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Production of liquid water on Mars by basal melting of ice sheets: a glacial interpretation of the 3 Ga old Thumbprint Terrain in Isidis Planitia

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Isidis Planitia is a 1350 km wide impact crater located close to the martian equator. Its floor exhibits a 2.8 to 3.4 Ga old landform assemblage, nicknamed Thumbprint Terrain, made of Arcuate Ridges, Aligned Cones, Isolated Cones, Cone Fields, associated with a peripheral network of Sinuous Ridges, Linear Depressions, and Mounds (Fig. 1). The spatial organization of these landforms is consistent with the hypothesis that they form a glacial landsystem inherited from the former presence of a polythermal ice sheet over the entire basin [1].

To explore the dynamics and thermal regime of this ice sheet, we perform a simulation with a thermomechanically coupled numerical model [2]. As model inputs, we use surface temperatures and ice accumulation patterns predicted by a General Circulation Model based on the present-day atmospheric characteristics, and values of the geothermal heat flux provided by a global model of planetary thermal evolution. We find that, under favorable orbital conditions, an ice sheet covering the entire basin can develop in 2 to 5 Ma, with a maximal thickness of 4.9 km (Figs. 2 and 4).

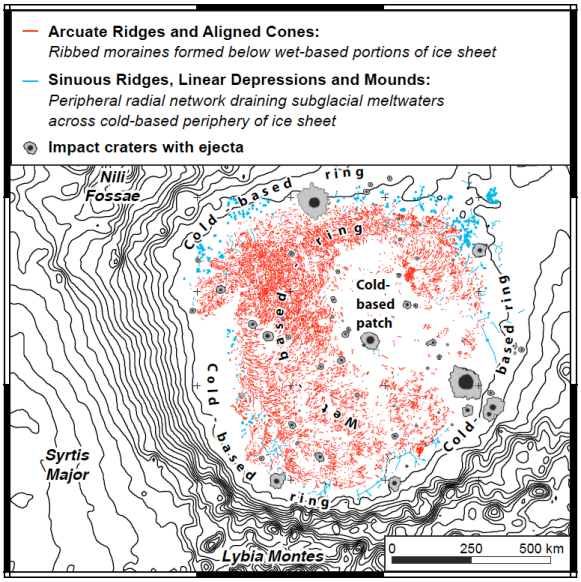

Figure 1: Map of the landform assemblage in Isidis Planitia (Mars), with interpretation in terms of a polythermal glacial landsystem [1].

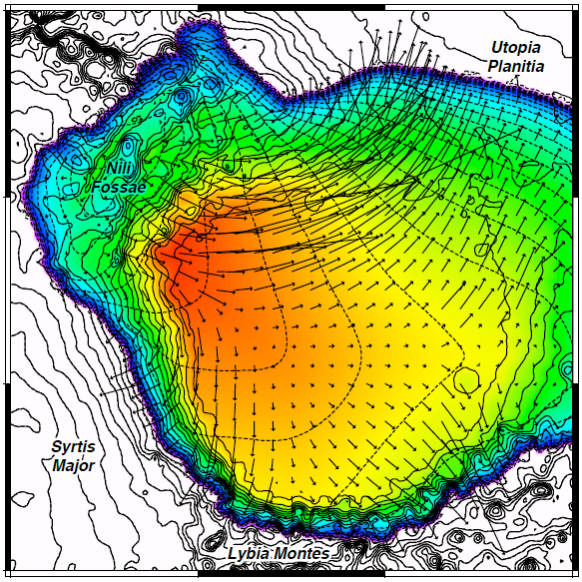

Figure 2: Thickness and surface flow lines of the modeled ice sheet at 5 Ma [2].

The modeled ice sheet is polythermal and its flow is controlled by its basal thermal regime. The pressure melting point is reached in a circular region, where Arcuate Ridges and Aligned Cones are present (Fig. 3). By contrast, the modeled ice sheet is permanently cold-based at the basin periphery and, due to a negative heat-flux anomaly, also in the basin center, where only Isolated Cones and Cones Fields are present.

