EXAMINING THERMAL INERTIA OF LAYERED EJECTA CRATERS AND SOUTHERN HEMISPHERE DUNES ON MARS

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INTRODUCTION:

Investigation of thermal inertia provides insight into the characteristics of near surface materials revealing geologic, erosional and depositional histories. Applying thermophysical analyses, our research investigates 171 southern hemisphere dunes and 50 layered ejecta (LE) craters to identify subsurface volatiles. We used multiple data sets to conduct analyses of derived thermal inertia and two-layer thermal models to characterize the near-surface properties.

THERMAL INERTIA:

•Thermal inertia of a material measures its resistance to temperature change and may be used to infer grain size, induration, rock abundance and, percent of exposed bedrock.
•Apparent thermal inertia (ATI) is derived from brightness temperatures values obtained at discrete times of day by the Mars Global Surveyor Thermal Emission Spectrometer (TES) and the Mars Odyssey Thermal Imaging System (THEMIS).
•Variations in ATI are a result of heterogeneities of surface materials which can aid in interpretation of surface and subsurface material properties and composition – and for this research can aid in the detection of subsurface ice.
•This research uses thermal inertia to infer grain size and classify the properties near surface materials (dust, crust, rock/ice, duricrust).

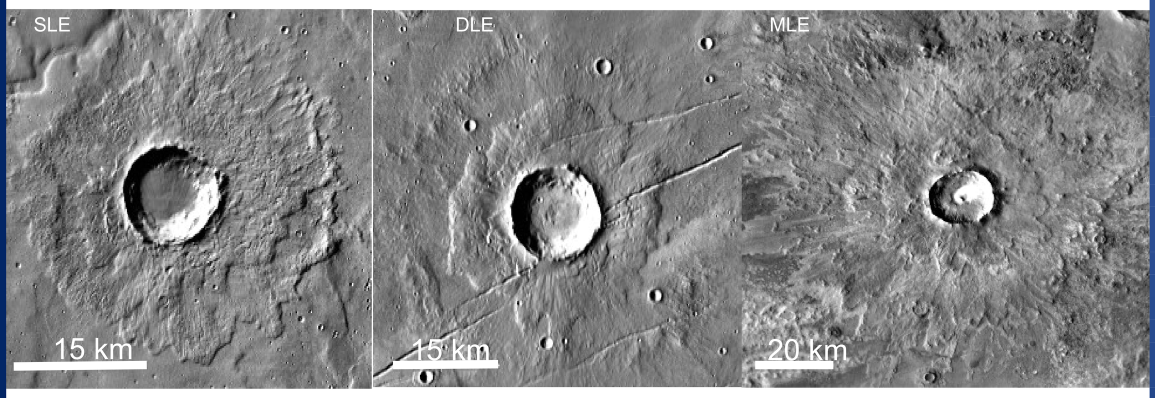
TES ANALYSIS:

•ATI from TES (3 km/pixel) is used to identify larger-scale heterogeneities.
•Compare diurnal and seasonal variations in TES ATI to values calculated for two-component heterogeneity models.

THEMIS ANALYSIS:

