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Not My Fault: The 1992 Cape Mendocino earthquakes, a 33-year perspective

Lori Dengler for the Times-Standard

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Car crushed by the toppled back parapet wall of the Valley Grocery in Ferndale during the 1992 M7.2 mainshock.

It's been nearly a third of a century since Humboldt County and the triple junction region was rocked by three large earthquakes in an 18-hour period. I've devoted eight columns to the earthquakes of April 25th and 26th, 1992 and by now, and you might think I've worn the subject out. But we've had more quakes and new techniques to put these earthquakes in context. There is always something to learn from a look back.

Anyone who lived in Humboldt County 33 years ago and was old enough to have memories knows where they were and what they were doing when the earthquakes struck. At 11:06 AM Saturday morning I was upstairs getting ready to go on a family picnic when, as I noted in my journal "wham, another earthquake hit." Note my use of 'another'. The early 90s had been busy for North Coast quakes. I had been at the Ferndale Fair during the August 17 M6 Honeydew earthquake, and it had felt much stronger to me.

Little did I realize as I crouched next to my bed and counted out 45 seconds of shaking how momentous the moment would be for me personally and in our understanding of earthquake hazards. I spent the rest of that day in my campus office, talking to media, communicating with

faculty and students in the field looking for the geologic effects of the shaking, and helping to arrange logistics for out-of-the-area colleagues headed up here to deploy instruments.

It was an exciting day. No cell phones in those days and the internet was in its infancy so most of the communications were via landlines. It took three hours for Berkeley and the USGS to announce a preliminary epicenter (M6.9) and a location near Petrolia. Bob McPherson and I had just finished a paper on the Honeydew earthquake and this one was less than ten miles away, so I quickly jumped to the conclusion that they were on the same fault.

There are a number of tools for finding earthquake faults. The clearest one is surface rupture. Major shallow earthquakes (typically ≥M7) often break to the surface leaving a scar on the ground and offsets displacing roads, fences, and other markers of how the fault moved. At Honeydew in 1961, Bob found a zone of cracks in the ground and boulders that had been tossed into the air that made a good argument for where the fault was. It seemed logical to me to just follow the extension of that zone to the north to the April 25th epicenter and we should find similar features.

The triple junction area can be humbling to earth scientists, and my assumption was dead wrong. There was plenty of evidence of strong shaking in Petrolia only three miles from the 1992 epicenter, but no sign of the fault Bob saw in Honeydew rupturing the surface in the area. As the day wore on other evidence began to accumulate that the Honeydew fault plane was not the culprit in this case.

In the 1960s several seismologists developed a technique to determine fault motion without having to go anywhere near the epicenter. Called first-motion or focal mechanism studies, the method relies on identifying how the very first part of the seismic signal moved the ground. Earthquakes always rupture a roughly planar surface pushing the ground on one side in the opposite direction of how the other sides move. P-waves, the fastest waves, reflect this motion. If the initial P-wave on a particular seismic station is “up,” the fault movement was towards that station, “down” means the ground moved away.

In the 1970s and the advent of broadband digital instruments, seismologists added another way to estimate fault sources. By digitally inverting the waveforms, the direction and magnitude of the forces driving the fault slip could be determined. Called moment tensors, the technique is now routinely used following any moderate to large earthquake. Both first motions and moment tensors are depicted on “beachball diagrams” that illustrate the type of faulting and narrow down causative fault to two planes. See https://seismo.berkeley.edu/mt/ for a quick tutorial on how to interpret beachballs.

