INTRODUCTION TO DIONE`S WISPY TERRAIN, AS A PUTATIVE MODEL REGION FOR WILSON-CYCLES ON ICY SATELLITES. B. Bradák[1], J. Kimura[2] and C. Gomez[1,3], [1]Faculty of Oceanology, Kobe University, 5-1-1 Fukaeminami-machi, Higashinada-ku, Kobe 658-0022, Japan; bradak.b@port.kobe-u.ac.jp [2]Department of Earth and Space Science, Osaka University, 1-1 Machikaneyama-cho, Toyonaka, 560-0043, Japan.[3]Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia.

Introduction: Saturn's icy moon Dione, and its enigmatic feature, the so-called Wispy Terrain have been the object of scientific debate for a long time. Almost three decades after the first geological mapping [1], the main terrains are re-evaluated in light of the new data from the Cassini spacecraft [2]. The markings of the Wispy Terrain are defined as a set of quasi-parallel troughs, scarps, and "horst and graben" systems, indicating extensional and shear stress in the region. The chasmata systems are defined as Fractured Cratered Plains and sub-divided into three facies types, regarding the timing of their formation, which date back to 3.7 Ga (with 100 Ma uncertainties) or alternatively between 2.7 Ga and 260 Ma [2]. The newly computed ages (4.5-1.6 and 4.5-0.6 Ga) for the Faulted Terrain (Wispy Terrain) showed that those ages do not reflect the timing of tectonic activity, but the time span over which the larger craters and their ejecta blankets erased the smaller craters [3]. Based on the analog geological characteristics between the fault system of chasmata and Earth`s regions with the extension-drive divergent plates, the Faulted Terrain was defined as hemisphere-scale rift zones [4,5].

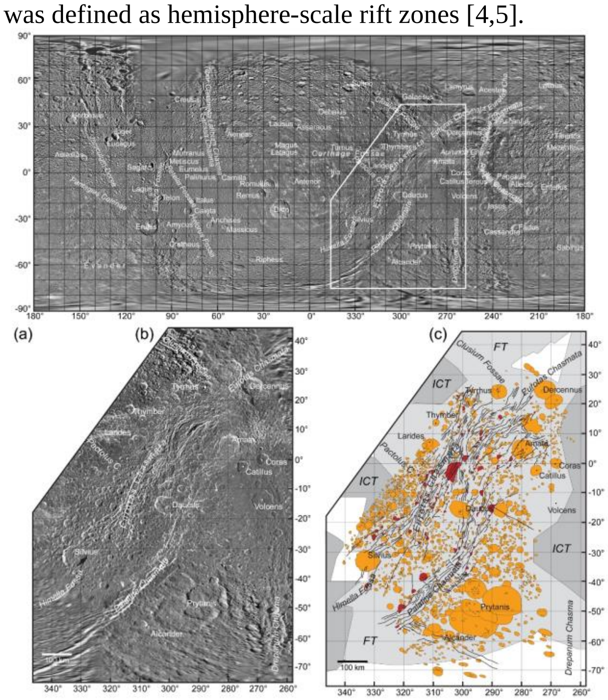

*Figure 1. (**a**) The Cassini-Voyager Global Mosaic 154m v1 map. (**b**) the studied region in the Wispy Terrain of Dione. (**c**) the simplified geological map of the studied location. Red craters indicate some of the identified fragmentary craters.*

The possibility of a subsurface ocean under the ice shell [6], brought a promise of a still active surface and a potential for life harbored under the icy shell. The study of the stratigraphic relationship between the craters and faults on the Wispy Terrain suggests that the faulting is a very recent event, dating back to 0.3-0.79 Ga [7]. Some of the newest studies go even further and suggest that the upper limit for the age of studied fault on Wispy Terrain is only 152 Ma, which observation supports the hypothesis that the cryotectonism might be still active or was active a very short time ago (c.a. 100 Ma) on the satellite [8].

