

Morphological Analysis of Bands in Europa's E-15 Region

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Introduction:

Of the Galilean moons circling Jupiter, Europa is the second closest and the smallest. It has attracted some interest from the scientific community, due to its subsurface ocean which is one of the most likely places to find life in our solar system, and its geologically young surface of ~100Myr. Europa's surface resembles an icy ball of string, covered in wide linear features called "Bands" and narrower linear ridges and fractures. We analyzed a portion of the E15 region in the northern hemisphere, to map these linear features and learn more about Europa's changing ice shell through time.

Background:

Europa experiences plate tectonics in the form of large slabs of brittle ice atop a layer of slightly warmer, slushier ice that convects and drives tectonic movement (Kattenhorn and Procktor 2014). The tectonic motion of the plates drives changes in surface morphologies. Divergence of the plates creates dilational features like bands and ridges (mapped in Figure 2), and convergence may cause subduction-like processes.

Three morphologies of bands are recognized; being smooth bands, lineated bands, and ridged bands, with bright bands and subsumption bands as subtypes (Howell and Pappalardo 2018; see Figure 3). Smooth bands are symmetric with distinct smooth surfaces, lineated bands have sets of lineations parallel to a central trough, and ridged bands do not have distinct margins and tend to be heavily overlaid by new material.

