GEOLOGIC MAPPING OF EUROPA AT GLOBAL AND REGIONAL SCALES. E. J. Leonard[1,2], D. A. Patthoff[3], and D. A. Senske[1] [1]Jet Propulsion Laboratory, California Institute of Technology (Erin.J.Leonard@jpl.nasa.gov; David.a.senske@jpl.nasa.gov), [2]University of California, Los Angeles, (erinleonard@ucla.edu) [3]Planetary Science Institute (apatthoff@psi.edu)

Introduction: Evaluating the potential habitability of Europa requires an understanding of the geology that drives the interaction between the surface and the deeper interior of the body. To this end, we have constructed a global geologic map at the scale of 1:15M (Fig. 1) [1]. To provide greater insight into the broad global stratigraphic relations, we are currently mosaicking and mapping, with a consistent set of units, ~10% of the surface imaged at the 100-220 m scale placed in the global-scale context (Fig. 1 and 2). In this paper, we discuss the general results of our global mapping and preliminary results from regional scale mapping of the Canamora Chaos region.

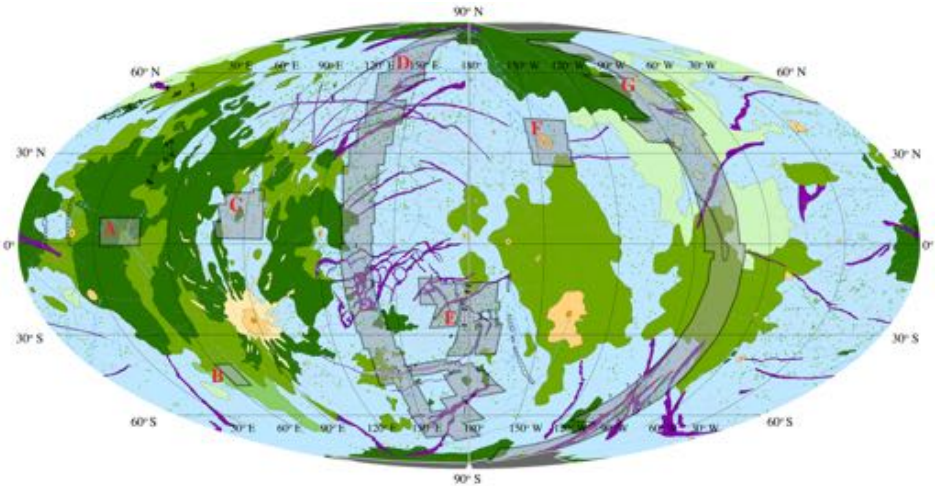
Europa Global Geologic Map: Our geologic mapping [1] has established four primary global material unit types, crater material, chaos, bands, and regional plains (Fig. 1). These units are divided into geologic subunits: (1) continuous crater ejecta (ce) and discontinuous crater ejecta (dce), crater ray material (cr), and central peak structure (cp)—materials associated with impact craters including the primary impact crater (c) and its local deposits and farther ranging ejecta material; (2) various morphological types of chaos materials identified as high albedo chaos (chh), mottled chaos (chm), low albedo chaos (chl) and knobby chaos (chk). Small (10 to 75 km in diameter) disrupted terrains, microchaos (mch), possess textures that vary, relative brightnesses that range from high to low, and are ubiquitous and significant enough to be identified on the map as a point; (3) Bands (b) are linear to curvilinear belts that are greater than 15 km in width and can have a distinct, abrupt relative brightness change from the surrounding region; and (4) regional plains (pr)--high-albedo, compared to the surrounding terrain and smooth at global resolution. We also identify structures which are too small be mapped aerially but are significant enough to be mapped with linear features (Fig.1).

Based on the relationships among the various map units, we have established a general stratigraphic chronology for Europa. The first and oldest period is dominated by the formation of regional plains, ridges, and undifferentiated linea, an epoch characterized by ridge building processes. The second, or middle, period is dominated by band and undifferentiated linea formation. The band unit generally appear younger and cross-cut the regional plains unit. Cycloids also appear to have formed during this period. The third, and most recent period, is dominated by chaos terrain formation including the emplacement of microchaos. At the global-scale, chaos terrain does not appear to have any cross-cutting units besides craters and their ejecta, troughs in the northern leading hemisphere, and potentially depression margins. Likewise, mircrochaos is observed breaking up previously formed bands, ridges, cycloids and other features, indicating that it is generally younger.

Geologic Map of the Conamara Chaos Region: Extending our mapping to the regional scale in Conamara Chaos (Fig. 2), initial results [2] provide greater insight into the regional plains unit by establishing relations between assemblages of key tectonic terrains. The regional units consist of: Wide bands (bw) made up of parallel ridges spaced between 550 m and 1.25 km apart. The overall width of the band assemblages ranges from 4 to 10 km; Bands (b) that are made up of several sets of parallel ridges spaced between 525 m and 950 m apart with individual bands ranging in width between 2 and 4 km (narrower than wide bands); Double ridges (rd) that are composed of two distinct parallel ridges separated by a central trough; and fractures (f) that are single troughs that lack discernable raised rims. Fractures are typically linear, through going, and cross cut most other units. Other geologic units include: Chaos (c) which are complex regions 10s to over 100 km across composed of disrupted pre-existing crustal blocks and a smoother "matrix" material between the outcrops and microchaos (mch). In comparison with the global units, the regional plains and band units can be subdivided into a wider array of outcrop units allowing for a more detailed set of stratigraphic relationships to be identified.