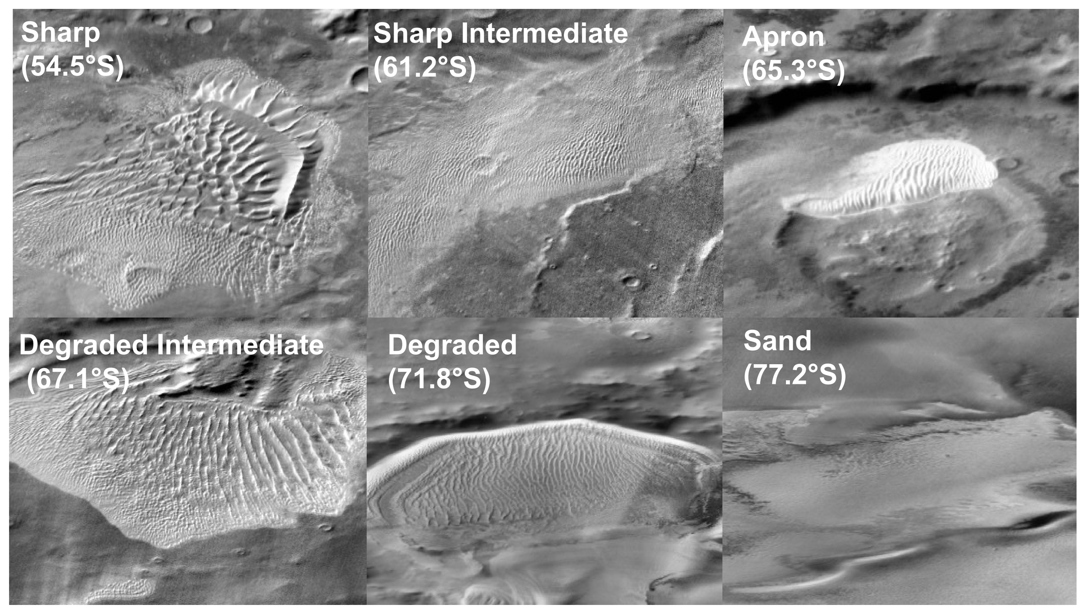
•ATI from THEMIS images (100m/pixel) are used to identify smaller-scale variations and patterns
•THEMIS maps are produced using MARSTHERM, imported into ArcGIS, and used to qualitatively identify and compare patterns between layered ejecta craters and dunes

LAYERED EJECTA CRATERS:



Examples of each type of layered ejecta crater – Single Layer Ejecta (SLE), Double Layer Ejecta (DLE) and Multi Layer Ejecta (MLE)

SOUTHERN HEMISPHERE DUNES:



Examples of the six classifications of dunes

LAYERED EJECTA CRATERS:

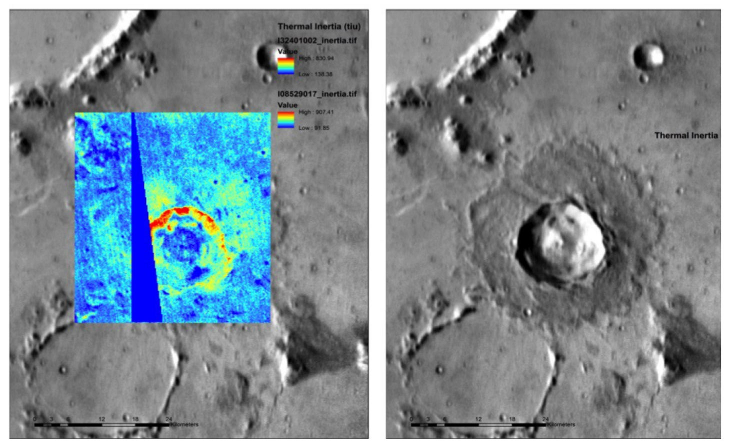
•There are two main types of formation mechanisms of layered ejecta described in the literature: Fluidized and Atmospheric model
•Fluidized model requires the presence of volatiles
  • Hypothesizes a fluid-like flow as the result of an impact melting subsurface volatiles
•The atmospheric model predicts the largest grains within the ejecta blanket to be located nearest the crater rim while the fluidized model predicts the largest grains to be located near the ejecta terminus

RESEARCH QUESTIONS:

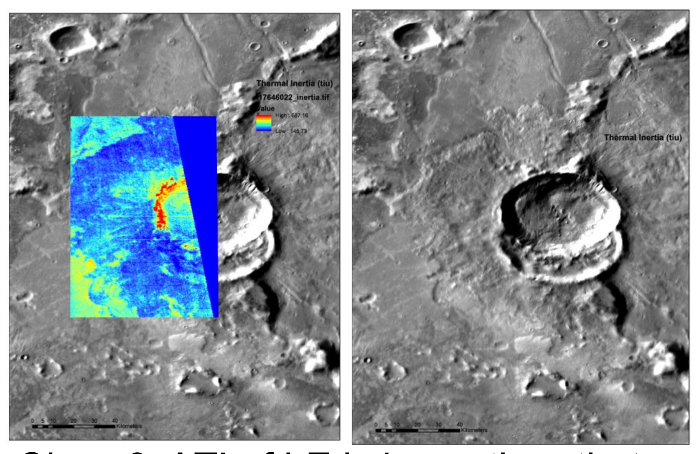
1) Are there distinct trends in apparent thermal inertia within LE craters?
2) Do the observed trends in apparent thermal inertia correlate with the presence of volatiles based on thermal models of subsurface ground ice?
3) Does the observed thermal inertia behavior support the fluidized model, atmospheric model, or neither?

RESULTS AND DISCUSSION:

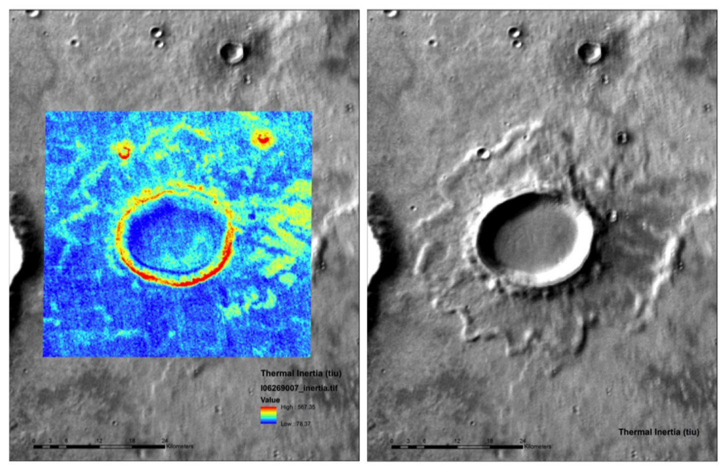
THEMIS QUALITATIVE ANALYSIS



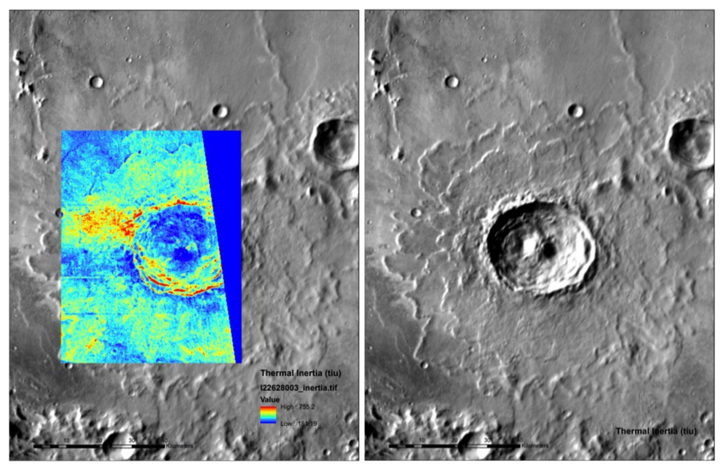
Class 1: ATI of LE is higher that that of surroundings.
Potential Interpretation: Target material was consolidated and contained relatively low amounts of volatiles resulting in lower amounts of fines in the ejecta blanket



Class 2: ATI of LE is lower than that of surroundings.
Potential Interpretation: Target material contained high amounts of volatiles resulting in higher amounts of fines in the ejecta blanket



Class 3: Edge of LE has higher ATI than that of surroundings
Potential Interpretation: Target material contained high amounts of volatiles resulting in higher amount of ground flow. Potentially supports fluidized model.



