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The new early Mars: implications for geodynamics, geology and climate

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The Tharsis bulge is the largest volcanic complex on Mars and is located close to the equator. Its equatorial position is likely the result of a True Polar Wander (TPW) driven by its own mass [1]. It has been suggested that that most of its topography was completed before the incision of valley networks (> 3.7 Ga) since the flow directions appear to be consistent with calculated effects of the load that the Tharsis bulge exerted on the elastic lithosphere [2]. We note however that early completion of the Tharsis' relief is questionable in light of recent studies, which together suggest a multi-stage growth from the Noachian (> 3.7 Ga) to the Amazonian (< 3 Ga). We have therefore calculated the rotational figure of Mars and its surface topography before Tharsis, when the spin-axis of the planet was controlled by the hemispheric dichotomy. We show that the observed directions of valley networks are also consistent with topographic gradients in this configuration and thus do not require the presence of the Tharsis load.

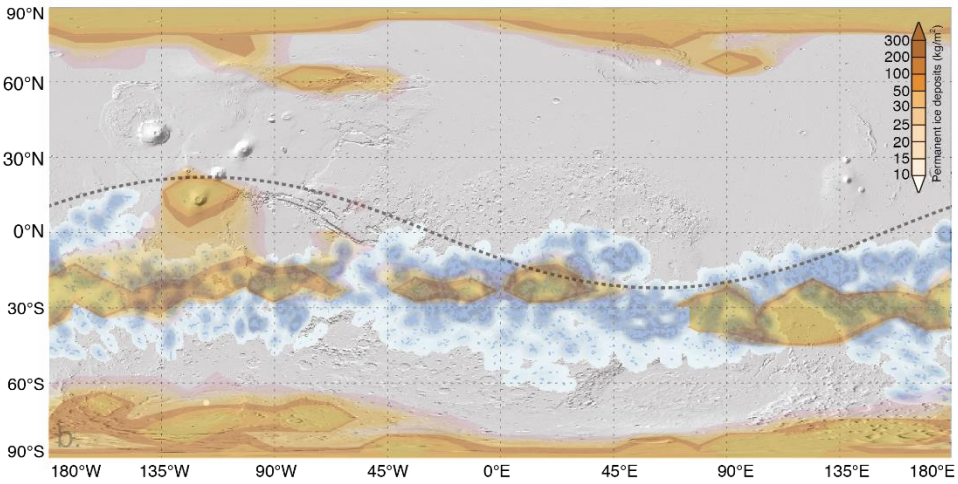

Fig. 1 Drainage intensity (blue) superposed with predicted perma-nent ice deposits (kg m^{-2}) (obliquity 45°, circular orbit and mean surface pressure ~0.2) bar in the pre-TPW/Tharsis refe-rence frame and topography.

Furthermore, we demonstrate that the intensity of drainage is distributed along a small circle tilted with respect to the present equator. The normal vector of the plane containing the small circle defines a north pole located north of Tharsis along the meridian passing through the center of the Tharsis bulge (118°W, 69°N), consistent with the calculated paleo north poles prior to the formation of Tharsis when the orientation of Mars was controlled by the dichotomy. This implies that fluvial incision was essentially localized within a regular south tropical band in the pre-TPW geographic frame (Fig. 1). Preferential accumulation of ice or water in a south tropical band is predicted by Early Mars climate model simulations applied to the pre-TPW topography (Fig. 1). Altogether, these results offer evidence that most of the valley

networks were incised before the Tharsis-driven TPW [3], in contrast with earlier studies. This conclusion implies a major overhaul of the relative chronology of the main events affecting the early Mars geodynamics, geological and climatic history. A late rise of Tharsis, contemporaneous with fluvial activity, also argues for a causal link between volcanic outgassing and the stability of superficial liquid water.

References:

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