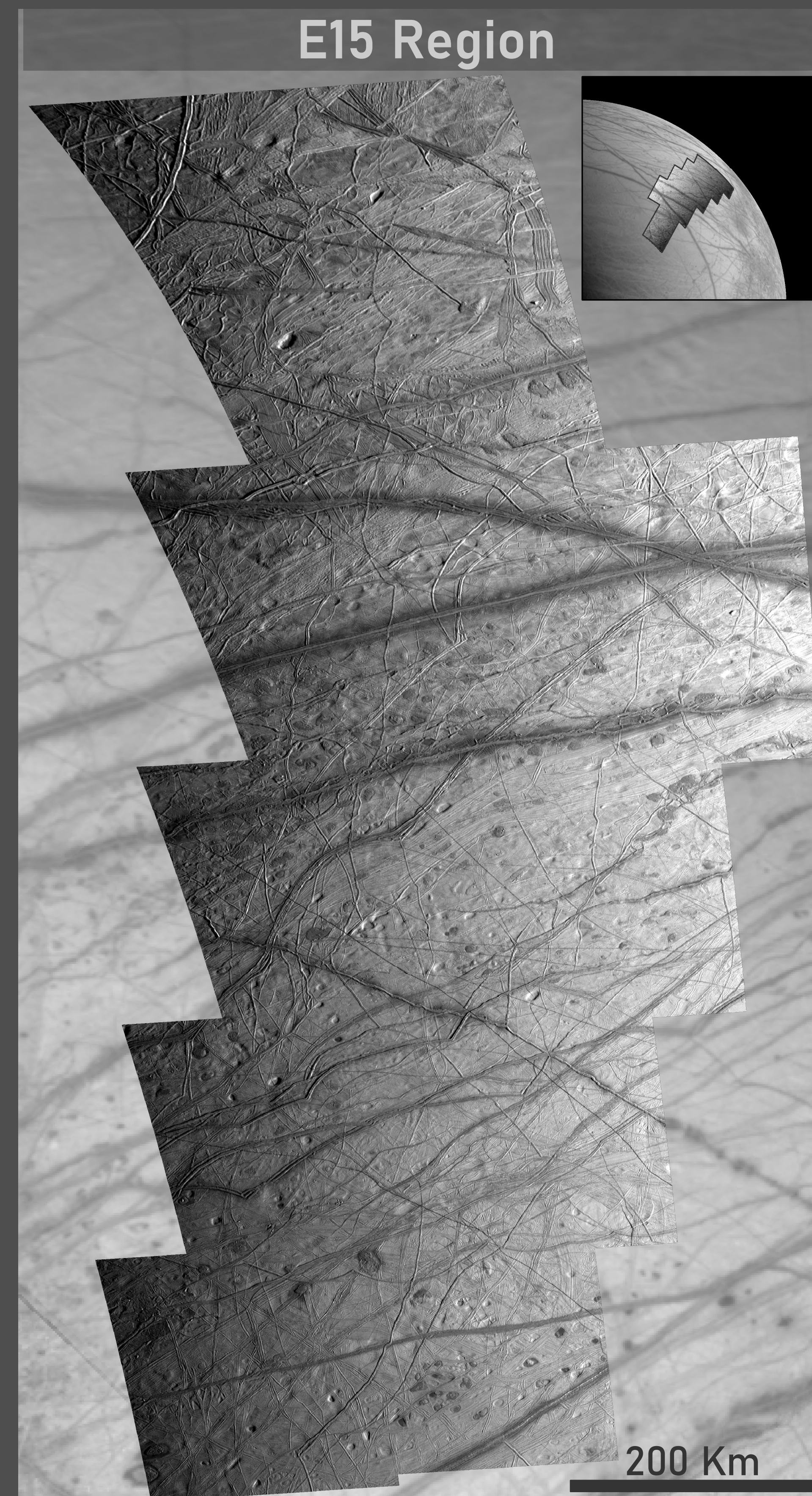


Figure 1: E15 Region in high resolution surface imagery collected from Galileo

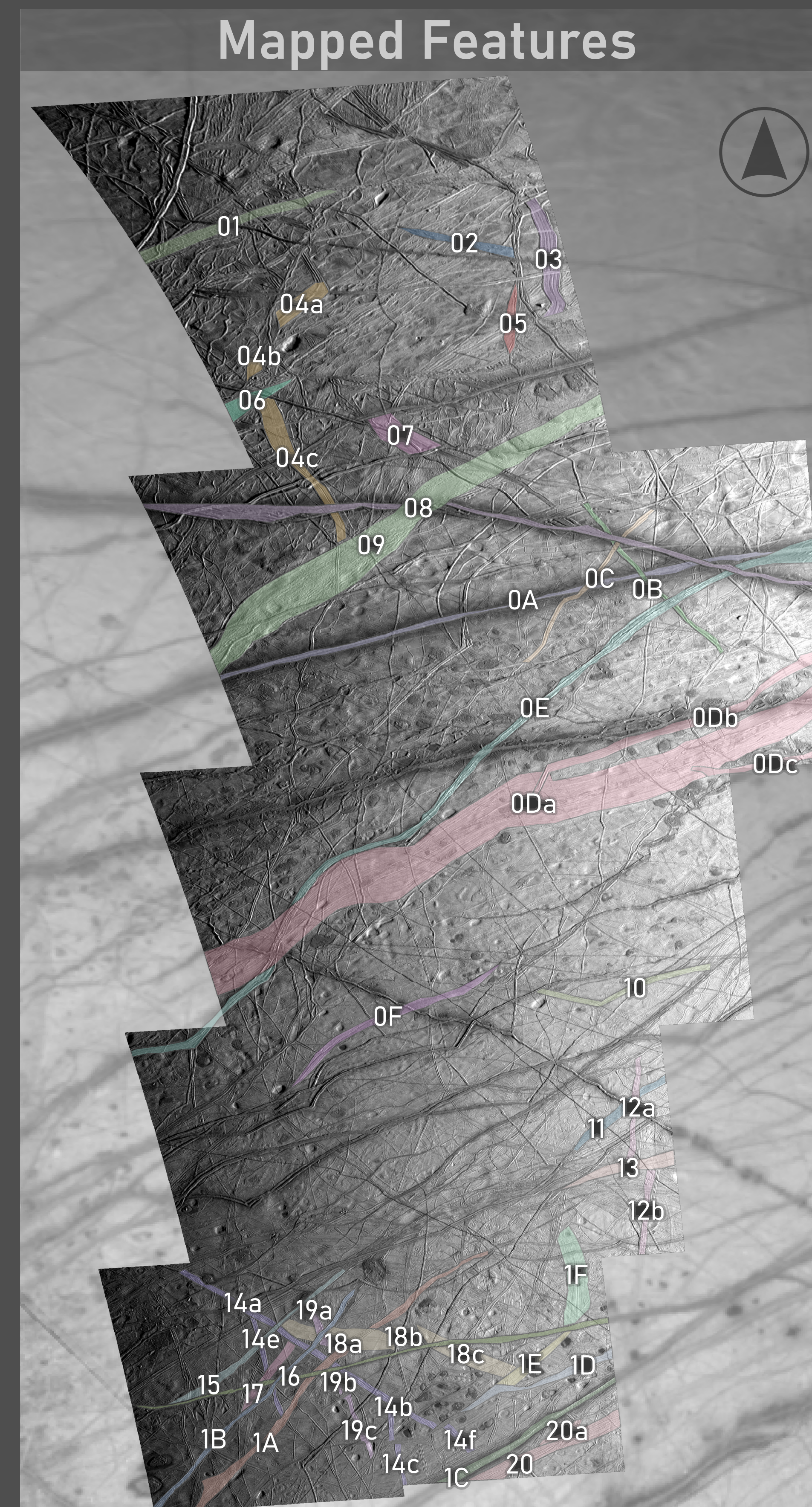


Figure 2: E15 Region with labeled, mapped surface features

Methods:

ArcGIS was used to collect width, length, and latitude range of mapped features. These values were used to calculate average width and standard deviation of width. We calculated normalized deviation to compare bands:

$$\sigma_{norm} = \frac{\sigma}{Width_{ave}}$$

Each band feature was assigned morphology based on Howell & Pappalardo, 2018 (Figure 3). Spatial relationships were explored by plotting characteristics against latitude. Features with normalized deviation higher than around 25% were further explored, These features had unique shapes.

