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Not My Fault: November is a reminder that the Atlantic can have tsunamis too

Lori Dengler for the Times-Standard

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An 18th century etching of Lisbon after the 1755 earthquake by an unknown artist depicts the scale of the earthquake's destruction (colorized more recently). The earthquake caused 80% of buildings in Lisbon to collapse, triggered fires and was followed by a tsunami that reached 20 feet high in the city.

Japan wanted World Tsunami Awareness Day in November to recognize the heroic actions of Hamaguchi Goryo who lit the rice harvest on fire to grab people's attention and light the evacuation route to safety in 1854. But Japan is not the only country, and the Pacific not the region to think about November for tsunami remembrance. The two greatest tsunamis to hit both coasts of the Atlantic also occurred in this month.

The largest North American east coast tsunami in written historic times occurred on November 18, 1929. It was centered off the coast of Newfoundland and was triggered by a magnitude 7.2 earthquake that was felt in Newfoundland, New Brunswick, Nova Scotia, southern Quebec, New England and by some in New York City 950 miles away. Called the Grand Banks earthquake for its epicenter on the edge of Newfoundland's continental shelf, the earthquake was too far from populated areas to cause major damage but was still strong enough to topple chimneys on Cape Breton Island and southern Nova Scotia more than 150 miles away.

There was a more important consequence of the shaking. Beneath the ocean surface, a great mass of sediment that had accumulated on the continental shelf since the ice ages suddenly

became unstable, sliding down the Grand Banks slope. We can estimate the timing and extent of the slide because it snapped 12 transatlantic telegraph lines. It is the largest submarine slide ever documented in Canada, displacing 48 cubic miles of material. When this much material is displaced, the inevitable result is a tsunami.

Eyewitnesses observed the tsunami on the east coast of Canada and the U.S., in Bermuda, and in Martinique in the Caribbean. It was also recorded on many tide gauges including areas as far away as Portugal and the Azores. At least three main tsunami surges were observed, the first arriving two and a half hours after the earthquake on Nova Scotia's Burin Peninsula. The complex topography of the coastline amplified the tsunami as it surged up narrow water ways. More than 40 villages were devastated and 29 lives lost. Peak observed water heights were more than 40 feet.

There was no tsunami warning system at the time and felt earthquakes exceedingly rare in the region. No one connected feeling shaking to a tsunami or recognized it as a signal to more away from low coastal areas. The disruption of the telegraph cables cut the region off from the rest of the world, taking three days before any outside relief efforts arrived. A winter storm hit the area the day after the earthquake with freezing temperature and snow. With so many homes destroyed, the weather compounded the misery. The survivors were on their own.

Impacts were long lasting, not only the time it took to rebuild coastal structures, but the tsunami also damaged the near-shore seabed. Scientists speculate that it caused a failure of bait fisheries leading to several years of poor fish catches, the mainstay of the regional economy. No natural disaster exists in a vacuum and the global economic collapse that began only a few weeks before the earthquake further hampered recovery efforts.

The Grand Banks tsunami is a reminder that Atlantic North American coastlines have a tsunami risk. Similar-sized earthquakes occurred offshore of South Carolina in 1886 and in Baffin Bay, Greenland in 1933. Neither of these earthquakes caused great tsunamis but they are reminder that the so-called "passive" continental margins of the Atlantic don't mean an absence of earthquakes or tsunami threats.

A passive continental margin has no plate boundary or fault network separating the land mass from the ocean basin. The Pacific ocean is an example of "active" margins. The Pacific is the world's oldest ocean, with some rock dating to 200 million years. But the basin itself formed far earlier, with the evidence of its birth consumed within the subduction zones that now define most of the rim. The most ancient rocks in the Atlantic are nearly as old (~180 million years), but unlike the Pacific, there are no subduction zones so all of the sea floor still exists, and we can track the entire history of the Atlantic from its earliest opening about 200 million years ago to the present.

A far larger and more deadly November earthquake occurred in 1755 on the opposite side of the Atlantic from the 1929 Grand Banks earthquake. The great Lisbon earthquake off the coast of Portugal was not only felt as far away as Finland, North Africa, and Greenland, the ensuing tsunami wreaked havoc in the Azores and reached coastlines in the Americas. The political and philosophic ramifications were arguably farther reaching, ushering in the Age of Enlightenment and paving the way to the American and French revolutions.

There were no seismographs or tide gauges in 1755, so it has required more detective work to pin down the location and the characteristics of the earthquake than the Grand Banks event. But it affected so many countries that there are masses of written account and artwork recording what happened and material continues to be uncovered in archival collections.

The earthquake struck at 9:40 AM local time on Saturday November 1. The time is well-documented as most of the populace was in church for All Saints Day. Unfortunately, the brick church construction was particularly vulnerable to seismic waves and thousands of people were buried by their collapse. Today the Carmo Church in Lisbon stands as a roofless monument to the 1755 devastation.

Maria Ana Baptista is a colleague of mine at the Universidade de Lisboa who has spent much of her career studying the Lisbon earthquake and tsunami. Through her work and that of colleagues, we've got a good idea of the location, size, and fault mechanism of the earthquake. It was offshore, roughly 60 miles west of Portugal. The felt area and damage characteristics give a minimum magnitude of 7.7. Baptista estimates it was likely in the upper M8 range from the size of the tsunami it produced.

The damage from the earthquake and tsunami was horrendous and the loss of life from both likely approached 50,000. NOAA's Global Tsunami Database lists the tsunami death toll in Lisbon alone at 30,000. There is solid evidence that the tsunami affected the entire Atlantic. It was documented in several areas of the Caribbean, reaching over 10 feet in the Dominican Republic and observed in Newfoundland. Modeling suggest tsunami heights on the order of two to three feet may have occurred in Florida and the U.S. east coast.

To produce such a far-reaching tsunami, one needs a very large source. A massive landslide like 1929 can produce large waves close to the source but they die out fairly quickly from the source. Explosive volcanic eruptions or asteroid impacts can also affect entire oceans, but those sources can be ruled out for 1755. We know there was a large earthquake, so the source is tectonic caused by the fault deformation of the seafloor. Baptista and colleagues were able to use the tsunami characteristics to work backwards and figure out the likely source. It's complex and likely involved both horizontal and vertical slip.

The big question is why such a large earthquake with thrust motion occurred in a location far from well-defined plate boundaries. Back in 1996, Baptista argued that the interaction of the African and Eurasian plates in the region offshore of the Iberian Peninsula could cause localized compression. Recent papers in Science and Nature Geoscience suggest a new take and relates it to the possible initiation of subduction in the eastern Atlantic.

This is exciting stuff for us tectonic geeks. For years we've believed that subduction zones are born when oceans become so large that the oldest seafloor on the edges of the basin become too heavy and gravitationally unstable and begins to sink into the deeper mantle below. But we've never seen the process in action, or perhaps until we were directed where to look. The new studies suggest that process has begun, and the 1755 earthquake was the result of delamination, where a layer of the oceanic plate begins to peel off and sink. Portugal is not the only place where such a process could occur, but anywhere in the oldest reaches of the Atlantic, including the U.S. east coast.

More on the 1929 Grand Banks earthquake and tsunami at https://www.earthquakescanada.nrcan.gc.ca/historic-historique/events/19291118-en.php
See https://www.science.org/content/article/new-look-1755-quake-europe-s-largest-ever-may-foretell-atlantic-ring-fire for a discussion of the new interpretation of the Lisbon earthquake

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