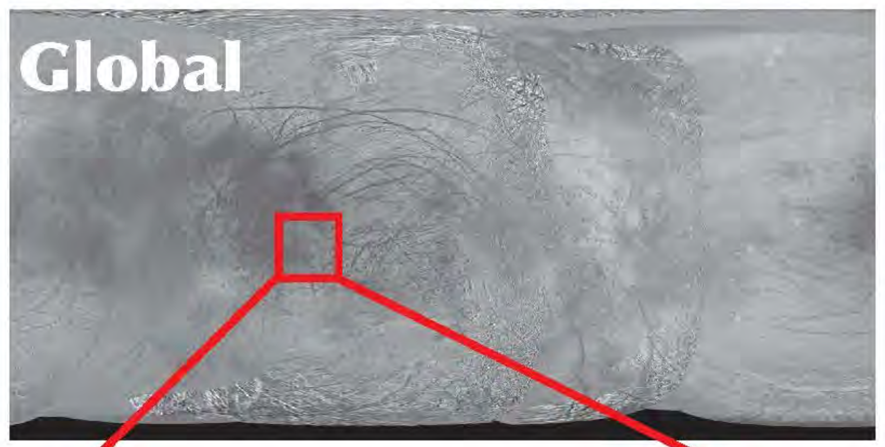
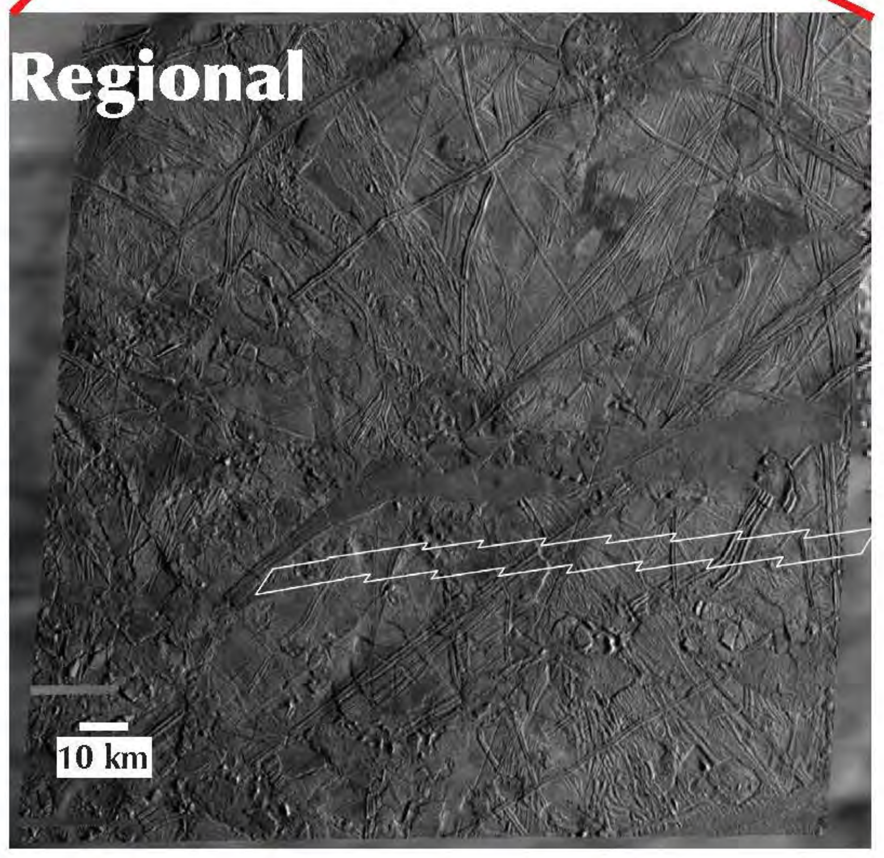
Structural Analysis of Very High-Resolution Galileo Images of Europa: Implications for Surface Evolution

Erin J. Leonard[1], An Yin[1], Robert T. Pappalardo[2], D. Alex Patthoff[2], Paul Schenk[3], Louise M. Prockter[4]
[1]University of California Los Angeles, Earth, Planetary and Space Science, erinleonard@ucla.edu, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [3]Lunar and Planetary Institute, Houston, TX, [4]John Hopkins University Applied Physics Laboratory, Laurel, MD

Area of Interest





Key Observations

1) Crosscutting relationships in both the structural and geological maps reveal relative ages (i.e.: folds are crosscut by a normal fault; normal faults are crosscut by tensile cracks) which leads to the "Possible Evolution".

