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Block rotation tectonics in the Enceladus South Polar Terrain

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Abstract

Enceladus is a strongly active satellite. Its South Pole is place of eruptions of gas and water ice particle plumes that testify intense internal activity. Plumes are located along series of tectonic structures called Tiger Stripes fractures (TSF) that represent regularly spaced and linear depressions surrounded by a rectangular complex pattern of sinuous chains of ridges and troughs. In this study we propose a tectonic model of the South Pole following multidisciplinary approach of structural geology, geological mapping, quantitative analyses and processing of remote sensed images to unravel the crustal dynamics that deforms the region. Results from lineament domain analysis and image processing allow to unravel the tectonic setting of the region. The TSF bound blocks that rotate clockwise following the block rotation model. The region is interested by right-lateral kinematics of the chain that in turn induces internal left-lateral displacement between the TSF. The block rotation defines transtensional and transpressional regimes that are symmetrically located at the opposite vertex areas of the rectangular chain.

1. Introduction

The South Polar Terrain (SPT) of Enceladus is characterized by complex pattern of sinuous chain of ridges and troughs that circumscribes an area of about 70 000 km2, from 55°S to the South Pole, where a series of nearly parallel fractures are located. These are regularly spaced and linear depressions about 35 km distant, 130 km long, 500 m deep, and 2 km wide, generally referred as “Tiger Stripes” (TSF) [1; 2]. The TSF are source of eruptions of gas and water ice particles in jets and plumes revealing strong internal activity [3]. The TSF and plumes of Enceladus are object of scientific interests and play a key role to the understanding of the tectonic and geodynamic processes of the satellite. This work aims to unravel their tectonic arrangement.

2. Methods and results

A spatial polymodal procedure of Gaussian best fit was performed for the azimuthal analysis of identified linear structures. This allows to recognize a total of five azimuthal systems in the SPT that were statistically analyzed [4; 5]. The surrounding chain is characterized by two systems of structures trending N32°W and N55°E; a total of two system oriented N62°W and N37°E characterize the transitional area within the chain and the TSF; and the TSF represent the fifth system, N45°W (Fig. 1).

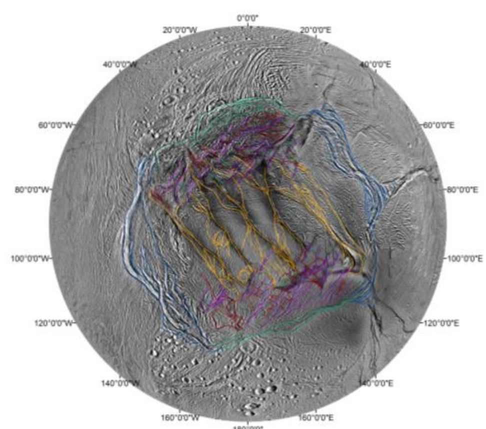

Figure 1: Azimuthal systems.

Lineament analysis [6] allows to automatically identify three lineament domains within the SPT, that agree with the found azimuthal systems. The main one is the N22°W, the second is the N84°W, and the trend of the third is N35°E.

Image processing and filtering allow to better characterize the textures and the periodicity of the morphology in the SPT, by identifying the various pixel response based on lighting conditions. We obtained the optimal frequency for the filtering that allowed to obtain a multi-band image. A K-means classification was used to identify pixel-texture clustering in the internal angles of the SPT rectangular chain.

3. Tectonic model

A total of four blocks characterize the SPT (Fig. 2). These are delimited by the TSF that rotate clockwise following the block rotation model [7]. The relative left-lateral movement between the TSF blocks is produced by the regional right-lateral strike-slip kinematics and forms the N and S ridges of the rectangular chain. The rotation of the blocks produces the symmetrical tectonic regimes at the opposite vertexes of the rectangular chain in the SPT region. Transpression occurs at the NE and SW angles, and extension at NW and SE one. Results allow to propose the evolutionary tectonic model for the SPT of Enceladus.

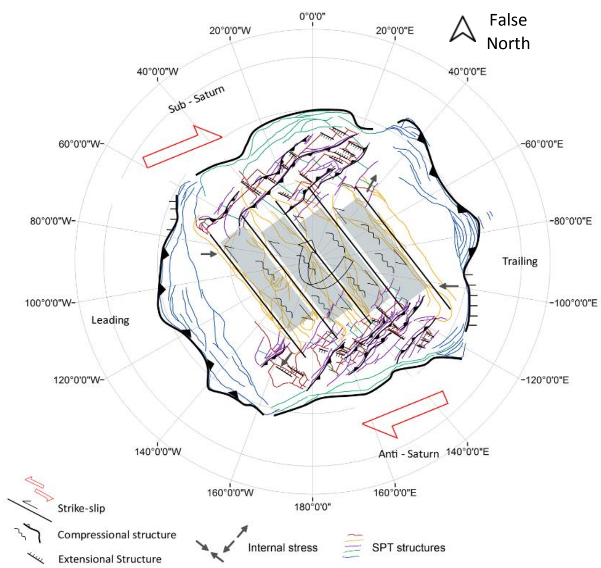

Figure 1: Block rotation of the SPT.

4. Conclusions

Block rotation tectonic model is proposed for the South Polar Terrain of Enceladus, where relatively opposite kinematics coexist. The Tiger Stripes represent left-lateral strike-slip fault that delimit blocks. The external chain is characterized by right-lateral strike-slip. Transpression and transtension occur within the region for the rotation of the blocks. This model confirms the role of strike-slip kinematics in the icy satellites and contributes to the preparation of future mission exploration with identification of potential target sites for observation and landing.

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