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Hesperian polythermal glaciation in Isidis Planitia, Mars - Ice sheet dynamics and thermal regime inferred from numerical modeling

Ondřej Souček (1), Olivier Bourgeois (2), Stéphane Pochat (2), and Thomas Guidat (3)

(1) Charles University in Prague, Faculty of Mathematics and Physics, Mathematical Institute, Prague, Czech Republic (soucek@karel.troja.mff.cuni.cz), (2) LPG-Nantes, Université de Nantes, Nantes, France, (3) Department of Geography, Trinity College, Dublin, Ireland

We test the hypothesis that the Thumbprint Terrain observed on the floor of Isidis Planitia, a giant impact crater located close to the martian equator, is a landform assemblage inherited from a glaciation during the Hesperian. For this purpose, we perform numerical simulations with a coupled thermo-mechanical model of ice sheet dynamics. We use surface temperatures and ice accumulation/ablation patterns predicted by a climatic Global Circulation Model, and values of the geothermal heat flux provided by a global model of planetary thermal evolution. We find that, with atmospheric physical properties similar to the current ones and under favorable orbital conditions, net ice accumulation in the northwestern part of Isidis Planitia leads within a few Ma to the development of a massive ice sheet, as much as 4.9 km in thickness, over the entire basin. The modeled ice sheet is polythermal: its center and its periphery are permanently frozen to the base, while the pressure melting point is reached episodically in an intermediate ring. Our simulations suggest that the propagation of thermo-mechanical melting waves in this ring is responsible for the formation of the Thumbprint Terrain, a probable martian equivalent of terrestrial ribbed moraines. They support the interpretation that sinuous ridges and linear valleys observed at the periphery of the basin are parts of a subglacial network of eskers and tunnel valleys that drained glacial meltwater outwards, across the cold-based outer part of the ice sheet. This work strengthens the hypothesis that massive glaciers covered large portions of the martian surface before the Amazonian and that basal melting below the wet-based portions of these ice sheets contributed significantly to the production and flow of liquid water in the ancient martian history.