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Driving mechanisms of coastal cliff retreat in flysch deposits on the eastern Adriatic coast

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Cliffs formed in soft rocks are rare coastal forms along the Croatian eastern Adriatic and most exposed to natural erosional processes. The rare example of such cliff affected by anthropogenic activities was developed in marl-dominated flysch in the Split urban zone. Due to the panoramic view cliff-top area is being massively occupied since the 1980ies mostly for the tourism industry and urban development. In spite of increased pressure, little attention has been given to the cliff stability. Ongoing cliff erosion seriously endangers both, coastal infrastructure on the cliff-top, as well as at the narrow shore platform used as a recreational beach area, demanding the urgent development of erosion management plan. In order to do so, fundamental knowledge is needed to understand the cliff erosion driving mechanisms.

The non-vegetated cliff face was scanned 11 times by terrestrial laser scanner during the 6-year period (2012-2018). Four representative profiles along the study area were compared on precisely georeferenced point clouds. Additionally, a close examination of the cliff-top, cliff face and shore platform was carried out over 15 times during various seasons and weather conditions in order to recognize erosional processes involved. Cliff retreat rates obtained from our monitoring ranged between 3 and 18 cm/y. Extreme erosion rates of 25-34 cm/y occurred during the 2014/2015 and 2017/2018 monitoring period. Both extremes occurred after autumn and spring high precipitation periods. A causal link between intensive rain periods and erosion was further observed after two landslides during spring 2018. Furthermore, many gullies caused by surface runoff were carved after heavy rains. At the same time, increased amount of groundwater caused seepage along structural discontinuities, inducing surface erosion below the seeping line. All observed erosional processes occasionally lead to the occasional formation of marly talus cones at the cliff toe. Their duration depends on wave climate, and are being gradually removed by waves.

Obtained results showed that monitored coastal cliff is predominantly subjected to various processes of surface erosion related with high precipitation, while wave abrasion is of subordinate role. Predominant marl lithology is likely to cause further surface mechanical erosion, highlighting the need for erosion management to be developed.