Lake sediments as archives of paleoseismic activity - potential and pitfalls

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Instrumental and historical records of past earthquakes generally do not extend further back in time than a few hundred years. This is often insufficient to provide reliable information on earthquake recurrence intervals and patterns, information that is indispensable for seismic hazard assessment. Paleoseismology aims to extend these records into the past by using natural archives that have recorded past seismic activity (e.g. fault surface ruptures, tsunami deposits, landslides, liquefaction structures, uplifted shorelines,...).

Sequences of lake sediments, which are typically continuous, undisturbed and of high temporal resolution, can constitute very valuable paleoseismic records. Pseudo-3D exploration of the sedimentary infill of lakes, using very-high resolution reflection seismics and/or transects of cores, can reveal a variety of earthquake-induced deposits and structures:

- Multiple mass-wasting deposits on a single stratigraphic level are relicts of a basin-wide event of subaqueous slope instability. Several types of mass-wasting processes can be involved, such as local slumping and rockfalls, mass-flowing and far-reaching turbidity currents.
- Homogenite deposits in the deepest parts of steep-sided basins indicate the occurrence of lake seiches and tsunamis.
- Fluidization structures, such as sediment volcanoes, document sudden liquefaction in a source layer and subsequent vertical fluidization flow.
- In-situ deformed units (e.g. contorted bedding, chaotic deposits, microfaults, liquefaction structures,...) in nearly-flat layers document events of strong ground accelerations.
- Tsunami deposits in coastal lakes in a subduction setting.
- Mega-flood deposits in a lake downstream a landslide-dammed river.
- Active fault segments of faults running through the lake providing information about rupture zone segmentation.

By recognition of these structures and deposits in the stratigraphic sequence, a paleo-earthquake catalogue can be built. Recently, successful attempts were made in Swiss lakes to actually quantify these paleo-earthquakes (i.e. revealing information about epicentre location and shaking intensity) by executing a regional approach and in-situ measuring and calculating of the lacustrine slope stability. However, several questions still remain, such as… What is the earthquake recording capacity of a lacustrine sequence? Does it record every strong earthquake? And if not, why not? Is there an Intensity threshold and what is this threshold for each of the above-mentioned types of paleoseismic structure? Can similar structures be formed by other triggers than earthquakes? Which kind of earthquake is recorded (i.e. local, regional)? Attempts are currently being made to address these questions by calibrating the sediment record to historical earthquakes in several parts of the world, by applying a regional approach (multiple lake basins, multiple lakes) and by comparing the lacustrine sedimentary record with other paleoseismic archives. A better understanding of how lake sediments can record earthquakes, in combination with accurate age-modelling, using independent techniques (varve-counting, radionuclides, radiocarbon, ...), can help to make lacustrine archives one of the most powerful paleoseismic proxies.