PACIFIC NORTHWEST EARTHQUAKE THREAT HEIGHTENED?

At any given time, a massive earthquake could strike the coast of the northwestern United States and southwestern Canada, the site of the Cascadia Subduction Zone. Scientists have long known about the potential earthquake threat to major population centers like Portland, Ore., Seattle, Wash., and Vancouver, British Columbia. But scientists thought that the likely place for such a quake was off the coast. New research, however, extends the region likely to quake farther inland, thus indicating the earthquake threat to the people living in the Pacific Northwest is much higher than scientists realized.

The Cascadia Subduction Zone, which extends from Cape Mendocino in Northern California to Vancouver Island, British Columbia, is where the northeast-moving Juan de Fuca Plate is diving beneath the North American Plate at a rate of about four centimeters a year. The subduction begins at the seafloor surface in the Pacific Ocean about 130 kilometers away from the coast, then slopes downward as it heads toward the shore, reaching a depth of 70 kilometers to the east of Seattle and Portland, where the volcanoes of Cascadia, such as Mount St. Helens, Mount Hood and Mount Rainier, are located.

As with most subduction zones, the area is susceptible to megathrust earthquakes, similar to the magnitude-9-plus Sumatra earthquake in December 2004, which spawned a tsunami that killed more than 230,000 people. "As the Juan de Fuca Plate is thrust under North America, and that fault is not slipping, the western edge of North America gets pushed along with it," explains geophysicist Timothy Melbourne, who co-authored the recent paper in Geophysical Research Letters with James Chapman, both of Central Washington University in Ellensburg. "The whole coastal region of Washington, Oregon and Northern California, and southwestern British Columbia, [is] being pushed to the northeast at a couple centimeters a year."

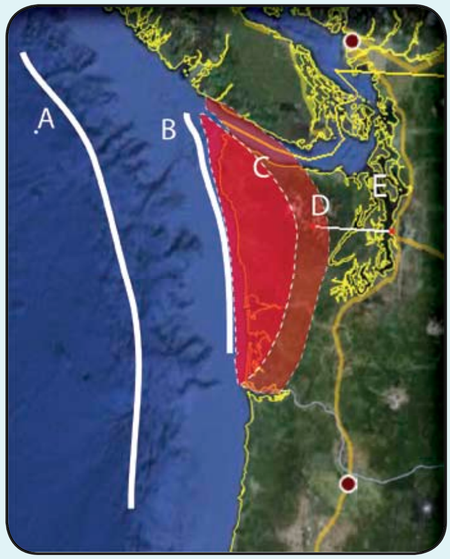
Roughly every 550 years, the strain is released and the fault slips: The west coast of the North American Plate suddenly slides westward over the top of the Juan de Fuca Plate, causing a large earthquake. (The most recent such event was in 1700.) Then, the fault gets jammed once more along the Juan de Fuca Plate, starting the deformation process again.

In 2001, the story became more complicated when scientists discovered that the plates had, that year, slipped at depths between 25 and 40 kilometers — corresponding to a surface area just west of Seattle. Although no earthquake had been felt, scientists detected the event using Central Washington University's network of hundreds of GPS receivers throughout the Cascadia region. According to Melbourne, the GPS units normally show North America moving to the northeast, "but for about 10 days, all the GPS receivers started going the opposite direction. We immediately realized that there were lots of these [slow slip events] going on all the time in Cascadia."

By comparing the expected northeastern movement of the GPS receivers with the sum of the movement that occurred in the opposite direction during this episodic tremor and slip event, over the course of 11 years, the researchers found that as much as 90 percent of the strain accumulation was released by these ongoing slow slip events.

However, though the researchers found strain is being released by these tremors in part of the plate interface, they found no such release occurring elsewhere along the subduction zone. This means that strain is continuing to accumulate throughout the shallower depths of the subduction zone. Although previous estimates had put the seismogenic zone — the region where a large rupture is likely to produce a massive quake — at 15 kilometers deep and offshore, the new data extend the seismogenic zone much farther east — and much closer to Seattle. No one ever thought that a large rupture would occur directly beneath Seattle, but these slow slip events show it will occur dangerously close, Melbourne and Chapman found.

According to Chris Goldfinger, a marine geologist and geophysicist at Oregon State University in Corvallis, the new research "does contradict some of the currently accepted literature." However, he notes that the models described in the current literature are not well-constrained, leaving the door open for the new findings.



Map of the area expected to produce a megathrust earthquake in the Cascadia Subduction Zone. (A) is the trench offshore where subduction begins; (B) is previous models' estimate of the landward limit of the area expected to quake in the next major event; (C) is a new estimate of where major slip could occur during the next megathrust event; (D) is a new estimate of the eastern limit of the fault rupture during the next major earthquake; (E) is the greater Puget Sound metropolitan basin.

Melbourne and Chapman, Central Washington University

The new paper has some other problems, Goldfinger notes. Some real-world evidence contradicts portions of the model in the paper; for example, in places where the paper suggests uplift has occurred, there is in fact subsidence, he says. "Overall, I'm uncertain [about the results], and I think time will tell," he says. "Others will have to start the process of testing this more formally against other datasets. There is just enough wiggle room that it could work, maybe."

The next step is to use these data in TeraShake earthquake simulations, which are conducted at the University of California at San Diego, to determine how the ground-shaking of a large earthquake would affect western Oregon, Washington and British Columbia. "I suspect [the results] will be sobering," Melbourne says. "But the existing models are also very sobering."

Bernard Langer