The tectonic origin of Planum Boreum spiral troughs, Mars

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The spiral troughs of the North Polar Layered deposits on Mars are deep depressions that dissect the Planum Boreum ice cap. These are enigmatic structures whose puzzling origin is still under debate. Advanced hypotheses on their genesis and evolution range between erosional to structural scenario. In this work, a double approach was followed to explore the structural/tectonic origin of the spiral troughs by means of Hybrid Cellular Automata (HCA) numerical modelling and lineament domain analysis. The SHARAD profile data were used to replicate the ice internal layering architecture associated to buried troughs in Gemina Lingula. Analysis of the lineament domains automatically detected at the ice surface from satellite images of the Mars Orbiter Camera strengthened the structural/tectonic interpretation of their origin and evolution. Similar, twofold approach was used for the investigation of a terrestrial analog identified in the Antarctic ice sheet. It presents at depth blind structures recognized as fractures/faults produced by ice sheet dynamics. Radargrams of Operation IceBridge mission and images from Sentinel-2 were used to produce a tectonic model that was in turn compared with the Planum Boreum one. Obtained results, and their comparison, show that the troughs of Gemina Lingula result from the activity of low-angle normal faults with listric geometry. The activity of listric faults is modelled and compared with the antarctic analog. At the surface the detected lineament domains confirm the tectonic setting by tracing the buried trough/fault orientations. The proposed tectonic model refers to extensional regime characterized by the presence of a deep detachment connecting the troughs at depth. This represents an internal ductile layer placed at depth greater than 1000 m whose kinematics induces the troughs/faults deformation. The extensional tectonics developed in Planum Boreum is possibly related to the ice cap collapse that induces internal dynamics. In this way, katabatic winds play a secondary role by maintaining at the surface the troughs nearly orthogonal to their directions.