

Tracking prehistoric earthquakes in lake sediments of Central Switzerland

M. SCHNELLMANN^{1*}, K. MONECKE², M. STRASSER³, M. HILBE⁴, F.S. ANSELMETTI⁴

¹ NAGRA, 5430 Wettingen, Switzerland (*correspondence: michael.schnellmann@nagra.ch)

² University of Pittsburgh at Johnstown, Johnstown, PA 15904, USA

³ MARUM, University of Bremen, Germany

⁴ Eawag, Swiss Federal Institute of Aquatic Science & Technology, Dübendorf, Switzerland

Recurrence intervals of strong earthquakes are important, but often poorly determined factors in seismic hazard assessment. In areas with low deformation rates, mainly intraplate regions, the recurrence intervals usually exceed the time span covered by historical records, so geological records have to be investigated. Lake sediments with their high temporal and spatial continuity are a powerful paleoseismic archive, as synchronicity of deformation at different locations is one of the basic concepts to establish a paleoseismic event catalog. In Central Switzerland numerous lakes with continuous sedimentary archives postdating the last deglaciation are situated in the region of the northern alpine front. Although the region was seismically relatively quiet in the instrumental period, three earthquakes with $M_w > 5.5$ are documented to have occurred in historical times. The study of the footprint of these events in the sediments of five lakes [1], as well as geotechnical investigations of sediment-charged slopes in Lake Lucerne [2], indicate a typical minimum EMS98 earthquake intensity of VII so that these events are recorded in the sediments.

During the strongest event (M_w 6.2 in 1601 AD), well described historical records document shore collapses and massive water movements in Lake Lucerne and its surroundings. Investigations of a dense grid of seismic data, a multibeam survey and numerous sediment cores show that this historic event triggered numerous synchronous mass-movements and megaturbidites within different subbasins of the lake, producing a characteristic pattern, that can be used to assign a seismic triggering mechanism. In the deeper subsurface of the lake, five similar multiple mass-movement horizons were identified using seismic-stratigraphic correlation, radiocarbon dating and tephrochronology [3]. Three events with a similar pattern of multiple mass-movement deposits have been identified in Lake Zurich. Radiocarbon dating of these events indicates a coincidence with three of the prehistoric events identified in Lake Lucerne [4]. Given a threshold intensity of EMS98 VII at both Lake Lucerne and Lake Zurich, minimal earthquake magnitudes were calculated over a grid of trial source locations using an empirical intensity attenuation relation, a function of epicentral distance and hypocentral depth. The resulting magnitude for the three earthquakes lies between 6.5 and 7 depending on assumed source depth and epicentral location. The consideration of negative evidence (absence of deformation structures or multiple mass-movements deposits) from paleoseismic records from additional small lakes in the region points towards faults connected to the alpine front (subalpine molasse or frontal helvetic nappes) as the most probable source for the three events.

[1] K. Monecke, F.S. Anselmetti, A. Becker, M. Sturm, D. Giardini (2004) *Tectonophysics* **394**, 21-40.

[2] M. Strasser, S. Stegmann, F. Bussmann, F.S. Anselmetti, B. Rick, A. Kopf (2007) *Marine Geology* **240**, 77-97.

[3] M. Schnellmann, F.S. Anselmetti, D. Giardini, J.A. McKenzie (2006) *Eclogae Geologicae Helveticae*, 409-428.

[4] M. Strasser, F.S. Anselmetti, D. Fäh, D. Giardini, M. Schnellmann (2006) *Geology*, 1005-1008.