Despite the widely accepted theories about the dilatation-ruled formation of the region [2,4,5], here we may provide some evidence that supports the existence of compressional stress field and subsumption during the evolution of the Wispy Terrain.

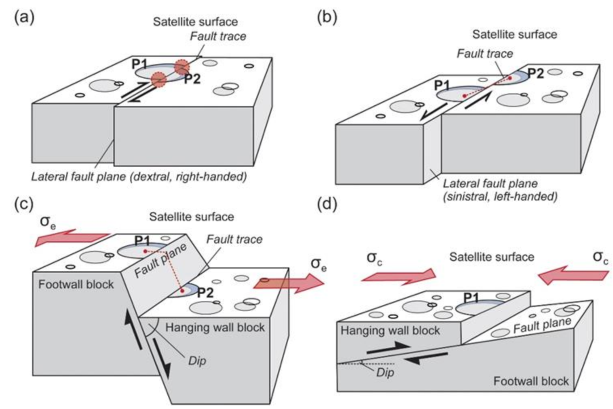

*Figure 2. Crater preservation in various fault settings - a simplified view. (**a**) strike-slip fault with minimal horizontal re-location; (**b**) strike-slip fault with the dislocation of crater parts; (**c**) normal fault with vertical re-location of some crater parts; and (**d**) formation of fragmentary craters by thrust faulting.*

Data and Methods: The studied region of the Wispy Terrains is spreading approximately between latitude 40° and -60° and longitude 260° to 350° (***Fig. 1***). The map is based on Cassini - Voyager Global Mosaic 154m v1 map (Astropedia – Lunar and Planetary Cartographic Catalog) [9-12]. The geological mapping (***Fig. 1c***) was performed by QGIS 3.22 software. ***Figure 2*** introduces the four basic crater-fault system relations investigated during the research.

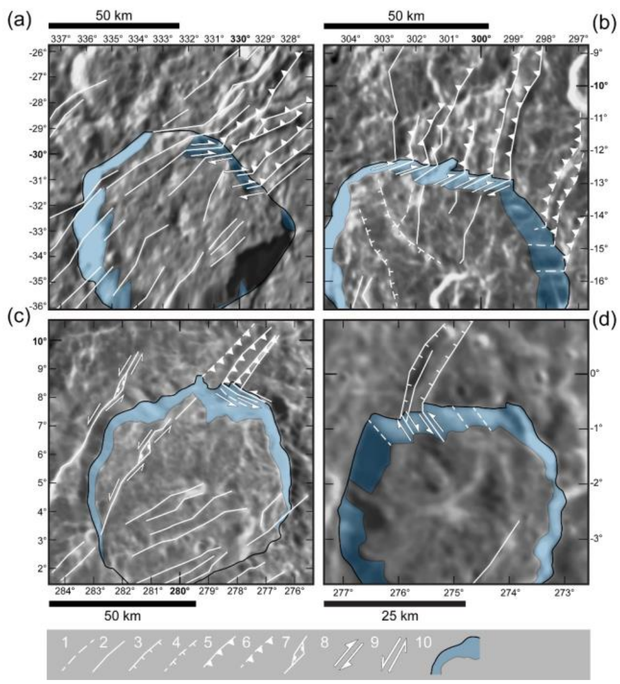

Figure 3. *Structural geological characteristics observed in the wall of large craters crosscut by putative tectonic lines. (**a**) Silvius; (**b**) Daucus; (**c**) Amata; and (**d**) Catillus craters. The numbers in the legend, represent the following features: 1-probable fault; 2-fault (uncertain direction of movement); 3-normal fault; 4-probable normal fault; 5-thrust fault; 6-probable thrust fault; 7–strike-slip fault with pull-apart basin, 8 - orientation of (quasi-)vertical block movement, 9 - orientation of (quasi-)horizontal block movement; and 10 - exposed crater wall.*

