HABITABILITY OF HIGH LATITUDE MARTIAN GROUND ICE, REVISITED. H. G. Sizemore[1], V. Demchenko[2], A. P. Zent[3], A. W. Rempel[4], D. E. Stillman[5]. [1]Planetary Science Institute (Tucson AZ, sizemore@psi.edu), [2]University of Colorado (Boulder CO), [3]NASA Ames Research Center (Mountain View CA), [4]University of Oregon (Eugene OR), [5]Southwest Research Institute (Boulder CO).

Introduction & motivation: Shallowly buried ground ice is nearly ubiquitous on Mars poleward of ~50° in both hemispheres. In the current climate, this ice is perennially cold, e.g., ~190 K on annual average at ~70° N. Despite low temperatures, thin "premelted" films of unfrozen water can exist in the shallow subsurface due to interfacial and Gibbs-Thomson premelting at soil-ice interfaces [1]. The presence of salts can further depress the freezing point, increasing the volume of unfrozen pore water [1, 2]. There has been long-term interest in ground ice as a potential microbial habitat on Mars [3], supported in part by the occurrence of viable bacteria in liquid vein networks of Antarctic glacial ice [4].

In the decade since the habitability of high-latitude ground ice was first systematically investigated [3], perchlorate salts have been discovered at the Phoenix and Curiosity landing sites and our understanding of unfrozen water content in ice-cemented soils has improved substantially [1, 2, 10, 11]. Here, we have employed new numerical simulations of subsurface temperature, unfrozen water content, and water activity in thin films to constrain habitability in shallow ice-cemented ground over the past 10 Ma.

Numerical models and parameter space: We used the set of numerical models employed by Sizemore et al. [1] in their investigation of Martian frost heave to simultaneously calculate temperature, *T*, unfrozen volume fraction, $S_l = 1-S_i$, and water activity a_{H2O} in the upper meter of ice-cemented ground poleward of 55° N.

Climate model. We use the climate model described [3] to simulate the evolution of temperature and ice-table depth, z_i, at latitudes north of 55° over the past 10 Ma. The model tracks temperatures in the upper 30 m of regolith based on Laskar et al. [9] orbits, and defines z_i assuming diffusive equilibrium with the atmosphere. Because atmospheric water vapor density at high latitude is buffered by the polar cap, ice-table depths and ice temperatures predicted by the model are very sensitive to assumptions about the fate of the residual cap at high obliquity. We assume that the cap remains a source of H_2O vapor at all times. We use results from the Ames GCM to guide our assumptions about meridional vapor transport. Temperature profiles and ice-table depths produced by the climate model provide the initial and boundary conditions for the thin film model.

Thin film model. We use the thin film model described by [1] to track temperatures and phase partitioning in a soil that is fully ice and water saturated. The premelting physics employed in this model is based on mass and energy conservation equations developed by Rempel [10] and modified for Martian conditions [1]. For computational simplicity, the soil-water-ice system is assumed to be gas and solute free in the majority of our simulations.

Results and discussion: Consistent with previous work by Zent, our simulations indicate that unfrozen water in shallow Martian ground ice has periodically met thresholds for habitability during the last 10 Ma. These "habitable" periods are correlated with high obliquity excursions; at low obliquity temperatures and water activities are too low for terrestrial metabolism. The most recent 4 Ma period presents challenges for extant life, due to longer cold/dormant periods during which organisms would accumulate radiation damage without extended opportunities for repair.

Our results indicate that a silt with 0.5-1 wt. % perchlorate is the most likely soil to be habitable in terms of both water activity and film volume during windows of opportunity. The presence of perchlorate also offers the advantage of protecting cells from ice crystal damage during low-temperature periods [12]. Substantial laboratory work is needed to better constrain the volume, ion concentration, viscosity, and water activity of perchlorate brines at Martian temperatures, in both icy and ice-free settings [2, 6]. However, our results underscore that shallow ground ice – which is accessible to small spacecraft missions and likely to be utilized as a resource for human missions – cannot be ruled out as a potential Martian habitat.

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