DEVELOPING A DATABASE FOR CANDIDATE CRYOVOLCANIC DOMES ON EUROPA. Karla A. Nuñez[1,] Lynnae C. Quick[2], Lori S. Glaze[3], Sarah A. Fagents[4], Ross A. Beyer[5], Louise M. Prockter[6], Emily S. Martin[2], [1]Middlebury College, Middlebury, VT, 05753 , [2]Center for Earth and Planetary Studies, National Air & Space Museum, Smithsonian Institution, Washington, DC 20560, [3]NASA Headquarters, Washington, DC 20546, [4]University of Hawaii at Manoa, Honolulu, HI 96822, [5]SETI Institute, Mountain View, CA 94043, [6] Lunar and Planetary Institute/USRA, Houston, TX 77058.

Introduction: The Galileo spacecraft has provided the highest resolution images of Europa to date. These images revealed a geologically active moon with a surface replete with "chaotic" terrain and "lenticulae', subcircular pits, spots, and domes that are approximately ~10-15 km in diameter [1-3]. A subset of domes on Europa do not reflect the character of the surrounding terrain and may have been emplaced via the eruption of viscous fluids from the interior [4-7] (Fig. 1). These candidate cryovolcanic domes are the focus of our study. The physical characteristics of cryovolcanic domes serve as important inputs to analytical models that explore their formation [4, 7]. Here we present new measurements of heights and diameters for candidate cryolava domes on Europa. These measurements will serve as inputs to models that will shed light on cryolava dome formation on Europa.

Method: Domes that were imaged during Galileo's E6 orbit of Europa were the focus of this study. Photoclinometry was used to obtain topography near the Conamara region, centered at approximately 10°N latitude and 271°W longitude. Data was extracted from a 300 km x 300 km mosaic with a resolution of approximately 180 m per pixel. 38 candidate cryovolcanic domes from this region were selected as part of this study. These domes were selected based on their distinct morphologies, including lobate margins and smooth surfaces that do not possess the character of the surrounding terrain (Fig. 1). Domes where characterized based on their dimensions, location, proximity to other geological features (e.g., ridges,) and surface morphology (e.g., smooth or mottled).

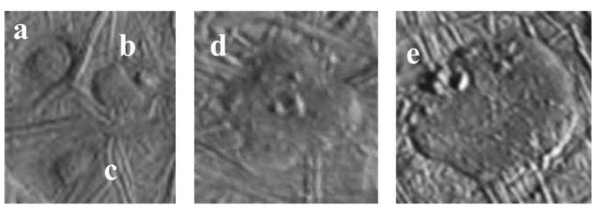

Figure 1. Putative cryovolcanic domes on Europa. These domes have been catalogued in terms of dimensions, location, and morphology in the database that was created in this study.

Background Slope Subtraction. A substantial number of candidate cryovolcanic domes in Europa's E6 region are situated on slopes or within topographic lows. Background slope subtraction was therefore implemented in order to ensure that measured dome heights were accurate. Dome profiles were created using the 3D analyst tool in ArcGIS. Multiple profiles were created across each dome, enabling the regional slope to be determined (Fig. 2). This slope was then subtracted to give a more accurate height value for each dome (Fig. 2). This process is summarized in Fig. 2. Background subtraction was performed two to four times for each dome, depending on its symmetry. Thus, any given dome could have two to four different apparent height values. Dome heights were obtained by averaging these values. We note here that background subtraction preserves small scale topography on top of each dome, which ultimately affects reported dome heights.

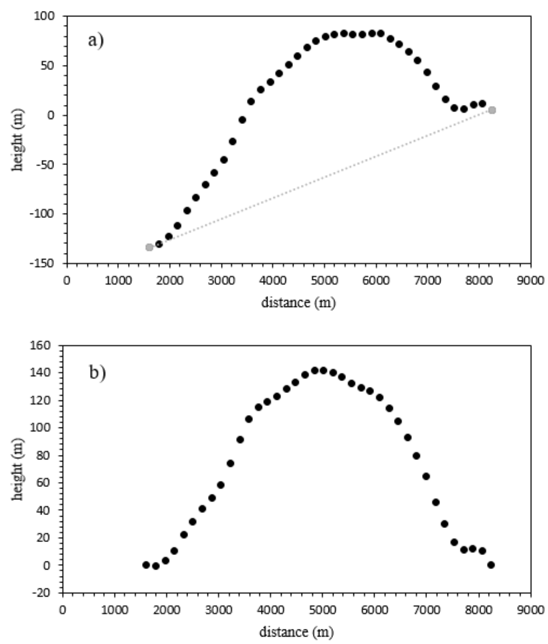

Figure 2. Background subtraction on a single profile line across the dome shown in Fig. 1a. (a) shows the profile of the dome before background subtraction. The gray line in graph a represents the slope of the region. (b) Dome profile after regional slope subtraction, enabling a more accurate apparent height to be determined.