Future Work: The global map will have been revised and resubmitted to the USGS by May 2019. Our regional-scale mapping will include the generation of new mosaics of the regions labelled A to G in Fig. 1, defining a consistent set of regional-scale units for use in all areas [e.g. 4] and incorporation of each region into the global context. The results will provide greater insight into how the icy curst of Europa formed and evolved.

References: [1] Leonard, E. J. et al. (2018) *USGS* in review. [2] Senske, D. A. (2016) *LPSC XLVII*, 1365-1366. [3] Figueredo, P. H. and Greeley, R. (2004) *Icarus*, 287-312. [4] Greeley R. et al. (2000) JGR, 22559-22578.



DESCRIPTION OF MAP UNITS

Label	Unit Name and Description	Type Example
	Impact Crater Units	100 km
c	Crater material—quasi-circular depression with a raised rim or complex annular structure. Crater floor can be roughly flat to bowl-shaped.	
ce	Continuous Crater Ejecta—Region around the crater material that has undergone modification due to an impact. Hummocky in texture. Can occur in a variety of albedos.	
cde	Discontinuous Crater Ejecta—High albedo patches aligned quasi-linearly, apparently emanating radially from a central point (crater).	
	Chaos Units	
lalb	Low Albedo Chaos—Disrupted terrain with a relatively uniform low albedo and smooth texture.	
chmg	Mottled Chaos—Disrupted terrain with a patchy/ variegated albedo. Rough, blocky texture.	
chh	High Albedo Chaos—Disrupted terrain with a uniform high albedo appearance with respect to the other chaos units and the surrounding terrain. Smooth texture.	
chk	Knobby Chaos—Disrupted terrain with rough and blocky texture. The rough texture is at a larger scale than the other chaos units. Slightly scalloped edges.	
	Band Units	
bha	High Albedo Band—Linear to curvilinear zones with a distinct, abrupt albedo increase from the surrounding region..	

Label	Unit Name and Description	Type Example
	Band Units (cont.)	100 km
b	Band—Linear to curvilinear zones with a distinct, abrupt albedo change from the surrounding region, greater than 15 km in width.	
	Plains Units	
pr	Ridged plains—High-albedo compared to surrounding terrain. Seemingly smooth at the global resolution but texture is revealed in higher resolution images.	
	Linear Features	50 km
	Depression Margin (dm)—Trace of broad, shallow topographic lows.	
	Troughs (t) —Linear, narrow topographic low with material on either side showing no apparent offset.	
	Multi-Ring Structures (mrs)—Identified by a quasi-circular series of ridge-trough structures surrounded by material with a hummocky texture.	
	Microchaos (mch)—Circular to oblong 10-75 km diameter disruptions of the background terrain. Commonly occurring on the ridged plains unit but has a lower albedo or different texture than the ridged plains unit.	
	Cycloids (cy)—A series of continuous arcs linked sharp cusps.	
	Band Linea (bl)—Linear to curvilinear zones with a distinct, abrupt albedo change from the surrounding region, less than 15 km in width.	
	Ridges (r)—Quasi-linear topographic highs containing one or more crests.	
	Undifferentiated Linea (ul)—Long (10s to 100s of km), linear, through-going features of either low or high albedo that do not have other discernable characteristics at the global scale or at the available resolution.	

Figure 1. Global geologic map of Europa and unit descriptions [1]. Regional plains and chaos make up 53% and 40% of the surface respectively. The areas being mapped at the regional scale are labelled A to G. The Conamara region ("C") is show in detail in Figure 2.

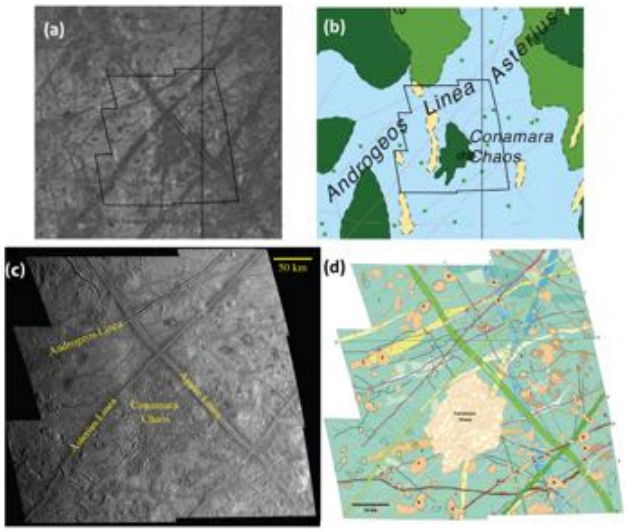


Figure 2. (a) Global base image showing the Conamara Chaos region. The black polygon outlines the location of regional-scale images. (b) Global-scale geologic map of the Conamara Chaos region showing that it contains ridge plains, distal crater ejecta, microchaos and numerous lineaments. (c) Regional-scale mosaic of the Conamara Chaos region and corresponding geologic map (d). Many of the ridge and band units are distinct stratigraphic markers allowing greater detail of the history of this region to be determined. In comparison with regional-scale mapping of the leading and trialing hemispheres [3] similar assemblages of units are identified in both areas.