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Time-dependent rock slope weakening processes: evidence from dated landslides in the Eastern Alps

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Some of the largest rockslides and rock avalanche deposits in the Alps cluster spatially in the Tyrol (Austria). Formerly it was assumed that several of these (pre-)historic slope failures were triggered by the retreat of the late-Pleistocene valley glaciers. In order to evaluate the temporal distribution of landslides in Tyrol and surrounding areas (Eastern Alps), an extensive database was set up, comprising radiometric ages, location data as well as kinematic types of landslides (Prager et al., 2008). The compiled dating data show activities of mass movements (incl. large alluvial fans and debris flows) throughout the Holocene. At least 2 periods of increased landslide activity were identified: 1) in the early Holocene at about 10500-9400 cal. yrs BP (e.g. the giant rockslides at Köfels, Kandertal and Flims), and 2) in the middle Holocene at about 4200-3000 cal. yrs BP. The younger age cluster also comprises a spatial concentration of at least 13 large-scale rockslides in the Fernpass, Oberinntal and Ötztal valley region, (e.g. Eibsee, Fernpass, Tschirgant and Tumpen). Based on these data, several rock slope failures were clearly not triggered by Pleistocene deglaciation processes, but rather occurred several 1000 years later in the Holocene.
The compiled data along with multidisciplinary field surveys suggest that crack growth and fracture propagation cause progressive coalescence of discontinuities and thus promote rock strength degradation. With regard to seismological data and paleoclimatic indicators (such as fluctuating glacier extents and fluviatile dynamics), these time-dependent slope weakening processes may be intensified by earthquakes and changing hydrogeological conditions. In the long term, deep-seated slope deformations are induced by complex and polyphase interactions of the lithological and structural predisposition with i) morphological changes, ii) subcritical fracture propagation, iii) variable seismic activity and iv) climatically controlled pore pressure changes. Any of these destabilising processes, even if only at subcritical thresholds, can trigger a failure event if slope stability is already close to its limit equilibrium.

Prager C., Zangerl C., Patzelt G. and Brandner R., 2008: Age distribution of fossil landslides in the Tyrol (Austria) and its surrounding areas. - Nat. Hazards Earth Syst. Sci. 8, 377-407