Scientists find odd twist in slow 'earthquakes': Tremor running backwards

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Earthquake scientists trying to unravel the mysteries of an unfelt, weeks-long seismic phenomenon called episodic tremor and slip have discovered a strange twist. The tremor can suddenly reverse direction and travel back through areas of the fault that it had ruptured in preceding days, and do so 20 to 40 times faster than the original fault rupture.

"Regular tremor and slip goes through an area fairly slowly, breaking it. Then once it's broken and weakened an area of the fault, it can propagate back across that area much faster," said Heidi Houston, a University of Washington professor of Earth and space sciences and lead author of a paper documenting the findings, published in *Nature Geoscience*.

Episodic tremor and slip, also referred to as slow slip, was documented in the Pacific Northwest a decade ago and individual events have been observed in Washington and British Columbia on a regular basis, every 12 to 15 months on average.

Slow-slip events tend to start in the southern Puget Sound region, from the Tacoma area to as far north as Bremerton, and move gradually to the northwest on the Olympic Peninsula, following the interface between the North American and Juan de Fuca tectonic plates toward Vancouver Island in Canada. The events typically last three to four weeks and release as much energy as a magnitude 6.8 earthquake, though they are not felt and cause no damage.

In a normal earthquake a rupture travels along the fault at great speed, producing potentially damaging ground shaking. In episodic tremor and slip, the rupture moves much more slowly along the fault but it maintains a steady pace, Houston said.

"There's not a good understanding yet of why it's so slow, what keeps it from picking up speed and becoming a full earthquake," she said.

Houston and her co-authors - Brent Delbridge, a UW physics undergraduate; Aaron Wech, a former UW graduate student now at Victoria University of Wellington, New Zealand; and Kenneth Creager, a UW Earth and space sciences professor - analyzed data collected from tremor events in July 2004, September 2005, January 2007, May 2008 and May 2009 (the 2004 and 2005 events took place only toward the north end of the Olympic Peninsula). The five events provided about 110 days' worth of data representing some 16,000 distinct locations.

The scientists found a distinct signal for clusters of tremor moving rapidly backwards from the leading edge of the tremor, through an area of the fault that had already experienced tremor.

They also noted that rapid tremor reversal appears to happen more readily near the Strait of Juan de Fuca, suggesting that stress from tides could play a role in generating the reversal because the interface appears to be more sensitive just after having been ruptured by the initial tremor event.

Houston noted that episodic tremor and slip occurs at a depth of 22 to 34 miles, where high temperatures have made the tectonic plates more pliable and thus more slippery. At a substantially shallower depth, perhaps 12 miles, the plates are not slippery and so are tightly locked together.

In the locked zone, the tectonic plates can hold the buildup of stress for hundreds of years, rather than just 15 months, but when the interface ruptures it can unleash a great megathrust earthquake such as the one that struck off the coast of Japan in March. Such earthquakes occur in the Cascadia subduction zone every 500 years, on average, and the last one - estimated at around magnitude 9.0 - happened in January 1700. Houston noted that the region is within the large time window when another megathrust earthquake could occur.

One key question still to be answered, she said, is what is happening on the plate interface between the locked zone and the depth where tremor occurs. Scientists hope to get a better understanding of the interplay between tremor events and subduction zone earthquakes, including whether the interval between tremor events changes as the end of the 500-year subduction zone earthquake cycle gets nearer.

"Various aspects of the tremor signal may change as the seismic cycle matures," Houston said. "It's also possible that the noise our seismometers detect from tremor events might get louder just before a big earthquake."

Provided by University of Washington

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