

SEPARATING OLD AND YOUNG: THE SOUTH POLAR DICHOTOMY ON ENCELADUS. D. A. Patthoff and S. A. Kattenhorn, Department of Geological Sciences, University of Idaho, Moscow, ID 83844-3022, patt0436@vandals.uidaho.edu, simkat@uidaho.edu.

Introduction: Young fractured ice in the south-polar terrain (SPT) of Enceladus is separated from older regions of the moon by a narrow band of deformation that defines a morphological dichotomy. The dichotomy is 100s m higher than the SPT [1] and is divided into segments, some of which appear to be parallel fold-like structures whereas others are dominated by numerous fractures. Some of the fold-like features are parallel to the trend of the present day tiger stripes suggesting a relationship between the structures [2,3,4]. Our previous work has revealed an age sequence of fracture sets with similar properties to the tiger stripes. These fracture sets appear to have been rotated clockwise about the south pole relative to their original locations, which we attribute to long-term nonsynchronous rotation. The older sets include prominent fractures that stand out as potentially ancient versions of the tiger stripes [5]. If these paleo-tiger stripes were similar in form and function to the contemporary tiger stripes, they should be related to specific segments of the SPT dichotomy analogously to the present day tiger stripes. Accordingly, if the tiger stripes contribute to the fold belt-like features in the SPT dichotomy, older versions of the tiger stripes may have contributed to the creation of older fold belts around the dichotomy. Our mapping shows that some of the fracture sets share similar orientations to sections of the fold-like terrains of the dichotomy, indicating a potential relationship.

Fracture Sets and Boundary Types: The SPT of Enceladus contains at least four fracture sets containing numerous fractures that share a common orientation and relative age. The superposition of different aged sets with unique orientations suggests the moon has experienced NSR [5]. The youngest set includes the tiger stripes and many other fractures that are parallel to them. Three additional, sequentially older sets have been identified with similar properties to the tiger stripes (Fig. 1). Most of the fractures within approximately 25° latitude of the south pole can be categorized into one of these four sets. A potential fifth set exists but contains far fewer fractures than any of the other four fracture sets and its relationship to the remaining fractures is uncertain. The region surrounding the south pole between Damascus and Cairo sulci appears to contain fewer fractures than the areas further from the center of Fig 1. This area may have experienced ductile deformation [3] in contrast to the apparent brittle deformation elsewhere in the SPT.

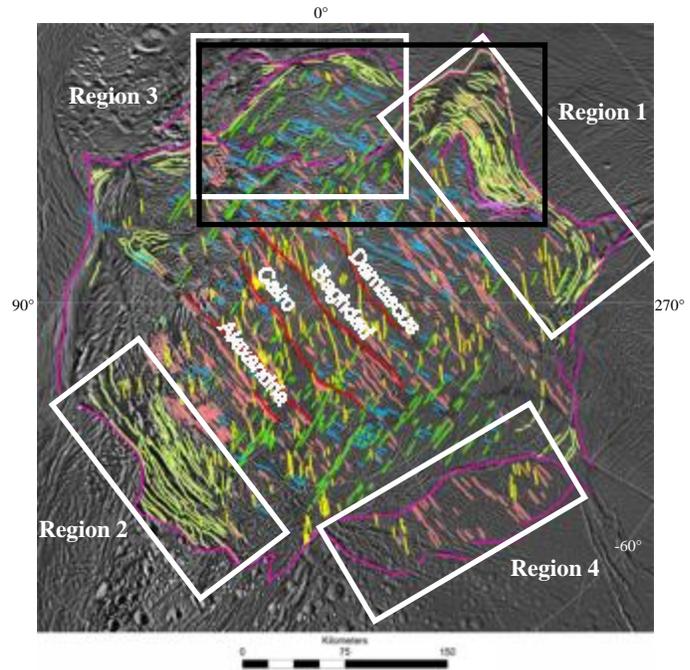


Figure 1: Dichotomy and fracture history. The dark red lines are the four named tiger stripes and the pink lines are the fractures which are parallel to them. Fracture sets 2, 3, and 4 are represented by the yellow, green, and blue lines respectively. The dark purple lines represent the dichotomy which separates the inner fractured terrain from the outer, older terrain. Light green lines are the fold-like features and light purple lines are fractures that crosscut the fold-like terrains of the dichotomy. White boxes outline the locations of regions 1-4. Black box shows the location of Fig. 2. This image is a polar projection mosaic from [11] where the scale is true at the south pole.

A structural and morphological dichotomy separates the SPT from mostly older terrains to the north. It resembles a terrestrial fold belt and rises hundreds of meters higher than the surrounding region [1]. The deformation belt (fold-like features) is not uniform along its length but is segmented, with some regions appearing as a series of parallel fold-like structures (Fig. 1, Regions 1-2) and others as groupings of fractures (Fig. 1, Regions 3-4). The dichotomy is also interrupted by Y-shaped bends from which long tension fractures extend to the north [1, 6].

