Turtle Mountain anticline (Alberta, Canada): Rock slope stability related fracturing

Folding, Fracturing, Rock m ass condition, Slope stability investigations and Geological modelling

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ABSTRACT

The aim of this study is to improve the general understanding of the Turtle Mountain anticline and its fracturing pattern as well as evaluating the implications of these latter two features in potential rock slope failures.

Turtle Mountain anticline is located in southwest Alberta (Canada) and is part of the Livingstone Thrust sheet of the Foothills. The latter form the eastern part of the Canadian Rockies which are located in the easternmost part of the Canadian Cordillera. The study area became well known when a 30 Mm^3 rock avalanche of massive limestone and dolostone, known as the Frank Slide, affected the eastern mountainside of Turtle Mountain on April 1903. It resulted in more that 70 causalities and buried part of the Frank village.

This study focuses on the structural features of the anticline, comprising the characterization of the fold geometry and formation mechanism as well as the related fracturing pattern using a high resolution digital elevation model (HRDEM) combined with a detailed field survey. The investigations allow describing the anticline as an eastern verging fold with multiple hinges that merge at depth. Field evidences revealed the expression of both *flexural slip* and *tangential longitudinal strain* folding mechanisms involved in the development of the fold.

Ten discontinuity sets are identified in the study area. The local variations of the sets are estimated in order to separate the study zone into homogenous Structural domains.

Based on the different tectonic phases affecting the region, the potential origin of the detected fractures is interpreted. It results that the origin of the four *major* discontinuity sets, in the sense that they are spatially homogenously represented, is attributed to the folding phase. Except the bedding plane and a pre-existing joint set, the other discontinuity sets are interpreted as resulting of post-folding deformations.

The conduction of a Rock mass condition analysis allows pointing out the influence of the fold geometry revealing a general decrease of the Rock mass strength with the proximity of the axial surface of the anticline. It also illustrates the importance of the high fracturing density of the hinge area on the weathering of the mountain. A predictive modelling of the GSI (SVR by Matlab) completes and supports this analysis.

A field and remote sensing analysis of the large open back cracks of crown area of the mountain (between North Peak and Third Peak) is performed in order to investigate the deformation modes affecting the rock compartments. It illustrates the control of the fold related fractures in the cracks' geometry and allows highlighting four main sectors characterized by distinct deformation modes. Additionally, it is estimated that the cumulative displacement of the top of the mountain reaches at least 10% due to the opening of the cracks.

Using both field measurement and numerical modelling (UDEC^{TM}), a slope stability analysis of a rocky spur NE of North-Peak is performed,. The results show that a volume of 0.2 Mm^3 is likely to collapse following a bi-planar sliding (or either a wedge sliding in a lesser extent)

failure mechanism. The joint sets involved in the failure mechanism are those which developed during the folding phase. The potential unstable volume is also calculated using the Sloping Local Base Level (SLBL) and there is a good accordance between both methods.

Globally, this study highlight that the fold related fracturing plays an important role in the destabilization of the mountain. Indeed, due to its homogenous spatial distribution in the study area as well as its geometrical configuration, it constitute an important predisposing factor leading to potential present day rock slope failures.