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Mechanical approach on Deep-seated Gravitational Spreading in Coprates Chasma, Valles Marineris, Mars.

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1. Introduction

Deep-seated gravitational spreading (DSGS; known also as sackung [1]) is a type of slope defamation involving collapse of a large blocks along structural features and faults, leading to formation of crestal graben, uphill-facing scarps and downslope bulging morphology. DSGS occurs on high wallslopes, with small rate of displacement but height comparable to the whole slope height. Occurences of DSGS are usually connected with formerly glaciated mountain ridges on Earth and on Mars [4] (Fig. 1). Vertical offset does usually not exceed ~10 metres on Earth, whereas on Mars it is at least one order of magnitude higher, consistent with vertical scaling between slope height and vertical fault offset [5].

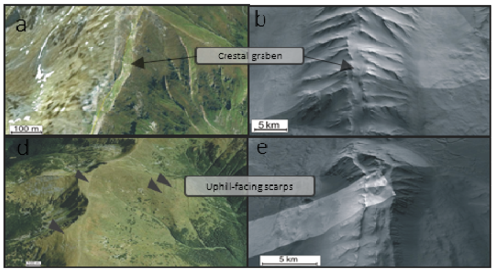

Figure 1a: Crestal graben near Kondracka Kopa in Polish Tatra Mountains; b: Crestal graben in Geryon Montes, western Valle Marineris, Mars; c: Uphill-facing scarps on Chabenec in Slovakia Tatra Mountains; d: Uphill-facing scarps in Melas Labes, central part of Valles Marineris.

2. Modelling

Modelling was performed using the finite element code ADELI, initially developed for studies of mechanical behaviour of the lithosphere and the crust at geologic time scale [6]**.** Two possible hypothesis of slope destabilization are considered that may contribute to gravitational spreading: 1. Glacier loading then unloading connected with activation of pre-existing faults, pore water pressure and joints 2. Glacier loading then unloading connected with slope anisotropy (layers). Study area is located in Coprates Chasma from where they are Digital Elevation Models (spacing grid of 30 meters and vertical accuracy of 15 meters)(Fig. 2).

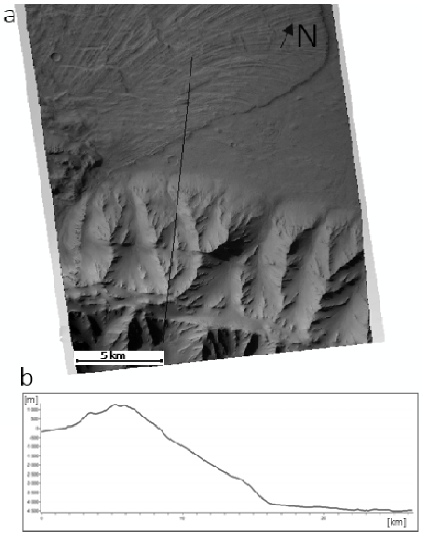

Figure 2a: Topographic profile across a ridge located within Coprates Chasma (b located in a), eastern Valles Marineris; b: cross-section of internal ridge in Coprates Chasma.

3. Results

The mechanical modelling results presented here (Fig.3) investigate the influence of glacier erosion and layers on strain distribution within topographic ridges. They were conducted for strongly fractured and jointed basaltic rock, during removal of glacier buttresses. Slope angles were taken between 20^0 and

35^0, which are most common slopes angles for the studied Valles Marineris DSGS cases. In case of testing second hypothesise, the strength parameters of layers introduced into the model are about 20% less than the slope. Results shows that instabilities develop differently depending on set-ups of the model. In case of modelling the first hypothesis (Fig.3a, c, e) results for slope 20^0 show accumulation of some plastic strain focuses in the middle part of the model, without forming failure surface. In next stage of modelling there is progressively evolution of instabilities up to slope angle 35^0 where two curved failure planes generates vertical displacement parallel to the mountain slopes, producing a bulged morphology at the toe of the slope. The vertical thickness of the sliding units scales with height of the mountain. In case of modelling second hypothesis situation is more complicated (Fig. 3b, d, f). Results shows much more accumulation of plastic strain in the middle part of the model comparing with this same stage in previous case. Curved failure surface stared to appearance in case of sloe 35^0 except it's not so well developed like in slope 35^0 in previous case moreover there is no curved failure surface in case of slope 30^0 which started to form in case of 30^0 in previous case. Results of modelling the two hypothesis in case of slope 35^0 shows accumulation of the plastic strain in the upper part of the slope, leading to the formation of ridge-top splitting.

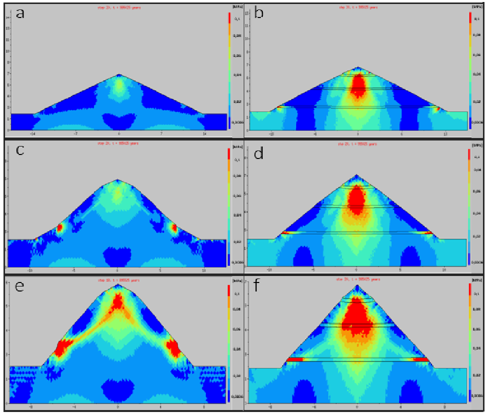

Fig. 3 Accumulation of plastic strain in the mode; a: symmetric slope, $\alpha=20^0$*; b: asymmetric slope,* $\alpha=20^0$*; c: symmetric slope,* $\alpha=30^0$*; d: asymmetric slope,* $\alpha=30^0$*; e: symmetric slope,* $\alpha=35^0$*; f: asymmetric slope,* $\alpha=35^0$*.*

4. Conclusion

Modelling showed that slope stability in a study case depended on stage of wallslope erosion. Fractures, cracks and joints influenced on cohesion of the rocks causing weakening of the rock strength. Introduced into the model layers additionally complicates the situation, therefore it is much harder to predict how the deformation will develop. Layers in visible way decreasing rock strength making slope more flexible for deformation. Also important factor for slope stability is removal of downslope buttresses.

References

[1] Zischinsky U. (1966) On the deformation of high slopes, *Proc.1st Congr. Int. Soc. Rock Mechanics, 2,* 179–185.

[2] Agliardi et al. (2001). Structural constrains on deep-seated slope deformation kinematics. *Engineering Geology 59, 82-102.*

[3] Drecki I. and Żyszkowska J., (2008). Case study of double ridges in the Polish part of Tatra Mountains. *6th ICA Mountain Cartography Workshop, Mountain Mapping and Visualisation,* Switzerland.

[4] Mège D. and Bourgeois O.(2011) Equatorial glaciations on Mars revealed by gravitational collapse of Valles Marineris wallslopes:. *Earth Planet. Sci. Lett., 310, 182-191*

[5] Kromuszczyńska O. et al. (2012). Giant sackung scarps in Valles Marineris. *43rd LPSC, 1161.pdf.*

[6] Chéry J. and Hassani R. (2005). A 2D/3D Finite Element Software for thermomechanical modeling of geological deformation. Guide book.