POSSIBILITY OF KARST MORPHOLOGY ON THE MARTIAN SURFACE AT THE MERIDIANI LANDING SITE FROM COMPARISON WITH TERRESTRIAL ANALOGS. Sz. Bérczi, Eötvös University, Department of General Physics, Cosmic Materials Space Research Group, H-1117 Budapest, Pázmány Péter s. 1/a. Hungary, (bercziszani@ludens.elte.hu)

Introduction: Surface morphology on images of MER-2 probe Opportunity sent from its landing site vicinity on the 70-74 sols exhibited chains of pits forming a trench. The landscape has been named Anatolia. The trench pits of Anatolia can be interpreted as dolines (closed surface depressions) and the whole surface trench pattern of Anatolia as a solution groove, both of them belonging to the karst morphology. Comparisons to terrestrial karst morphology strengthened this interpretation.

Earlier studies: Costard et al. (1995) Kargel et al., (2004), Schaefer, (1990), Spencer, et al., (1986) collected evidences of probable karst morphology on Mars. However, these were large scale morphology interpretations. The NASA JPL homepage (http://marsrovers.jpl.nasa.gov/) about MER activities day by day made it possible to follow the regional morphology around MER rovers. During the 70-74 sol period Opportunity reached a chain of pits very similar to small scale dolines.

During the first two months Opportunity observed the Eagle crater (Squyres et al., 2004) and especially the rock outcrop around an NW arc of the Eagle crater (Christensen et al., 2004) and found that the rock composition is probably jarosite (Klingelhöfer et al., 2004). Together with field work morphology of cross-stratified layers the date were interpreted as shoreline sedimentation in the Meridiani Region (http://marsrovers.jpl.nasa.gov/). Comparing these data with those of Mars Odyssey the conclusion was inferred that large amount of near surface water observed by Odyssey may be involved the brine soluble rocks (jarosite) found by Opportunity [Klingelhöfer et al., 2004, Morris et al., 2004, Rieder et al., 2004). All these data opened the possibility to infer that landscape data of 70-74 sols may be interpreted as to comparable to terrestrial karst forms (http://marsrovers.jpl.nasa.gov/).

Terrestrial karst characteristics: Karst landscapes on the Earth can be found on terrains composed of water soluble rocks. Karst landscapes are formed in the mutual interplay of surface erosion, and ground water dissolution, or, as written by Jakucs: as a result of the "dissolving power of surface and underground waters" (Jakucs, 1977). There are characteristic features of this interaction between atmospheric and hydrospheric flows and lithology. The first is among them: the doline, a closed around depression, which serves as a sinking hole, where the solving fluid seeps. Fractures in the brittle surface rocks helps movement of the surface water to invade soluble rocks from top, and channelling to the groundwater region forms drainage system. The subsurface drainage helps to develop a surface coalescence of the dolines such way forming a groove (Jakucs, 1977). These steps can be observed and interpreted on the Opportunity's Martian landscape, too.

Martian karst characteristics: Karst landscapes probably can exist on Mars on the Meridiani Region because of the interaction of water (or some brine) and water (or some brine) soluble rock produced by earlier fluid sedimentation. On the Martian surface characteristic closed depressions can be observed, which can be interpreted as dolines and these closed depressions are connected, coalesced in some portions forming a solution trench.

According to the observations of Opportunity's Research Groups [7, 8, 9,] the whole region of Meridiani Landing Site is covered that type of sedimentary rocks which were found in the Eagle crater. These rocks outcrop again and again in the walls of the closed depressions of the Anatolia region (http://marsrovers.jpl.nasa.gov/).