Broad sections of the dichotomy are marked by isolated fractured terrains instead of the fold-like belts (Fig. 1, Regions 3-4) associated with the tiger stripes. These fractured terrains contain cracks that share orientations with the oldest fracture sets (mostly sets 3 and 4) within the SPT, indicating these sections of the

dichotomy are likely older than the fold-like terrains. The transition from the fractured terrain to the fold-like terrain is abrupt, with a single large fracture separating the two types of terrains (Fig. 2, white arrows).

Individual fold-like features along the dichotomy (Fig. 1, Regions 1 and 2; Fig. 2, Deformation belt) are curvilinear with smooth changes from one orientation to another. The fold-like structures are closely spaced and commonly inosculate. To determine the relative ages of these fold-like structures, we looked first at their orientation relative to the fracture sets. However, orientation alone is not enough to firmly establish ages with respect to the SPT fractures and must be supplemented with crosscutting relationships. Most apparent folds appear to not be crosscut by the fractures of the SPT but a few are cut by narrow fractures with orientations that do not belong to one of the four major fracture sets. These fractures appear to cut across numerous fold-like structures, creating minor amounts of displacement. Some fold-like features have a northward pointing, Y-shaped bend-like appearance similar to that found along the dichotomy. The sections of the bends that point to the north, as well as the section of the dichotomy shown at the base of Region 1 (Fig. 1), have been interpreted to be relatively young scarps, due to a bluish color to the ice [7]. The bluish color is thought to be caused by a difference in grain size with larger grains being younger and more blue and older sections being less blue [1,7]. For example, the tiger stripes appear more blue due to younger material and larger grains compared to older terrains farther from the youthful tiger stripes.

Fold-like Boundaries: The sections of the dichotomy that have been interpreted as compressional features [1,3,4,8] (Fig. 1, Regions 1 and 2) may actually be extensional features [9]. The SPT is lower than the surrounding regions [1] possibly due a thinner ice shell created by greater melting in this region [10]. The thinning of the ice shell may induce extension along the dichotomy creating normal faults to accommodate the deformation. Future detailed analysis of the dichotomy will focus on establishing the geometry of the fold-like features and determine if they are compressional or extensional features. If the features of Regions 1 and 2 (Fig. 1) appear to be normal faults, that may indicate the tiger stripes are not related to the dichotomy through a spreading process [1,2,3,4,8].

Conclusions: The present day tiger stripes are the latest large fissures to dominate the SPT. Before these, a series of similar tiger stripes likely dominated the region until the ice shell of Enceladus rotated enough to create new fractures rather than reactivating the older ones. These old tiger stripes are still preserved in the

ice shell but have since been crosscut and offset by progressively younger fracture sets. The present day tiger stripes appear to be related to sections of the dichotomy based on their similar orientations. Old tiger stripes likely also contributed to the dichotomy in a similar manner when they were active in the past. The relationship between these old fractures and the dichotomy is preserved in the orientations of the deformation belts within the dichotomy. Some sections of the deformation belt are parallel to the old tiger stripes and appear more muted than their younger counterparts, indicating the dichotomy has multiple ages which may be similar to the older fracture sets. The exact nature of the genetic relationship between the dichotomy and the fracture sets remains to be satisfactorily unraveled.

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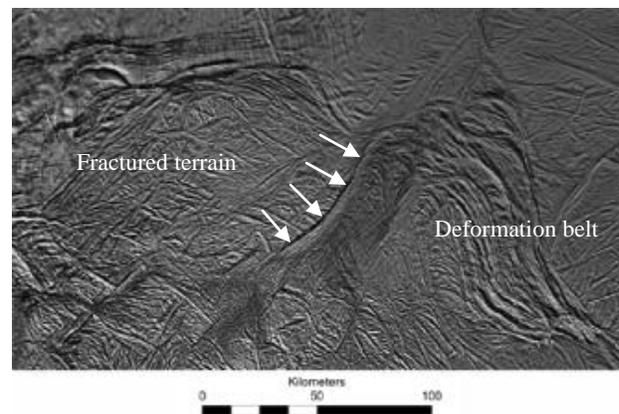


Figure 2: Boundary types. The dichotomy is composed of fold-like terrains (deformation belt on right side of image, Fig. 1, Region 1) or fractured terrains (left side of image, Fig. 1, Region 3). The transition between them is abrupt, defined by a single large fracture (shown by the white arrows) separating the two different boundary types. See Fig.1 for interpreted map and location. This image is a polar projection mosaic from [11].

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