Faulting in Mars Polar Layered deposits modeled by HCA method

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The polar layered deposits (PLD) of Mars constitute the water ice stratigraphy of polar spiral troughs up to several kilometers thick (Phillips et al., 2011; Smith et al. 2015). PLD cross section profiles from the Shallow Subsurface Radar (SHARAD) instrument on NASA’s Mars Reconnaissance Orbiter, show the presence of internal discontinuities within these layers (Foss et al., 2017; Putzig et al., 2017). The mechanisms responsible for these deformations are still an open issue (Guallini et al., 2017) and this work represents the contribution of stress-related deformations. Layered ice is simulated by a mesh of cells within a HCA grid build replicating the physical properties and preserving volumes following balanced cross-section principles. Three major types of link exist among adjacent cells: 1. intra-layer relations link cells belonging to the same layer; 2. inter-layer relations regulate the relationships among adjacent layers; 3. discontinuity relations correspond to the presence of ruptures such as faults (Salvini et al., 2001). The HCA method allows to replicate the natural material anisotropies, such as rocks and ice sheet internal layering, and to simulate complex tectonic evolutionary paths (Cianfarra and Salvini, 2016; Cianfarra and Maggi, 2017). The models allow simulating the kinematics of the internal architecture of the layered deposits from both the north and the south Martian ice caps. In particular the observed stratigraphy (geometries and thickness of the ice layers) is replicated as resulting from the relative, normal movement among blocks separated by listric shaped normal faults and minor inversions.

The used HCA numerical methodology revealed an effective tool to support planetary geological mapping and 3D subsurface geological reconstructions. Through the integration of a net of spatially distributed along- and across- strike (balanced) sections it is possible to simulate the 4D (3D plus time) geological evolution of buried and/or topographic structures. Results have a wide range of applications including the optimal selection of landing sites for scheduled and future planetary exploration missions, as well as unravelling the geological and structural setting of enigmatic features on the planetary surfaces affected, for example, by salt tectonism, volcano-tectonics, tectonically-related hydrothermal activity, fluid storage and release, and ice tectonics.