GEOMORPHOLOGICAL ANALYSES OF LANDSLIDE DEPOSITS IN HEBES CHASMA (VALLES MARINERIS, MARS). O. Kromuszczyńska[1*] and K. T. Dębniak[1**], [1]Planetary Geology Lab, Institute of Geological Sciences, Polish Academy of Sciences, Research Centre in Wrocław, Podwale St. 75, PL-50449 Wrocław, Poland ([*]okromuszczynska@twarda.pan.pl; [**]krzysztof.debniak@twarda.pan.pl).

Introduction: Hebes Chasma, one of twelve troughs constituting the Valles Marineris complex, is a host of numerous landslides. Large-scale landslide scars are visible on both walls of Hebes Chasma and slopes of Interior Layered Deposits' (ILDs') mound, Hebes Mensa, located in the central part of the trough. The presented study was based on a creation of landslide deposits' inventory. It was used for the morphological classification and interpretation of landslide deposits generation.

Hebes Chasma: Hebes Chasma is a closed depression of an approximately elliptical shape, measuring 315 by 126 km, covering an area of about 25 200 km^2 (Fig. 1). It is located ~55 km from the northern margin of Ophir Chasma. Hebes Chasma is one of the deepest trough on Mars with a maximum depth of ~8 km. This large cavity originated in a removal of 10^5 km^3 of material. However the process responsible for the material vanishing is still an enigma – the hypotheses for Hebes Chasma origin follow three major pathways: erosional excavation, tectonic rifting, and karstic collapse [1]. The main geomorphologic feature inside the chasma is Hebes Mensa following the chasma E-W elongation [1,2,3,4].

Landslides on Hebes Chasma walls: Ten large landslides (marked *L1-L10* in Fig. 1) emerged from the Hebes Chasma walls. Five of them (*L1-L3*, *L5*, *L7*) were characterized geometrically in [5] and for three (*L3-L5*) the age was determined in [6].

Wall landslides within the trough are entirely chaotic. Among all large Valles Marineris landslides, these located in Hebes Chasma are characterized by medium mobility (M = Length/Vertical drop = 5.61) and the highest material deficit (average material balance here = 62.67%) [5]. This chasma is the only completely enclosed depression of the Valles Marineris system, so material exportation after landslide is simply impossible. That is why the reduced sediment volume after collapse might have been caused by high source sediment porosity and a deposit fluidization [5].

The modeled data [7] showed that these slope failures might have been triggered by two processes: fluid influence or ground shaking. The disturbed and undisturbed basaltic rocks might have collapsed under artesian fluid pressures equal to 66% and 82% of overburden pressure, respectively. The failure might have been triggered also by ground acceleration of 2.3-2.7 m/s^2, caused by a fault of >1000 m length (within disturbed rock mass), or 3.2 m/s^2 induced by a fault of 3.5 km length (for undisturbed rocks) [7].

Landslides on Hebes Mensa slopes: There are at least five large collapse zones in Hebes Mensa slopes (marked *Li1-Li5* in Fig. 1). They are 6-23 km wide and each of them removed up to ~290 km^2 of the slope, what constitutes ~550 km^2 of the total removal. The run-outs and debris emplacements in front of the collapse zones consist of extensive hummocky terrains. Deposits of the landslide *Li4* are mostly intact, with slight fluting on the toes suggesting insignificant eolian erosion. On the other hand, scarps of landslides *Li1* and *Li4* are heavily fluted, implying a substantial erodibility [7]. The possible origin of landslides are karstic processes related to groundwater action [2], or the landslide movement was initiated by ground shaking under dry conditions [7,8].

Methods: The study results were obtained through geomorphological mapping of Hebes Chasma landslide deposits conducted on the basis of CTX dataset. 20 CTX images with reduced spatial resolution to 12 m/pxl were used to create a mosaic in Integrated Software for Imagers and Spectrometers (ISIS). ArcGIS was used to perform the mapping procedure.

Preliminary results: Landslide scars in Hebes Chasma are present on each wallslope of the trough, among which those on the northern wall are the largest (*L1-L3*). There is a difference in scar shapes, i.e. *L4-L6* scars are linear, while others are alcove-shaped. The evidences of structural control of mass-wasting process are visible for *L5* and *L8-L10*. Landslide deposits in Hebes Chasma are spatially limited to scar proximity which differ Hebes landslides from landslides in other Valles Marineris chasmata. Landslide deposits display different morphologies, including *coarse* (disordered, large-scale material of numerous scarps; *L1* near scar, *L2*, *L4*, *L8*), *ridged* (mountainous deposits arranged in parallel ridges; *L5*), *flat* (plane, smooth material located adjacent to a scar; *L1*), and *gentle* (smooth material of mild hills appearing as water-influenced; *L4-L5*). Other distinctive landslide deposits in Hebes Chasma are located in: *L6-L7* (where mass-wasted material is firmly chaotic and spatially impossible to distinguish from deposit bulk), *L2* (where deposits become more degraded as the distance from the scar increases), *L8*

and *L10* (which appear as hanging landslides). In addition, landslides *L4-L5* display unique geometry indicating evolution in two large stages: first, parallel to the chasma walls (meridional), and second, perpendicular (westward) to the major wall direction.

The second group of landslides in Hebes Chasma are those related to the Hebes Mensa slopes (ILDs' landslides: *Li1-Li5*). Scars of ILDs' landslides are rectangular and display *fluted* wall morphology. Deposits of these landslides are composed of two morphological zones, *fluted* near walls (imitating scar morphology) and *remnant* located in further areas (dark, fine-graded material). "Fresh" morphology of *fluted* deposits might indicate their younger age than deposits of *remnant* morphology. Mass-wasting processes from Hebes Mensa are accompanied by accumulation of dark, fine-grained material (sand or gravel) originated from the Mensa walls, the most impressive example is located west from the ILDs' mound (marked *D1* in Fig. 1).

