GLOBAL DISTRIBTUTION OF BEDROCK AND THE NATURE OF THE UPPER MARTIAN CRUST.
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Introduction: An investigation of martian high thermal inertia surfaces has been made using Thermal Emission Imaging System (THEMIS) one hundred meter per pixel spatial sampling nighttime temperature data. High thermal inertia surfaces or interpreted bedrock exposures are defined as any pixel in a THEMIS image with a thermal inertia over 1200 $JK^{-1}m^{-2}s^{-1/2}$ and may refer to *in situ* rock exposures or rock-dominated surfaces. Without the use of high-resolution imagery, thermal inertia data alone cannot distinguish between exposed bedrock and boulder fields, as they behave similarly in thermal inertia data.

Three distinct morphologies, ranked from most to least common, are associated with these high inertia surfaces: 1) valley and crater walls associated with mass wasting and high surface slope angles, 2) crater floors related to melting and re-crystallization of surface materials or volcanism associated with large (typically >25 km), high energy impacts, 3) plains surface with compositions significantly more mafic than the surrounding regolith, possibly indicating that the martian regolith has been processed, both chemically and mechanically [1, 2]. The mapping and identification of these types will not be discussed in detail, rather the implications for the distribution and regional to global scale processes will be the focus.

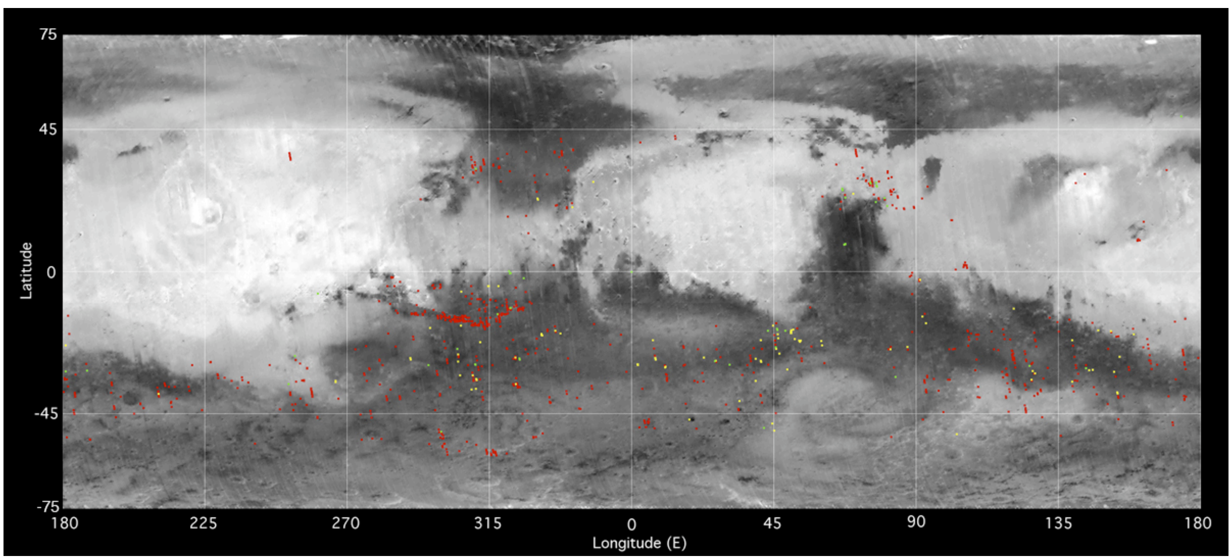

Figure 1. Global distribution of identified bedrock morphologies overlain on a Thermal Emission Spectrometer (TES) Lambert Albedo global map of Mars. In all, 960 instances have been identified using THEMIS high-resolution thermal inertia. Red corresponds to the valley and crater walls surfaces; Yellow corresponds to the crater floor surfaces; and Green corresponds to the plains surfaces. Most of these instances occur in low albedo regions and indicating that these surfaces are generally exposed where dust content is low. Additionally, there are few instances of high inertia surfaces observed >45˚N and < 55˚S.

