Mars Subsurface Water Ice Mapping (SWIM): Thermal Analysis

R. H. Hoover,¹ H. G. Sizemore,² Z. Bain,³ N. E. Putzig,² G. A. Morgan³, M. R. Perry,² M. Mastrogiuseppe³, D. M. H. Baker⁴, A. M. Bramson⁵, E. Petersen⁵, I. B. Smith,² B. A. Campbell.⁶

¹Southwest Research Institute (RHoover@boulder.swri.edu), ²Planetary Science Institute, ³California Institute of Technology, ⁴NASA Goddard Space Flight Center, ⁵University of Arizona Lunar and Planetary Laboratory, ⁶Smithsonian Institution.

What is SWIM?

The Subsurface Water Ice Mapping (SWIM) in the Northern Hemisphere of Mars Project supports an effort by NASA’s Mars Exploration Program to determine in situ resource availability for future human missions. Using several techniques and instruments, we are performing global reconnaissance mapping as well as focused multi-dataset mapping from 0° to 60°N. Results presented on this poster are focused on the thermal analysis of the SWIM Project.

For results from the other datasets, see the other SWIM Project posters at this LPSC:

- Bramson et al. (subsurface reflectors) Perry et al. (SWIM infrastructure)
- Bain et al. (surface reflectivity) Putzig et al. (geomorphology)
- as well as the talk by Morgan et al. (overview) at 9:45 AM Friday morning

Final results will be presented at the next Human Landing Site Selection workshop.

Follow us on Twitter for project news and product release information.

https://swim.psi.edu/   @RedPlanetSWIM

Proposed Extension Activities

- Improved thermal models to include model scenarios with 3+ layers
- Further integrate THEMIS analysis with geomorphic mapping
- Focused seasonal analysis of geomorphic features indicative of ice

Thermal Analysis

We use apparent thermal inertia (ATI) derived from the Mars Global Surveyor Thermal Emission Spectrometer (TES) and the Mars Odyssey Thermal Imaging System (THEMIS) to identify material layering consistent with ice in the upper 1 meter of the near surface.

We compare derived ATI to numerically modeled ATI for heterogeneous surfaces to distinguish layering and horizontal mixing of different materials: dust, sand, duricrust, and ‘rock,’ where rock is thermally indistinguishable from ice and ice-cemented soil.

Our analysis compares model results for TES and THEMIS, combining them to determine consistency of the presence of ice for both data sets.

Global TES Layered Heterogeneity Map

We generated the TES layered heterogeneity map at right by matching modeled and observed seasonal variations in apparent thermal inertia at 1.25º per pixel.

Blue and green pixels indicate a layer of lower thermal inertia material over a higher thermal inertia material, which is consistent with the presence of ice and is therefore assigned a value of 1 in the consistency map.

High-over-low matches are generally removed by the consistency constraint to layers thicker than a diurnal skin depth.

Experimental Results

- Using geomorphological mapping results to direct our analyses, we take advantage of the high spatial resolution of THEMIS (100 m/pixel).
- We bundled THEMIS ATI data from pixels on Lobate Debris Aprons (LDAs), which are features indicative of subsurface glacial ice (Baker and Carter, 2019).
- Seasonal trends in THEMIS data are consistent with an ice layer and stronger for LDAs north of 42°, which is consistent with an observed change in surface texture.
- Similar trends are not observed in TES data here, likely because the 3-km resolution cells include both LDA and non-LDA material.

REFERENCES:


Thermal Consistency Map

TES Consistency Values

+1 = Low ATI unit over a high ATI unit
-1 = High ATI unit over a low ATI unit
0 = No model match
0 = Top layer thickness d < 1 diurnal skin depth

Integrating spatially coincident THEMIS and TES data

+1 = TES nighttime data matches a low ATI over high ATI layering scenario and THEMIS and TES data are consistent
-1 = TES nighttime data matches a material layering scenario inconsistent with ice and THEMIS and TES data are consistent
0 = THEMIS nighttime data are inconsistent
0 = THEMIS nighttime data are inconsistent
0 = No nighttime model match OR d < 1 diurnal skin depth

Analysis of TES and THEMIS data is consistent with the presence of ice or buried rock from high latitudes to the equator. Refined thermal analysis will likely identify additional locations of subsurface ice in areas with laterally heterogeneous soil types and depth to ice.

THEMIS Study Regions

Deuteronilus: Proposed Extension Work

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