IDENTIFICATION OF POTENTIAL PLANETARY-SCALE LONG-TERM TIDAL-CRYOTECTONIC CYCLES IN EUROPA – FIRST APPROACH B. Bradák[1], Á. Kereszturi[2,3], and C. Gomez[1,4] [1]bradak.b@port.kobe-u.ac.jp; Graduate School of Maritime Sciences, Kobe University, 5-1-1 Fukaeminami-machi, Higashinada-ku, Kobe 658-0022, Japan, [2]Konkoly Thege Miklos Astronomical Institute, Research Centre for Astronomy and Earth Sciences, MTA Centre for Excellence, [3]European Astrobiology Institute, hosted by the European Science Foundation, Strasbourg, France, [4]Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia

Introduction: More and more attention has been raising toward the icy moons of the Solar System since the discovery of their potential liquid water [1], and the astrobiology potential below their surface ice [2]. In addition, the ongoing preparation of JUICE (JUpiter ICy moons Explorer) mission from ESA is boosting the research as well.

One of the many research topics, connected to the study of Europa, the second Galilean satellites of Jupiter is the interpretation of the cryo-tectonic features on its surface and their relation to tidal processes triggered by Jupiter [3] and moon-moon interaction as well [4]. Following the detailed studies around the early 2000s, [5, 6] the goal of this research is to revisit Europa and re-investigate its surface by mapping one of its most characteristic surface patterns and test an approach toward an established "linea-stratigraphy" and the identification of planetary-scale tidal-cryotectonic cycles.

Data and Methods: The base map of the studied area is used trough the "Planetary WMS service hosted by Astrogeology, USGS of Jupiter's moon Europa" [7]. The focus of the research is the complex lineage system of Awnn and Balgatan Regio, in the location between longitude 60°W and 30°E and latitude 30°N and 60°S [8]. The studied area was referred as the "Jupiter facing hemisphere" as well [3]. Based on the recent geological map of the moon [9], the regions are defined by "ridged plains" with "bands", "high albedo bands", "undifferentiated lineas" and "chaos" terrains.

During the separation of the linea (e.g., faults and ridges) generations, parameters, such as the i) physical-morphological appearance; ii) "linear feature stratigraphy", i.e., the appearance of overlapping and transform faults; iii) impact crater density; and iv) unique morphological indicators were considered.

Under- ("stratigraphically older") and overlying ("stratigraphically younger") lines were counted in the case of the sampled linear features and the ratio of the two parameters were calculated. The correlation between the under- and overlying lines and the length of the linear feature were examined to avoid the bias of crossing lines triggered by the differences in the length parameter (Fig. 1a). If there were strong mathematical connection between the number of the under and/or overlying lines, it may suggest the influence of the length on the amount of crossing lines.

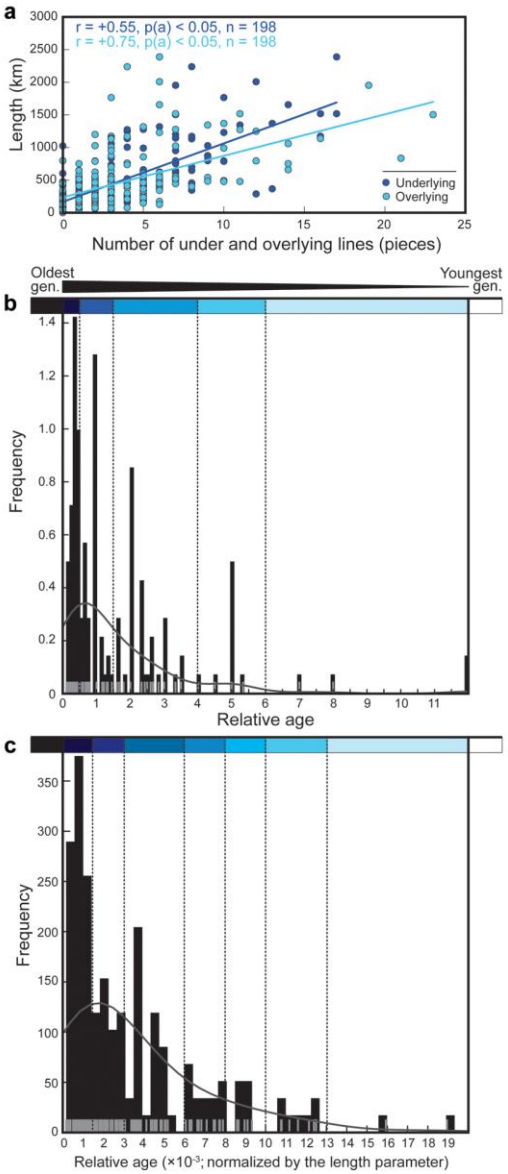

Figure 1. *Examination of the relationship between the number of under and overlying lines and the length of the actual linear feature (a). Separation of various linea-generations by b) the ratio of underlying and overlying lines ("Relative age"), and c) by the same ratio but normalized by the length of the studied linear features.*

To avoid such bias the length parameter was used on the calculated over/underlying lines ratio as a normalizer to decrease its possible effect on the results.