Results:

In the E15 region, we map a slightly greater concentration of bands at low latitudes. Overall though, we conclude that spatial factors do not correlate with band shape in our region, indicating a fairly homogenous stress regime across space.

Longer features generally have higher normalized deviations of width than shorter ones, although only weakly correlated, which might be an artifact of our mapping.

Features with high (>25%) normalized deviation are unique in shape (Table 1), with nonlinear forms interpreted to have undergone variable stress regimes during their formation. Features with normalized deviations around 30% have width that varies significantly (Figure 5). The features that have greater deviations, from 35% to ~50% are either wedge shaped, or collapse at their margins.

Temporal analysis could reveal further information about the stresses these features were subject to during formation, as well as spatial relationships through time. Region specific surface textures and morphologies were likely the result of dissimilar material properties, and/or variations between past stress states.

References & Acknowledgments:

[1] Collins G. et al. JGR Planets (2022); [2] Daubar, et al. Space science reviews (2024); [3] Greeley et al. JGR (2000); [4] Howell and Pappalardo, GRL (2018); [5] Howell and Pappalardo, Nature Communications (2020); [6] Kattenhorn and Prockter, Nature Geosci. (2014)

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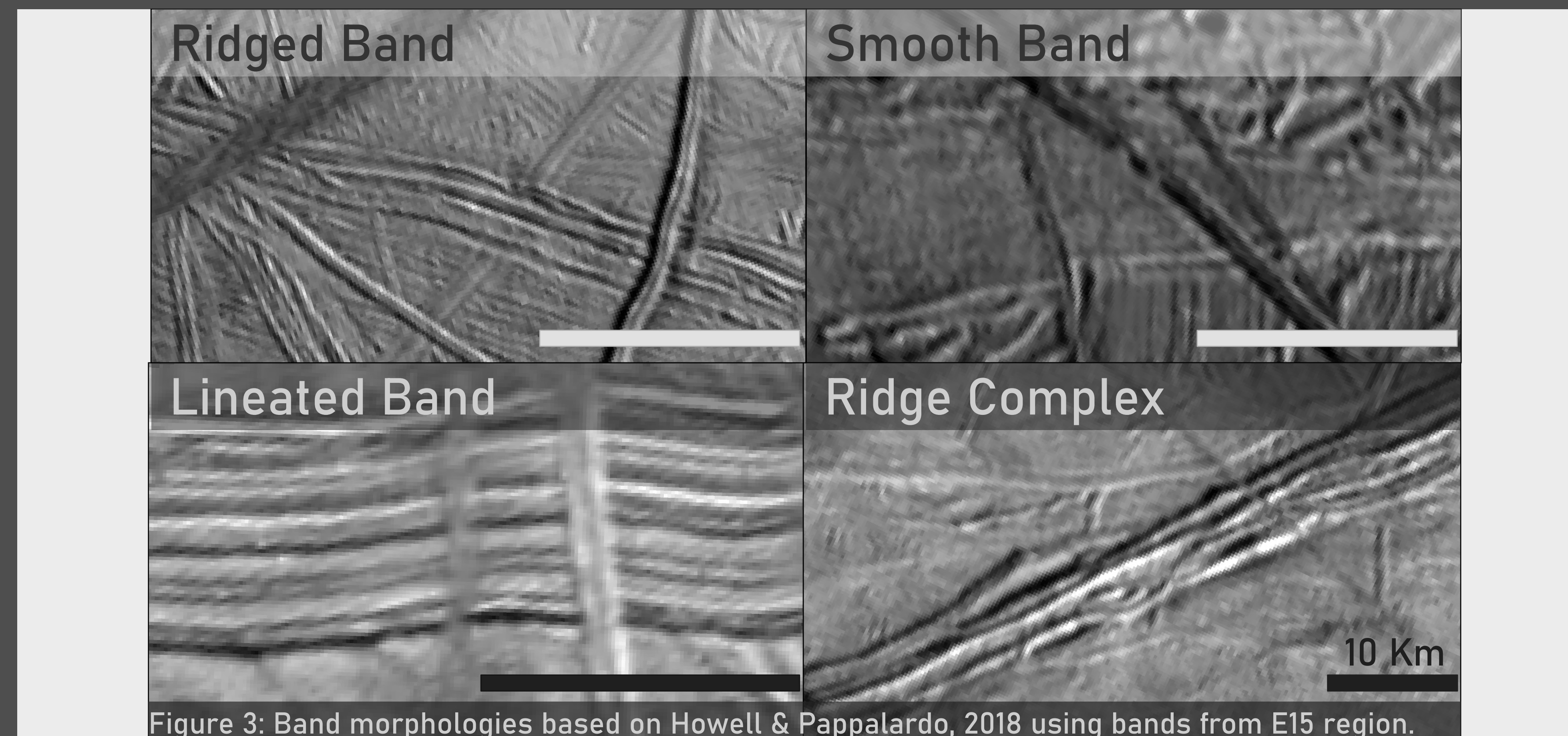
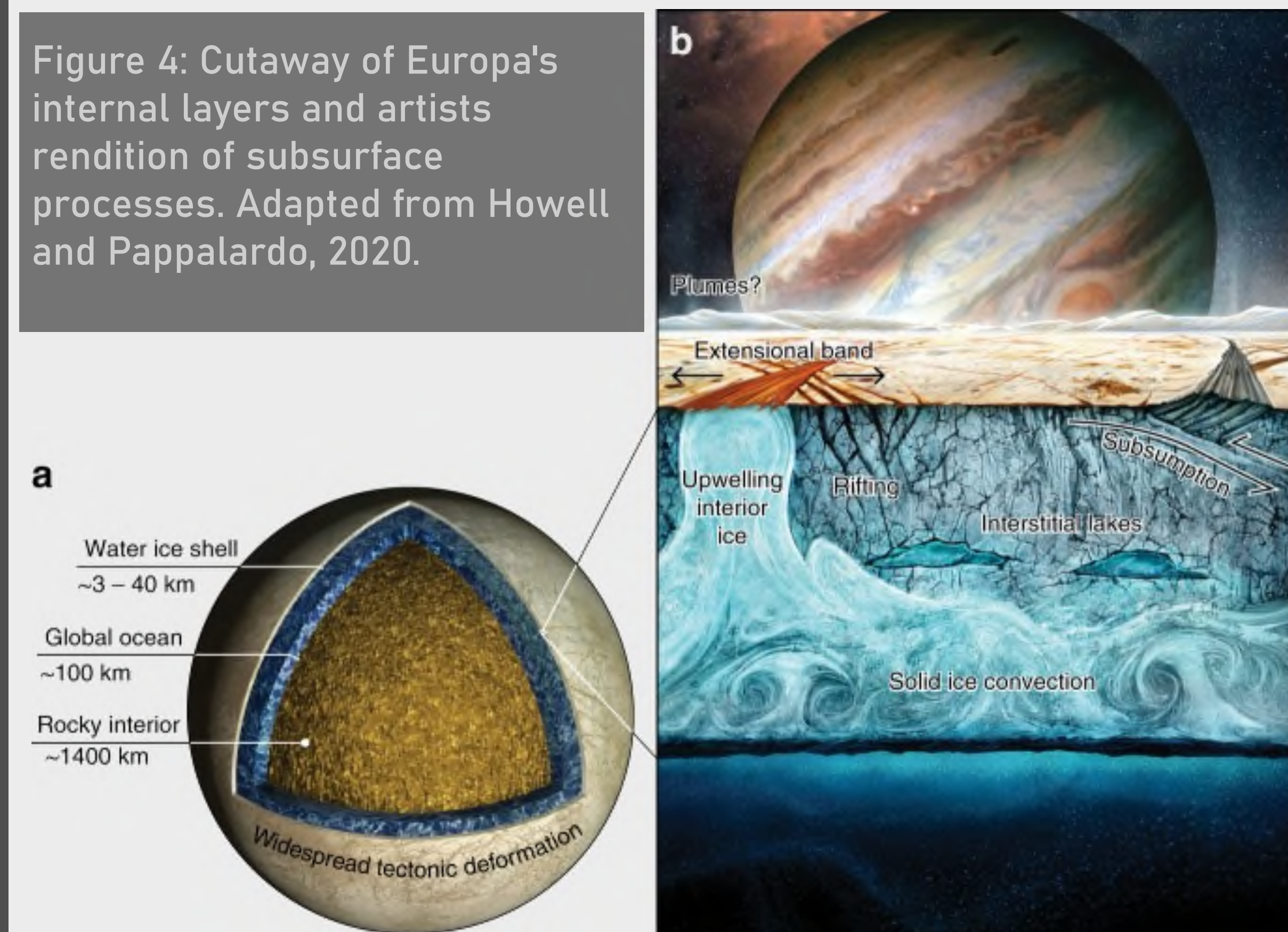


Figure 3: Band morphologies based on Howell & Pappalardo, 2018 using bands from E15 region.