IMPLICATIONS OF MARTIAN EXCESS GROUND ICE STABILITY. A. M. Bramson[1] and S. Byrne[1], [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ (bramson@lpl.arizona.edu)

Introduction: Many lines of evidence point to the existence of relatively pure, excess ice (higher water ice abundances than can fit into the pore spaces of the regolith) in the northern mid-latitudes of Mars. Geomorphological evidence (Figure 1) includes thermokarstically expanded craters [1], scalloped depressions [2] and ice-exposing impacts [3]. Additionally, SHAllow RADar (SHARAD) sounding of the subsurface detects dielectric interfaces at these latitudes that have been attributed to the bottom of excess ice layers in the subsurface [4, 5].

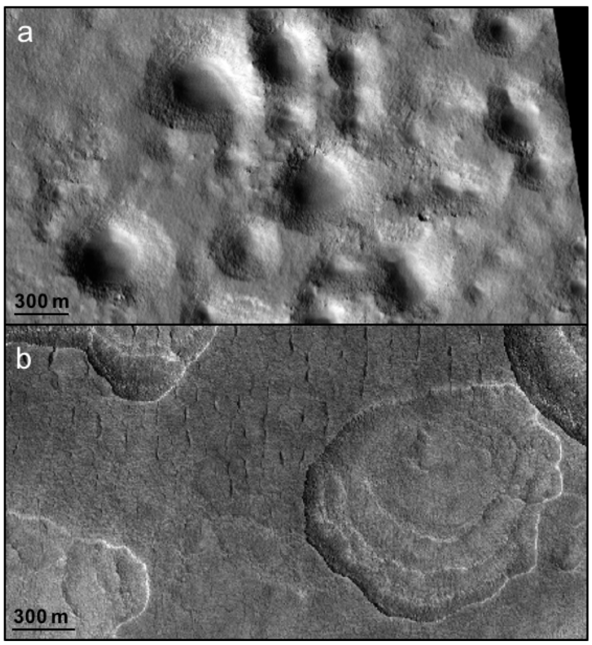

Figure 1: Thermokarstic features indicative of excess ice: (a) cluster of expanded craters (HiRISE image ESP_028411_2330) and (b) scalloped depressions (HiRISE image PSP_001938_2265).

Previous work has put constraints on the present extent and thickness of excess ice in the subsurfaces of Arcadia Planitia [4] and Utopia Planitia [5]. These studies have measured the thicknesses of ice deposits to be on the order of decameters, while the dielectric constants contrained through analysis of SHAllow RADar (SHARAD) and High Resolution Imaging Science Experiment (HiRISE) stereo topography data (Figure 2) have put constraints on the porosity and dirt content of the ice, finding it to be relatively clean, consistent with excess ice. The Arcadia Planitia ice was found to cover an area of up to 1,200,000 km^2 over the latitude range of 38°N-50°N [4], while the Utopia Planitia ice covers 400,000 km^2 between 40°-50°N [5]. Each of these deposits hold ice volumes on the order of 10s of thousands of km^3.

There is a disparity between these thick deposits of excess ice and the conventional picture of mid-latitude ice as young, pore-filling ground ice that reacts quickly to climatic conditions through interactions with the atmosphere [6, 7]. Lab experiments predict ground ice to be in equilibrium with the atmosphere and thus react quickly to climatic changes [8, 9]. However, the ice layer in Arcadia Planitia is thought to be 10s of millions of years old [1]. Within this period, Mars has had many excursions through low obliquities (when equatorial ground ice gets transported to the poles) that should have caused any mid-latitude ice (excess or pore-filling) to sublimate away. Replenishment of this ice in subsequent epochs can only create pore-filling ice. Because of this paradox between expected and observed old excess ice, we investigate the conditions necessary to preserve decameters of ice within the mid-latitude subsurface for 10s of millions of years. Understanding the conditions that have led to the ice's continued survival to the present day is important for understanding the link between ice stability and climates on Mars.

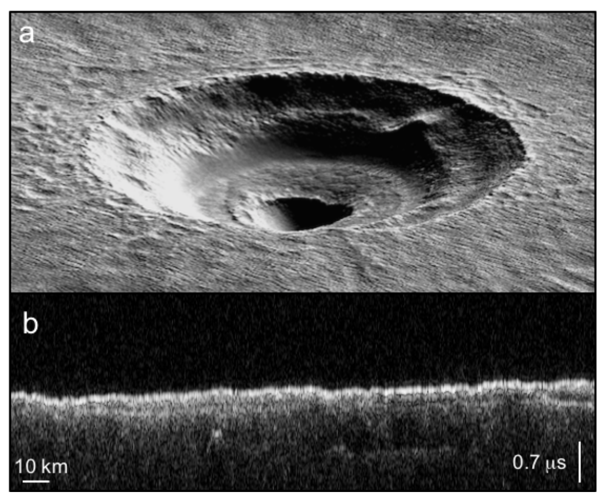

Figure 2: A terraced crater (a) formed from an impact into a decameters-thick layer of excess ice; the deeper floor-level terrace, at 43 meters depth, is interpreted to be at the ice-rock interface. The prospective is a 3D view created from HiRISE Digital Terrain Model DTEEC_018522_2270_019010_2270_A01. A nearby SHARAD track 949601000 (b) shows a subsurface radar reflector at the bottom of the layer (additional details available in [4]).

Methods: We use a thermal model based on the same physics used in many other numerical models in the field [10, 11, 7, 12, 13, 14] to compute surface and subsurface temperatures. The model allows for multiple subsurface layers that we will use to investigate the properties (e.g. conductivity, density, vapor diffusivity, etc) of a protective lag coating (which damps temperature oscillations) necessary for the ice to be out of equilibrium with the atmosphere and persist through times of low obliquity.

Solutions for Mars' orbital elements extend back ~20Myr [15]. We will use this record and statistical expectations of obliquity, eccentricity and longitude of perihelion over times previous to that. We will experiment with relationships between these parameters and important climatic parameters such as near-surface atmospheric water vapor abundances, a major factor for ice stability. Therefore, testing the orbitally-induced changes to ice stability will put constraints on the link between climate and water vapor.

Discussion: Global climate models suggest widespread deposition of ice could have occurred in the mid-latitudes during Mars' high obliquity (> 35°) periods under certain conditions [16]. These depositional episodes would be good candidates for the origin of the ice layers in Arcadia Planitia and Utopia Planitia. However, the results of [17] suggest that a 30 m thick ice layer 4.5 Ma would not be able to survive at these latitudes to the present day. They predict a thick ice sheet would be geologically young and actively retreating towards equilibrium with the current atmospheric conditions. Solving this discrepancy between the theoretical predictions of ice stability and the observed quantities of old (10s of Myr), excess ice is important if we wish to understand the stability of ice in the Amazonian (the most recent Martian geologic time period, 3 Ga to present), the subsurface structure in the mid-latitudes and the orbital forcing of the Martian climate.

We will present a review of the abundant evidence for excess ice in the Martian mid-latitudes as well as the implications for its stability on the Martian climate system. The goal for our model is to reproduce the current-day observed thicknesses and volumetric ice fractions of the Arcadia Planitia and Utopia Planitia ice deposits. We will present results on the depth to stable ice in these regions as a function of time, and map out the periods where this ice should be unstable over the last ~20 Myr. We will report on climatic scenarios where this ice can be preserved and their implications for Martian ground ice distribution throughout the Amazonian.

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