Class 4: Edge of LE has lower ATI than that of surroundings
Potential Interpretation: Target material contained low amounts of volatiles and therefore minimal ground flows occurred

TES QUALITATIVE ANALYSIS

	Class 1	Class 2	Class 3	Class 4	Class 5	Total
Crust over dust	2	2			2	6
Dust over crust	1				2	3
Dust over rock			3		1	4
Sand over rock	1			1		2
Dust-crust mix			1			1
Dust-rock mix	2		1			3
Inconclusive	2	1	4	1	5	13

- Summary of two-layer heterogeneity models matching TES ATI results for single-, double-, and multi-layered ejecta craters. A total of 23 craters had matches to the models while 19 had no apparent match and were classified as inconclusive.
- Eleven craters exhibit characteristics matching that of a rock/ice thermal signature, but no trends were observed between identification and crater type.
- THEMIS and TES analyses provided equivocal results. A lack of the identification of trends in material properties between LE craters may be a result of dust cover or crater degradation state.

TES QUANTITATIVE ANALYSIS

•Use statistical models to study trends in thermal inertia
•Preliminary analyses suggest that statistical methodology employed demonstrates that individual crater thermal inertia is predictable using the crater's morphological variables as classifiers for thermal inertia commonalities
  • Morphological variables include: layers, terminate, edge type, location and diameter

SOUTHERN HEMISPHERE DUNES

•Trend from active to stabilized dunes poleward from the equator
•Stabilization coincides with 20% increase in hydrogen concentrations potentially indicating the likely presence of subsurface volatiles

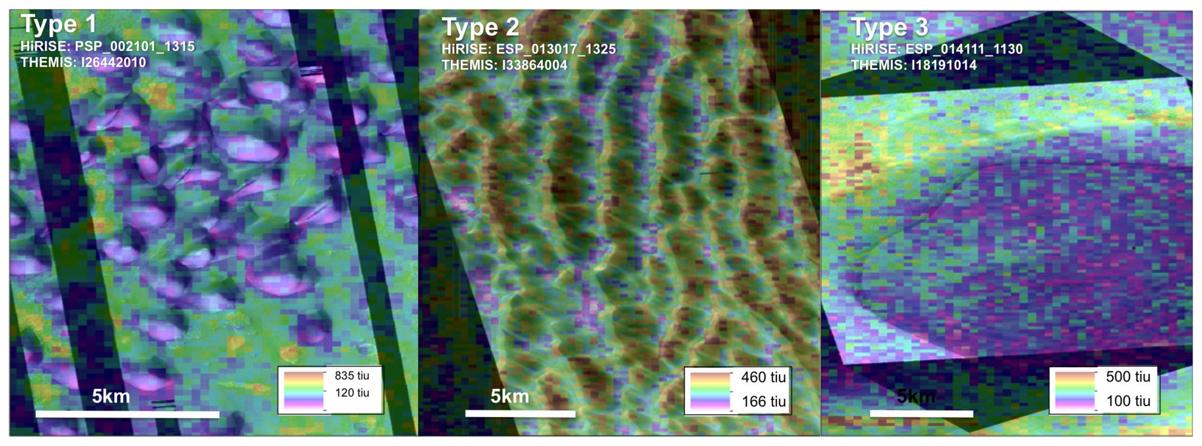
RESEARCH QUESTIONS:

1) What are the thermophysical properties of southern hemisphere dunes located in the morphological transition zone?
2) Can the observed thermophysical properties be categorized based on previously established morphological classes?