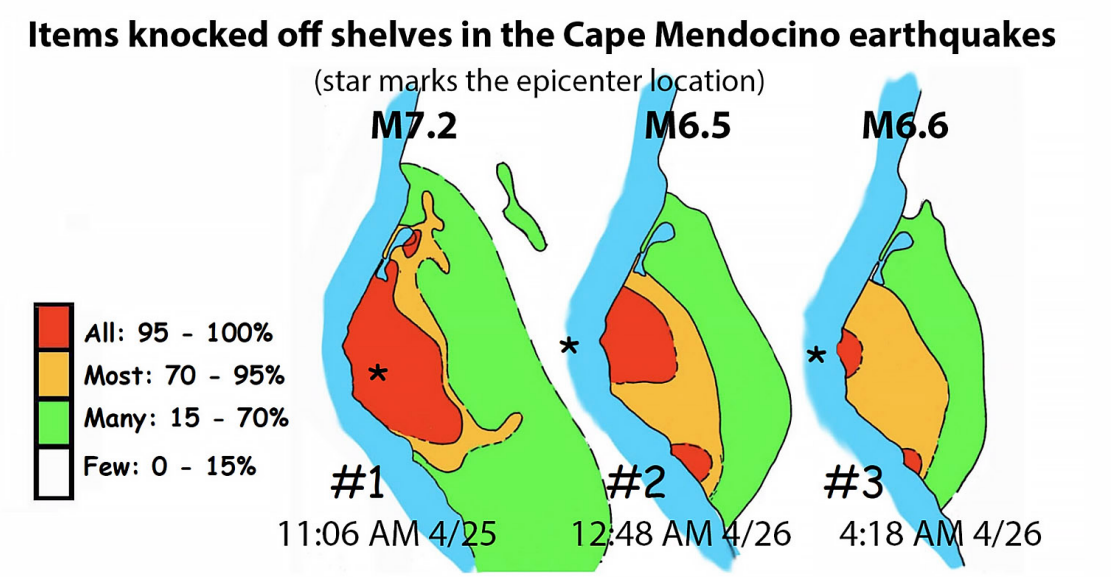
By Saturday afternoon, it was clear that the earthquake was on a thrust or reverse fault where one side of the fault moves up and over the other side. This was the same type of faulting that produced the Honeydew rupture, but the orientation was in the opposite direction. The Honeydew quake was on a plane dipping down to the west and the April 25th quake was on a plane dipping east.

It was pretty mind boggling for two earthquakes six miles away from each other and eight months apart be oriented in nearly opposite directions. But that wasn’t the only surprising aspect of April 1992. At 12:48 AM on April 26th, we were rocked by another strong quake.

There had been plenty of aftershocks during the day. In the minutes after the mainshock, I had laid down on our front lawn and felt several. But the midnight tremor lasted 35 seconds by my count, nearly as long and strong as the main quake. The show still wasn't over. At 4:18 AM another large tremor occurred – it lasted 40 seconds by my count.

It would take months to carefully analyze these earthquakes. The April 25 quake ended up as a magnitude 7.2 and the early morning quakes a 6.5 and 6.6 respectively. The latter quakes were offshore, deeper, and much more like the earthquakes in 2022 and 2024 where the fault motion was horizontal. I led a study of how people reacted to all three earthquakes, and most stated the nighttime quakes were more frightening. A sheriff's deputy called me after the last one audibly shaken and asking if that was going to be the last one. I could only say I hoped so but there was no guarantee.

Between August 1991 and April 1992, we experienced four earthquake of magnitude 6 and larger in an area with dimensions of less than 20 miles. Two were onshore and less than 6 miles deep, two were offshore and twice as deep. The onshore quakes were compressional, and the offshore ones were on strike-slip faults. The 7.2 caused the most damage and had the largest area of impact, but Shelter Cove residents experienced more damage from the offshore quakes.



Comparing the relative shaking strength of the Cape Mendocino earthquakes from a survey of residents estimating relative percent of items knocked from shelves in each earthquake.

Our present-day perspective is that all four of these earthquakes are part of the same sequence, but not your typical foreshock – mainshock – aftershock pattern where only one fault is involved. Blame it on the Mendocino triple junction where the San Andreas transform fault, Mendocino fault, and Cascadia subduction zone meet and interact. Geologic forces have been squeezing and distorting the geologic fabric of this region for at least a million years.

The 1991 Honeydew and the April 25th M7.2 were on closely related faults, but one piece twisted backwards relative to the other. Does the Cascadia subduction zone (CSZ) play a role here? Definitely – both of these earthquakes are the result of the compressional forces of the plate interaction in the region. David Oppenheimer of the USGS headed a team publication in Science arguing that the M7.2 was on the subduction zone interface, making it the first major

CSZ quake in instrumental times. Other papers argue it was on a shallower fault within the North American plate. Bob McPherson has been re-weighing the evidence and has convinced me it belongs on the interface.

The earthquakes of the past four years have gotten many of rethinking about how our earthquakes are related. It's a three-dimensional jigsaw puzzle. When one piece moves, it changes the stresses on nearby pieces. Rocks have long memories, and it may take years to decades or longer for a neighboring piece to respond. Five more earthquake in the magnitude 6 to 7 range followed the Cape Mendocino earthquake sequence to make the 1990s the most seismically active decade of the past 50 years and helped set the stage for our current earthquake environment.

Photographs and more about the 1992 earthquakes at https://rctwg.humboldt.edu/capemendo92.

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. 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."