QUALITATIVE ANALYSIS OF THEMIS-DERIVED BRIGHTNESS TEMPERATURE OF THE LOWER NW FLANK OF THE HECATES THOLUS VOLCANO, MARS. M.A. de Pablo[1,2] and J.D. Centeno[2], [1]Unidad de Geología. Universidad de Alcalá. 28871 Madrid, Spain. (miguelangel.depablo@uah.es), [2]Departamento de Geodinámica. Universidad Complutense de Madrid. 28040 Madrid, Spain.

Introduction: The NW flank of the Hecates Tholus volcano (31.6ºN, 150ºE), at the Elysium volcanic rise (Fig. 1) on Mars, shows different features marking the existence of a possible glacier covered by a thin layer of dust and aeolian sediments. This idea is supported by different authors [1-8] by the analysis of satellite images. The geomorphological features seems to reveal the existence of surface morphologies similar to moraines, crevasses, cirques, etc. [6-8], but the present surface does not show any evidence of ice nowadays. So, could be ice underneath the surficial regolithe and materials? Some thermophysical properfies of the materials studies revealed that the ice could be stable in this site at few meters below the surface [9]. Then, are those geomorphological features evidence of ice-cored glacier or rocky glaciers? In order to study this topic and try to solve this questions, we tested the use of THEMIS-derived Brightness Temperature Record (BTR) data in order to analyze the surface temperature [10]. Our preliminary analysis showed different surface temperature behaviors in areas with similar conditions (materials, albedos, elevation, etc.), what we preliminary interpreted to be a possible reflect of ice presence beneth the surface. Here we present a more extended qualitative analysis of THEMIS-derived BTR data of the NW flank of the Hecates Tholus volcano showing daytime and nighttime temperature maps, and also apparent thermal inertia and spectrometrical image compositions.

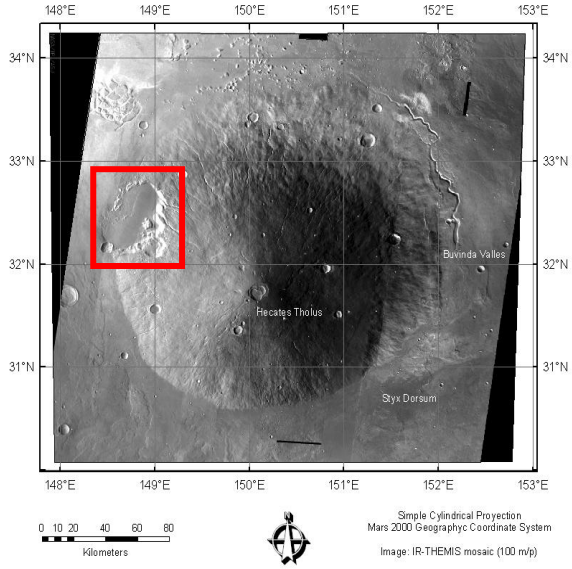

Fig. 1: Location map of the study area (red box) in the lower NW flank of the Hecates Tholus volcano.

Data and Methods: The analyzed data are infrared (IR) images (about 100 meters/pixel) acquired by THEMIS instrument on board Mars Odyssey spacecraft. We used the available images on the public release until august 2012. We derived Brightness Temperature from band number 9, thanks to the use of THMPROC on-line tool (THEMIS Processing Web Interface from Arizona State University – ASU) [11]. We assume not atmospheric influence, and then, the brightness temperature is equal to surface temperature. After processing those images we introduce them into a GIS to analyze them together with CTX images and HRSC-derived Digital Elevation Model (DEM). Additionaly, Apparent Thermal Inertia (ATI) [12] was calculated such as:

ATI = (1 – Albedo) / (Tdaytime – Tnighttime)

where albedo was approached (in order to have only a qualitative result) by the recalculation (to 0-1 range) of the CTX images digital numbers, and daytime and nighttime temperatures by the use of a mosaic of similar Solar Longitude images to reduce the spatial variability on surface temperature.

Surface temperature: The temperature in the area is characterized, during the daytime period, by a wide range of temperatures (Fig. 2-Left). Higher temperatures are reached at the lava flows from the Elysium Mons volcano, surrounding the base of the Hecates Tholus volcano, but mainly in the NW sector of the studied area. Only the materials forming the western flank of the volcano have similar (but still slightly lower) temperatures, what could be related to differences in isolation due to the flanks aspect. The lower temperatures in the northern flank of the volcano in the studied area could corroborate this interpretation. The higher and lower temperatures of the depressions walls are also due to this difference in insolation. Channels and valleys of the northern sector of the volcano flank show also very low temperatures.

Specialy interesting are the low temperatures in most of the ground of the depression in the NW flank of the volcano, clearly lower than the temperature of the lave flows from the Elysium Mons volcano. Althought they are not extremelly low temperatures, from our point of view, this difference could not be due to differences in isolation related to the different terrain aspects. Moreover, the low temperatures seems to reflect some surficial landforms such as the already mapped moraines [8].

