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Not My Fault: The December 20th earthquake was actually two earthquakes

Lori Dengler/For the Times-Standard

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Remember that 6.2 five weeks ago? It made an impression on many of us and intrigued seismologists. Any time a magnitude 6 earthquake occurs near populated areas piques interest in the earth science community, but even more so in the Mendocino triple junction (MTJ) area where earthquakes give clues to structure and behavior.

When I last wrote about the earthquake (Not My Fault 12/26/22), I mentioned the complexity of the MTJ and how the December 20th M6.2 might not be what it first seemed. A month of study by USGS and Berkeley seismologists gives an interesting answer.

The Mendocino triple junction (MTJ) shows up on maps as a point just offshore of Cape Mendocino, 40 miles SSW of Eureka, where the Pacific, North American and Gorda plates meet. It is also the juncture of three great fault systems: the San Andreas, the Mendocino, and the Cascadia subduction zone. But the map belies its true nature. It is an incredibly complicated zone that first formed over 30 million years ago in the vicinity of what is now Los Angeles and has been inching northward ever since. Around 12 million years ago it reached the San Francisco Bay area and has been parked in our neighborhood for the last few million years.

That northward progress has not just brought the triple junction north, but a large chunk of the older, colder Pacific plate as well that forms a buttress against the southward push of our northern neighbor, the Juan de Fuca plate. Scientists agree that the triple junction area comprises a zone at least thirty miles around the point shown on maps, including all of the Cape Mendocino area and the SE part of the Gorda plate. And when an earthquake occurs in the MTJ zone, it often involves more than one fault and one plate.

The initial analysis done shortly after the earthquake put the 6.2 epicenter offshore on the Mendocino fault about 23 miles west of Petrolia. But from the beginning, there were problems with getting a good fit for the moment tensor, the model of the likely fault motion that produced the earthquake. The process involves examining seismic traces, making a model of the slip, and then seeing how good the model matches the data. No single quake could produce what was being observed.

A USGS press release issued yesterday (https://www.usgs.gov/programs/earthquake-hazards/news/m62-petrolia-earthquake-december-20-2021-was-really-two) comes up with the answer. The December 20th earthquake couldn't fit the modeled fault slip for a single earthquake because it was actually two earthquakes 11 seconds apart. The earthquakes were on different faults and in different parts of the triple junction area.

"We can usually see the beginning and ending of one earthquake on a seismic record before another one starts. Normally earthquakes are well-behaved and happen one at a time... but sometimes they don't," the press release begins. When separate earthquakes are closely spaced, it is hard to sort out where each begins and ends because the seismic traces overlap. Fortunately, we now have a number of seismic stations in the triple junction area and many more have been established in Northern California as part of the earthquake early warning efforts. By carefully examining all the records, the trained eyes of seismologists were able to separate these near twins and put each in its proper place.

The first large earthquake did occur on the Mendocino fault offshore of Petrolia. It had a magnitude of 5.7 and is located near where the 6.2 was initially located. The fault slip was east west strike-slip (horizontal) motion consistent with the Mendocino fault orientation. I don't usually include seconds with earthquake times, but in this case it is important. The 5.7 occurred at 12:10:20 PST – 20 seconds after 12:10 and it was felt a few seconds later in the Cape Mendocino area.

At 12:10:31, the magnitude 6.2 earthquake occurred. It was centered on land four miles north of Petrolia at a depth of 17 miles beneath the surface. I have several friends in Petrolia and they described the earthquake as lasting along time. They were still feeling the 5.7 when the first 6.2 vibrations began arriving. If you were elsewhere in Humboldt County, you might have felt the 5.7 and then the stronger shaking from the 6.2. But from a human perspective it felt like a single quake, the seismic waves from each blending together.

The 6.2 was on a different fault and nearly twice as deep as the 5.7. The motion was also stride-slip, but the fault was likely oriented NE – SW, consistent with the type of faults

in the Gorda plate. With earthquakes, we can't ignore three dimensions and depth is important. For people in Petrolia, the 5.7 was about 20 miles away. The 6.2 was nearly as far – four miles to the north and 17 miles down.

Previously, I wrote about the MyShake alert that triggered on my phone a few seconds before I felt the earthquake. The earthquake early warning algorithm was triggered by the 5.7, but where I live in McKinleyville, it was probably the M6.2 I mainly felt. MyShake isn't designed to separate two earthquakes so closely together – and I don't think it needs to. This unusual triple junction doublet was a single shaker from a human perspective.

The December 20th sequence isn't over. It has produced 125 aftershocks of M2.5 or larger to date, the largest were a 4.8 only three minutes after the 6.2 and a 4.6 on January 6. A 3.0 was reported on January 29, felt as two sharp bumps in the Petrolia area. The aftershocks are grouped in two main areas: on the Mendocino fault near the 5.7 foreshock and on Cape Mendocino in a zone around the 6.2. I don't think it's finished yet – we will continue to see M2s and 3s, and there is a small but real chance that the triple junction region could pop another 5 or 6.

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt (formerly Humboldt State University), 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."