The difference in morphology of landslide deposits between material derived from chasma walls and ILDs' slopes is the consequence of their lithological differences. The spatial arrangement of both landslide deposit types allow to distinguish individual landslide materials in the northern part of Hebes Chasma, while landslide materials in the southern area are mixed and greatly disrupted.

References: [1] Jackson M. P. A. et al (2011) *GSA Bulletin*, *B30307*, 1-32. [2] Grindrod P. M and Balme M. R. (2010) *Geoph. Res. Lett. 37*, L13202, 1-5. [3] Hauber E. et al. (2006) *LPSC XXXVII*, Abstract #2022. [4] Rossi A. P. et al. (2008) *JGR, 113*, E08016, 1-17. [5] Quantin C. et al. (2004) *Planet. Space Sci., 52*, 1011-1022. [6] Quatnin C. et al. (2004) *Icarus, 172*, 555-572. [7] Neuffer D. P. and Schultz R. A. (2006) *QJEGH, 39*, 227-240. [8] Neuffer D. P. and Schultz R. A. (2005) *LPSC XXXVI*, Abstract #2076.

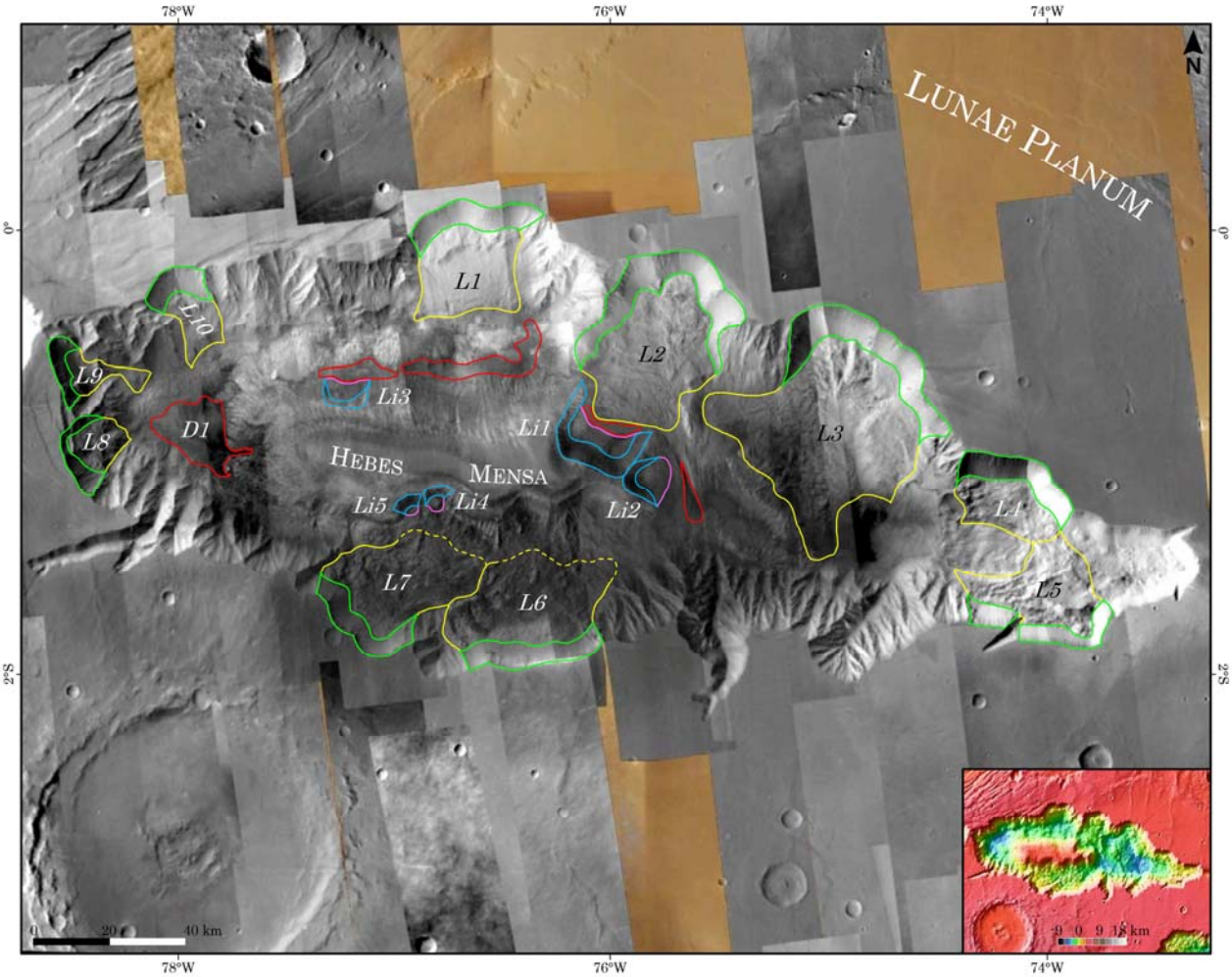

Fig. 1. Map of landslides in Hebes Chasma. *L1-L10* - chasma wall derived landslides; *Li1-Li5* - ILDs' slope derived landslides; *D1* - the largest dark fine-grained material accumulation site in Hebes Chasma; *green lines* - wall landslide scars; *yellow lines* - wall landslide deposits; *blue lines* - ILDs' landslide scars; *purple line* - ILDs' landslide deposits; *red lines* - main largest dark fine-grained material accumulation sites; *dashed lines* - uncertain extent of marked units. Google™ Earth, MRO/CTX mosaic, small box - MOLA topography.