Geologic record of ancient earthquakes and tsunamis will help understand future impacts

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Simon Engelhart. Credit: Robert Witter

The devastating 2004 Indian Ocean earthquake and tsunami that killed 230,000 people has raised questions among coastal residents about when the next big tsunami will strike. It's a question that University of Rhode Island geologist Simon Engelhart knows cannot be answered with any precision.

But he and colleagues from Humboldt State University, Rutgers University and the Earth Observatory of Singapore, in collaboration with geologists from Indonesia, examined the geological record in northern Sumatra to better understand how frequently large earthquakes and tsunamis occur there. The research was published in the August edition of the journal *Geology*.

What they found was evidence that five to seven major tsunamis had occurred between 7,400 and 3,800 years ago, with an additional four to six tsunamis since that time. "We can surmise from this that a major earthquake and tsunami occurred about every 600 to 900 years," said Engelhart, URI assistant professor of geosciences. "But those are maximum recurrences. We're not at a point where we can predict earthquakes."

The researchers examined a dozen sediment cores up to 6 meters long from two sites near the shoreline of Sumatra's Aceh province. Within the sediments in the cores were three layers of soil containing mangrove pollen that dropped into the intertidal zone during earthquakes and were buried by tidal flat sediments. Sands above the soils contained species of marine organisms called foraminifera that live far offshore, evidence that the sand was brought onshore by ancient tsunamis.

Radiocarbon dating of these soil layers and associated sands found that local earthquakes causing tsunamis occurred about 7,000, 5,800 and 3,800 years ago. Two turbid layers in the cores containing more oceanic foraminifera were evidence of additional tsunamis that took place during the same period.

"The archive of sedimentary evidence in the cores doesn't tell the whole story, though," Engelhart said. "We had to figure out what the sea level was doing for the last 8,000 years to identify when we would find geological records of earthquakes and tsunamis."

According to Engelhart, sea level rose rapidly in the Indian Ocean up until about 8,000 years ago, when it slowed to a rate that allowed sediment to accumulate in predictable layers, enabling present-day scientists to study the environment of the time. About 3,800 years ago, however, sea level gradually stopped rising and sediments no longer accumulated. Instead, wave action mixed up the newer sands, blurring

the historic chronology.

Even so, the research team was able to calculate the proportion of sediment that came from offshore in tsunamis by examining the number of fossilized forams that are typically found far out at sea. From this, they concluded that four to six tsunamis struck Sumatra in the last 3,800 years.

For Engelhart, part of the relevance of this study is in the realization of the importance of sea level in conducting this type of analysis.

"You need to understand how sea level varied at a site before you can think about the methods to improve our understanding of how often earthquakes and tsunamis occur and how big they are," he said. "The relative sea-level history of this region demonstrates that we couldn't use the classic sedimentary methods to reconstruct earthquakes and tsunamis during the last 3,800 years at these sites."

Understanding the relative sea-level history will be especially important when scientists conduct analyses of earthquake-prone areas like Alaska, Chile, Peru, Japan and New Zealand, all of which have sea level records that raise similar issues. Engelhart is already applying these findings to related studies in Alaska and the west coast of North America at Cascadia.

Provided by University of Rhode Island