RESULTS:

•THEMIS and TES analyses compiled and included in the updated Mars Dune Database – Results presented at Gullikson et al., Poster Location: 191)

THEMIS QUALITATIVE ANALYSIS

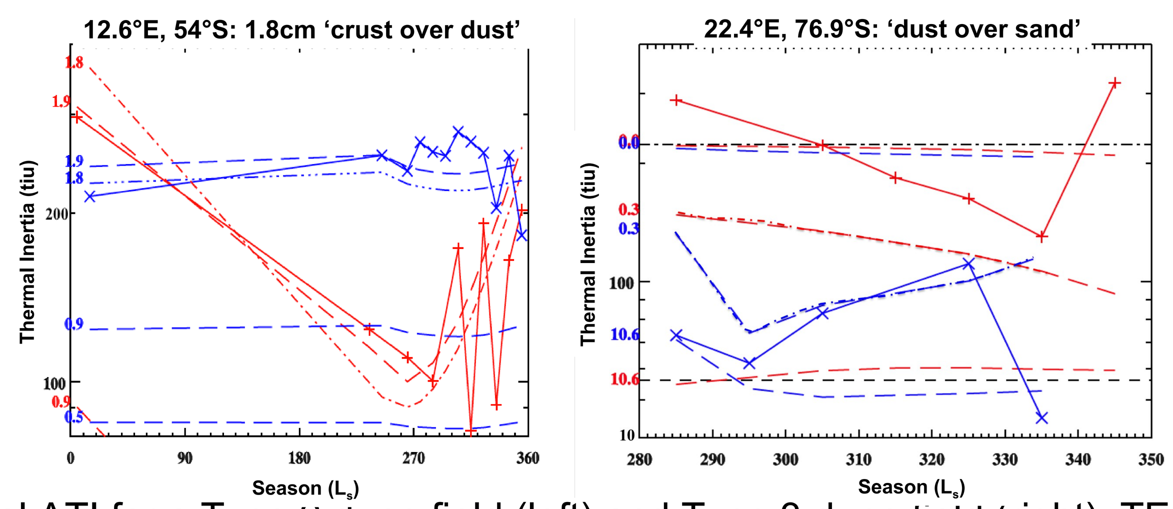


- Type 1: Exposed substrate in the interdunes, lower ATI compared to the surrounding material.
- Type 2: Higher ATI in the crests than in the troughs.
- Type 3: Homogenous ATI with no interdunes

TES QUALITATIVE ANALYSIS

	crust over dust	dust over crust	dust over rock	dust over sand	dust-crust mix	dust-rock mix	dust-sand mix	Total
Apron	1	2			1			4
Degraded	2	5	1	3	3	1	1	16
Degraded Intermediate	3	5	1	1	4			14
Sand		6		12	1	3	1	23
Sharp	18							18
Sharp Intermediate	6	3		2	3	3		17
Total	**30**	**21**	**2**	**18**	**12**	**7**	**2**	**92**

•Several dune morphologies match with different TES models:
•'crust over dust' primarily matches with sharp and sharp intermediate dunes
•'dust over sand' primarily matches with sand sheets
•9 dunes match models with a rock/ice thermal signature and are located between 63°S and 80°S



- Seasonal ATI for a Type 2 dune field (left) and Type 3 dune field (right). TES 2AM (blue) and 2PM (red) results (symbols and solid lines) are compared with modeled values (dashed lines) at the same times times. Colored labels on the left axis indicate model upper-layer thickness in cm.
- Left Figure: TES results correlate best with a model of 1.8 cm 'crust over dust' (dot-dashed lines).
  - Right Figure: TES results correlate best with a model of 0.3 cm 'dust over sand' (dot-dashed lines).

DISCUSSION:

•Comparing TES ATI results to those of heterogeneity models is useful for identifying larger-scale variations. However, available 2-layer models do not fully explain the observed behavior.
•For example, crust over dust is not expected for the active dunes (presumably the sharp and sharp intermediate)
•ATI potentially influenced by shadowing, slope, dune orientation, armoring or actively migrating ripples on the dune surface.
•Research being conducted concurrently is using SHARAD data to identify potential subsurface ice that could be influencing dune morphology (Putzig and Hoover Poster Location: 625)
•Overall results do not provide evidence supporting the hypothesis that subsurface ice is responsible for transition from active to stabilized dunes

REFERENCES: