ANALYSIS OF CRYOKARSTIC SURFACE PATTERNS ON DEBRIS APRONS AT THE MID–LATITUDES OF MARS.
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Introduction: The presence of ice-related glacier-like landforms on the Martian mid-latitudes have been studying on the basis of Viking imagery. These features are evidences of colder climatic conditions in the Martian geologic history, which have three proposed origin [1][2][3]. Three types of landforms are distinguished on Mars: Lobate Debris Aprons (LDA), Lineated Valley Fills (LVF), and Concentric Crater Fills (CCF) [4][5][6]. This work focuses on the morphological analysis and interpretation of the surface patterns like mounds, furrows, ridges, pits, craters, and different surface types like „smooth surface", „corn-like surface", polygonal mantling material and „brain-like texture" based on MRO HiRISE's images [6][7][8]. The basic questions are the followings: 1. What are the differences between the studied surface patterns of the examined terrains? 2. Currently are there any seasonal changes on ice-related surfaces? 3. Are there any signs of recent movement? Four study locations were selected in the Deuteronilus Mensae region (Deuteronilus-A: 37.4° N, 24.6° E and Deuteronilus-B: 41.16° N, 29.54° E) and in the eastern Hellas basin (Hourglass: 39° S, 102.8° E; and Tongues: 38.1° S, 113.2° E). The research may facilitate to understanding the Martian climate change.

Data and Methods: The main images were in this work the HiRISE Reduced Data Record (RDR)'s photos from the Primary Science Phase (PSP) and the Extended Science Phase (ESP). For change detection, HiRISE stereo pairs were available and have been added to ArcGIS 9.3 software. Other image datasets include: High Resolution Imaging Science Experiment (HiRISE, 0,25 m/pixel), Context Imager (CTX, 8 m/pixel), High Resolution Stereo Camera (HRSC, 10 m/pixel), Mars Orbiter Laser Altimeter (MOLA, 300 m/pixel horizontal and 0,30 m/pixel vertical). HRSC and CTX were used as a basemap for performing detailed analysis with HiRISE. From MOLA Mission Experiment Gridded Data Records (MEGDR) have been produced topographic maps and digital elevation models.

Observations and interpretations: (1) Three mound types have been separated: 1. small, fractured mounds with 15-30 m diameter (*Fig.1./A-B*). 2. 80-125 m sized „buttle-like mounds" (*Fig.1./C*). 3. irregular-shaped, pingo-like mounds, 100-300 m in diameter (*Fig.1./D-E-F*). The origin of these knobby materials are not clarified yet. The „buttle-like mounds" are the remnants of ridges as a result of eolian activity. The small, fractured mounds and irregular-shaped, pingo-like features indicate hydrological processes beneath the surface. (2) Perpendicular (*Fig.1./J*) and parallel (*Fig.1./K*) furrows have been observed in Deuteronilus-A on inner crater walls, parallel ones are possible the result of melting flows or gully processes near the faults-like features. Verges of furrows in Hourglass region are rounded, causing of viscous material. (3) The craters of the debris apron surfaces are classificated in different types: 1. Pitted ring-mold craters (*Fig.1./G*). 2. Bowl-shaped craters (*Fig.1./H*). 3. Inverted-relief craters (*Fig.1./I*). 4. Softened craters. Deuteronilus-A has small, high number of bowl-shaped craters, which can indicate low-percent of ice in the near-surface layers. Hourglass has larger and lesser number of craters than Deuteronilus-A in variation of crater types: 1. Bowl-shaped craters. 2. Inverted-relief craters. 3. Pitted ring-mold crater. This result suggest a higher volume of ice, than in Deuteronilus-A. Two explanations are for this: 1. The LDA currently move, and the surface relax quickly. 2. Resurfacing process can occured in the recent past, based on traces of glaciofluvial activity and the analysis of „smooth surface". Deuteronilus-B and Tongue-shaped features surfaces are smooth without craters, which can be evidence of much higher ice-content, than in the previously discussed areas. (4) Two stratigraphical surface units were observed in Deuteronilus-A: polygonal mantling material stratigraphically superimpose on „brain-like terrain" (*Fig.1./L*). In contrast to [6] the possible development history is the following based on the dendritic surface pattern (*Fig.1./L*) and other locations of the area: The extent of mantling deposit can decrease with ice loss process, where the surface collapse and develop into „brain-like texture". As a result of eolian activity, ice-free deposit can be transported from cells to accumulate on other areas. (5) Two surface types were analyzed in Hourglass region: pitted, eroded „corn-like surface" (*Fig.1./I*) and a superposed „smooth surface" (*Fig.1./E*). „Smooth surface" can be the result of a water outbreak or flow phenomenon, which could be young and related to glaciofluvial activity or collapsing of pingo-like mound's summit.

Conclusion: (1) The Deuteronilus-A and Hourglass surfaces have a great variety of patterns, but none of these patterns appear on both of these surfaces. The Deuteronilus-B and Tongues surfaces (*Fig.2.*) are smooth, neither craters nor mounds can be find there. But their surrounding areas are cratered, and mounds, as well as traces of glaciofluvial activity can be find there. Explanations of unusual lack of patterns on surfaces are the followings: 1. High-volume of ice, evidence of lack of craters. 2. The areas are very young, possible forming features occur in Reull Vallis region. 3. The surfaces are moving downslope, and as a result of the movement, the craters are disappeared. (2) The differential development history of the examined terrains is suggesting multiple glacial events in Late-Amazonian period. (3) Based on the comparison of the HiRISE stereo pairs, seasonal changes have not been detected on the surfaces. It is important to mention, that HiRISE stereo images were taken either in spring/summer, winter/spring or spring time. It could be more effective, that images would be taken for seasonal change detection in winter/summer time. (4) Traces of movement were not find, but the accessible HiRISE images are not really suitable for this kind of analysis. But analysis of new images, search for new furrows might be indicated current movement of LDA/LVF systems.

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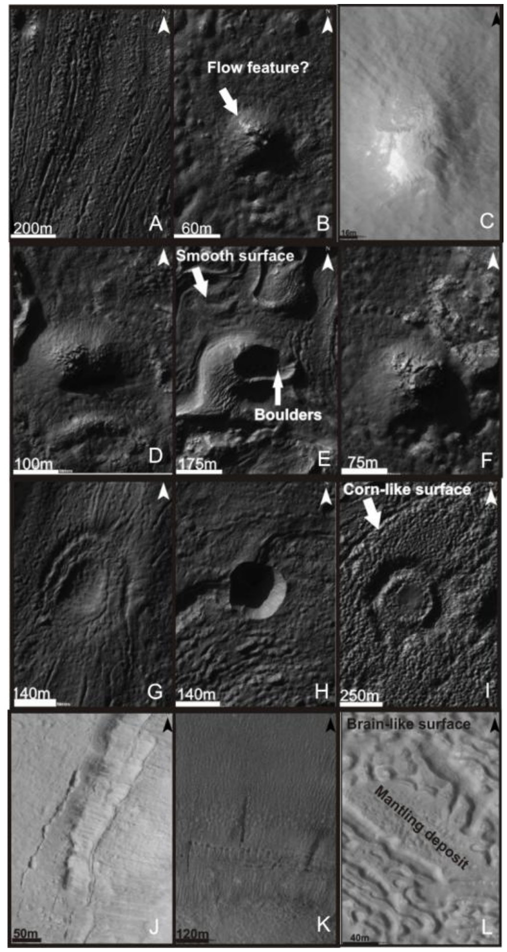

Fig.1.: A/Small mounds arranged in lines near furrows. B/ Enlarged image of small mound with possible flow feature. C/Buttle-like mounds. D-E-F/ Pingo-like mounds with „smooth-surface type" in (E) portion. G/ Ring-mold crater. H/ Bowl-shaped crater. I/ Inverted-relief crater with „corn-like surface type". J/ Perpendicular furrow. K/ Parallel furrow. L/ Polygonal mantling material in superposition on „brain-like texture". HiRISE images: A-B-D-E-F-G-H-I: PSP_008834_1405. C-J-K-L: PSP_009588_2175

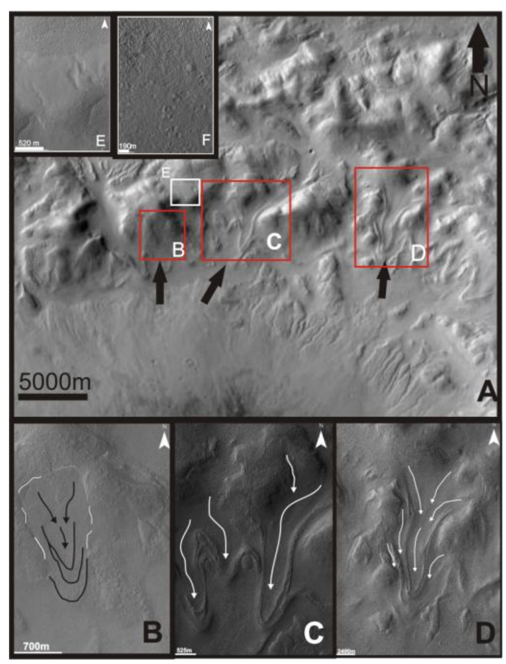

Fig.2.: A/ Tongue-shaped features on unnamed crater wall near to Reull Vallis. B/ Possible forming tongue shaped landform. C-D/ Developed tongue shaped features. E/ Surrounding area of rock glacier with three "chanels". F/ Surrounding area with softened craters and mounds. Portion of (A) CTX image: P04_002676_1413_XI_38S247W. (B) HiRISE image: ESP_013541_1415. (C) HiRISE image: PSP_002676_1415. (D) HiRISE image: PSP_003243_1415. (E) HiRISE image: ESP_013541_1415. (F) HiRISE image: