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Tectonic model of Enceladus South Pole

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The Saturnian icy satellite Enceladus represents one of the most geologically active moons of the Solar System. In particular, the South Pole is long known to be tectonically active and is characterized by a rectangular complex pattern of sinuous chains of ridges and troughs that surround four main structures. These are referred as Tiger Stripes fractures (TSF), and represent equidistant, NW-SE oriented, linear depressions. The TSF are locations of gas and water ice particles eruptions in jets and plumes. This reveals the intense internal activity whose origin is still under debate. For this reason, the TSF and plumes of Enceladus are object of scientific interests and play a key role in the understanding of the tectonic and geodynamic processes of the satellite. An effective way to understand the internal processes and possible places of uprising of the below liquid layer is to unravel the crustal dynamics that deforms the region of the South Pole. Many hypotheses on extensional and compressional faulting have been proposed for the tectonic activity of the region, yet the mechanism responsible for the observed brittle deformation is still not clear.

In this contribution we propose a tectonic model of the TSF and the surrounding region based on the multidisciplinary approach of structural geology, structural glaciology, mapping, quantitative analyses and processing of remote sensed images of the satellite surface in the South Pole region. We detect lineament domains and quantitatively analyse the properties of the tectonic structures (i.e. the TSF and the boundary ridges) that belong to the identified systems. These are characterized by the ratio (L/S) between the Length of structures of the same system and their Spacing measured at adjacent structures. This allows to unravel the fracturing history of the systems, the crustal rheology variations and the relative lithospheric thickness. Image processing and filtering is used to better characterize the textures and the periodicity of the morphology in the studied region.

Results allow to propose the kinematic tectonic model of Enceladus South Pole. The structures of the region are formed by the presence of significant horizontal stresses that produce strike-slip motion following a limited block rotation model. Strike-slip regime involves the region of the South Pole with external right-lateral kinematics of the ridge chains that induce internal left-lateral displacement along the TSF. The rotation of the blocks is accommodated by symmetrical transtensional and transpressional zones both at the vertex areas of the surrounding chain and within the TSF. Results of this work suggest the significance of strike-slip displacements on the tectonic history of the icy satellites and provide implications on future programmed missions.