THERMOPHYSICAL CHARACTERISATION OF LATITUDINALLY DISTINCT SITES ON MARS

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Introduction: Thermophysical properties serve as a useful proxy for understanding the surface properties and processes on Mars[1-3]. Thermal inertia is one such property which provides an insight about the surface physical characteristics and the nature of the surface and near subsurface[4]. Systematic variation in the diurnal and seasonal surface temperatures at a region enables us to estimate itsThermal Inertia (TI) value. As the surface of Mars is geologically complex exhibiting diverse landforms, a significant variation in thermophysical properties at Mars is expected. High resolution observations at Mars during the past decade has significantly improved our understanding about the temperatures and thermophysical properties of the Martian surface. Several models have also been developed for a better understanding and interpretation[5,6]. While global observations (except high latitudes and poles) are available through remote sensing, limited in-situ measurements are available from the landing locations. Comparative assessment of thermophysical properties of diverse locations at Mars is limited. An attempt has been made to carry out a comparative study of thermophysical characteristics of latitudinally distinct sites and some preliminary results are presented here.

Study area and methodology: Four latitudinally, morphologically and climatically distinct sites have been selected for initial phase of the present study. These sites include (a) Jazero crater (b) Gale crater (c) Penticton crater and (d) Green Valley.

Jazero Crater: Jazero crater is a 45 km diameter crater situated in the Martian equator region and belongs to the Syrtis Major Quadrangle which manifests several interesting geological features. Jazero crater is also the landing site for Mars 2020 Perseverance rover.

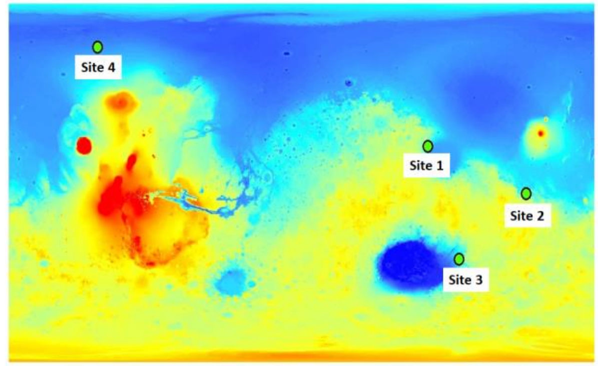

Figure 1. *Location of the study areas in HRSC-MOLA blended global elevation map.*

Gale Crater: Gale crater is situated in the Aeolis quadrangle on Mars. Gale crater is the landing site for Mars Science Laboratory (MSL) – Curiosity rover and the site refers to an existence of dry ancient lake and a mineralogy favorable for past life.

Penticton Crater: Penticton crater is an 8 km crater lying in Hellas basin of Mars. The crater's location is considered to be the most favorable site for the gully formation process.

Green Valley: Green Valley is a region in Vastitas Borealis area of Mars Arctic and also the landing location for Phoenix lander. This location is a polar region favorable for water/ice activity and expected to exhibit distinct surface thermophysical behavior.

The latitudinal distribution of the selected sites is shown in figure 1 and their characteristics are given in table 1. Orbital data from the 2001 Mars Odyssey THEMIS was used to study the day time and night time surface temperatures for all seasons. THEMIS band 9 brightness temperature data were utilized to derive the surface temperature and thermal inertia[7].

		Site 1	Site 2	Site 3	Site 4
Crater Name		Jazero crater	Gale crater	Penticton crater	Green Valley
Site type		Lacustrine environment with fan delta deposits	Fluvial & lacustrine environment with interstratified clays	Multiple gullies in the crater walls	Valley with numerous polygonal features
Size		Crater Diameter = 49 KM	Crater Diameter = 154 KM	Crater Diameter = 8 KM	50 KM wide and 250 m deep valley
Altitude (MOLA)	**Min**	-3527	-4688	-2983	-4236
	Max	-500	1464	-1421	-4197
Latitude		18.38° N	5.4° S	38.35° S	68.35° N
Longitude		77.58° E	137.8° E	263.35° W	125.75° W

Table 1. *Characteristics of the study area*

Thermal inertia values from the THEMIS data set are derived using a single temperature measurement. Night time temperatures only are used in this study because the effects of albedo and sun-heated slopes have dissipated throughout the night, and the thermal contrast due to differences in particle sizes are at a maximum. This done by utilising MARSTHERM, a web based system providing Thermophysical Analysis Tools for Mars Research[8].

