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Not My Fault: Fantastical tsunamis

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What is the largest possible tsunami? The highest tsunami ever recorded occurred in Lituya Bay, Southeastern Alaska. In July 1958, an earthquake triggered a massive landslide that tumbled into the head of Lituya Bay, creating a giant slosh that scraped the hills bare of old growth Sitka spruce. You can still see a faint scar today at 1,720 feet above sea level.

Lituya Bay is an unusual setting. The fjord is a narrow slot 7 miles long, 2 miles wide and 720 feet deep. The landslide displaced all the water at the head that surged out to the coast. !958 wasn't the first time a huge tsunami struck Lituya Bay. Previous landslide-triggered surges struck in 1854, 1874, 1899, and 1936. Outside the confines of the Bay, these tsunamis quickly dissipated and were unnoticed in other areas of the Gulf of Alaska.

!958 Lituya Bay can claim to be the highest historic tsunami, but certainly not the largest in terms of volume, areal extent, or impact. Unlike earthquakes, we don't have a widely accepted tsunami magnitude scale. A number of scales have been proposed, some based on the height of surges far away, others attempting to estimate the total energy in the tsunami. None have yet to be widely accepted in the tsunami community.

For impacts, the 2004 Indian Ocean tsunami tops the scale. Nearly 230,000 lives were lost from 14 different countries in the Indian Ocean. Five other countries experienced damage. More than 2200 deaths were tourists and travelers from 45 other countries. The tsunami was recorded on almost every coastal tide gauge on the planet. The highest water surges were 167 feet, far less than Lituya Bay. But tsunami heights in excess of 60 feet were recorded along 140 miles of the Aceh coast and approached 30 feet in Sri Lanka 1200 miles away.

There are other candidates for 'largest' tsunami. The 1960 magnitude 9.5 Chile earthquake caused damage throughout the Pacific basin and was powerful enough to produce surges over 30 feet high in Hilo 6,600 miles away from the source region. The champion for largest wave far from the source is arguably 1946. A M8.6 earthquake in the Aleutians produced 60-foot waves in the Marquesas Islands 4,500 miles from the source region.

But these historic tsunamis are small potatoes compared to tsunamis in the more distant geologic past. The size of a tsunami depends on the source – how large the source is and how much it displaces the ocean floor. Megathrust earthquakes such as those in 1946, 1960 and 2004 do a pretty good job of moving a lot of water. With source dimensions of hundreds of miles and fault slip of 60 feet or more, they produce major tsunamis. But for really big tsunamis, look to the sky.

Last October, a group of scientists led by Molly Range of the University of Michigan published an article in AGU Advances about the tsunami caused by the asteroid impact 66 million years ago. Most scientists agree that the impact led to mass extinction at the end of the Cretaceous period.

In early 1980, the father and son team of Luis and Walter Alvarez proposed a massive asteroid impact led to the demise of the dinosaurs and many other flora and fauna. Since then, we've learned far more about the location and size of that impact and have a pretty good idea of where it hit and how big it was.

Chicxulub crater in Mexico's Yucatán Peninsula was discovered nearly a decade before the Alvarez's impact hypothesis. 110 miles wide and 12 miles deep, it is the second largest impact structure on earth, exceeded only by the 2-billion-year-old Vredefort crater in South Africa. By the early 1990s, Chicxulub had emerged as the best candidate for the Cretaceous-ending impact site.

The AGU Advances paper is the next chapter in the impact story. Range's group gathered evidence of asteroid size and impacts, reconstructed the likely ocean bathymetry and continent outlines, and ran numerical models on the tsunami that would result. Molly Range described the tsunami as "strong enough to disturb and erode sediments in ocean basins halfway around the globe, leaving either a gap in the sedimentary records or a jumble of older sediments."

One of the members of the tsunami modeling group was Vasily Titov who I've worked with on tsunami field surveys and known for three decades. He argues that there are many uncertainties, particularly in the reconstruction of the sea floor and coast lines 66 million years ago. But the study gives a reasonable general picture. The model is posted at https://pmel.noaa.gov/news-story/first-global-tsunami-simulation-chicxulub-asteroid-impact-66-million-years-ago .

Asteroids don't just impact earth. In 2016, scientists from the Planetary Science Institute in Tucson, Arizona proposed tsunamis on Mars. The team led by J. A. Rodriguez were studying depositional features associated with ancient oceans that covered areas of Mars early in its history and found evidence of disturbed sediments outside of the ocean beds.

They examined evidence from Mars Orbiter thermal images showing boulder strewn regions bordering flat sediment layers. Two weeks ago, the group released new data identifying an impact structure, similar to Chicxulub could have been the tsunami source. Named Pohl, the Martian crater is similar in dimensions to the Yucatán structure and was produced 3.4 bullion years ago. Based on estimates of the Martian ocean depth at the time, a tsunami over 600 feet high may have been the result.

The Pohl impact out-of-this-world tsunami carries even more uncertainty than reconstructing the 66-million-year earth asteroid. But the geomorphic evidence of water on Mars is irrefutable to me and asteroid impacts were certainly likely in the period of Martian oceans.

Back on earth it is important to remember that most tsunami damage is caused by far more moderate tsunamis. Our last two damaging North Coast tsunamis in 2006 and 2011 never made it above the high tide level yet were able to damage dock and harbor structures to the tune of $45 million.

Note: Listen to a father and son recount their experience on a fishing boat on Lituya Bay in 1958:
https://www.dailymotion.com/video/xhqagp

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt and an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times-Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/resources and may be reused for educational purposes. Leave a message at (707) 826-6019 or email rctwg@humboldt.edu for questions and comments about this column, or to request a free copy of the North Coast preparedness magazine "Living on Shaky Ground."