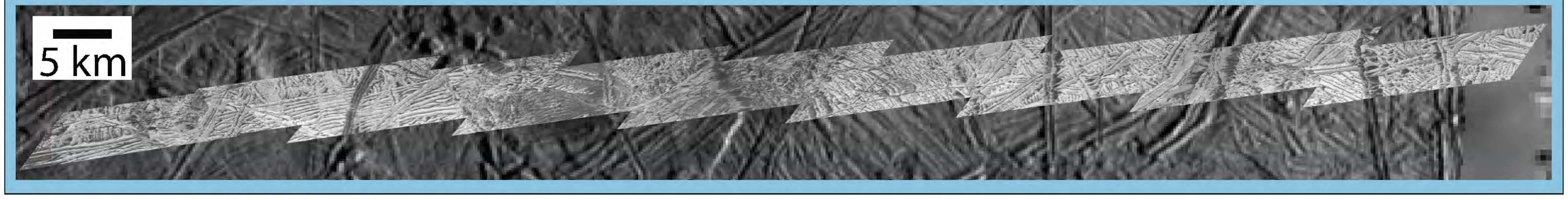
2) Cross-section of ridge-trough (orange box on "Structural Map") is indicative of a fold, (compressional structure) as opposed to a tilt-block (extensional structure) [3]. Folds are the preferred interpretation here based on observed geometry (i.e.: anostomosing ridges, drag folds, possible cleavage planes, and symmetry) and regularity.

3) Ridges in the area of interest (see red box on "Structural Map") form hook-like shapes, which is reminiscent of drag folds.

Introduction

The Galileo Solid State Imager (SSI) obtained nine very high-resolution frames (eight at 12 m/pixel and one at 6 m/pixel) during the E12 flyby of Europa in Dec. 1997. To understand the implications for the formation of small-scale structures and surface evolution of Europa, we mosaicked these frames (observations 12ESMOTTLE01 and 02, incidence ≈18°, emission ≈77°) into their regional context (part of observation 11ESREGMAP01, 220 m/pixel, incidence ≈74°, emission ≈23°), despite their very different viewing and lighting conditions ("Image Mosaic", below). Additionally, to gain a better understanding of Europa's resurfacing processes, we created both a morpho-geological map and a structural map of the region ("Geomorphological Map" and "Structural Map"), expanding and modifying previous work in this area [1 and 2].

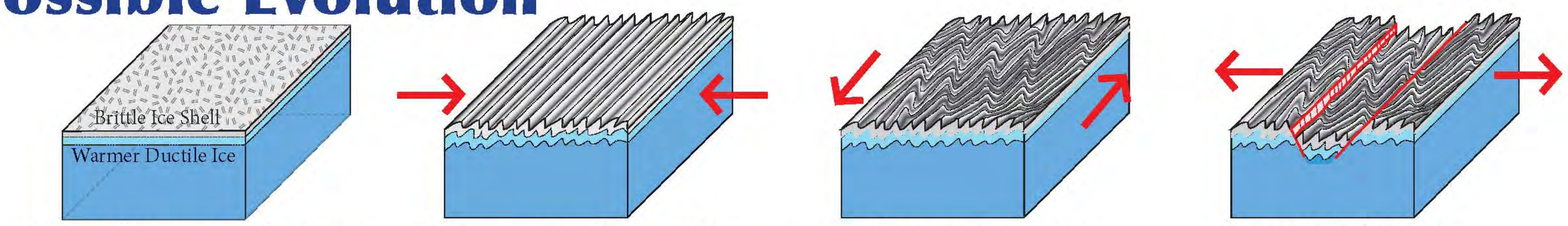
Image Mosaic



Geomorphological Map

Structural Map

Possible Evolution



(1) Initial State: Heavily porous and fractured layer lies on top of progressively warmer more ductile ice with depth.

(2) Compressive forces induces folding in the ductile ice which is expressed on the surface as ridges and troughs (wavelength of 50-100 meters).

(3) Shear motion creates drag folds along ridges. This motion is confined along a band seen in the regional image.

(4) Ice shell thickening causes normal faulting.

(5) Stress in a thickening ice shell causes tensile cracks to form.

Conclusions and Implications

The proposed evolutionary sequence is non-unique, but is a plausible option for how this area may have developed. The progression of this region from small-scale folding to larger-scale normal faulting and then to tensile cracking could be indicative of the ice-shell thickening over time. By further refining the classification of Europa's structures at high-resolution, we can continue to refine the inferred stages of surface evolution on the icy satellite. Resurfacing processes and the surface evolution in this region have possible implications for the different suggested models for chaos formation [e.g. 4,5 and 6] which depend on ice-shell thickness, and thus have implications for the interaction of the surface and the ocean.

Future Work

1) Further investigate plausibility of folding as a mechanism for ridge-trough formation on Europa (i.e.: calculate required stresses and physical analogue modeling)

2) Test candidate evolution model by comparing this area to other high-resolution regions of Europa.

References

[1] Figueredo, P. H. and Greeley, R. (2004) Icarus, 167, 287–312. [2] Prockter, L. M. (2004) LPSC XXXV, Abstract #1714. [3] Prockter, L. et al. (2002) JGR, 107. [4] Schmidt, B. E. et al. (2011) Nature, 479, 502-505. [5] Greenberg, R. et al. (1999) Icarus, 141, 263–286. [6] Pappalardo, R. T. et al. (1999) JGR, 104, 24,015-24,055.