Results and discussion: Using the datasets and methodology described earlier, diurnal and seasonal variation in surface temperatures and seasonal variation in Thermal Inertia were derived for all the selected sites. While observations for non-polar sites were from THEMIS observations, data for polar site, Green Valley, is in-situ from Phoenix lander observations. Orbital coverage was not available in this case. Observations showed similar values for maximum and minimum day and night time surface temperatures for all non-polar sites (Jazero, Gale and Penticton). However, diurnal variations are significantly variable for these sites. The average diurnal variations have been found to be around 50 K, 60 K and 70 K for Jazero, Gale and Penticton craters respectively. For the polar site (Green Valley), relatively low peak temperatures were found while the average diurnal variation has been found to be very low at around 20K. On the other hand, Thermal Inertia (TI) values exhibited a significant site to site variation. The average thermal inertia for Jazero, Gale and Penticton craters were found to be 487, 630 and 620 TI units respectively. The derived surface temperatures and thermal inertia for Gale crater is shown in figure 2. In-situ observations from curiosity for similar conditions is also shown in the figure. Although, it may appear that the surface temperatures may follow latitudinal variability forced by solar insolation, it is not the case here. A significant variability with possibly no direct dependence is seen in all the parameters irrespective of the site or its characteristics. The possible reason is that the surface temperatures are a complex interplay of solar insolation, surface morphology, topography and thermophysical properties. In other words, if an estimate of surface thermophysical properties are available from remote sensing or in-situ observations, it will help in estimating the surface characteristics and its heterogeneity. To accomplish this, mission observations need to be supported by numerical modeling and laboratory experiments.

Summary and future work: Thermophysical properties of mars serves as a proxy to understand its surface properties, heterogeneity and geological processes. In this work, we have attempted to understand the thermophysical characteristics of latitudinally distinct sites. Results show that the dependence of thermophysical properties on various parameters is not straight forward and is a complex formulation. In future, it is planned to use numerical simulations and laboratory experiment to derive a better formulation for understanding surface properties using thermophysics of Mars.

References: [1] Ahern et al., (2021), JGR Planets, 126(6) [2] Golombek et al., Space. Sci. Rev., 214(5) [3] Rebecca et al., (2018), Earth & Space Sci., 5(9) [4] Mellon et al., (2000), 148(2), p. 437 [5] Kieffer,(2013), JGR Planets, 118(3) [6] Amundsen et al., (2007), https://doi.org/10.4271/2007-01-3243 [7] NASA PDS (https://pds-geosciences.wustl.edu/) [8] Putzig et al., (2013), AGU, 2013AGUFM.P43C2023P

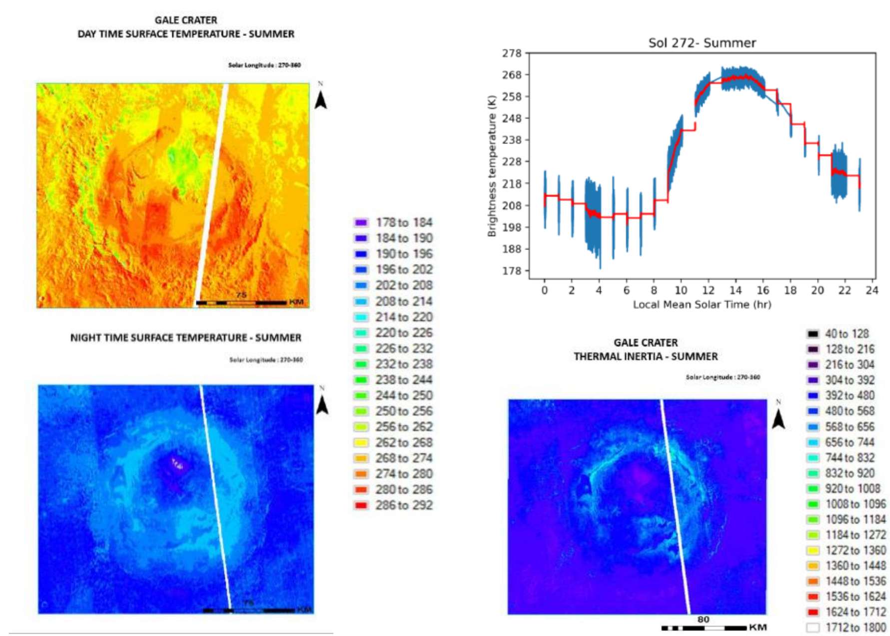

Figure 2. *Derived thermophysical characteristics for Site 2 and in-situ ground truth*