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Not My Fault: The complex relationship between small and large earthquakes

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Two magnitude 4 earthquakes in three days followed by a 3.7 five days later. I am asked three inevitable questions – What does this mean? Are they relieving stress? Is the big one coming?

I'm glad when we have felt earthquakes that cause no damage. Tickles from Mother Nature are better at getting your attention than my words. But they also bring up several common misconceptions.

On ShakeOut day October 20th, a M4.3 earthquake occurred near the Humboldt/Trinity County border. Sixty people filed felt reports on the USGS Did You Feel It site from Fort Bragg to Arcata and inland to Redding. A 4.1 occurred on October 23. It was centered near Fortuna, about 37 miles NW of the 4.3. More than 500 people filed felt reports, from Fort Bragg to Trinidad. And finally, the 3.7 last Thursday in the triple junction area with 32 felt reports.

No surprise that the M4.1 was felt by the most people. It was centered in a more populated area. It was not an aftershock of the earlier earthquake. How can I tell? There are three ways to assess the "DNA" of an earthquake to test for kinship. The first is location and characteristics. A true aftershock is located within or near the fault zone of the first earthquake. It also has faulting consistent with the larger earthquake.

Our two 4s were nearly 40 miles apart. They were also different types of earthquakes. The 4.3 was on a normal fault, the result of E - W stretching in the Gorda plate. The 4.1 was on a strike slip fault, a result of N-S compression. They were both the result of the complex orientation of forces in the region, but it was just a coincidence that they happened a few days apart.

A second test is stress shadows. Seismologists calculate how much an earthquake changes stress in the surrounding area. Some areas will be squeezed or compressed, increasing the load and others are stretched after an earthquake. These stress shadows do a great job of predicting where most aftershocks occur (near the ends of the rupture) and explains why earthquakes are sometimes triggered on adjacent faults. Our two fours didn't create much of a stress shadow, certainly nothing 40 miles away.

The third is statistics. Was an earthquake followed by an upsurge in earthquake activity that is far different than typical. The M7.3 Landers earthquake in July 1992 was immediate followed by a swath of small earthquakes in the eastern part of California. For more than a week afterwards, Eastern California lit up with M2s and 3s. Some were more than 750 miles away, far outside of where the static stress change calculations show any effect (https://www.science.org/doi/10.1126/science.260.5114.1617). The explanation proposed for Landers is that deformation associated with surface waves produced by the 7.3 where enough to trigger these small quakes, especially in areas of geothermal activity. Our recent activity was not accompanied by an increase in smaller quakes.

Were these 'good' earthquakes? They were good in that they caused no damage, but it's a common misconception that small quakes reduce stress so that larger earthquakes are less likely.

It's not difficult to estimate how much energy gets released in an earthquake. By knowing the size of a fault, how much it slipped and how tightly the earth is pushing the two sides of the fault together, energy can be determined. Big quakes produce a lot of energy. Our 1992 earthquake sequence released almost as much as a 1 megaton nuclear bomb. The 1960 M9.5 Chile earthquake could have easily provided a year's worth of US energy needs if only that energy could have been harnessed.

Small earthquakes also release energy, but not very much. Each step in magnitude means about a 32-fold increase in energy. It takes 32 magnitude 5s to equal a magnitude 6. It takes about a thousand 5s to equal a 7. At this rate, we would need roughly five M5 earthquakes every day for 500 years to take care of the amount of energy a single Cascadia earthquake will release. Don't count on the small quakes to take on the job.

Is the 'big one' coming? Yes, but the earthquakes of the last two weeks haven't changed those odds. Could they be foreshocks? It's hard to say if any given earthquake might portend something bigger in the next few days or weeks. The USGS compiles statistics on foreshocks and aftershocks

and after moderate earthquakes they publish aftershock forecasts

Last Tuesday, a 5.1 earthquake occurred near the Calaveras fault just east of San Jose. The USGS website (https://earthquake.usgs.gov/earthquakes/eventpage/nc73799091/executive) is a treasure trove of information including felt reports, fault characteristics, and slip distribution. Scrolling through the menu on the left, you will come to aftershock forecast. The summary gives an 18% chance of felt aftershocks in the next week and a 1 in 500 chance that a larger earthquake could occur.

The USGS foreshock/aftershock estimates are based only on statistics – what we typically see following M5s in the Bay area. But there are some additional clues to look for to rule out if an earthquake is a foreshock. In our area, our concern is an earthquake on the Cascadia subduction zone (CSZ), the interface between the subducting Gorda plate and the overlying North American plate. If you live in coastal Humboldt County, you are only six to eight miles above this fault.

I am confident that last week's quakes had nothing to do with the subduction zone. They were deeper, below the interface. One of the most interesting features of the CSZ is how seismically quiet it has been for as long as we've had seismic instruments in the region. Most of our felt earthquakes are within the Gorda plate either offshore or beneath the interface onshore. If we had a 5 or 6 on or near the interface, I would be much more concerned that something bigger could soon follow.

These earthquakes are interesting. They reveal some of the complexity of the North Coast earthquake terrain. They didn't cause damage, but the next one could.

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/resources and may be reused for educational purposes. Leave a message at (707) 826-6019 or email rctwg@humboldt.edu for questions and comments about this column, or to request a free copy of the North Coast preparedness magazine "Living on Shaky Ground."