HIGH-RESOLUTION APPARENT THERMAL INERTIA MAPPING OF VALLES MARINERIS (MARS).

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Introduction: The minerals absorb and reflect thermal infrared (TIR) light of the different wavelengths depending on their composition and structure. Thus, every rock absorbs and reflects different wavelengths in TIR and has its own spectral signature. The TIR images can be used in the thermal inertia (TI) mapping and more precisely, in its approximation called apparent thermal inertia (ATI), which can be calculated from surface albedo (A) and diurnal temperature difference (ΔT) [1]. Hereby, the thermal images can provide an information complementary to visible and near-infrared (NIR) data (e.g. CTX, CRISM, OMEGA).

For interpreting the TIR spectra of the Martian surface obtained from orbiters, we can use the spectral libraries of terrestrial rocks and minerals [2].

Thermal data: Thermal data for Mars were obtained by two instruments: Thermal Emission Spectrometer (TES) on board Mars Global Surveyor, and Thermal Emission Imaging System (THEMIS) on board the Mars Odyssey spacecraft. THEMIS IR data was applied in our research due to the better spatial resolution (100 m/pixel). High-resolution mapping of apparent thermal inertia has not been performed so far in the Valles Marineris region.

Thermal data processing: THEMIS IR images were processed online using the Themis Processing Web Interface (THMPROC, http://thmproc.mars.asu.edu). THMPROC enables calculation of i.a. emissivity and brightness temperature values. The brightness (radiant) temperature (T_{rad}) can be then converted to kinetic temperature (T_{kin}) based on broadband emissivity values (e), according to the following equation:

$$T_{kin} = \frac{T_{rad}}{e^{1/4}} \qquad (1)$$

The broadband emissivity has been calculated based on nine THEMIS IR bands with relation to the Plank's curve (Fig. 1 B). Each pixel of the calculated emissivity map had nine different emissivity values – one from each band/wavelength. Those values were calculated having assumed that the band with the highest temperature had an emissivity of ~1. This band was used to anchor the Planck curve of blackbody radiation and to calculate the emissivities from the other bands which had lower emissivity values. The assumption that the highest temperature has an emissivity of ~1 is a simplification. Nevertheless, this is the best way to calculate emissivity, since the absolute emissivity of the surface materials underneath each pixel is unknown.

Apparent thermal inertia map: As real thermal inertia (TI) cannot be measured by the remote sensing methods (conductivity, density and thermal capacity can be measured only by the contact methods), its approximation called apparent thermal inertia (*ATI*) was applied. ATI is defined as:

$$ATI = \frac{1-A}{\Delta T} \qquad (2)$$

where A is the albedo in the visible range and ΔT is the difference of the maximum and the minimum temperature. ΔT can be determined by substracting the digitally recorded nighttime temperature from the daytime temperature. ΔT is low for the materials with high thermal inertia and high for those with low thermal inertia. Albedo is use to compensate the various absorptivity values of the rocks. [3]. For the calculation of ΔT, the THEMIS images of good quality were chosen: the minimum and maximum "summing" parameter was set to 1 (it gives the full-resolution images only), the minimum and maximum "image rating values" were set to 4 and 7 respectively. The maximum (day) and minimum (night) temperatures were defined based on MARSTHERM model (https://marstherm.boulder.swri.edu/). The local times of minimum and maximum temperatures for the Valles Marineris are 06:00 (night) and 13:00 (day).

The albedo values were estimated based on the CTX images (Fig. 1 C). They have been acquired using the PILOT website (http://pilot.wr.usgs.gov/), and processed online following the ISIS procedures *spiceinit* (update camera pointing information), *ctxcal* (apply radiometric calibration), *ctxevenodd* (remove even odd detector striping from CTX/MRO) and *cam2map* (project from camera space to map space). After the PILOT processing, CTX images represent the ratio of reflected energy to incoming energy (irradiance/solar flux, often simply called I/F). In order to convert I/F factor into Lambert albedo, the I/F values were divided by the cosine of the solar incidence angle. In the calculations, one average value of incident angle was adopted for the whole CTX image. The preliminary calculation of ATI for a selected part of Valles Marineris (275.2° E, 7.4° N was made (Fig. 1 D). The obtained values are within the ranges cited in the literature [4].

Perspectives: The high-resolution apparent thermal inertia map will be calculated for the other selected Martian landforms. The methodology will be verified and compared to the existing thermal inertia maps in the next step [5, 6]. The transparence of the atmosphere and the relief will be also included in the calculation.

References: [1] Xue Y. and Cracknell A.P. (1996) *Int. J. Remote Sensing*, 17, 431-461. [2] Christensen, P.R., et al. (2003) *Science*, 300, 2056-2061. [3] Sabins F.F. (2007) Waveland Press, Incorporated. [4] Kahle A., B. (1981), Pasadena, Calif. : National Aeronautics and Space Administration, JPL. [5] Christensen et al. (2001), *J. Geophys. Res.*, 106, 23,823-23,871. [6] Putzig, N. E., Mellon M. T., Kretke K. A. and Arvidson R. E. (2005), *Icarus* 173, 325-341.