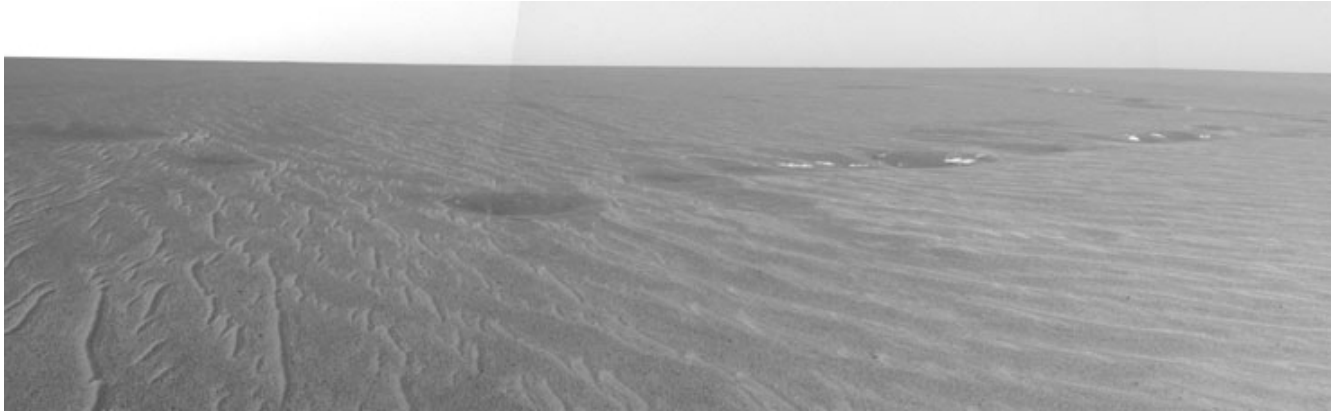

Fig. 1. Images of MER-2 Opportunity (http://marsrovers.jpl.nasa.gov/) were united into a photomosaic in order to show a section of the sequence of closed depressions at the Meridiani Region of Mars. The depressions seem to be sinkholes characteristic of karst landscape in Earth. In some sections the series of closed depressions coalesce and form a shallow trench. In the sinkholes white outcrops appear, which are known from the Eagle crater, the landing site of Opportunity, too. At Anatolia region coalesced depressions form a longer trough where larger surface of the slopes are covered by the white outcrops. (http://marsrovers.jpl.nasa.gov/gallery/press/opportunity/20040408a/06-JT-01-sol70-B074R1_br.jpg)

Discussion: The formation of this layer goes back to the last stages of the probably Martian Ocean withdrawing to the northern deeper elevations. However, the withdrawal of the Northern Ocean was a gradual process in a geologic timescale. During this ocean withdrawal period wet climate caused that water circle moves water in the Martian atmosphere. This was the period of the Martian karst morphology (Boynton et al., 2003). First heavy, later gradually fainter raining may have been the precipitation agent forming this Meridiani Karst landscape.

Acknowledgments: The images of NASA JPL (http://marsrovers.jpl.nasa.gov/) and grant MÜI-TP-154/2003-2004 of Hungarian Space Office is acknowledged.

References: [1] BOYNTON, W. V.; CHAMBERLAIN, M.; FELDMAN, W. C.; PRETTYMAN, T.; HAMARA, D.; JANES, D.; KERRY, K.; GRS TEAM (2003): Ice in the Polar Regions of Mars: Evidence for Wet Periods in the Recent Past. Third International Conference on Mars Polar Science and Exploration, (Oct. 13-17 2003, Alberta, Canada) #8133. [2] CHRISTENSEN, P.; ARVIDSON, R.; BANDFIELD, J. L.; BLANEY, D.; BUDNEY, C.; CALVIN, W.; CICCOLELLA, S.; FALLACARO, A.; FERGASON, R.; GLOTCH, T.ET AL. (2004): Mini-TES Observations of the Gusev and Meridiani Landing Sites. **35**th *LPSC*, #2186. LPI, CD-ROM, Houston; [3] COSTARD, F. M.; KARGEL, J. S. (1995): Outwash plains and thermokarst on Mars. *Icarus*, **114**, 93-11; [4] http://marsrovers.jpl.nasa.gov/ [5] JAKUCS, L. (1977): *Morphogenetics of Karst Regions*. John Wiley & Sons; [12] Head, J. W., III; Mustard, J. F. (2004): Geological Evidence for Climate Change on Mars. **35**th *LPSC*, #1889. LPI, CD-ROM, Houston; [6] KARGEL, J. S.; WESSELS, R.; BEGÉT, J. E.; EDDY, T.; LLOYD, S.; MACAULAY, D.; PROCH, M.; SKINNER, J.; TANAKA, K. L. (2004): Alaskan Permafrost Analogs of Martian Small Valley Networks, Thermokarst, Terrain Softening, Terraces, and Volcanic Craters. *35th LPSC*, #1995. LPI, CD-ROM, Houston; [7] KLINGELHÖFER, G.; MORRIS, R. V.; BERNHARDT, B.; SCHROEDER, C.; RODIONOV, D.; DE SOUZA, P. A., JR.; YEN, A.; RENZ, F.; WDOWIAK, T.; SQUYRES, S.; THE ATHENA SCIENCE TEAM (2004): Mössbauer Spectroscopy of Soils and Rocks at Gusev Crater and Meridiani Planum. **35**th *LPSC*, #2184. LPI, CD-ROM, Houston; [8] MORRIS, R. V.; SQUYRES, S.; ARVIDSON, R. E.; BELL, J. F., III; CHRISTENSEN, P. C.; GOREVAN, S.; HERKENHOFF, K.; KLINGELHÖFER, G.; RIEDER, R.; FARRAND, W. ET AL. (2004): A First Look at the Mineralogy and Geochemistry of the MER-B Landing Site in Meridiani Planum. **35**th *LPSC*, #2179. LPI, CD-ROM, Houston; [9] RIEDER, R.; GELLERT, R.; BRÜCKNER, J.; CLARK, B. C.; DREIBUS, G.; D'USTON, C.; ECONOMOU, T.; KLINGELHÖFER, G.; LUGMAIR, G. W.; WÄNKE, H. ET AL. (2004): APXS on Mars: Analyses of Soils and Rocks at Gusev Crater and Meridiani Planum, **35**th *LPSC*, #2172. LPI, CD-ROM, Houston; [10] SCHAEFER, M. W. (1990): Karst on Mars? The thumbprint terrain. *Icarus*, **83**, 244-247; [11] SPENCER, J. R.; CROFT, S. K. (1986): Valles Marineris as karst: Feasibility and implications for martian atmospheric evolution. (MECA Workshop on the Evolution of the Martian Atmosphere. Honolulu, Hawaii, August 9-10, 1985. Ed.: M. Carr, P. J. Leovy Conway, R. Pepin, J. Pollack) LPI Technical Report 86-07; [12] SQUYRES, S. W.; THE ATHENA SCIENCE TEAM (2004): Initial Results from the MER Athena Science Investigation at Gusev Crater and Meridiani Planum. **35**th *LPSC*, #2187. LPI, CD-ROM, Houston;