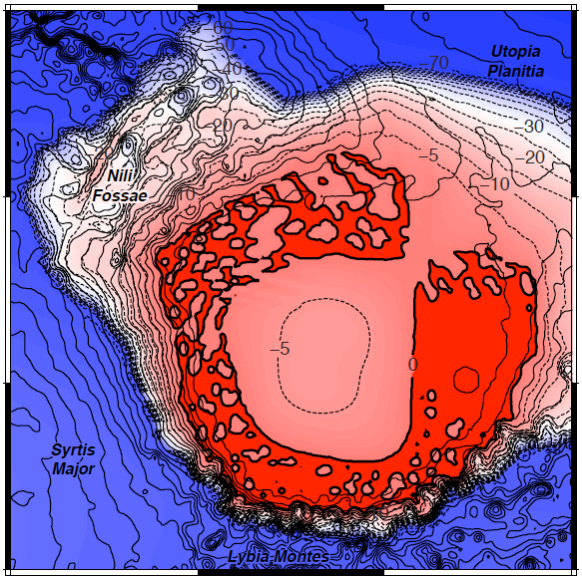

Figure 3: Basal temperature of the modeled ice sheet at 5 Ma. Red regions correspond to wet-based areas, where liquid water is produced by basal melting [2].

These results are consistent with the interpretation that the Thumbprint Terrain in Isidis Planitia is a martian equivalent of terrestrial fields of ribbed moraines and has formed below wet-based ice. They support also the interpretation that Sinuous Ridges, Linear Depressions and Mounds observed at the basin periphery are parts of a subglacial network of eskers, tunnel valleys and subglacial lakes that drained the glacial meltwater outwards, across the cold-based periphery of the ice sheet.

This work strengthens the hypothesis that glaciers as thick as a few km may have existed on Mars in the past and that glacial basal melting may have contributed to the production and flow of surface liquid water at that time, under an atmosphere no thicker than the present-day one [3].

References

[1] Guidat, T., Pochat, S., Bourgeois, O., and Souček, O.: Landform assemblage in Isidis Planitia, Mars: Evidence for a 3 Ga old polythermal ice sheet. Earth Planet. Sci. Lett. Vol 411, pp. 253-267, 2015.

[2] Souček, O., Bourgeois, O., Pochat, S., and Guidat, T.: A 3 Ga old polythermal ice sheet in Isidis Planitia, Mars: dynamics and thermal regime inferred from numerical modeling. Earth Planet. Sci. Lett., submitted.

[3] Carr, M.H., and Head, J.W.: Basal melting of snow on early Mars: a possible origin of some valley networks. Geophys. Res. Lett. Vol 30, 2245.

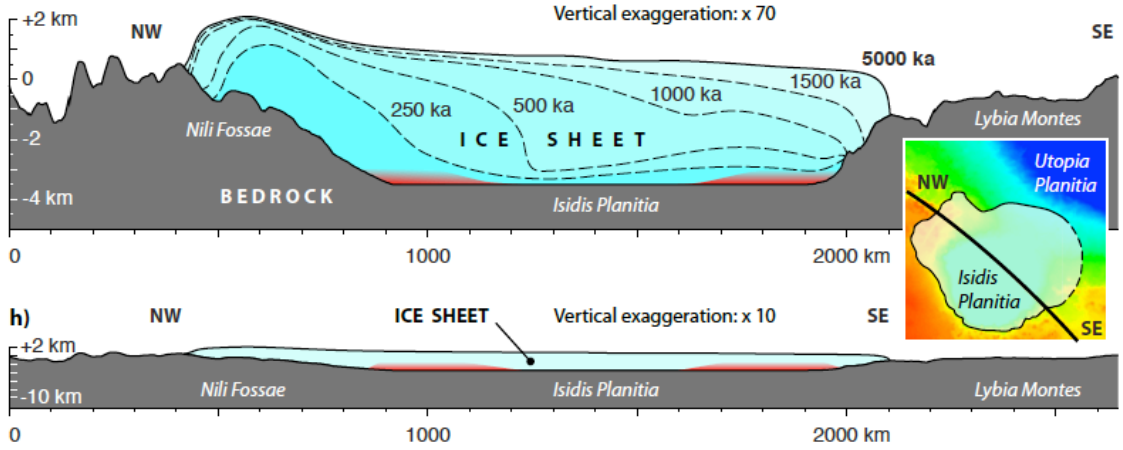

Figure 4: Topographic profiles of the modeled ice sheet at different time steps. Wet-based regions at 5 Ma indicated by red lines at base of ice sheet. Location of profiles indicated by black line in inset map [2].