Earthquake Forecast: 4 California Faults Are Ready to Rupture

By Becky Oskin, Senior Writer | October 13, 2014 05:00pm ET

Pin it San Francisco Bay Area earthquake faults are drawn in red. Credit: USGS

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With several faults slicing through the San Francisco Bay Area, forecasting the next deadly earthquake becomes a question of when and where, not if.

Now researchers propose that four faults have built up enough seismic strain (stored energy) to unleash destructive earthquakes, according to a study published today (Oct. 13) in the Bulletin of the Seismological Society of America.

The quartet includes the Hayward Fault, the Rodgers Creek Fault, the Green Valley Fault and the Calaveras Fault. While all are smaller pieces of California's San Andreas Fault system, which is more than 800 miles (1,300 kilometers) long, the four faults are a serious threat because they directly underlie cities. [Photo Journal: The Gorgeous San Andreas Fault]

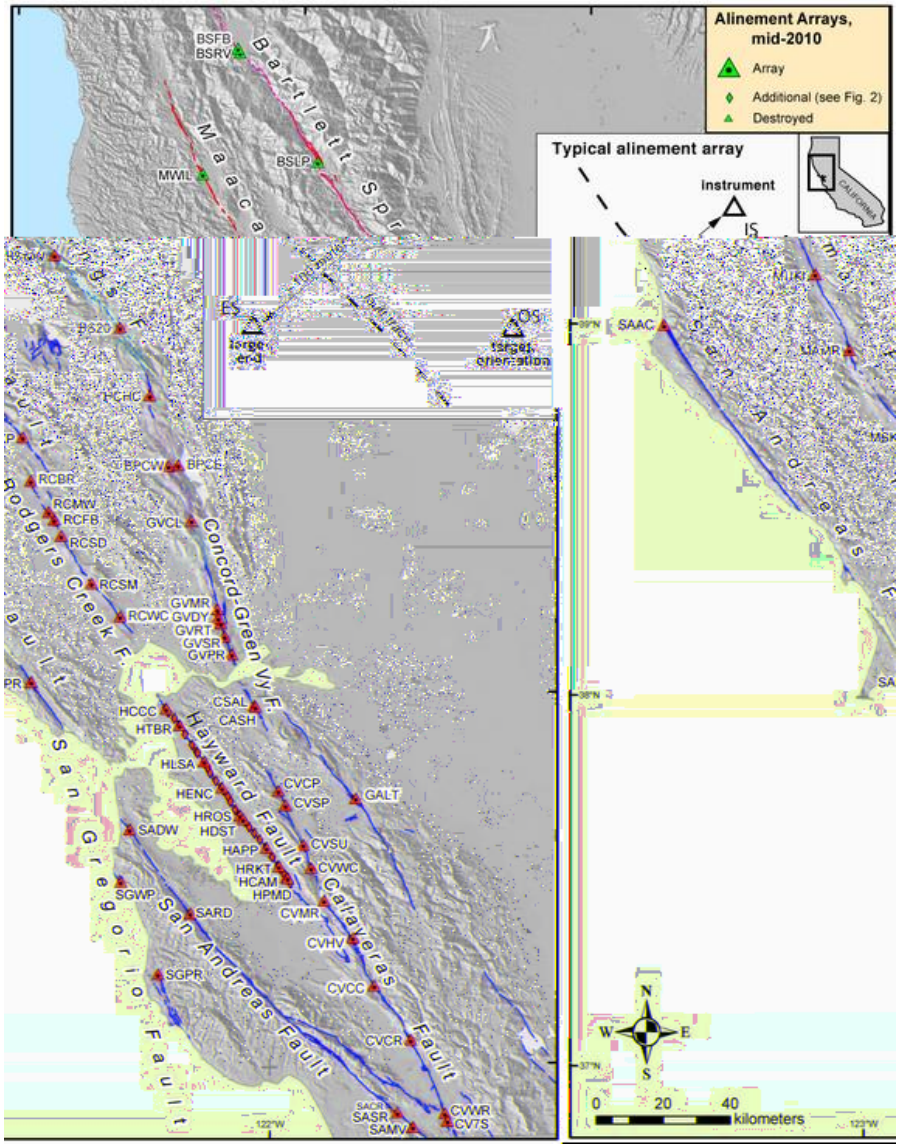
"The Hayward Fault is just right in the heart of where people live, and the most buildings and the most infrastructure," said Jim Lienkaemper, lead study author and a research geophysicist at the U.S. Geological Survey's Earthquake Science Center in Menlo Park,

California. "But it's not just one fault, it's the whole shopping basket. If you are in the middle of the Bay Area, you are near a whole lot of faults, and I'm concerned about all of them."

Lienkaemper and his colleagues gauged the potential for destructive earthquakes by monitoring tiny surface shifts along California faults. Certain faults are in constant motion, creeping steadily by less than 0.4 inches (1 centimeter) each year. These slow movements add up over time, cracking sidewalk curbs and buildings. They also serve as clues to what's happening deep below ground, where earthquakes strike.

"If you figure out where faults are creeping, it tells you where they're locked and how much they're locked," Lienkaemper told Live Science.

Fault creep varies, with some faults sliding at a snail's pace and others barely budging. Models suggest that the diversity comes from locked zones that are 3 to 6 miles (5 to 10 km) below the surface, where the fault is stuck instead of sliding. For example, the relatively fast-creeping southern Hayward Fault is only about 40 percent locked, on average, while the slow-creeping Rodgers Creek Fault is 89 percent locked, the study reports. When these locked areas build up a critical amount of strain, they break apart in an earthquake.



