Enhanced Ice Flow at High Martian Obliquity: A Rheological Model of the Polar Layered Deposits.

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Introduction: The origin of the layering characteristic of the Polar Layered Deposits (PLD) of Mars is generally not thought to arise from the flow of the water ice presumed (along with dust) to comprise these layers, since rheological modeling indicates that Mars is presently too cold to permit substantial ice flow in the polar regions.

However, Martian obliquity deviates chaotically from its current Earth-like value of 25º, surpassing 45º within the last several Myr. Not only will the polar regions receive additional insolation at these high obliquities, but the resulting increase in H_2O sublimation from the ice caps will initiate a water vapor greenhouse heating effect. Hence, surface and subsurface temperatures will be elevated at high obliquity, leading to dramatic increases in ice flow velocities.

Methodology: We will discuss the results of our high obliquity ice flow model, which subjects several circumpolar surfaces with albedos and thermal inertias representative of the PLD to the full range of predicted orbital conditions. Using a one-D radiative-convective quasi-random Voigt model and sublimation parameterizations appropriate to moist atmospheres, we calculate surface temperatures throughout the chaotic Martian obliquity "cycle" as a function of dust opacity and advection rate.

Annual average temperatures are then input into a subsurface heat conduction model to derive both equilibrium and time-dependent thermal profiles for various subsurface conductivities and heat flows. Lastly, we use these subsurface temperatures to calculate rheological parameters such as stress, strain, and flow velocity (for both standard dislocation and grain-size dependent creep) as a function of depth and volumetric dust fraction over an entire obliquity "cycle."

Implications: We will also discuss the ramifications of our rheological model on such topics as: (1) the relative dust/ice composition of the PLD, including both its latitudinal and vertical variation; (2) the multi-million year disparity in crater retention age between the north and south PLD; and, of course, (3) the possible role of flow in the origin of the layering of the PLD.