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Investigating trigger mechanisms for Mid-to-Late Holocene landslide clustering in the Eastern Alps using the sedimentary infill of Piburgersee (Central Tyrol, Austria)

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Large rockslides are major landscape modifiers in Alpine valleys and may constitute a significant natural hazard. Previous research has shown that rock-slope failures generating catastrophic mass movements often cluster in space and time. An early Holocene rockslide clustering is often associated to glacier withdrawal leading to increased stresses within over-steepened slopes and enhanced seismicity. In contrast, during the Mid- to Late Holocene, potential trigger mechanisms for slope failures are pore pressure increase due to wet climate conditions or shaking during strong earthquakes. Although their timing and mass movement processes are often well studied, no conclusive interpretation for their main trigger can be extracted by directly studying the landslide scarp or its deposit.

The small and shallow lake Piburgersee (0,14 km^2; 29 m deep) is uniquely located in between a spatially and temporally (4.2 - 3.0 ka BP) cluster of six large rockslides in the Eastern Alps, containing e.g. the Fernpass and Tschirgant landslides and Köfels landslide (9.8 ka BP). Applying geophysical methods (Multi-beam bathymetry, subbottom profiling) in combination with multiple sediment analyses, such as X-CT, MSCL and μ-XRF scanning, grainsize and C/N measurements, and 14C age dating on two 12 m long piston cores allow to distinguish different environmental impacts affecting the lake sediments.

Piburgersee is surrounded by a mountainous morphology consisting of metamorphic rocks and a rockslide deposit at one side, which is believed to have dammed the lake in Late Glacial times. The lake has only one basin and one surface inflow generating a small delta. Lacustrine organic-rich sedimentation started with the onset of the Holocene. Normal graded, detrital intercalations with high C/N ratios are interpreted as flood layers occurring on a centennial scale. Between 7.3 – 2.8 ka BP several thick event deposits are recorded in Piburgersee, which differ from the typical flood deposits: Three, up to 50 cm thick, sand-rich detrital deposits occured in the period 4.5 - 6.9 ka BP suggesting a terrigeneous source such as a local rock slide or a debris flow. CT-images reveal three horizons bearing deformation structures and three intraclast breccia layers in the period 4.5 – 10.5 ka BP, which all possibly characterise a seismic event. A local rockfall impacted the lake at 2.8 +/- 0.2 ka BP generating a two meter thick deposit of remobilised lacustrine sediments with a deformed and potentially eroded base containing a local rock.

Preliminary results show that within the period of rockslide clustering no event deposit hinting at seismic shaking is present, except the local rock fall which was potentially simultaneously triggered with the Tschirgant rockslide at 3.0 ka BP. Additionally an intraclast breccia layer potentially falls in the time range of the Köfels rockslide at 9.8 ka BP. Available data hints at a phase of enhanced flood activity and at least six strong earthquakes in the Early- to Mid Holocene preceding the landslide cluster and possibly acting as important pre-conditioning factors. Future investigations on a longcore of the nearly located Plansee will test this preliminary interpretation and further specify the main trigger mechanisms.