Transport mechanisms of gravitational carbonate blocks in the broader area of Lokavec in Vipava Valley, Slovenia

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INTRODUCTION

Studied area is located in the SW Slovenia on the northern edge of the Vipava Valley, near the village of Lokavec north of Ajdovščina. Topographic setting of this area is controlled by thrust fronts of the upper Trnovo Nappe and the lower Hrušica Nappe of the External Dinaric Thrust Belt, composed of Mesozoic carbonate rocks of the Adriatic-Dinaric Carbonate Platform, which are thrust over Paleogene clastic flysch (Buser, 1973; Placer, 1981). Carbonate rocks form steep cliffs over the flysch in the lower Vipava Valley. Overthrusting and tectonic damage of the carbonate rocks accelerated their mechanical disintegration. As a result, large deposits of limestone and dolomite gravel accumulate on the slopes formed in the transition zone between the steep carbonate cliffs and the relatively low-relief flysch surface of the valley. In the broader analyzed area, large carbonate blocks are situated on the slopes among the slope gravel. Blocks that were initially part of one carbonate massive, were detached from the undisturbed referenced area and were gravitationally transported down the flysch slopes, and appear as huge positive relief features. Based on results from previous research (Placer et al., 2008), geological mapping and analysis of the 1x1 m lidar DEM (Popit et al., 2014), ten gravitational blocks were identified: Mala Gora, Gola Gorica, Visoko, Križec, block B, Gradišče, blocks Č, D, E and F (Figure 1).

METHODS

The purpose of the research was to determine the transport mechanisms of gravitational blocks. Data of locations, lithology and measurements of dip direction and dip of strata of each block was analyzed in ArcGIS and analyzed with programs Stereonet9 (Allmendinger, 2014) and Stereo32 (Röller and Trepmann, 2003) for stereographic projection of orientation of beddings. These values were then compared to the orientation of beddings of the referenced area, to analyze the deviation of strata due to the tilt and rotation of the block. For each block, length of the transport on the slope was evaluated from the high-resolution lidar digital elevation model in GIS.

RESULTS AND DISCUSSION

Results indicate that the displacement of gravitational blocks from reference area ranged from approximately 80 m of block F to 1950 m of block Gradišče. Some poor correlation of block displacement and orientation of beddings were also observed. Carbonate strata of gravitational blocks changed their dip direction and dip according to the dip direction and dip of carbonate strata of the reference area. Prevailing transport mechanisms of blocks were therefore a change in azimuth with rotation around the vertical axis clockwise or counter-clockwise, and a change in dip with rotation around the horizontal axis. The maximum value of change in dip direction was 130° clockwise on block Visoko and 45° counter-clockwise on block B. The maximum value of change in dip of strata with rotation toward the slope was 25° on block Gradišče and on block E. As follows, the maximum difference between the dip angles was 59° between the block Visoko and the referenced area, and the minimum difference of 4° for block Mala Gora (Figure 1). There are no significant correlations between the length of transport and difference in angle.

CONCLUSIONS

Carbonate blocks recently do not pose any threat to humans or objects in the village of Lokavec, however the question remains whether they are still transported very slowly or not. During some extreme rainfall and/or earthquake events, transport could be possible, so the gravitational blocks would require monitoring. By observing the movement, the presently unknown velocity of the blocks

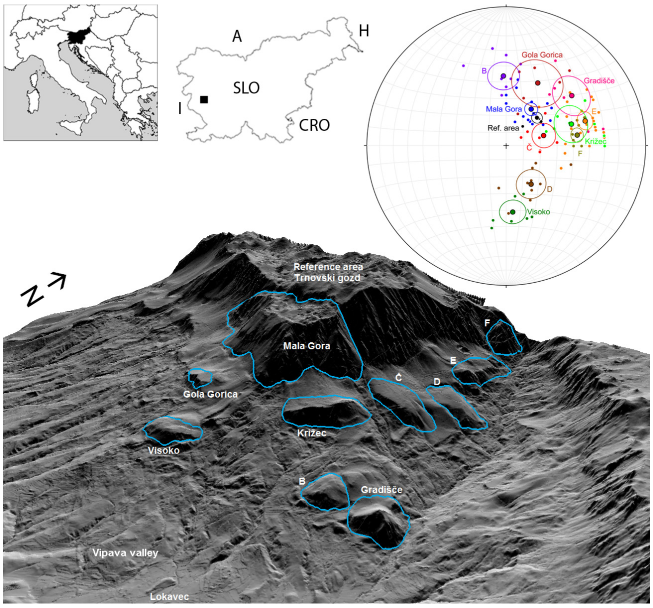

Figure 1. 3-D view of the identified gravitational carbonate blocks on the slopes between the referenced area of steep carbonate rocks and the low-lying flysch of Vipava Valley. In upper right corner, stereographical projection of poles of measured dip direction/dip of strata of carbonate blocks and of the referenced area (RO) is presented, with circles representing Mean Vectors for each data set.

could be established and most importantly, it would be possible to assess whether the movement is more or less slow and constant during the year, or occasional and related to extreme tectonic or climatic catastrophic events or perhaps it has already completely stopped in the past. Such observations would be useful for people living below the blocks in the nearby village. For further practical purposes, we would not recommend construction of new houses or infrastructure in vicinity of the blocks, as rockfall is possible from steep slopes of carbonate rocks due to their weathering, and damage on the buildings can appear because of slow creeping of the blocks and weathered flysch below. In addition, carbonate blocks and scree deposit in the hinterland of the blocks act as small accumulations of groundwater (this is not present on flysch), and several spring indeed appear below some of the blocks. For mentioned reasons, carbonate blocks should be identified and monitored also in other settings.

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KEYWORDS

gravitational carbonate blocks; block transport; flysch; Vipava Valley; Slovenia

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