Method: Nighttime THEMIS temperature data in combination with a variety of observational parameters (e.g. latitude, Ls, local time, etc.) were used to calculate thermal inertia values on a framelet basis (every 256 line segment) for minimum, maximum and average temperatures using the KRC thermal model [3]. A similar method has been applied to full THEMIS images by [4] After the calculation of thermal inertia values for every nighttime THEMIS framelet (up to Mars Odyssey orbit ~25,000), values were stored in a database, which could be related to many other image and framelet observation and derived parameters. These parameters, such as the time difference between the end of an image and the shutter closing image, the difference between TES and THEMIS band 10 radiance, as well as the difference between average THEMIS and TES thermal inertia, were used to help assess the calibration and overall quality of the data.

After this first quality control constraint, each framelet was examined and characterized by the associated morphology, using a variety of datasets, including THEMIS VIS, Mars Orbiter Camera (MOC) and High Resolution Imaging Science Experiment (HiRISE) imagery. The study area was limited from 75˚N to 75˚S to help eliminate the effects of seasonal CO_2 frost. Additionally, high latitude data (poleward of 60˚N/S) were limited to late summer.

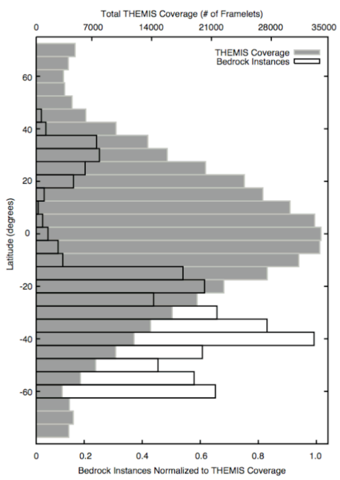

Figure 2. Histograms of total THEMIS coverage (solid grey and the upper scale) and bedrock instances normalized to THEMIS coverage (black outline and the lower scale) versus latitude. Only potentially valid THEMIS framelets have been included in these histograms.

Implications: The abundance of high inertia surface instances in the cratered southern highlands (Figure 1 and 2) corresponds well with the moderate thermal inertia regions described by [5-7]. Generally, high inertia surfaces are not found in other mid-latitude and equatorial regions because of the large degree of dust mantling in these areas. This corresponds well with albedo and TES Dust Cover Index (DCI) data, which indicate that bedrock outcrops typically occur in low albedo, relatively dust free areas with moderate average THEMIS thermal inertia values. While global coverage was limited to ±75˚ latitude, only one instance of high inertia surfaces north of 45˚N and no instances south of -58˚N have been identified. This leads to the possibility that a high latitude periglacial process [e.g. 8] is obscuring the bedrock instances due to enhanced regolith formation associated with freeze/thaw processes. Numerous studies [e.g. 9, 10] have identified near surface ice throughout these regions further supporting this hypothesis.

In addition to the distinct lack of these surfaces at high latitudes, an asymmetry in the maximum latitudinal extent is observed (Figure 2). This may indicate that the process acting on the underlying rock is/was occurring at lower latitudes in the northern hemisphere than the southern hemisphere. With changes in obliquity and eccentricity, it is possible that the latitudinal asymmetry in observed bedrock instances could be explained by enhanced freeze/thaw action in the past. However, it is expected that most seasonal processes would act similarly in each hemisphere.

There are many locations on Mars where surface conditions are seemingly met (e.g. DCI > 0.95, albedo of <0.18, THEMIS average thermal inertia of > $JK^{-1}m^{-2}s^{-1/2}$) and these types of exposures would be expected; yet they are not observed. Additionally, there are many locations where the surface slopes are steep (like those typically found in the Crater and Valley Walls type), yet this surface type, while the most common of the three identified, is still surprisingly rare. This lack of widespread exposures (only 960 instances identified of ~450,000 valid framelets, Figure 2) may indicate global scale crustal processing, which either obscures or destroys most bedrock on Mars. The locations that are observed may have undergone less processing than the rest of the planet or may have experienced some reset mechanism.

The plains surface is perhaps the most interesting of the three morphologic types identified, as these surfaces are typically isolated exposures of more mafic bedrock spread over and area of $>106km^2$, which are surrounded by less mafic, lower thermal inertia plains [2]. [1] propose that a process where by acidic dissolution, olivine-rich material weathers to olivine-poor materials in the process of being mechanically broken down, as observed in Argyre Planitia. They also propose that this process may be widespread on Mars and that the primary igneous compositions may be typically more mafic and subsequently become olivine-depleted through dissolution by acidic fluids. The few locations of in-place plains bedrock seem to be largely mafic in nature relative to the surrounding lower inertia regolith and are distributed throughout the surface of Mars, possibly supporting this hypothesis.

References:

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