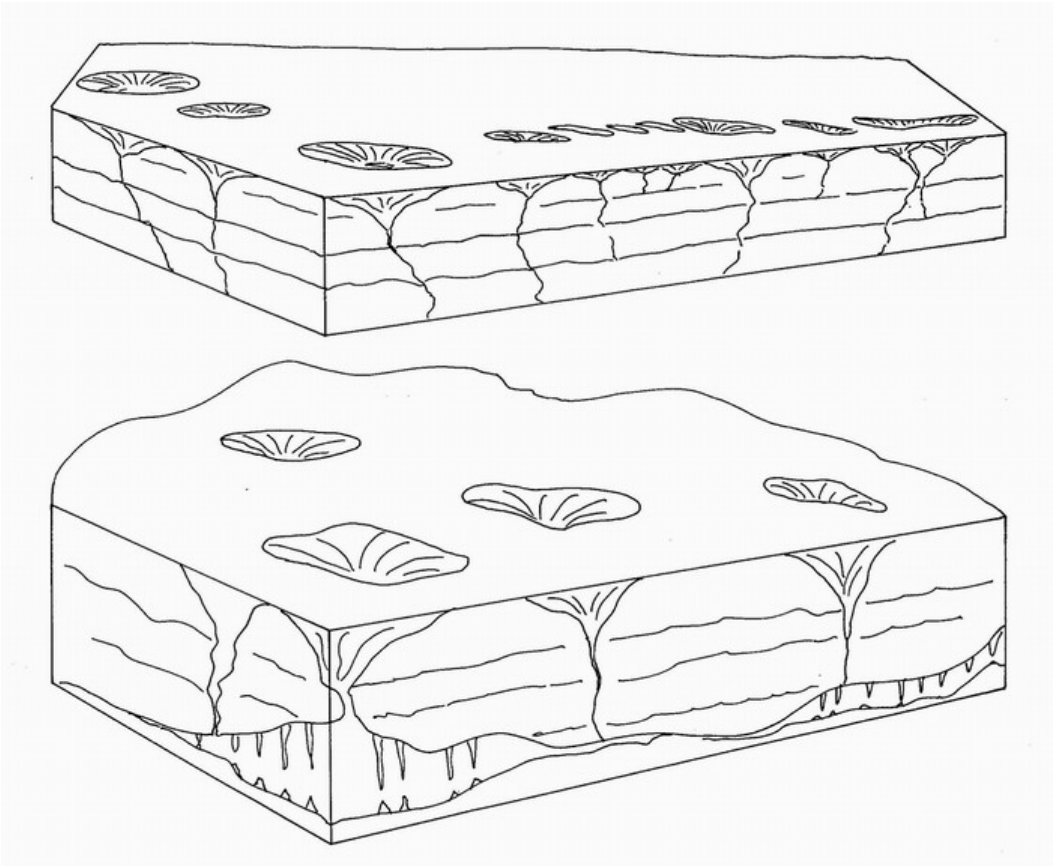

Fig. 2. Sketch of the probably karst landscape on Mars and its terrestrial counterpart landscape from the Bükk Mountains, Hungary. On the Meridiani Region some of the closed depressions coalesced forming the Anatolia trench. In the terrestrial section the analog doline region can be found above a cave system which was also shown on the sketch. The corresponding Martian section is hypothetical, but the layered structure is exhibited in several localities along the trench, at an impact crater on the way of Opportunity to the Endurance crater and was also exposed in Endurance crater (http://marsrovers.jpl.nasa.gov/).