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Lake sediments as systematic recorders of seismic shaking: potential and limitations

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Instrumental and written 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 patterns, information that is indispensable for a reliable seismic hazard assessment. Seismically-induced sedimentary features have been found in many lake records worldwide. This encompasses features created during and shortly after the earthquake such as in-situ deformations, liquefaction features, sublacustrine landslides, turbidites and subaerial landslides which propagated into the lake. Also, sedimentary imprints of long-term postseismic effects can be present, such as increased sedimentation rates, outburst floods, changes in water level and chemistry, etc. Up to now, only few comparative studies have been conducted to determine in which ways and how reliably lacustrine sediment sequences can register strong seismic shaking. Therefore, effectively quantifing paleo-earthquake parameters such as magnitude, rupture type and location based on lacustrine sedimentary archives remains a challenging task.

Here, we present a comparative overview of relatively recent studies on earthquake-induced sedimentary features in different types of modern lakes in different tectonic settings and discuss the criteria used to single out earthquake shaking as their causative mechanism. Landslide records in Switzerland and turbidite records in Chile and Japan pointed out that the occurrence and/or scale of subaquatic slope failures can correlate with seismic intensity. It also seems that the continuity and type of the paleoseismic record is strongly dependent on lithology, sedimentation rate and slope morphology within the lake basins. Especially in settings with high frequency of strong earthquakes, this can lead to an underrepresentation of paleoseismic events in the records. However, for lake systems which exhibit ideal characteristics, a single coring site can be sufficient for extracting a complete and continuous paleoseismic record.

Multiple lake basins need to be addressed for determining rupture location and length, and thus the mode of earthquake recurrence. In effect, to discriminate between a single long rupture and several short ruptures closely spaced in time, high-resolution correlation of paleoseismic records is needed. Annually-laminated records and distinct chronostratigraphic horizons formed by volcanic deposits (tephra, lahar) or climatic events (floods, abrupt climate changes) prove to be vital. In this way, lacustrine sediment series from multiple, well-suited lakes can be regarded as powerful paleoseismic archives, which can be found in different tectonic settings worldwide.