Geohazards: Earthquakes and tsunamis at convergent and transform plate boundaries

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Earthquakes and tsunamis pose direct threats to communities and infrastructure. Global economic losses and fatalities related to these geohazards can be huge. For example, the Mw9.0, 2011Tōhoku-oki earthquake and tsunami in Japan was the most expensive natural disaster in human history, causing the death of ~20,000 people, and an estimated US$235 billion in economic losses. In the Caribbean region the Mw7.0, 2010 Haiti earthquake caused an estimated $13 billion in economic loss and 220,000 deaths. Submarine paleoseismology aims to document the record of earthquake ruptures in submarine environments providing information about the seismogenic history of a plate boundary. The goal is to learn when and where will the next large rupture happen.

The largest known earthquakes at subduction boundaries such as the M9.2 Sumatra in 2004 and the M9.0 Japan in 2011, ruptured megathrusts and the entire seismogenic depth range up to the seafloor generating regionally destructive tsunamis. To learn about this type of earthquakes, we are characterizing the 2011 Tohoku earthquake depositional record. One of the most significant contributions to these efforts, derived from short-lived radioisotopes, is the recognition that surface sediments were remobilized over an area of ~10,000 km^2. In the Japan trench we identified thick, acoustically transparent layers that have homogeneous isotope (Nd, Sr, Pb) signatures, unlike the background sediments and likely resulted from surface sediment remobilization during megathrust ruptures 1454CE Kyotoku, CE869 Jogan.

Continental transforms are associated with comparatively smaller but more frequent shallow earthquakes than convergent plate boundaries, but pose a larger geohazard because they cross heavily populated regions and cause both ground deformation and shaking. Two earthquakes close in time and space ruptured the Enriquillo-Plantain Garden Fault (EPGF) transpressional plate boundary in Haiti. The Mw7.0, 2010 Haiti earthquake and Mw7.2, 2021 Nippes earthquake. Their ruptures displayed similar partitioning of transpressional strain between the EPGF and the thrust belt north of the transform suggesting that these earthquakes may be mechanically related and part of a sequence that can potentially extend west towards Jamaica.

Our approach has been to compare earthquake event deposits in various ocean settings (Haiti 2010: Jamaica 2022; Japan 2011). From core data and high-resolution acoustic images, it is possible to recognize event deposits from earthquakes, constrain their ages, sources, and spatial extent of ruptures. This information directly feeds into numerical models and hazard.