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Holocene earthquake-triggered mass-wasting events recorded in the sediments of Lake Puyehue (South-Central Chile)

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Despite South-Central Chile's high seismicity and the occurrence of earth's largest instrumentally recorded earthquake (AD 1960; M_w: 9.5), paleoseismic data is still scarce for this region. In this study, very high-resolution reflection seismic profiles (3.5 kHz) in Lake Puyehue (41°S) were utilized to trace giant seismic events back into time. The seismic profiles show repeated occurrences of multiple mass-wasting deposits (slumps, debris flows, homogenites) occurring at a same seismic-stratigraphic horizon, indicating that they are coeval and caused by a single mass-wasting event of basin-wide importance. An age-depth model, based on 9 AMS radiocarbon datings and varve-counting on an 11 m-long sediment core, has been used to develop a "seismic chronostratigraphy". It allows dating of the mass-wasting events by interpolation between dated seismic horizons to the distal parts of the mass-wasting deposits. The mass-wasting events are assumed to be earthquake-triggered because:
A) The recentmost mass-wasting events correlate with the devastating historical earthquakes of AD 1575 and AD 1960.
B) Synchronicity of multiple slope failures (mass-wasting events) requires a strong regional trigger, such as an earthquake. Consequently, local slope oversteepening at delta fronts or local fluid expulsion could not initiate such widespread events.
C) South-Central Chile has been historically subjected to several strong ($M > 8$) subduction earthquakes and subduction processes have been constantly active since Mesozoic times.
D) Multiple slope failures occur at water depths > 70 m, which rules out shallow

instability triggers, such as storm wave action and lake-level fluctuations.

This study reveals nine paleoseismic events during the Holocene with a mean recurrence rate of about 1000 yr, but with an overall relatively aperiodic occurrence (ranging between 400-2000 yrs.). The most prominent event took place around 1660 cal. yr. BP, evidenced by at least 29 simultaneous mass-movements and a homogenite deposit. Quantitative comparison of mass-wasting events related to the historical earthquakes of AD 1960 and AD 1575 showed significant differences (respectively 17 and 4 observed mass-wasting deposits) although these earthquakes are assumed to have had a comparable strength. This can be attributed to a lowered sedimentation rate on the potentially unstable slopes in the period 3000 cal. yr. BP – 500 cal. yr. BP, which would have made lacustrine earthquake recording less likely in AD 1575. The absence of mass-wasting deposits associated with other historical earthquakes (e.g.: AD 1737 (M_s: 7.5) and AD 1837 (M_s: 8)) indicates that only mega-earthquakes (M_w >8.5) within a range of about 300 km are recorded in the sedimentary sequence of Lake Puyehue.

Reflection seismic profiles also show vertical fluidisation structures with large-scale sediment injections, which disturb the upper sedimentary sequences. The top of these fluidisation structures and diverse deformation levels could be spatially linked to seismically induced mass-wasting deposits and consequently indicate an additional method for lacustrine paleo-earthquake tracing.

Several reconaissance seismic surveys on other glacigenic lakes in the Chilean Lake District also show promising paleoseismic records, which will offer the opportunity to correlate lacustrine records to reveal South-Central Chile's paleoseismic history in detail and the earthquake registration capacities of its glacigenic lakes.