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

Jasper Moernaut (1), Maarten Van Daele (2), Michael Strasser (1), and Marc De Batist (2)

(1) University of Innsbruck, Institute of Geology, Austria (jasper.moernaut@uibk.ac.at), (2) Ghent University, Renard Centre of Marine Geology, Belgium

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 ($\geq$VII$\frac{1}{2}$ vs. $\geq$VI$\frac{1}{2}$) for the generation of turbidites at the coring sites. The strongest earthquakes ($\geq$VII$\frac{1}{2}$) have longer recurrence intervals (292 ±93 yrs) than earthquakes with intensity of $\geq$VI$\frac{1}{2}$ (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$\frac{1}{2}$) 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 $\geq$VII$\frac{1}{2}$ events repeatedly ruptured the same part of the megathrust over a distance of at least ∼300 km and can be assigned to a Mw $\geq$ 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 $\geq$ 8.6 (AD1960-like) earthquake remains very low.