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Advances and challenges of (paleo) -earthquake and -tsunami research

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Earthquakes and tsunamis represent natural hazards that can leave various footprints in different geological, archaeological and historical archives. These footprints can be used to infer magnitudes and recurrence rates of past events, which is crucial for better hazard assessments and improved risk mitigation. Depending on the geological setting, different research approaches may be combined to reconstruct past earthquakes and tsunamis.

In this issue, we present a wide range of techniques to study recent (years to decades ago) and (pre)historical earthquakes and tsunamis performed in diverse terrestrial and aquatic settings. The studies presented cover regions that are characterized by high recurrence rates of seismic (and related tsunami) activity, as well as those with large time gaps between events. A broad variety of different methodologies is included, all aiming to better understand location, timing, and recurrence rates of earthquakes and tsunamis. Novel concepts and methodologies, as well as challenges regarding the identification of the seismic and tsunami hazard in the geological record, are presented.

Subaquatic environments (lakes, fjords and oceans) are ideal settings to study recent and past earthquakes because of the high preservation potential compared to terrestrial settings. Such well-preserved archives can be used as "paleoseismometers". For example, lake and fjord sediments from Alaska provide records of recent earthquakes in which the sedimentary signal differs depending on the epicentral distances, type and magnitude of the earthquake (Singleton et al. p. 4). Further calibration of the paleoseismometer requires verification of the relationship between earthquake parameters and their characteristics in the sediment record. Howarth et al. (p. 6) use the recent 2016 Kaikōura earthquake (New Zealand) to explore the genesis and deposition of deep-sea turbidites over a large area. However, determination of the spatial extent of past seismic events is difficult due to potential chronological uncertainties. The study by Brooks (p. 8) showcases how high-precision varve chronology in lake sediments can be used to define the regional signature of a postglacial earthquake. Lu (p. 10) uses a seismite record of a paleolake as a proxy for regional tectonism in northwestern Tibet.

While previous studies focused on secondary seismic evidence (e.g. mass movements), the following studies focus on primary evidence of earthquakes on terrestrial settings. In Grützner (p. 12), a multi-method approach is used, combining remote sensing, geophysics and paleoseismology to study earthquake activity on a fault in Slovenia. Patria and Daryono's study (p. 14) highlights the high seismic hazard potential on a fault in Indonesia, based on data from trenching. In Lallemand et al. (p. 16), the authors look at geomorphological and archaeological evidence, showing that a potential displacement in walls may indicate evidence for surface rupturing during a recent earthquake. Kleeman (p. 18) uses historical documents and artifacts to determine the exact timing of earthquakes in the last centuries, in order to reconstruct wave propagation in the northwestern USA.

Coastal paleoearthquake records enable the linking of terrestrial and subaquatic evidence of seismicity. The study of Pizer et al. (p. 20) combines on- and offshore paleoseismic evidence for better understanding the size, location and spatial impacts of past large earthquakes at subduction margins. In Philibosian (p. 22) we see how intertidal corals preserve past uplift or subsidence at annual resolution along subduction zones. Another proxy that can archive the seismic deformation along subduction zones are diatoms, as presented in Summers et al. (p. 24) and Dura and DePaolis (p. 26). Hocking et al. (p. 28) show that diatoms not only serve as a proxy for earthquakes, but also for tsunamis. Another approach using geochemical signals in sediment cores from salt marshes to reconstruct abrupt sea-level changes that may be related to earthquakes or tsunamis is conceptually presented by Giang et al. (p. 30).

However, distinguishing between tsunami and other sedimentary processes in coastal areas presents a challenge. For example, Gouramanis et al. (p. 32) could not detect any distinguishable features between recent tsunami and cyclone deposits along the shore of southern India based on a multi-proxy approach, despite including *sed*aDNA analyses. However, the final series of articles propose different approaches to disentangle and detect these deposits. Two studies describe a successful distinction between tsunami and hurricane/storm deposits; Fabbri et al. (p. 34) present a study on historical examples of tsunami and hurricanes from the Caribbean using a sedimentological and geochemical approach, and Prizomwala et al. (p. 36) distinguish between paleotsunamis and cyclone surges along the western shoreline of India with a sedimentological, geochemical and micropaleontological approach. Cuven et al. (p. 38) again show the potential for sedimentological studies revealing the paleotsunami record in Peruvian coastal environments. Izquierdo and Abad (p. 40) close this special issue by presenting evidence for past tsunamis camouflaged in desert environments, as shown in the example of the Atacama Desert.

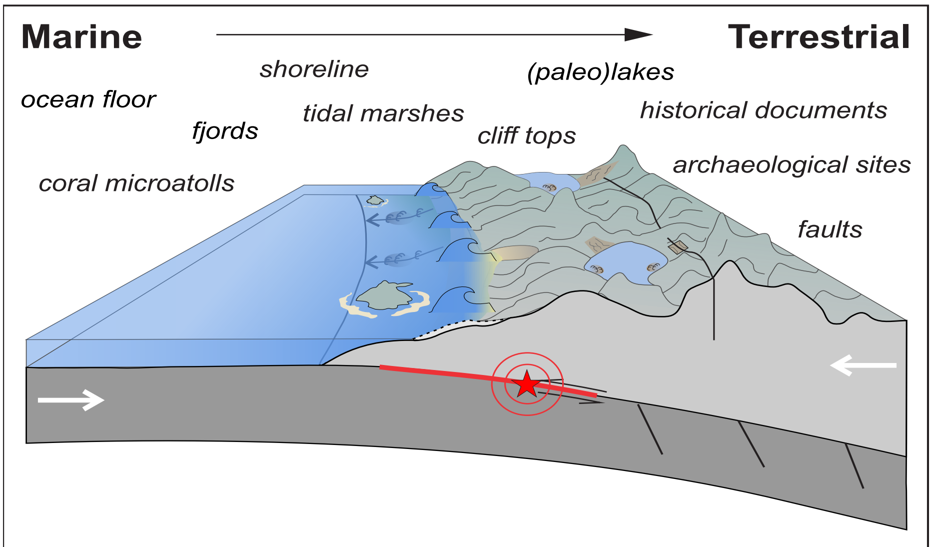

Figure 1: Cartoon of a subduction zone, indicating the various settings and archives in which earthquake and/or tsunami records can be found. Image credit: Katleen Wils.

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