Map of Bay Area earthquake faults and creep measurement sites.
Credit: USGS
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Lienkaemper and his co-author estimated a fault's future earthquake potential by combining creep measurements with mathematical fault models and other regional data, such as the time since the last earthquake.

The Hayward Fault has banked enough energy for a magnitude-6.8 earthquake, according to the study. The Rodgers Creek Fault could trigger a magnitude-7.1 earthquake, and the Green Valley Fault also has the potential to unleash a magnitude-7.1 shaker. The Northern Calaveras Fault is set for a magnitude-6.8 temblor.

Of all Bay Area faults, the Hayward Fault is most likely to spawn a damaging earthquake in the next 30 years, scientists think. Its 1868 earthquake was called the Big One until the great 1906 San Francisco quake came along. The Hayward Fault has ruptured about every 140 years for its previous five large earthquakes. The probability of a magnitude-6.7 earthquake on the Hayward Fault is 30 percent in the next 30 years.

Though 146 years have now passed since the last Hayward earthquake, that doesn't mean the fault is overdue for another quake, Lienkaemper said. "The average is 160 years, but the uncertainty is plus or minus 100 years, which is almost as big as the time [interval] itself." The 160-year average comes from an analysis of data collected from trenches dug across the fault that revealed evidence of earthquakes over thousands of years.

The Rodgers Creek and Green Valley Faults are also closing in on their average repeat times between earthquakes.

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Fracking Linked to More Ohio Earthquakes

By Becky Oskin, Senior Writer | October 14, 2014 05:00pm ET

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Another rare case of fracking-caused earthquakes has jolted Ohio.

A new study connects some 400 micro-earthquakes in Harrison County, near the town of Canton, to hydraulic fracturing wells. The three wells operated from September through October 2013 in the Utica Shale. Ten of the quakes registered between magnitude 1.7 and magnitude 2.2, but the tremors were too deep to cause damage or to be easily felt by people, according to the study, published today (Oct. 14) in the journal Seismological Research Letters.

The new study is the second report this year of fracking-linked earthquakes from drilling in the Utica Shale. The shale is a rock formation that is deeper and closer than the Marcellus Shale to the crystalline basement rocks where faults are more common. In March, scientists with Ohio's Department of Natural Resources (ODNR) shut down drilling at seven Utica Shale gas wells in Poland Township after fracking triggered two small earthquakes. The ODNR now requiresmonitoring of seismic activity at fracking sites near known fault lines, and reducing the flow of water if earthquakes begin to occur.

The Harrison case is one of the few scientifically documented incidents of hydraulic fracturing causing earthquakes on a fault, said lead study author Paul Friberg, a seismologist and owner of InstrumentalSoftware Technologies Inc. (ISTI). Harrison County is the fifth documented case in the world, Friberg said. Other locations of earthquakes caused by fracking include Oklahoma; the United Kingdom; British Columbia, Canada; and Ohio's Poland Township. [7 Ways the Earth Changes in the Blink of an Eye]

Fracking involves pumping large volumes of water, sand and chemicals into underground shale or other rocks, such as coal. The pressure forces open the rocks, allowing trapped oil and gas to escape.

Within the oil and gas industry, hydraulic fracturing is known to cause earthquakes, but the tremors are usually so small that seismometers barely wiggle in response. The micro-earthquakes from fracturing rocks often register as negative magnitude 1 to negative magnitude 3. (Themagnitude scale is logarithmic. On a seismogram, a wiggle of 20 millimeters, or 0.8 inches, corresponds to a magnitude 2 earthquake, and a wiggle of 0.02 millimeters is magnitude minus 1.)

"Fracking earthquakes pose no real hazard, because they are so small in the majority of cases," Friberg told Live Science in an email interview.

The Harrison County quakes struck less than 1 mile (1.4 kilometers) below the horizontal wells. Shaking started just 26 hours after fracking began on Sept. 29, 2013. Nearly 190 earthquakes hit during a 39-hour period on Oct. 1 and 2.

The quakes tapered off after the fracking was completed on the wells, the study reports.

Because the earthquakes line up in an east-west direction in ancient crystalline rocks beneath the Utica Shale, Friberg and his co-authors think the fracking activated a small, unknown fault. The fracking water could have "greased" the fault, unclamping the fracture and allowing it to slip.

Since 2008, shale gas drilling has been linked to earthquakes from Oklahoma to Ohio, but in almost all cases, the quakes are tied to wastewater disposal wells. Fracking produces millions of gallons of wastewater, which is pumped back underground and stored in deep wells to protect groundwater.

Though Ohio is one of the few states to monitor wells for earthquake activity, many of the small faults triggered by injection wells or fracking have never been previously identified by scientists.

"Ohio has been very proactive in installing seismometers throughout eastern Ohio to better analyze seismic data as it relates to oil and gas activity. If the data conclusively shows a probable correlation to a felt event, ODNR has and will continue to take the appropriate steps necessary to ensure public health and safety is protected," said Bethany McCorkle, ODNR spokeswoman.

Editor's note: *This story was updated to clarify that Paul Friberg said that this was a rare case of hydraulic fracturing causing earthquakes on a fault, not of felt earthquakes.*

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