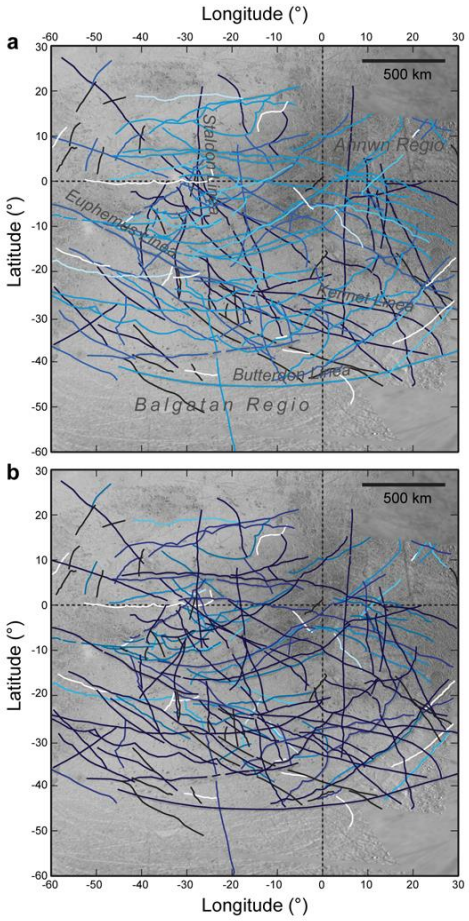

Figure 2. *Linea-generations in the studied locations (indicated by various colors). The color gradient toward lighter colors indicates younger and younger "relative age" defined by the under- and overlying line ratio (histogram analysis; Fig. 1b and c)*

The distribution of the normalized ratio was analyzed by histograms (Fig. 1b and c). Theoretically, the distribution peaks on the histogram indicates characteristic groups of linea, which possibly belongs to the same linea-generation, i.e., formed at the same time and are overlaying and underlaid by similar amount of other linear features. Based on the distribution peaks in the histograms seven and nine possible ratio-categories were separated: i) a linea overlaying other linear features, but not underlaid by others ("youngest"), and ii) a linea underlaid by other linear objects, but not overlaying any others ("oldest") were also categorized separately (Fig. 1b and c). These categories may represent stratigraphical units, which indicates various linea-generations.

Results and discussion: The allocation and the morphological characteristics of the lineas are similar to some tectonic features observed on Earth [10]. Such features are e.g. the regional-scale "cycloidal ridges" [3] and smaller asymmetrical Y fault patterns, which may indicate quasi-circular shape dome forming-like processes [10]. The observed linea-generations (Fig. 2a and b) may indicate regional(/palenetary)-size, repeating bulge of the ice-crust, possibly triggered by the allocation of water-mass in the subsurface hydrosphere (ocean) below the ice shell of Europa, driven by tidal forces (e.g., bulging during "high tide" ↔ falling subsurface water level during low tide and formation of drained space between the subsurface water table and the icy crust) (Fig. 2).

Completing the observations of some of the previous studies [3] suggesting that "tidal pumping" happens maybe in daily basis, the identified generations of cryotectonic features may suggest the existence of longer tidal cycles, possibly related not only to the tidal force between Europa and Jupiter [3], but the effect of the other moons [4] and possibly other celestial bodies in the Solar system.

Conclusion: Although the first results are promising, reaching the final goal of this study, i.e., the separation of various cryotectonic cycles and revealing information about the possible planet-scale long-term tidal periods of the subsurface ocean of Europa, needs more support.

Before the hopefully successful JUICE mission and the flow of new information, the re-evaluation of the existing data from new viewpoints may help to understand some segment of the cryotectonic processes and its relation to the subsurface ocean of Europa. The future use of statistical methods (principal component, and hierarchical cluster analysis) and physical and morphometrical parameters of the linear features may help to gain more and more information about the characteristics about the most likely existing long-term cryotectonic cycles on Europa.

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