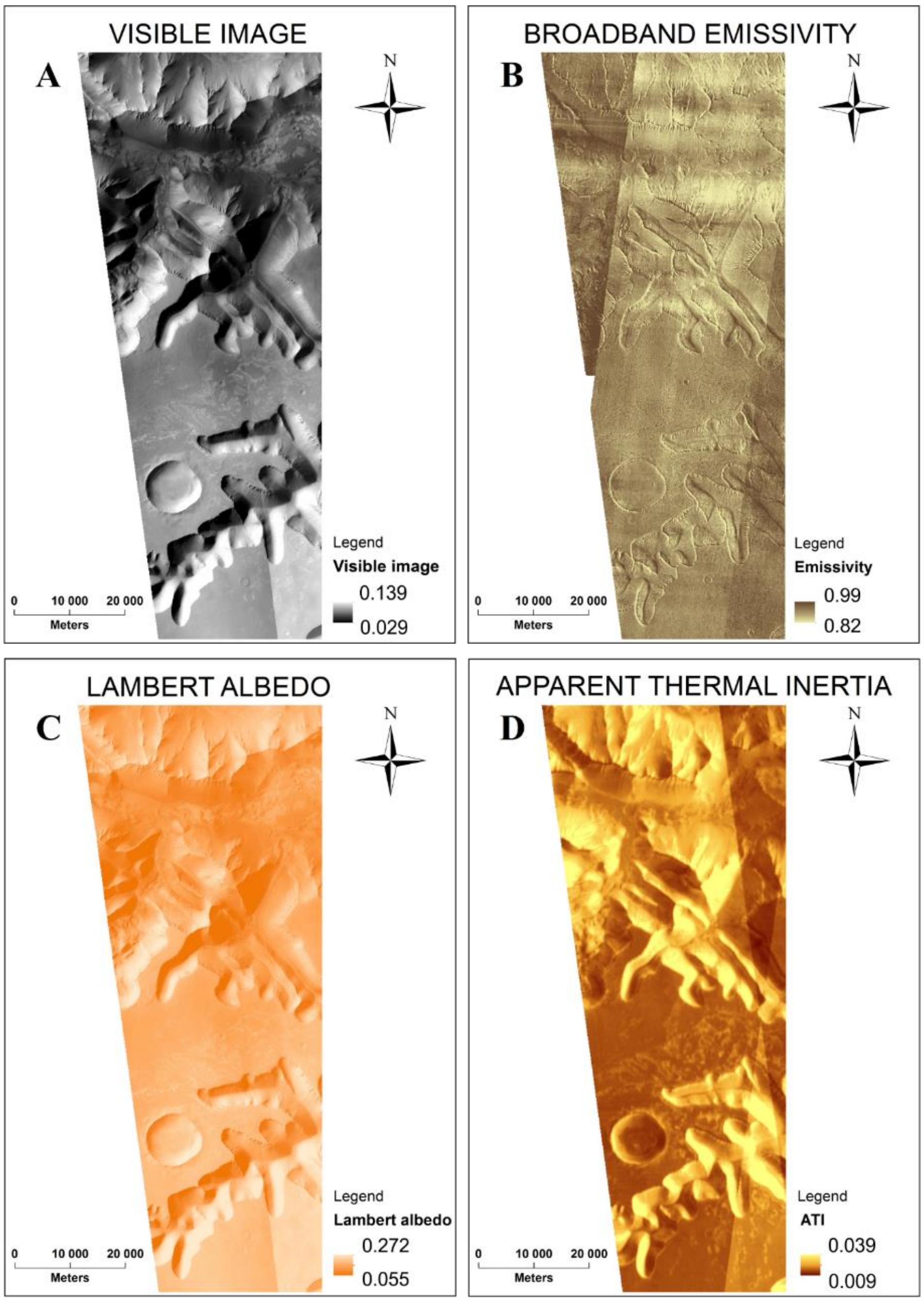

Figure 1. Preliminary ATI* map (D) calculated for the selected test surface in Valles Marineris (275.2°E, -7.4°N), broadband emissivity map (B), Lambert albedo map (C), and CTX visible light image in [I/F] (A). The dominant ATI values (0.13-0.15) indicate the presence of sand. The areas with higher values are correlated with the eastern and northern slopes, which probably results from lower real incident angle. That has to be verified and taken into account in the further investigations.*ATI values are relative to dolomite standard with a thermal inertia of 0.984 [cal*cm^{-2}*sec$^{-1/2}$*°C^{-1}]. Error limits are approximately ±10 percent. Source: Kahle et al., 1981 (Table 4) [4].