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Geometric comparison of deep-seated gravitational spreading features on Mars (Coprates Chasma,Valles Marineris) and Earth (Ornak, Tatra Mountains)

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Abstract

Uphill-facing normal faults scarps and crestal grabens, which are characteristic of deep-seated gravitational spreading (DSGS) of topographic ridges, are described in Coprates Chasma in Valles Marineris, Mars, and Ornak ridge and compared. The vertical offset of normal faults in the Martian instances varies from 40 to 1000 meters, with an average of 300 meters. The terrestrial faults offset is between few teens of centimeters up to 34 meters with an average of 10 meters. The values of horizontal displacement in Coprates Chasma vary from 10 to 680 meters, and at Ornak are in a range between 1 and 20 meters. Such difference corresponds with the difference of ridges scale and is due to the topographic gradient which is one order of magnitude higher on Mars than on Earth.

1. Introduction

Deep-seated gravitational spreading (DSGS; known also as sackung [1, 2]) is a type of slow, large-scale slope deformation. The diagnostic features of DSGS deformation are crestal grabens and uphill-facing normal faults scarps. Such features have been identified on topographic ridges in Valles Marineris, the large trough system on Mars [3], as well as many terrestrial topographic ridges in orogens that were glaciated during the Quaternary [3]. The goal of this work is a comparison of geometry of the DSGS features identified on Mars and Earth. The studied here are internal ridge in Coprates Chasma (Figure 1a) and a ridge south from Ornak, in the Polish Tatra Mountains (Figure 1b).

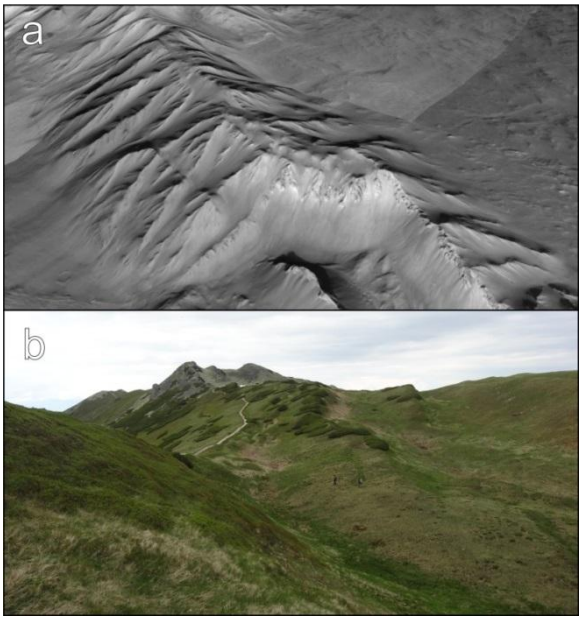

Figure 1: Topographic ridges affected by deep-seated gravitational spreading; a: Martian example, internal ridge in Coprates Chasma, Valles Marineris; b: terrestrial instance, Ornak ridge in Polish Tatra Mountains.

2. Data and methods

The vertical and horizontal displacement of the normal faults are compared. These values are estimated from topography data and corrected from scarp erosion and slope deposit accumulation by assuming the fault dip angles to be 60-70º (Figure 2), typical of normal faults in extensional settings on Earth [e.g., 4].

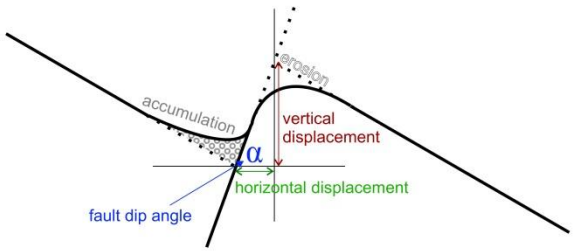

Figure 2: Parameters used for calculation of vertical and horizontal displacement.

The results from Coprates Chasma were obtained along 11 profiles made on the north slope of the ridge based on Digital Elevation Models with grid spacing of 30 meters and vertical accuracy of 15 meters [5]. During field studies in the High Tatras, 13 profiles across the Ornak ridge top were made using GPS device Garmin GPSmap 62s. The vertical accuracy of the GPS measurements has been analysed and the result of the analysis will be provided in the presentation.

3. Results

3.1 Coprates Chasma

The vertical offset of the measured normal faults at Coprates Chasma is between 40 and 1000 meters, with an average value of about 300 meters [5]. Horizontal displacement is between 10 and 680 meters. The average horizontal displacement is about 150 meters.

3.2 Ornak ridge

The field observations showed that the smallest features related to DSGS on the Ornak ridge have a vertical displacement of a few tens of centimeters. The resolution of GPS profiles does not allow to recognize features with vertical displacement smaller than a few meters. The results of profile analysis shows that the vertical displacement of faults related to DSGS are from 2 to 34 meters. The average vertical displacement obtained from GPS profiles is 10 meters. The horizontal displacement is between 1 and 20 meters with an average value of about 5 meters.

4. Summary and Conclusions

The vertical displacement of normal faults related to DSGS is significantly smaller at Ornak, 2-34 meters, than in Coprates Chasma, 40-1000 meters. The values of horizontal displacement at Ornak and Coprates Chasma are in the range 1-20 meters and 10-680 meters. At least one order of magnitude of difference in scale exists between the terrestrial and Martian DSGS features. The scaled value of displacements *Dv* and *Dh*

$$Dv = \frac{\text{vertical displacement}}{\text{height of the ridge}} \quad (1)$$

$$Dh = \frac{\text{horizontal displacement}}{\text{width of the ridge}} \quad (2)$$

are slimiar for Earth and Mars: Dv=0,05; Dh=0,006 for Mars, and Dv=0,02; Dh=0,004 for Earth. Therefore, the difference in faults displacement scales with the difference in ridge dimensions.

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