Natural Probes of Ground Ice on Mars

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The last several years have seen a growing appreciation that Mars is an ice rich planet. Hydrogen abundances inferred from gamma-ray and neutron spectrometer data show that the upper-most decimeters of the martian surface contain large amounts of water ice poleward of latitudes ±60°, which can exceed 50% by mass (~75% by volume). Geomorphological indicators such as viscous flow features, putative snowpacks and pervasive polygons all contribute to the growing body of evidence that the deposition and removal of water ice and the associated glacial and periglacial processes have had a dominant effect on shaping the high-latitude surfaces of the planet. Interest generated by these discoveries recently culminated in the Phoenix mission, which focused on the investigation of high-latitude ground ice.

Here we report on a new method to probe subsurface ice on Mars. New, meter-scale, impact craters that formed within the period covered by spacecraft datasets have been observed. We have identified new mid-latitude craters at five sites that excavated material with a brightness and color in High-Resolution Imaging Science Experiment (HiRISE) images that is strongly indicative of water ice (e.g. Figure 1). These sites, located near the boundary of Utopia and Arcadia Planitia both on and adjacent to the Phlegra Montes, were identified by the Context Camera (CTX). Constraints on their formation times come from before and after images. Although small in area, a water ice composition for this bright material can be confirmed in one case with lower-resolution hyperspectral data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM).

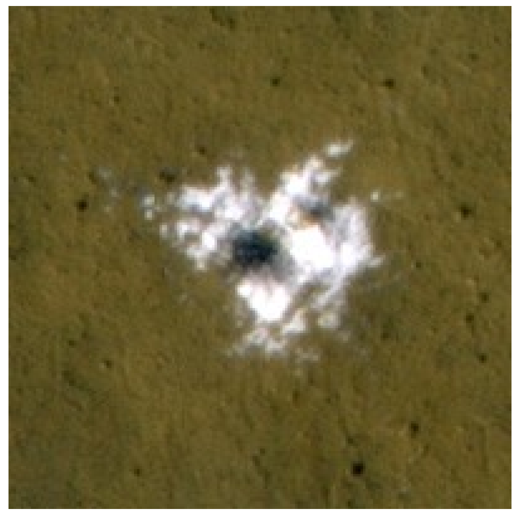

Figure 1. HiRISE false color image PSP_010625_2360 of a new crater (formed between 1/26/2008 and 9/18/2008). Image is 50m across.

Theoretical models predict that buried water ice is stable in the high-latitudes of Mars beneath a desiccated soil layer with an extent and depth that depend on temperature and humidity (which vary with changing orbital elements). A key parameter setting the extent of stable ground ice is the global average atmospheric water vapor. The mid-latitude boundary enclosing the area where buried ice is presently stable is expected to be abrupt and its position is sensitive to this long-term global average. However, gamma-ray and neutron spectrometer data do not tightly constrain the location of this abrupt edge and although these instruments can constrain the depth to the top of the high-latitude ice table, they are insensitive to changes in ice concentration a few centimeters below that.

These impacts provide our first probe beneath the top of the ice-table providing information on the ice's vertical distribution. Monitoring and analysis of the craters and the ice they expose indicates that the ice in this location forms a relatively pure layer, which is underlain by regolith with pore-filling ice. The extent and depth of the ice table is consistent with an atmospheric water vapor content significantly higher than present which can be reconciled with the today's values by recent orbitally-forced climate change.