Lacustrine turbidites reveal a quasi-periodic recurrence of great and giant earthquakes in South-Central Chile

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Coastal paleoseismic records of coseismic subsidence and tsunamis in south-central Chile indicate that giant megathrust earthquakes — such as in AD1960 (Mw9.5) — occur on average every ~300 yrs. Based on geodetic data, it was postulated that the area already has the potential for a Mw8 earthquake. However, to estimate the probability for such a great earthquake from a paleo-perspective, one needs to consider its long-term recurrence pattern.

Here, we present two long lacustrine records, comprising up to 35 earthquake-triggered turbidites over the last 4800 yrs. Calibration of turbidite extent with historical earthquake intensity reveals a different macroseismic intensity threshold (≥VII\textsubscript{1/2} vs. ≥VI\textsubscript{1/2}) for the generation of turbidites at the coring sites. The strongest earthquakes (≥VII\textsubscript{1/2}) have longer recurrence intervals (292 ±93 yrs) than earthquakes with intensity of ≥VI\textsubscript{1/2} (139 ±69 yrs). The coefficient of variation (CoV) of inter-event times indicate that the strongest earthquakes recur in a quasi-periodic way (CoV: 0.32) and may follow a normal distribution. Including also “smaller” earthquakes (Intensity down to VI\textsubscript{1/2}) increases the CoV (0.5) and fits best with a Weibull distribution. The instrumental seismicity record (AD1999-2010; Mw 4.6-6.7) is in accordance with a time-independent (Poissonian) process, as expected for a regional record of small earthquakes.

Regional correlation of our multi-threshold shaking records with coastal records of tsunami and coseismic subsidence suggests that the intensity ≥VII\textsubscript{1/2} events repeatedly ruptured the same part of the megathrust over a distance of at least ~300 km and can be assigned to a Mw ≥ 8.6. We hypothesize that a zone of high plate locking — identified by GPS data and large slip in AD 1960— acts as a dominant regional asperity, on which elastic strain builds up over several centuries and mostly gets released in quasi-periodic great and giant earthquakes. For the next 110 yrs, we infer an enhanced probability for a Mw 7.7-8.5 earthquake whereas the probability for a Mw ≥ 8.6 (AD1960-like) earthquake remains very low.