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In situ characterisation of sediment-mechanical parameters of failure-prone slope sediments of Lake Lucerne, Switzerland

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Similar to marine settings, lakes and their subaquatic slopes are prone to rapid mass movement processes with the potential to trigger a tsunami. The interdisciplinary SNF-funded SINERGIA project “Lake Tsunamis: Causes, Controls, and Hazard” between several Swiss institutions and MARUM, Germany aims to advance the understanding of fundamental mechanisms of tsunamigenesis and propagation to the lake shore on a regional scale. The project cross-links different disciplines (limnology, seismology, geotechnics, hydrology, sedimentology) to develop key concepts and factors relevant for causes and controls of lake-tsunamis. The project encompasses work packages to study delta collapses, past tsunamites, the response of slopes to earthquakes, tsunami generation and propagation, as well as risk assessment. In the context of characterising the non-linear response of sediment physical properties to seismic triggers, we do
i) geotechnical site investigation of the stability of sediments as well as the geometry of landslide-prone portions along the lateral slopes of the lake, and
ii) characterisation of the seismically-induced site response of lake sediments.
For the SINERGIA project, the peri-Alpine Lake Lucerne in Central Switzerland serves as natural laboratory since it represents one of the most vulnerable regions to mass movements (e.g. seismically induced submarine landslides, spontaneous delta collapse, rockfalls) and associated tsunamis with historically documented tsunamis in the past and a high social-economical threat at present.
Here, we present initial geotechnical data obtained during two campaigns in March and September 2018. Geophysical surveys, coring and in situ cone penetration tests (CPTu) were carried out along 11 different locations of the 150 km-long shores slopes along the stable as well as failed flanks of Lake Lucerne. The comprehensive data base consists of
- 150 dynamic CPTu profiles, which define the stiffness, the state of consolidation as well as the pore pressure regime to a maximum depth of 7.5 m below lake ground,
- 30 short cores up to 1.5 meters length, and
- several 3.5 kHz seismic reflection profiles along and across the shore line in each location.
The initial results attest that there are mass transport deposits, the most prominent of which relates to the 1601 M6.2 Unterwalden earthquake, which mobilised numerous landslides simultaneously. CPTu data attest that the sliding plane is located on top of glacially overconsolidated clays that are significantly stronger than their clayey overburden deposits. The core material serves to quantify a series of non-linear parameters in geotechnical laboratory experiments, which will help to model the site response to earthquakes at large strains.