seven were patches of ice that appeared dark in the low-resolution image, but had no associated feature in the moderate-resolution images. Six false spots were actually small chaos features whose rough surfaces or rafts were not discernable in low-resolution. Three false spots were actually the dark side of a dome or a pit, and one was the dark side of the uplift within a hybrid feature. The remaining one was associated with a feature that remained unclassified in the high-resolution images. The only spot that was misclassified in low-resolution was instead classified as chaos.

In the low-resolution images, chaos was correctly identified in 29 out of 44 cases. Chaos was mistaken for a hybrid feature in five cases, a spot in one case, and the remaining cases were either unmapped or were mapped but unclassified in the high-resolution images.

Discussion: These preliminary results indicate that chaos, hybrid features, and spots are relatively easy to map and classify even in low-resolution images, though diffirentiating between the three is still challengng. This is consistent with previous results [4]. Additionally, at least one third of all spots could be small chaos whose topography is invisible in low-resolution images.

Of the features that failed to be mapped, 89% of them were below the detection limit of approximately five times the resolution of the image, or about 7.8 km. This limit, however, did not preclude the detection and identification of some smaller features. The smallest features missed were domes and pits, perhaps because the topography necessary for identifying them is obscured in low-resolution images. This result indicates that any mapping in low-resolution images is unlikely to reveal the locations of domes or pits. A confounding finding is that some spots are merely the shadowy halves of pits and domes. More work will be done to determine the likelihood of a "spot" in low-resolution actually being a pit or a dome.

Interestingly, the sizes of the majority of chaos features that were missed were around or over the detection limit, implying that there is another aspect of chaos feature identification that is lost in low-resolution images. It could be that these chaos features are not as dark as the ones that were identified, and therefore did not stand out as a separate feature.

Future work: We will map in additional low-resolution images in the E17 and E11 mosaics. This work will help characterize regions of Europa in terms of its small-scale morphology for use in selecting key areas for the upcoming Clipper mission.

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