Can magnitude 4 earthquake rates be used to forecast large earthquake events?

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Boston College seismologist John Ebel and his colleagues have noted a pattern for some large California earthquakes: magnitude 4 or larger earthquakes occur at a higher rate along a fault in the two decades or

more prior to a magnitude 6.7 or larger earthquake on the fault.

The findings prompted Ebel in 2017 to suggest a prospective test. He looked for the California faults that had magnitude 4 or larger earthquakes occurring at a rate higher than 0.5 earthquakes per year from 1997 to 2016. If the pattern holds, the next magnitude 6.7 earthquakes in California are most likely to occur along these faults, he said at the Seismological Society of America (SSA)'s 2021 Annual Meeting.

The eight faults identified in the 2017 forecast are the creeping section of the San Andreas Fault, the Southern San Andreas Fault, the Calaveras Fault, the Little Lake Fault, the Maacama Fault, the Anza section of the San Jacinto Fault, the San Bernardino Section of the San Jacinto Fault and the offshore San Clemente Fault.

So far, there has only been one magnitude 6.7 or larger earthquake in California since the forecast was made. The magnitude 7.1 Searles Valley earthquake of the July 2019 Ridgecrest earthquake sequence occurred on a fault that was very near and at a slight angle to the Little Lake Fault.

"My forecast was not exactly fulfilled," said Ebel. "Strictly speaking, the 2019 earthquake did not fall on the fault that I forecast, but it did occur in the area that I forecast."

Large earthquakes occur every three to five years in California, so it may be some time before the forecast is put to the test again, he noted. The pattern doesn't predict when a large earthquake might be expected after a higher rate of magnitude 4 earthquakes.

Ebel first became interested in patterns of magnitude 4 earthquakes in eastern North America, where older rupture zones are more difficult to

trace than in California. He noticed there that magnitude 4 and larger earthquakes seemed to be occurring at the ends of modern earthquake zones. "I wondered if I could find where the ends of old earthquake ruptures were by figuring out where the modern magnitude 4s are," he said.

In California, there are more faults with decades' long histories of magnitude 4 and larger earthquakes to help answer the question. "The first thing I noticed there was the rate of magnitude 4s was a lot higher before a large earthquake than it was after a large earthquake occurred," Ebel said. "And then the other thing I noticed was that those magnitude 4s were scattered all along those faults that were eventually to have the big earthquake."

The pattern of magnitude 4 earthquakes occurring all along a fault before a large earthquake and then concentrating at the ends of the rupture afterward reflects how seismic stress is redistributed by a large earthquake, he said.

Ebel has also looked for the pattern in other regions with good recent earthquake records, such as Japan. The 2016 magnitude 7.3 Kumamoto, Kyushu earthquake and the 2016 magnitude 6.2 in Central Tottori earthquake on Honshu had some magnitude 4 or larger earthquakes along their faults in the two decades before the large earthquakes, but the 1995 magnitude 6.9 Kobe earthquake had few magnitude 4 earthquakes before the mainshock. He concluded that the pattern may not happen before all large earthquakes.

Ebel hopes that discussing the California forecast will prompt other researchers to look for data sets or theoretical work that could be used to test the magnitude 4 pattern more thoroughly and across the globe.

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