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Not My Fault: Did the recent Alaska earthquake fill a "seismic gap"?

Lori Dengler/For the Times-Standard
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The July 21 (July 22 GMT) M7.8 was not only the largest earthquake to occur anywhere in the world in 2020, it has also renewed discussion among seismologists about seismic gaps. The good news is that this very large earthquake caused almost no damage. Other than a few landslides, cracks in roads and items knocked from shelves, the impact was minimal. I'd call it a good earthquake – providing insight into the how and why of very large earthquakes.

The size and tsunami potential of this earthquake first got my attention. Once it became clear that only a small tsunami had been produced, the location became my focus. The earthquake was within the Shumagin gap, an area geophysicists have speculated could produce the next great Alaska earthquake.

A 1979 paper by McCann and others, published in the journal Pure and Applied Geophysics suggested a link between plate tectonics and forecasting large earthquakes. Note that I said forecasting, not prediction. Prediction means giving a size, location and date of a future earthquake with a high degree of accuracy and reliability. For example, if I stated there was a 90% likelihood of an earthquake in the magnitude 6 to 7 range in the Mendocino triple junction region within the next five days, that would be a prediction. But I can't make such a prediction nor can anyone else because we don't have the science to do so.

Earthquake forecasting is different. It's a way of assessing the odds or likelihood that a region will have an earthquake of a given size or experience a certain level of ground shaking over a much longer time period, typically 30 to 50 years. This might not seem very useful. A forecast won't help you leave town a few days or hours before that next big shaker. But it will focus attention on the areas most likely to experience a major earthquake and does influence building codes and design criteria throughout much of the world.

Long before plate tectonics, geologists knew that some areas were more likely to produce earthquakes than others based on historic patterns. Plate tectonics helped to explain the location of the hot spots. Most (but not all) earthquakes were centered near plate boundaries and all the really big ones (larger than 8.5) were in convergent settings where two massive parts of the earth's surface were colliding with each other. Subduction zones where one plate is pulled beneath another are the main culprits – accounting for more that 90% of the annual release of seismic energy.

At the heart of McCann's paper are two contentions: earthquakes are the mechanism by which plates move relative to one another and the largest magnitude earthquakes are the ones that do almost all of the work. The paper looked at the distribution of very large earthquakes in subduction zones and constructed maps showing the rupture areas. By focusing only on earthquakes of magnitude 7 and larger, they had a data set going back into the 19th century.

Almost all subduction zones are too large for a single earthquake to rupture the entire plate boundary. The 1979 paper defined a seismic gap as any region along an active plate boundary that had not experienced a major earthquake in the past 30 years and argued that the longer the time interval since the last great quake, the greater the potential for this gap to rupture in a future quake.

A good example is the Alaska – Aleutian subduction zone. It is over 2300 miles long and since 1930, has produced seven earthquakes of magnitude 7.9 or larger. Great earthquakes have very large rupture zones. The 1957 M8.6 rupture was nearly 700 miles long and the 1964 M9.2 over 500 miles. In lining up all of these rupture areas on a map, two empty spots stand out. The Yakutat gap is at the eastern end of the subduction zone and the Shumagin gap includes the Alaska Peninsula from the towns of Sand Point to Perryville.

At the heart of the seismic gap idea is that eventually, all parts of the subduction interface need to slip. If one segment didn't move, it would be left behind and create all sorts of geologic features that would be readily observable. A number of papers have addressed the Shumagin gap. Some suggested that this section of the subduction zone is somehow more lubricated and doesn't accumulate as much stress as the other parts of the zone. But three years ago a paper in Nature identified offshore splay similar to those seen off the coast of Tohuku, Japan and the Shumagin debate was on again.

The July 21 magnitude 7.8 earthquake was centered near the eastern end of the Shumagin gap and the aftershocks recorded to date appear to fill most of the gap area. So case closed. Or is it? There are several peculiarities about this earthquake. It produced a very small tsunami, smaller at first glance than what one might have expected from a 7.8, and most of the earthquake locations are between 12 and 46 miles beneath the surface. This suggests that the earthquake fault did not rupture all the way to the surface but stopped at a depth of 10 to 15 miles, the lower part of the locked seismogenic zone.

If the upper part of the subduction interface is still locked, it could still produce a quake similar in size to the July event but with much more seafloor deformation and consequently, a larger tsunami. Or perhaps the reason this section didn't rupture is because it isn't as tightly locked as the rock below it. Seismologists will be closely watching the continued evolution of the aftershock sequence and surface deformation. Only time will tell.

More about the June 22 earthquake and whether it may or may not have filled the gap at https://temblor.net/earthquake-insights/does-alaskas-magnitude-7-8-simeonof-earthquake-finally-close-a-seismic-gap-11496/

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