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Not My Fault: Data explains duration of 6.4 quake, hundreds of aftershocks

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We've learned a lot about the December 20th M6.4 Ferndale earthquake in the past ten days. Seismologists have poured over data relocating epicenters and analyzing strong motion data. Engineers have examined structures and inspectors are nearly done looking at damage. Additional instruments are in the ground to further refine locations and detect smaller aftershocks. A picture of how the earthquake ruptured and why it produced such strong ground motions is beginning to emerge.

The basic outlines of the earthquake remain the same. Rupture began at 2:34 AM offshore of False Cape and then propagated inland towards Fortuna and Hydesville. Newer analyses suggest the primary rupture was about seven to eight miles in length, all confined to depths between 10 and 14 miles beneath the surface. There was no tsunami threat in part because most of the rupture was on land.

Many people have asked me how long the earthquake lasted. It depends on where you were. Many factors affect duration including how far away you are from the source, the local and regional geology, and what type of structure you were in. Shaking lasts longer on upper floors and your previous experiences can factor in too.

We have recordings of the ground motion in many areas, and these give quantitative answers for those specific locations. In Rio Del where the strongest motions were recorded, the total duration was about 15 seconds, but the strongest part of the earthquake was over in 8. Many people commented on how long the shaking seemed to last but everyone who actually counted out durations came up with only 10 to 15 seconds. This is typical for an earthquake in the M7 range. A magnitude 7 will last more than twice as long.

Duration and shaking strength together are responsible for damage. We are lucky the earthquake was relatively short. Longer duration would have caused a much larger area of significant damage. But damage in earthquakes is complex and the Ferndale earthquake is a good illustration.

A look at both the strong motions and the damage does not show a simple bull's eye pattern lessening with distance from the epicenter. Rio Del took the brunt the impacts. Yet it was 17 miles from the epicenter. A strong motion sensor on Cape Mendocino was less than 7 miles from the epicenter but recorded accelerations less than a tenth of what was detected in Rio Del. My good friend Thomas Dunklin in Petrolia, about the same epicentral distance as Rio Del, felt rolling motion that barely tilted his pictures on the wall.

Earthquake faults are not like explosions blasting energy out equally in all directions. Fault slip concentrates shaking in some areas more than others. The earthquake rupture doesn't happen in a single instant. It began with a crack beneath the sea floor two miles off the coast. That crack proceeded to grow, much like a track on your windshield after a rock hits. The crack grows very quickly, at a couple of miles per second.

You may be aware of the doppler effect. If a train or large truck is moving towards you. The sound gets louder and higher pitched. The sound waves are getting squeezed closer together. As the train moves away from you, the sound gets lower pitched as the waves are stretched. This may have played a role in Rio Del – the rupture was moving towards them. And Thomas in Petrolia had the advantage of the rupture moving away from him.

Regional geology plays a role too. Rio Dell is at the edge of the Eel River Basin where the softer sediments abut firmer bedrock. That interface may have amplified shaking, like what was observed in Kobe, Japan in 1995.

I'm getting questions about aftershocks too. We've recorded 270 since the 6.4. First to clarify any confusion. Aftershocks are earthquakes in their own right. If we looked at a recording of a single aftershock, there is no way to tell if it is a singleton or part of a sequence. Aftershocks are quite capable of causing additional damage or even more damage than the larger quake depending upon their size and location.

The aftershock designation is statistical. It occurs in the vicinity of a larger earthquake either on or near the fault that caused the main quake and in the time window of elevated activity following the larger quake.

The Ferndale earthquake caused rock on the SE side of the fault to slip a foot relative to the rock on the NW side. This is a fairly large amount of real estate and faults aren't smooth or uniform. Some patches slipped more than

others, resulting in a complex new pattern of stress. Aftershocks are the process of adapting to a new equilibrium. Many aftershocks are concentrated near the ends of the faults to make adjustments between areas that slipped and those that didn't.

We usually see a surge in aftershocks in the hours immediately after the main earthquake and a slow decrease over the days and weeks that follow. The larger the magnitude of the main earthquake, the longer aftershocks period lasts. There are still aftershocks being recorded off the NE coast of Honshu Japan linked to the 2011 M9.1 earthquake. Not until the activity level goes back to what it was before the earthquake, will the aftershock phase be over.

Regional geology and tectonics also affect how long aftershocks persist. Aftershocks are still being recorded in W. Nevada that are linked to the May 15, 2020, M6.5 Monte Cristo earthquake. On the North Coast, our aftershock sequences usually decay more quickly. The December 2021 M6.2 aftershocks lasted about two months. I can't predict what will happen from our 2022 earthquake - but aftershocks have already steeply dropped.

The Ferndale earthquake aftershock phase will likely end in the next few weeks or months but that doesn't mean our earthquake threat has diminished. This earthquake did nothing to reduce stress on neighboring fault systems and may have increased stress on some. Anyone living in California is in earthquake country.

My New Year's request is that we all – families, businesses, government agencies, and other organizations – think about what you could have done differently in the wee hours of December 20th. I will share those suggestions in a future column.

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."