Results: The preliminary geological mapping of the area resulted in the identification of close to 450 main tectonic lines and 2500 craters (***Fig. 1c***). The relationship between the tectonically active zones and the increasing number of fragmentary craters along those tectonic lines seems clear and may indicate thrust faulting (***Fig. 2d***) as one of the key cryotectonic processes in the region. Compared to the previous studies [4,5,13], thrust/ splay and décollement faults indicate a compressional stress field and convergence of plates [14]. To verify the results of the crater mapping, the wall of larger craters found in a region, and crosscut by tectonic lines were investigated (***Fig. 3***). Putative faults, observed in ***Figure 3a***, and ***b***, might be identified as domino-style normal faults, or thrust faults, but supported by various evidence, the possibility of the former ones was already excluded [13]. As an alternative to thrust faults, the features in ***Figure 3c*** may be recognized as listric normal faults. In this resolution, it is hard to recognize key features such as the thrust sheets (the “imbricating splays” of the splay and décollement faults) or the tilted face of the blocks (a listric normal fault), which may help to decide between the two features. As a comparison to the putative thrust faults, the features in ***Figure 3d***, most likely indicate a normal fault system of a “graben” structure between two uplifted blocks.

Discussion and Conclusion: Extensional stress seems common on Dione`s crust, resulting in various types of normal faults [4,5,13]. The discovery of potential thrust/splay and décollement faults may indicate compression and tectonic features whose morphology reminds of the structure of an accretionary prism and may suggest the existence of subsumption (subduction-like process) [14]. Theoretically, it means that Wilson cycle-like tectonic cycles may appear in icy planetary bodies [15], and Dione`s Wispy Terrain, which consists of divergent and convergent sections, may also turn out to be the model region for it. Rifting may be triggered by endogenic (e.g., phase change within the satellite, solid-state convection in the crust, and thermal plumes) and exogenic (e.g., diurnal tides, tidal forces, orbital forcing, and non-synchronous rotation of the ice shell) processes [4,5,16,17]. This section of the ice crust may spread due to the continuous material accretion via cryovolcanic activity [8] and at a certain geological moment it may collide with thicker, more stable, and possibly older terrain of the crust (***Fig. 1c***), e.g., some evolving part of the Faulted Terrain collides the much older Intermediate Cratered Terrain [3].

References: [1] Moore, J.M. (1984) *Icarus*, *59*, 205-220.[2] Stephan, K., et al. (2010) *Icarus 206*, 631-652. [3] Kirchoff, M.R. and Schenk, P. (2015) *Icarus 256*, 78–89. [4] Byrne, P.K., et al. (2015) *LPSC XLVI*, Abstract #2251. [5] Byrne, P.K., et al. (2016) *Enceladus and the Icy Moons of Saturn Conf.*, Abstract #3020. [6] Beuthe, M., et al. (2016) *GRL 43*, 10,088-10,096. [7] Hirata, N. (2016), *JGR:Planets 121*, 2325–2334. [8] Dalle Ore, C.M., et al. (2021) *PSJ* 2(83) 10 pp. [9] Batson, R. 1984. Voyager 1 and 2 Atlas of Six Saturnian Satellites (NASA-SP-474). [10] Greely, R., and Batson, R. (2007) Planetary Mapping. Cambridge University Press, 312 p. [11] Roatsch, T., et al. (2016) *Enceladus and the Icy Moons of Saturn Conf.*, Abstract #3032. [12] Schenk, P. (2016) *Enceladus and the Icy Moons of Saturn Conf.*, Abstract # 3053. [13] Beddingfield, C. B., et al. (2015) *JGR: Planets 120*, 2053–2083. [14] Moore, G. F., et al. (2007), *Science 318*, 1128–1131. [15] Wilson, R.W., et al. (2019) *Geol. Soc. Spec. Publ. 470* (1), 1. [16] Sotin, C., et al. (2002), *GRL 29*, p. 74-1-74-4, 1233. [17] Běhounková, M., et al. (2021), *GRL 48*, e2020GL090077.