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Testing the Late Noachian Icy Highlands Model: Geological Observations, Processes and Origin of Fluvial and Lacustrine Features.

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Testing the Late Noachian Icy Highlands Model: Geological Observations, Processes and Origin of Fluvial and Lacustrine Features.

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A new reconstruction of the Late Noachian Mars atmosphere and climate shows atmosphere-surface thermal coupling and an adiabatic cooling effect producing preferential distribution of snow and ice in the highlands. In this Late Noachian Icy Highlands (LNIH) scenario, snow and ice accumulate in the south circumpolar region and in the higher altitudes of the southern uplands, but the mean annual temperature is everywhere below freezing. How can the abundant evidence for water-related fluvial and lacustrine activity (valley networks, VN; open-basin lakes, OBL; closed-basin lakes; CBL) be reconciled with the icy highlands model? We investigate the nature of geologic processes operating in the icy highlands and use the Antarctic McMurdo Dry Valleys (MDV) as guidance in understanding and assessing how melting might be taking place. In the MDV, mean annual temperatures (MAT) are well below freezing. This results in a thick regional permafrost layer, the presence of an ice-table at shallow depths, and an overlying dry active layer. This configuration produces a perched aquifer and a horizontally stratified hydrologic system, where any melting results in local saturation of the dry active layer and channelized flow on top of the ice table. Top-down melting results in the dominance of lateral water transport, in contrast to temperate climates with vertical infiltration and transport to the groundwater table. Despite subzero MAT, MDV peak seasonal and peak daytime temperatures can exceed 273K and have a strong influence on the melting of available water ice. We present maps of the predicted distribution of LNIH snow and ice, compare these to the distribution of VN, OBL and CBL, and assess how top-down and bottom-up melting processes might explain the formation of these features in an otherwise cold and icy LN Mars. We assess the global near-surface water budget, analyze thickness estimates to distinguish areas of cold-based and wet-based glaciation, analyze the state of the ice cover and its susceptibility to melting and runoff, and describe top-down melting and fluvial channel formation processes in a LNIH environment. We find that: 1) episodic top-down melting of the LNIH is a robust mechanism to produce the observed fluvial and lacustrine features; 2) the characteristics and distribution of features in the Dorsa Argentea Formation are consistent with an extensive circum-polar ice cap during LNIH time; and 3) the nature of preserved LN impact craters is consistent with impact cratering processes in the LNIH environment.

393 words.