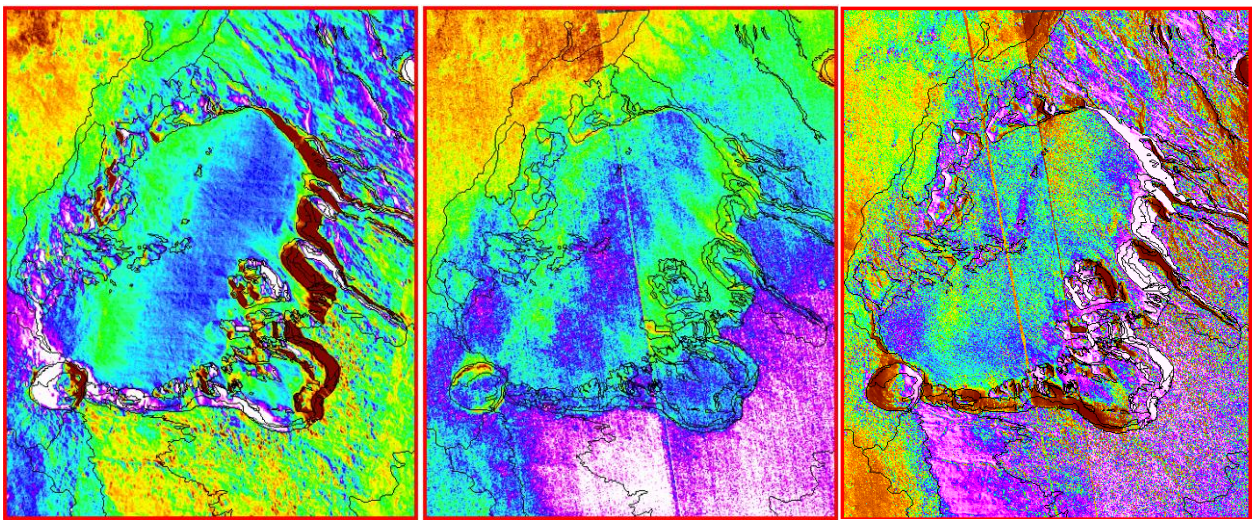

Fig. 2: Daytime (left) and nighttime (center) surface temperature mosaics from THEMIS-IR-derived BTR data, and Apparent Thermal Innertia (right) calculated. Showing differences in temperature in the lower NW flank of the Hecates Tholus volcano. Black lines marks the limits of the geomorphological units mapped in the area [8].

Nighttime surface temperature: surface temperature behavior during the nighttime follows a slightly different pattern (Fig. 2-Center). The higher temperatures are also related to the lava flows from the Elysium Mons volcano bordering the Hecates Tholus edifice. However, this temperature clearly decrease with the altitude. So, the higher part of the NW flank shows lower surface temperatures, such as expected to be caused by an altitudinal gradient.

Channels in the lower part of the northern sector of the studied area also shows low temperatures, but not as lower as during the daytime, and with small differences respect the surrounding slopes. However, nighttime surface temperatures shows. Finally, the surface temperature of the floor of the depressions are also low temperatures, lower than expected form the altitudinal gradient observed in othe other sectors of the studied area, also reflecting some landforms and structures interpreted to have a glacial origin [5][8].

Apparent thermal inertia: Derived ATI shows a clear and defined pattern (Fig. 2-Right). The lava flows from the Elyisum Mons volcano surrounding the base of the Hecates Tholus edifice show the higher ATI values, showing an exact correlation with the cartography of the area (black lines in Figure 2, based on [8] map). This highe ATi could be related to rocky materials suchas as the lava flows. Lower ATI values are related to the materials forming the flanks of the Hecates Tholus volcano, probably due to the fine-grained mantle deposits described and mapped in the area [5][8]. Mean ATI values are related to the materials forming the floor of the depression, and their spatials pattern also seems to reflect terrain structures.

Conclusions: Our qualitative analysis of BTR data shows very common spatial patterns related to aspect, altitude and grain-size characteristics of the materials on the surface. However, there are some special behaviours in the channels dissecting the flanks and, mainly, in the floor of both nested depressions in this flank of the volcano, what reflects a relative and qualitative lower temperatures. The spatial temperature patterns in this area also reflect/agree with the geomorphological features observed in the area [8], mostly glacial and periglacial related. Then, we propose, such as a working hypothesis for future researchs (for example based on the analysis of ground penetration radar data), that there is ice deposits beneath the surface on the floor of the flank depressions, remnants of the last glacial activity in the area, and covered by debris deposits later. This hypothesis agrees with works what also propose the presence of ice in the same sites by the analysis of TES data [9], although further and quantitative studies are required.

References: [1] Head and Marchant (2003) *Geology* 31, 641–644. [2] Shean et al. (2005) *JGR* doi:10.1029/2004. [3] Milkovich et al. (2006) *Icarus* 181. 388-407. [4] Shean et al. (2007) *JGR* doi: 2006JE002761. [5] Hauber et al. (2005) *Nature* 434. 356-361. [6] de Pablo and Centeno (2011) *LPSC*, 42. Abstract #1030. [7] Centeno and de Pablo (2011). *LPSC*, 42. Abstract #1031. [8] de Pablo and Centeno (2012) *J. Maps*, 8(3) 208-214. [9] Helbert et al. (2005) GRL, 32. doi: 10.1029/2005GL023712 [10] Centeno and de Pablo (2012). *LPSC*, 43. Abstract #1097. [11] http://thmproc.mars.asu.edu/ [12] Price, 1977. *JGR*, 82. 2582-2590.