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Not My Fault: Recent studies highlight North Coast earthquake threats
Lori Dengler for the Times-Standard
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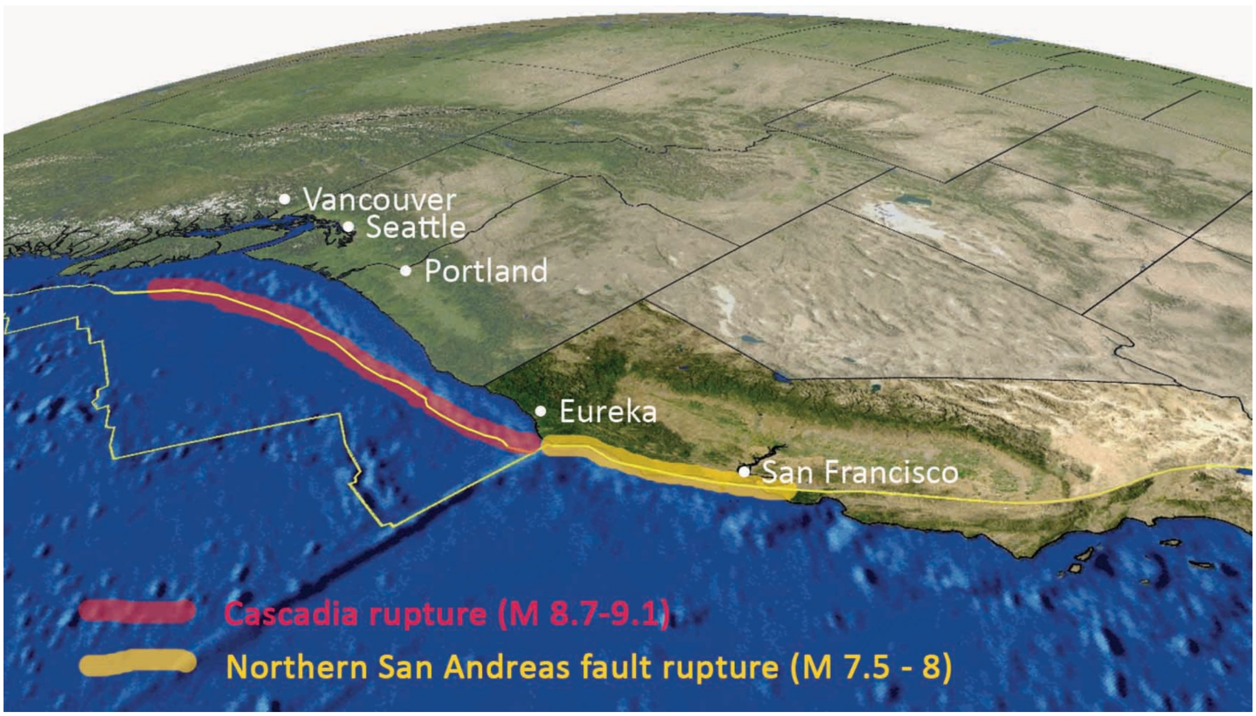

The Cascadia subduction zone (highlighted in red) runs from Cape Mendocino to British Columbia. The San Andreas fault (in yellow) extends from Cape Mendocino to the Salton Sea in Southern California. Recent studies suggest that great earthquakes on these two faults may occur in pairs, with a Cascadia earthquake potentially triggering a large San Andreas earthquake within minutes to days.

I often get asked how I come up with topics to write about each week. It's easy. Between Mother Nature and the many brilliant, hardworking, and imaginative scientists in my field, the problem is usually paring down the multiple possibilities. I had a hard time choosing this week, so I'll attempt a quick overview of two papers that caught my eye because they are both relevant to where we live.

In August, Seismological Research Letters published an opinion article about supershear earthquakes. The piece, by Ahmed Elbanna and six co-authors, argues that supershear earthquakes are more common than previously thought and that current design codes both in California and throughout the world don't adequately address the strong shaking they can produce.

I've written about supershear earthquakes before (Not My Fault 5/23/21). Like the shock waves produced by supersonic flight, supershear earthquakes result when the speed of the fault rupture exceeds the speed of sound waves in the ground. The result is a "sonic boom" so to speak, a concentrated cone of seismic waves that focuses the shaking strength, particularly in the direction that the rupture is propagating.

We've known that earthquake shaking strength is not uniform relative to distance from the epicenter for more than half a century. The type of fault motion concentrates much of the shaking perpendicular to fault slip, particularly in strike-slip earthquakes. This was one of the factors that made the December 2022 earthquake feel so much stronger in Rio Dell than in Ferndale.

The possibility of supershear rupture was hypothesized in the 1970s but it's hard to measure directly. In the field it requires a dense network of high-precision seismic instruments close to the fault to detect the first arrivals of the secondary or S-wave. With newer analysis techniques and awareness of what to look for, it's looking like supershear rupture may be the rule rather than the exception for large strike-slip earthquakes.

Examples of recent supershear earthquakes include the 1999 M7.6 Izmit, Turkey earthquake, the 2018 M7.5 Palu, Indonesia quake that I wrote about in 2021, the 2023 M7.8 Turkey-Syria earthquake, and this year's M7.7 earthquake in Burma (Myanmar). Re-examining older events adds 1906 San Francisco to this list. Experiments by Ares Rosakis, one of the coauthors of the recent study, have now confirmed the supershear rupture process in the laboratory.