Calculating Dome Diameters. Three different methods were used to calculate the average diameter of the domes. The first method involved creating five distinct profile lines across each dome and taking the average of all of the profile lines. The second method involved taking the average value of the largest and shortest possible profile lines that could be made within the boundaries of each dome. The third method assumed that each dome was a perfect circle. In this case, a shapefile was created in ArcGIS to cover the entire surface of the dome. From this shapefile the area of the dome was calculated. The dome's diameter could then be obtained by solving for the radius in the equation for the area of the circle. In an effort to keep the amount of error introduced into our measurements low, we chose the first of these methods as a reliable determination of dome diameter. The diameter values obtained via this method will be used in continuing efforts to model cryovolcanic dome emplacement.

Additional dome characteristics were also included in the database created during this study, such as: the slope of the background terrain, dome perimeter, area, maximum elevation, minimum elevation, range of elevation, location (i.e., latitude & longitude), proximity to other geological features, and surface roughness.

Results: This study resulted in the creation of a database containing extensive quantitative and qualitative information for 38 putative cryolava domes. Dome heights obtained in this study were somewhat smaller than expected, while dome diameter values were typically in agreement with values from previous studies [e.g., 4, 6] The maximum height of the candidate cryolava domes we analyzed was 228 m, while the minimum height was 35 m. The average dome height in our sample was 81 m. The maximum and minimum dome diameters were 16.2 km and 3.6 km, respectively, with an average diameter of 7.6 m. Dome heights and diameters obtained in this study are compared to the dome heights and diameters obtained in [4] in Table 1. 11 candidate cryovolcanic domes were analyzed in [4]. Background slope subtraction

was not performed in [4], hence the difference in reported dome heights between the two studies. On average, the dome heights obtained in this study differ by about 18% from the dome heights reported in [4]. With the exception of dome b (Fig. 1) dome heights in this study were all less than those reported in [4].
In addition, dome diameters obtained in this study differ from those reported in [4] by about 17%.

Discussion: This study resulted in the creation of a database containing extensive quantitative and qualitative information for 38 putative cryolava domes on Europa. Dome heights obtained in this study were somewhat smaller than expected, while dome diameter values were typically in agreement with values from previous studies. Future work for this project will involve characterizing candidate cryolava domes on Europa from Galileo's E15 and E17 orbits. This larger sample size will reveal if and how the cryolava domes morphologies vary based on their locations on Europa's surface.

References: [1] G. Collins and F. Nimmo, *Europa*, pp. 259-282, 2009, and references therein. [2] Pappalardo et al., *Nature*, 391, 365-368, 1998 [3] R. Greenberg et al., *Icarus,* 161, 102-126, 2003. [4] S. A. Fagents et al., *JGR-Planets*, 108, 2003. [5] H. Miyamoto, et al., *Icarus*, 177, 413- 424, 2005. [6] S. A. Fagents et al, LPSC XXIX, 1721, 1998. [7] L. C. Quick et al., *Icarus*, 284, 477-488, 2017.

Dome	Longitude	Latitude	Height 1 (m)	Height 2 (m)	Diameter 1 (km)	Diameter 2 (km)
a	274° W	7° N	63	80	6.0	5.7
b	275° W	7° N	88	70	7.0	5.1
c	275° W	6.6° N	73	75	5.5	4.6
d	271° W	12° N	47	60	9.1	9.7
e	275° W	16° N	64	n/a	15.9	n/a

Table 1. Comparison of dome properties from this study with those from [4]. Height 1 and Diameter 1 refer to the measurements obtained in this study, while Height 2 and Diameter 2 are those from [4]. Domes **a**, **b**, **c**, **d**, and **e** refer to the domes in Fig. 1. Though we calculated these properties for 38 domes, the table below is just a sample of the database.