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Characterisation and movements' quantification using structural analysis, remote sensing and geological modelling methods of the "Bornes du Diable" cliff (Switzerland)

Martin Franz, Clément Michoud, Marc-Henri Derron, Michel Jaboyedoff, and Andrea Pedrazzini
Institute of Geomatics and Risk Analysis, University of Lausanne, Switzerland (martin.franz@unil.ch)

The case study is the 160 meters high "Bornes du Diables" cliff which is located directly above the reservoir of Mauvoisin dam, in the south western Switzerland. The analysis, which continues a previous study, is conducted due to the observation of many recent rockfalls, which reached the lake and an alpine road, and to the presence of clear back cracks. The important rock fracture, the thin schistosity and the highly weathered surface give a fair Geological Strength Index (about 35). The entire area is located in the Penninic domain. The "marbres phylliteux roux" (foliated marbles) and the base complex which compose the cliff are into the Tsaté nappe. The albitic gneiss is in the Mt. Fort Nappe. The boundary between these two nappes is located at the base of the cliff.

The goals of this study are the characterisation of the structural settings as well as the quantification of movement that occurred in the area, in order to assess the risk for the road, the reservoir of Mauvoisin and its dam.

The structural analysis is performed using both field investigation and TLS point cloud processed with Coltop3D. Seven discontinuity sets are identified. Their kinematic analysis leads to highlight the three potential failure mechanisms which are mostly wedge and planar sliding as well as toppling, and that are responsible of fragmental rockfall.
Three discontinuity sets correspond to the observed back cracks, which divide the cliff into four compartments, basally delimited by the contact of the Mt Fort Nappe and the Tsaté Nappe. Their corresponding volumes range between 100'000 m3 to 500'000 m3. The most important mechanism which controls the movement of those compartments is planar sliding.

In order to characterize the recent movements, seven DGPS measurements were performed in 2009 and 2010 on determined points. Five of them are in "RTK fixed" which permit a 2 mm horizontal and a 4 mm vertical precision. Their comparison allows calculating displacements of 2 cm to 8 cm.
In order to analyze the movements that occur in the past, stereophotogrammetry was performed between 1961 and 2009 pairs of photographs. Using ERDAS IMAGINE® software and its components LPS and Stereo Analyst®, the resulting calculated displacements are of about 1 cm per year.

The gathering of the results from both movement and structural analysis allows the interpretation of a potential complete collapse's mechanism, which is supported by a model performed with UDEC™ software. The results of the model support the failure mechanisms and the displacement expectation.

As the cliff is above a dam lake, its potential collapse could generate an impulse wave which could have catastrophic consequences. The characteristics of the wave, i.e. its high, run-up and over topping, are calculated using VAW model (ETH Zurich). Simulation results of the impulse wave propagation and the associated risk will be shown in the present session.