Thanks to new technology, our recent Mendocino fault earthquake appears to have ruptured at supershear speeds. For the last five years, a consortium of scientists led by the USGS has been studying optic fibers as a way of detecting earthquakes. By a great strike of fortune, an experimental array was running on the new section of cable along Old Arcata road to Myrtle east of 101 and captured the December 5th earthquake. The optic signal provides extremely precise timing and allows a detailed picture of the rupture process as it started about 40 miles offshore, slowed in the vicinity of the triple junction area, and then jumped to supershear speeds as it hit the coast. Fortunately, the region is sparsely populated, and damage was light.

Elbanna and team argue that much more work is needed to fully understand the hazards of supershear ruptures and that California, a state riddled with strike-slip faults, would be remiss not to include them in building design codes and zoning considerations. More instrumentation in fault zones, modeling and simulations, and examining structural response to concentrated S-wave shaking are essential to real-world applications.

The second publication also has a clear West Coast perspective. "Unravelling the dance of earthquakes: Evidence of partial synchronization of the northern San Andreas fault and Cascadia megathrust," came out two weeks ago in Geosphere, a publication of the Geological Society of America and examines evidence for linkage between earthquakes on the Cascadia subduction zone and the San Andreas fault. The team, led by Chris Goldfinger of Oregon State, examined offshore cores and has come to the conclusion that we could be in for a one-two punch of great quakes.

The crux of the story is turbidites. Turbidites are a type of submarine landslide ubiquitous in coastal marine environments. Rivers constantly deliver sediments to the continental shelf where they are redistributed by currents, accumulating at the heads of submarine canyons.

When they become gravitationally unstable, a turbidity current forms. A mass of sediment and water slides down the canyon and spreads out on the abyssal plane below. Turbidites are gravitationally sorted with larger grains on the bottom, fining upwards in a distinct sequence. The evidence of ancient turbidity currents is preserved in many places on the North Coast where uplifted rock shows the layering of avalanches that occurred many millions of years ago.

In the absence of any external forcing mechanism, one would expect the ages of turbidites to differ from one area to the next in a somewhat random pattern. John Adams of Canada's Geological Survey was the first to note that turbidites were not random in age but rather occurred at the same time in areas far apart off the coast of Washington and S British Columbia. He suggested that great earthquakes could be the trigger.

Many people have looked at turbidite ages since then, no one more thoroughly than Chris Goldfinger who has made offshore mapping and turbidite core retrieval a cornerstone of his academic work. His work has verified the synchronicity pattern – turbidites occur in pulses, slides triggered over a vast offshore area essentially at the same time. Great earthquakes that produce strong shaking over many hundreds of miles are an obvious triggering mechanism.

Goldfinger's research isn't restricted to the Cascadia region. His group has worked in earthquake areas all over the world studying turbidites in Indonesia and Chile. He has also ventured south of the Mendocino triple junction into the world of the San Andreas fault. He's not the first to suggest that there could be tectonic linkage between Cascadia and the San Andreas. The two great fault systems essentially touch at the Mendocino triple junction and significant slip on either fault will change the stress pattern on the other. But the stratigraphic data this paper provides is as close to a smoking gun that we are likely to get – until an actual "doublet" event occurs.

What is the evidence? It's all in the details of the core and the distribution of features from core to core. Instead of finding just one clear turbidite event with the typical coarse grains on the bottom fining upwards, they found two events very close to each and the later one disturbing the earlier one. That constrains the timing of the two to a short time window. There are three instances in the past 1,500 years where these odd doublets occur, including the most recent Cascadia earthquake of January 26, 1700, where the two ruptures appear to be only minutes to hours apart.

Whenever a great earthquake occurs, aftershocks are inevitable and emergency responders take this into account, closely monitoring aftershocks to be able to quickly evacuate unstable areas. But a Cascadia - San Andreas doublet is a very different beast indeed. Either one alone will require massive response from areas outside of the earthquake zone and our current planning focuses on one at a time with one region providing mutual aid to the other. Goldfinger says it's time to include the double event into our planning and buckle down now on reducing all the hazards we can ahead of time.

Which brings me to ShakeOut. This Thursday, California and much of the world will participate in the Great ShakeOut, a time to practice what to do when the ground begins to tremble. Most schools and many businesses and other organizations will be practicing DROP, COVER, HOLD ON drills at 10:16 AM on October 16th. I hope this year we can stretch our thinking beyond the drill – reducing hazards at home and in the workplace, encouraging our decision makers to prioritize public and personal safety, and incorporating resilience into all community planning. Please visit https://rctwg.humboldt.edu/great-shakeout for more ideas on how you can participate.

Note: Free OLLI talk tomorrow on the 1954 Fickle Hill earthquake (Mondy October 13 noon – 1:30) visit https://www.humboldt.edu/olli/events/1954-north-coast-earthquake-enigmablue-lake-earthquake for the ZOOM link.

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/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column or to request copies of the preparedness magazine "Living on Shaky Ground."