

# Sediment could be a major factor in biggest subduction zone earthquakes

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The most powerful earthquakes – such as those that shook Indonesia in 2004, Alaska in 1964, Chile in 1960 and the Pacific Northwest in 1700 – occur in subduction zones, areas of the sea floor just offshore where two tectonic plates meet and one dives beneath the other.

But not all subduction zones are created equal, and University of Washington researchers believe they have found a key to determine which subduction zones – or which specific areas within a subduction zone – might produce the most severe shaking when they rupture.

As the subducting plate slides beneath the upper plate, stress begins to build where the plates meet and the upper plate can deform to create a large structure called a forearc basin. The basin, a sort of a bowl-shaped depression, fills with sediment from nearby rivers that empty into the ocean. Over millions of years, the sediment typically piles to great depths, from a half-mile to nearly 2 miles, and in rare cases might reach 3 miles deep, said Christopher Fuller, a University of Washington doctoral student in Earth and space sciences.

"In many of them, the sediment will stop the deformation of the upper plate," Fuller said. "The simplest way to think of it is that the increased weight of the sediment stops the deformation from occurring."

It appears the most severe subduction zone earthquakes occur in areas where such sediment-filled basins are found, but the reasons aren't exactly clear. Fuller and his colleagues conducted computer simulations

of force experienced during plate subduction to determine how sediment buildup influences major earthquakes. They found that the weight of the sediment strengthens the edge of the plate directly above where the earthquakes happen. The stronger edge is deformed far less by subduction than nearby areas without such basins, he said, and that increases the likelihood that large earthquakes will occur in regions with basins.

Fuller is the lead author of a paper explaining the modeling research, published in the February edition of the journal *Geology*. Co-authors are Sean Willett, a UW associate professor of Earth and space sciences, and Mark Brandon, a professor of geology and geophysics at Yale University. The work was supported by grants from the National Science Foundation.

Hypotheses for why earthquakes associated with forearc basins can be so severe include:

- Changing conditions where the plates meet, as the top part of the subducting plate meets more resistance and travels at a slower speed than the bottom part of the plate, creating a great strain in the plate. Fuller regards this as the least likely scenario.
- Fault strengthening over time, like the seal a mayonnaise jar lid develops when it hasn't been opened for weeks. Slight movement on the fault caused by deformation within the upper plate (like tapping the jar lid) loosens the bonds and then the fault suddenly moves (like twisting the jar lid). Fuller believes this is the most likely hypothesis.
- Fluid between the plates becomes superheated under pressure and, like water boiling in a teakettle, the fluid pushes upward and counteracts the downward pressure from the upper plate, allowing the fault to rupture.

The Cascadia subduction zone off the coasts of Washington, Oregon and northern California has forearc basins in several areas, Fuller said. As it

moves to the east at 2 inches a year, the Juan de Fuca tectonic plate slides beneath the North American plate that contains the landmass of the Pacific Northwest. In the process, sediment as deep as 1½ miles is scraped off the top of the Juan de Fuca plate and is deformed into surface depressions on the North American plate, forming the basins where sediment from coastal rivers is deposited. The probability of large earthquakes is greatest in these areas.

The modeling could have implications in figuring out where, within a subduction zone such as Cascadia, great earthquakes are the most likely to occur, Fuller said. But the work is not applicable to every subduction zone because each has different characteristics. For instance, forearc basins do not play the same role in the subduction zone off the Indonesian island of Sumatra, where the massive 2004 earthquake triggered tsunamis that killed hundreds of thousands of people.

"You have to understand the nature of basins and how they work in each area before you can use them as an interpretive tool," Fuller said. "You can't just apply these correlations everywhere."

Source: University of Washington

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