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Rock slope and rockfall dynamics in flysch formation under mid-latitude cold climate

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Stratified sedimentary rock slope are conducive to differential erosion. The retreat and settlement of weak rock strata (shale, siltstone) causes the gradual cantilevering of stronger rock strata (sandstone, greywacke), contributing to the development of tension cracks. As a result, blocks may break away from these stronger rock strata and they will eventually slide or topple on the eroding weak rock strata below. Since 1987, more than 17 500 rockfalls reaching the road have been reported by the Québec Ministry of Transport (MTQ) in northern Gaspésie (eastern Canada). Although these events are well correlated with the meteorological conditions, it is not clear if and how the weathering process affect the failure mechanism. These dynamics have been observed, but rarely studied to 1) determine the mechanical stresses and weathering conditions that promote rock cracking and 2) assess the effect of meteorological conditions on the mechanical deformations promoting rockfalls. We use the cantilever beam theory to model critical cantilever length (block size) and a frost cracking model (Rempel et al., 2016) was then used to explain the decrease of rock tensile strength over time. Meteorological instruments and crack-meters were installed on a flysch rockwall to monitored and explained mechanical deformations. In addition, rockwalls were scanned with a terrestrial laser scanner (TLS) during specific pre-targeted meteorological conditions. The results show that the areas of frost damage concentration correspond to those of maximum stress in the overhanging blocks. The gradual settling measured with the crack-meters in the shale strata causes the destabilization of the above stronger rock strata. Sandstone blocks may then slide or topple on the inclining plane. Heavy rainfall, snowmelt and freeze-thaw cycles are then responsible for most irreversible deformation in both silstone/shale strata and sandstone strata. Over a period of 18 months, 17 LiDAR surveys have allowed to identify 1287 rockfalls with a magnitude above 0.005 m^3 on a scanned surface of 12 056 m^2 resulting in retreat rate between 2.8 to 5.4 mm/years. In winter, rockfall frequency is 12 times higher during a superficial thaw than during a cold period in which temperature remains below 0°C. In summer, rockfall frequency is 22 times higher during a heavy rainfall event than during a dry period. Superficial freeze-thaw cycle (< 50 cm) causes mostly a high frequency of small magnitude events while deeper spring thaw (> 100 cm) results in a high frequency of large magnitude events. Influence of meteorological conditions on mechanical deformations and on rockfall frequency and magnitude is crucial in order to improve risk management since large magnitude events represent higher potential hazards.